ACKNOWLEDGMENT

Written during the entire course of my post-graduate period, this book comprises a complete clinical guide to orthognathic surgery for budding Orthodontists.

I thank God, My family, my guide and Dean of Yenepoya Dental College, Dr. Akhter Husain, and the Head of the department, Dr. Rohan Mascarenhas.

Sincere gratitude to Professor Dr. Shahistha Parveen, whose dissertation on orthognathic surgery has been an important source for this updated clinical guide, and all my teachers and friends who supported me.

Dedicated to all the Orthodontists and Maxillofacial surgeons.

Kevin Joseph

CONTENTS

INTRODUCTION

Symmetry is considered a hallmark of facial attractiveness. Skeletal deformities generally, require surgical intervention to improve facial esthetics and correct any associated malocclusions. The classic approach involves a presurgical phase of orthodontics, during which dental compensations are eliminated, and a postsurgical phase to refine the occlusion. The presurgical phase can be lengthy, involving tooth decompensations that often exaggerate the existing dentofacial deformities.

Surgical orthodontics is the art and science of diagnosis, treatment planning, and execution of treatment by combining orthodontics and oral and maxillofacial surgery to correct musculoskeletal, dento-osseous, and soft tissue deformity of the jaws and associated structures. The term orthognathic surgery was first coined by Hullihen[1] in 1849. Since the introduction of the mandibular sagittal split ramus osteotomy by Trauner and Obwegeser[2] in 1957, which marked the beginning of the modern era of orthognathic surgery. This intraoral approach could move the mandible in three dimensions according to the designated surgical plan, keeping the condyle in the glenoid fossa. Maxillary Lefort I osteotomy was first reported by Obwegeser[3] to move the maxilla in all three dimensions reporting a large series of maxillary osteotomy cases in 1969, which has become one of the most popular methods for correcting skeletal class II or III deformities.

Pre-surgical orthodontic preparation was uncommon for patients requiring orthognathic surgery until the 1960’s[4]. However, as surgical techniques advanced and the number of patients choosing an orthognathic approach increased, the patients’ and clinicians’ desire for optimal esthetic and occlusal results led to the most common current treatment approach. This conventional approach for the correction of severe dentofacial anomalies consists of three stages. These stages involve pre-orthognathic orthodontic treatment to relieve the dental compensations followed by the orthognathic surgical procedure and finally post-surgical orthodontics to finish the case and settle the occlusion.

According to conventional orthognathic surgery, presurgical treatment is crucial for satisfactory surgical treatment and stable results. This presurgical orthodontic treatment precedes the orthognathic surgery to show the true skeletal discrepancy preoperatively and to fit the maxilla and mandible into a solid occlusion after surgery and is believed that without appropriate dental decompensation preoperatively, the surgeon is limited by the tooth position in fully correcting the skeletal deformity. The objectives of presurgical orthodontic treatment consist of Dental decompensation for positioning the teeth over their basal bones without considerations for the bite relationship to the opposite arch; Leveling and aligning the teeth, relieving any crowding; Coordinating upper and lower dental arch forms; and divergence of roots adjacent to surgical sites where interdental osteotomies are planned.

Presurgical orthodontic procedures usually produce satisfactory results and are considered routine[5]. However, this process can be time-consuming, taking as long as 24 months, depending on the complexity of orthodontic treatment requirements. In addition, there are worsening of facial profile, masticatory discomfort during presurgical orthodontic treatment, and psychosocial problems associated with delay in responding to the patient’s usual complaint concerning facial esthetics treatment and because of the long-term orthodontic preparation, there may be complications such as dental caries, gingival recession, gingival hyperplasia, and root resorption.

These are claimed disadvantages of the conventional approach that require two phases of orthodontic treatment.

Shortening of the total treatment time and accelerated tooth movement after surgery due to altered bone remodeling are the most frequently reported advantages of the surgery-first approach. Altered bone remodeling after periodontal surgery was first described decades ago.

The phenomenon of altered bone remodeling is not restricted to the periodontium but is also observed after orthognathic surgery in the operation field and adjacent regions. Frost described this local tissue reaction, accelerating the healing process, as the regional acceleratory phenomenon (RAP). In orthodontics, corticotomies or interdental osteotomies to accelerate tooth movement are currently receiving increasing attention.

The acceleratory phenomenon is not fully understood. In particular, molecular and cellular factors, as well as the regulatory processes, are unknown. However, RAP requires the coordinated, accelerated activity of both cell types involved in bone remodeling, osteoblasts, and osteoclasts, and the spatial extension of the phenomenon requires soluble diffusible factors to control these activities.[61]

To overcome the above disadvantages and inconveniences of presurgical orthodontics, surgery first orthognathic approach has been introduced by Behrman and Behrman[6] in 1988.

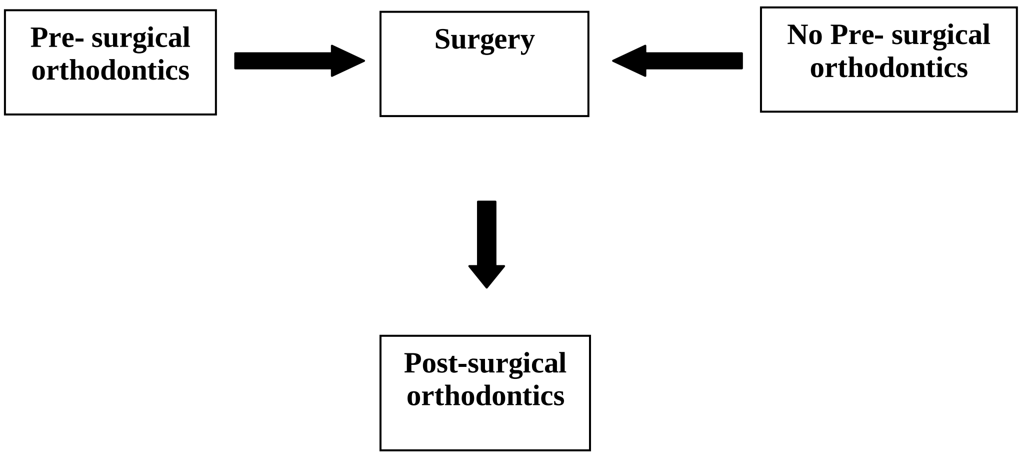
They claimed that the normalized surrounding soft tissues (lips, cheeks, and tongue) settled teeth into better positions after surgery thereby facilitating remaining orthodontic tooth movement and reducing the total orthodontic treatment period. This concept of "surgery-first and orthodontics second" is called "SFOA" (Surgery-First- Orthognathic-

Approach) or "SFA" (Surgery-First approach). As usual new ideas in any field go through a predictable cycle, first, initial rejection by nearly everyone; then, acceptance by a few whiles ignored by the majority; finally, adoption by almost everyone.

***Surgery first approach*:** Surgery first is an alternative methodology to conventional orthognathic surgery "orthodontics– orthognathic surgery–orthodontics," which performs directly an orthognathic surgery, without the previous orthodontic preparation, followed by a post-surgical orthodontic treatment to achieve the desired final dental alignment[5]. The concept of this technique is for no prior tooth movement or minimal tooth decompensation for a shorter period in cases of occlusal interference, to use surgery to rapidly achieve facial esthetic improvement that is usually the patient's chief complaint at the beginning of the treatment. This approach was made possible by replacing pre-surgical orthodontic treatment with surgical modifications of multiple osteotomies (maxillary posterior impaction with occlusal plane rotation and segmentalization of maxilla) good laboratory work (set-up model and indirect bonding) and successful utilization of regional acceleratory phenomenon (RAP).

The main advantage of SFA[7,8] in the early improvement of the facial profile and thereby eliminating ugly looking decompensation period, the establishment of proper maxillomandibular relationship before orthodontic treatment, and a shorter total treatment duration period. Amongst other advantages, this protocol allows patients to choose when they want to be operated on. But, predicting the final occlusion is the hardest challenge with the surgery first approach and this type of treatment is not applicable to all cases, especially when the basic deformity is very complex or when the main interest is a specific occlusal result.

SEQUENCE OF ORTHODONTIC TREATMENT



The flow chart shows orthodontic treatment required prior to the surgery and /or following surgery. Very seldom it may be required only before or after surgery and very rarely no treatment is required. The basic objective of presurgical orthodontics is to decompensate, align and coordinate the upper and lower teeth for obtaining maximum cuspal interdigitation when jaws are surgically aligned. The objective of post-surgical orthodontics is to fine-tune the occlusion. Clinical experience shows that some form of pre-and post-surgical orthodontics is required for patients undergoing orthognathic surgery.

REVIEW OF LITERATURE

Weaver N, Glover K, Paul Major, Varnhagen C, Grace M (1998)[1] The study described where Canadian orthodontists were surveyed by mail to determine the latest skeletal age at which they would recommend orthopedic therapy and orthognathic surgery and the earliest at which they would recommend orthognathic surgery. For the purposes of this introductory study, orthopedic therapy implied stimulation of physiologic response using appliance force, without specification of appliance type. The response rate from 512 orthodontists was 65% (*n* 5 334), with the response rate by item varying from 92% to 95%. By Greulich and Pyle standards, the latest recommended age for orthopedic therapy was at 97% completion of skeletal growth (females 13.5 years, males 15 years), whereas the earliest recommended age for orthognathic surgery was when skeletal growth is 99% complete (females 14.9 years, males 16.5 years). Surgery would be recommended by 32% of respondents for a patient before the age of 8 years if the deformity is severe. For orthognathic surgery, respondents either perceived no age maximum or recommended 69 years, the maximum age on the questionnaire item. Orthodontists' traits influenced recommendations for timing treatment.

Proffit WR, Bailey TJ, Phillips C et al (2000) observed Skeletal changes greater than those in untreated adults have been noted beyond 1-year post-surgery in adult patients who had surgical correction of a long face deformity. cephalometric radiographs are selected for patients who had surgical correction of anterior open bite .2 mm by either Le Fort I osteotomy alone or the combination of Le Fort I and mandibular ramus osteotomies, for whom presurgery, immediate post-surgery, 1-year, and at least 3-year post-surgery. Data for 54 patients, 28 with maxilla-only and 26 with 2-jaw surgery, are available. The cephalometric radiographs were digitized using the UNC 140-point model and changes in landmark positions were evaluated relative to a previously described x-y coordinate system.

Mandibular advancement beyond upward-forward rotation occurred in most but not all the 2-jaw patients. The cephalometric radiographs were digitized using the UNC 140-point model. Changes .2 mm or .2 degrees were considered clinically significant and changes .4 mm or .4 degrees were highly clinically significant. Mean changes from presurgery to the end of the first post-surgical year are displayed in composite cephalometric tracings. On average, beyond 1-year post-surgery, there was a tendency for the maxilla and mandible to move slightly downward in both groups, and for maxillary posterior teeth and both maxillary and mandibular anterior teeth to erupt. For both surgical groups, statistically significant changes in the mandibular plane angle, the vertical position of point B, and total face height were observed. In the 2-jaw group, no patients showed a decrease in Co-Pg length, and one-third had an increase. For both groups, changes in overjet were smaller and less frequent than changes in mandibular length.

Hunt OT, Johnston CD et al (2001) reported psychosocial benefits of orthognathic surgery. A systematic review of the literature was conducted using MEDLINE. The database contains more than 9.5 million records from more than 3900 journals. Hand searching was conducted on the following journals from 1984 to December 2000. Randomized controlled trials, other controlled clinical trials, prospective studies (with or without controls), and retrospective studies (with or without controls) are considered for inclusion. The review concerned studies of patients who are considering orthognathic surgery or about to undergo orthognathic surgery, and patients who had completed orthognathic surgery. Studies focusing on patients with syndromal conditions such as cleft lip and palate were not included. Only studies in which patients self-reported their psychosocial status were considered. A variety of study designs has been used to examine the psychosocial benefits of orthognathic surgery, including cohort studies with controls, prospective studies, and retrospective studies. The authors compared the psychological status of 156 patients who are referred for possible orthognathic surgery.

Ninety of them eventually received orthognathic surgery, 33 declined orthognathic surgery but underwent orthodontic treatment only, and 33 declined any form of treatment. The surgery group expressed a significantly more positive mood, more vigor, less fatigue, less depression, and less tension-anxiety 6 months after surgery compared with those who completed orthodontic treatment only and those who had no treatment. The results indicated that patients may acquire a number of psychosocial benefits as a result of orthognathic surgery. According to these longitudinal data, the psychosocial benefits gained by patients who undergo orthognathic surgery are better social functioning, social adjustment, self-confidence, self-concept, body image, emotional stability, self-esteem, and facial-attractiveness image; positive life changes; and reduced anxiety.

Jacobsan A, Bailey LTJ, Haltiwanger LH et al (2002) examined the characteristics and trends in surgical orthodontic patients who sought treatment in the 1990s and compare them with patients treated in the 1980s. The diagnostic records of 2074 patients taken between 1979 and 1998 were examined. The female-male ratio of 2:1 remained constant throughout the 1990s, Class III and long-face persons are more likely to seek evaluation than those with Class II problems. However, more patients in the Class II group who are offered surgery accepted it when a surgical plan was offered.

Whites are more likely to accept surgery than blacks, and women are more likely than men to accept surgical treatment. Thirty percent of all clinic patients displayed some sort of facial asymmetry. Although women were more likely than men to be treated surgically when facial asymmetries were evident, the findings of the study suggest that the presence of asymmetry did not seem to influence the decision to accept or reject treatment. One might think that patients with more noticeable or disfiguring characteristics would be more likely to agree to surgical treatment, but this was shown not to be the case. The decision to have surgical treatment appears to be influenced more by what patients perceive than by what doctors observe.

Aziz SR (2004) described the Origin of Orthognathic Surgery. Its early evolution is often credited to Vilray Blair, Hullihen advocated surgical repair in infancy, before the eruption of dentition. He also used an “adhesive strap” from one cheek to another prior to surgery. Hullihen also fabricated obturators for adult cleft palate patients. Hullihen decided that a 3-phase surgical plan was in order: the initial procedure focused on correcting the skeletal deformity of the mandible, followed by resection of the large cicatrix of the right face and neck and then correction of the lower lip defect. He noted that correcting the malocclusion was most important— it provided for the restoration of function. He also noted that there were edentulous spaces between the first premolar and the canine on the right; in the left mandible, there was a space between the premolars. Most likely, these spaces were secondary to the cicatrix distracting anterior mandible as it developed. Hullihen used these spaces to treat the prognathism by performing wedge resection of bone bilaterally combined with what is now known as an anterior subapical osteotomy, as described by Kole in 1959. Once the bone wedges were removed and the osteotomy completed, Hullihen then took an impression of the new mandibular occlusion, created a stone cast, and fabricated a silver plate (occlusal splint) combined with maxillomandibular fixation to immobilize the anterior mandible in its new position and facilitate bony healing. Postoperatively, Hullihen noted that the patient was relatively comfortable, without any significant complications. He left the splint on for 6 weeks to allow for the bony union.

Kneafsey LC, Cunningham SJ et al (2008) estimated the postsurgical soft-tissue outcomes that can be achieved by using simple ratios of the hard and soft tissues. This was a retrospective cephalometric study in patients undergoing mandibular advancement surgery. Surgical fixation involved miniplates or bicortical screws.

Patients who had received additional surgery such as genioplasty, rhinoplasty, mandibulotomy, or any maxillary surgery and those with congenital deformities such as cleft lip and palate were excluded. Two cephalograms were required for each patient, and each was taken in centric occlusion with the lips in repose: T1, a presurgical radiograph; and T2, taken near the end of postsurgical treatment. The constructed x-reference plane was 7° inferior to the sella-nasion line, rotated at sella, and the y-reference plane was constructed as a line perpendicular to the x-reference plane through sella. A paired *t-test* was used to investigate the systematic error. the results of the paired *t-test* showed no evidence of any systematic error between the 2 readings. Two landmarks showed significant systematic error (superior labial sulcus and pronasale, both in the vertical plane). At least 96% of the variation of each dependent variable was explained by its relationship with the explanatory variables in the relevant multivariable regression equation, and the results appeared to be clinically useful.

Nagasaka H, Sugawara J et al (2009) described the treatment of a skeletal class III malocclusion with the combination of skeletal anchorage devices (titanium miniplates as TAD) using surgery first approach. The subject included one female patient of 17 years old who presented with a Class III skeletal relationship. Cephalometric and occlusogram predictions are used for treatment planning. Before OGS 0.22" preadjusted brackets were bonded to all teeth except the maxillary second molars and passive rectangular 0.018x0.025" stainless steel archwire was inserted.

Model surgery was performed according to the cephalometric prediction. A surgical splint was fabricated with a lingual bar and ball end clasp to cover the posterior occlusal surfaces, then bilateral sagittal split osteotomy was performed to correct class III malocclusion. Titanium miniplates were used for rigid internal fixation. Immediately after surgery, the patient demonstrated a class II profile and a class II occlusal relationship with open bite. Postsurgical orthodontics was initiated one month after surgery. The maxillary posterior teeth were leveled with NiTi wires and simultaneously distalized using SAS mechanics after one and a half months of bonding in the lower arch was started.

A total treatment time of 12 months, then all brackets are debonded and miniplates are removed. Post-treatment records showed complete resolution of all patient's orthodontic problems resulting in a balanced profile with a good occlusal relationship. Three years post retention showed stable results.

The authors concluded that SFOA combined with SAS mechanics provides significant benefits to skeletal class III patients compared with conventional orthodontic treatment.

Wang YC, Ching Ko EW et al (2010) investigated the differences of transverse dimensional change of dental arches in patients with surgical skeletal Class III with and without presurgical orthodontics. The study consisted of 36 patients with skeletal Class III undergoing surgical-orthodontic treatment. Eighteen patients comprised the surgery-first group (SF group) and the other 18 patients the orthodontics-first group (OF group). All patients received orthodontic treatment with 0.022- _ 0.028-inch preadjusted appliances and sliding mechanics. Patients in the SF group did not receive any presurgical orthodontic adjustments. Only the orthodontic appliances were prepared on the teeth 1 to 2 weeks before surgery. In OF group sectioned open coil springs might be used between the lateral incisor and canines to expand the intercanine width because occlusal interferences still happen. For each patient, posteroanterior cephalometric radiographs are taken. In the OF group, the maxillary molars (1.3°), maxillary canines (3.4°), mandibular molars (_1.5°), and mandibular canines (_0.8°) showed buccal tilt during the period of the presurgical orthodontic treatment. After surgery in the SF group, the maxillary canines (0.8°) and mandibular molars (_3.7°) were buccally tilted. The maxillary molars (_2.4°) and mandibular canines (2.5°) were lingually tilted. In the OF group, the maxillary canines (_1.0°), mandibular canines (2.6°), and maxillary molars (_1.3°) were lingually tilted. The mandibular molars (_0.9°) were buccally tilted. The amount of postsurgical change showed no statistically significant differences between the 2 groups. They concluded that the magnitude and trend of transverse dental changes in patients with surgical skeletal Class III are similar whether receiving presurgical orthodontics or not.

Chih Yu C, Chen PH, Liou EJW et al (2010) described the surgical-orthodontic treatment of mandibular prognathism using surgery first approach. The subject included was one male patient of 19 years old with mandibular prognathism, an anterior open bite, and severe crowding treated with SFOA. He also presented with a horse-like facial appearance. The patient was diagnosed with class III malocclusion and long lower anterior facial height. SFOA was advised for this patient with Lefort I posterior impaction by 3mm, clockwise rotation of maxilla with 3mm of advancement at the ANS, and autorotate the mandible counterclockwise to decrease the lower anterior facial height and open bite. Then BSSO was performed to setback the mandible by 16mm and to achieve class I occlusion. After the 1-week patient was braced. The total postoperative orthodontic treatment took only four months. During the first two weeks after the surgery, intermaxillary fixation was applied to ensure postoperative stability. A symmetric, harmonious relationship of the facial soft tissue and a pleasant profile was obtained after treatment and the results are not compromised

Villegas C, Uribe F et al (2010) corrected a dentofacial asymmetry using a "surgery first" approach and Class III malocclusion. The subject included was a 20-year-old female presented with facial asymmetry and underbite and she accepted a SFOA that would achieve an esthetic smile and normal occlusion. 1 week before surgery .022" preadjusted brackets are bonded. Asymmetrical single jaw surgery with the mandible setback of 7mm on the left and 3mm on the right to address both asymmetry and prognathism. In addition, anterior sliding genioplasty was done. Two months after surgery the molars and canines are in class I occlusion. Seven months after surgery fixed appliances are removed. The final records showed good esthetic and occlusal results, the miniplates were left in place for six months of retention. During this time, they evaluated the stability of the orthodontic treatment, and the miniplates could have been used if any postoperative orthodontic or surgical relapse had occurred.

Sugawara J, Aymach Z et al (2010) treated a Skeletal Class II malocclusion with an Impinging Bite using “Surgery First” Orthognathic. The age of the patient was 44 years presented with impinging bite, obstructive sleep apnea, skeletally class II malocclusion indicated the need for OGS. The patient chose the “surgery first” approach. Before orthognathic surgery, the mandibular right third molar was extracted, .022" preadjusted brackets are bonded to all remaining teeth, and passive rectangular .019" × .026" archwires were placed. A bilateral sagittal split ramus osteotomy (BSSRO) was then carried out to advance the mandible as indicated by the splint. Postsurgical orthodontic treatment began two weeks later. After nine months of treatment, all brackets were debonded and the titanium miniplates and screws are removed under local anesthesia. Post-treatment examination showed complete resolution of all orthodontic problems, resulting in a balanced profile and good occlusal relationship.

Faber J et al (2010) introduced a new protocol—named Anticipated Benefit—to illustrate it with a clinical case. The planning stages are presented and then illustrated by treating a patient with a Class III deformity. The age of the patient was 19 years with facial disharmony. A facial analysis showed a symmetric Class III dentofacial deformity with the prognathic mandible. After the orthodontic and surgical plans had been defined the fixed orthodontic appliance was installed with 0.022 x 0.028-in preadjusted brackets on both dental arches. Orthodontic-surgical correction of the dentofacial deformity was started by combining a mandibular setback with potential maxillary advancement. All the treatment options included orthodontic treatment and orthognathic surgery using the Anticipated Benefit protocol, then mini-plates are placed on the maxilla for anchorage to retract the upper posterior teeth. The third molars are extracted. After surgery, the dental relationship was that of Class II but with facial Pattern I. The patient was very pleased with the end result of treatment as reflected in both facial aesthetics and occlusion. The appliance was removed after 15 months of treatment. A wraparound type removable appliance was used on the upper arch and a 3 x 3 fixed retainer was bonded on the lower arch. Two years after treatment the occlusion remained stable.

Liou EJW, Chen PH, Wang YC et al (2011) observed the phenomenon of postoperatively accelerated orthodontic tooth movement in patients who had orthognathic surgery. Twenty-two consecutive adult patients who had 2 jaw orthognathic surgery were included in this study. All patients underwent Lefort I osteotomy of the maxilla and the bilateral sagittal split osteotomy of the mandible for

their dentofacial deformities. The tooth mobility was also examined preoperatively, 1 week postoperatively and 1,2,3, and 4 months postoperatively. The changes in tooth mobility of the upper and lower incisors are then correlated to the changes in ALP and ICTP. The tooth mobility of upper and lower incisors significantly increased from 1 week to 3 months postoperatively. The highest mobility was found in the first month after OGS and mobility then decreased and approached the preoperative level in the fourth month postoperatively except for the lower central incisors. They summarized that RAP might be a contributing factor to increased mobility of the teeth after periodontal surgery.

Alfaro FH, Martinez RG, et al (2011) reported two cases of bimaxillary surgery with the "surgery first" approach. The subjects included were 2 female patients. The age of the patient was 22 years complains of open bite and also shows angle class II malocclusion with transverse maxillary deficiency of the maxilla, pronounced curve of spee, and moderate crowding in the lower arch. The treatment plan included a segmented Le Fort I maxillary osteotomy with 5-mm advancement, 4-mm expansion, and 3-mm posterior impaction, plus bilateral sagittal split osteotomies (BSSO) for mandibular advancement of 8 mm and counterclockwise rotation. Surgery was performed 3 weeks after the first appointment. The usual maxilla-first approach was followed Before starting the osteotomies, 6 anchorage screws are placed transmucosal to assist in intraoperative stabilization of the segments and splints. Fixation of the 4-piece maxilla was achieved with 4 titanium miniplates and 16 screws. The BSSO for advancement was stabilized with 2 plates and 8 screws. The final splint was left in place to aid in transversal contention of the expanded maxilla. The patient's postoperative recovery was uneventful at 2 weeks postoperatively, the final splint was removed, and the orthodontic movements are begun using round wires and intermaxillary elastics.

The total orthodontic treatment required 250 days. In another case of 20 years female patient presented with Class III malocclusion with maxillary deficiency and mandibular asymmetry. The Cant of the occlusal plane was also evident on frontal inspection. The virtual surgical treatment plan included Le Fort I maxillary osteotomy for 7-mm advancement and 4-mm descent and a BSSO for 3-mm retrusion and centering. temporary screws are placed, and a maxilla-first protocol was followed two preformed plates with 7 screws on each were used to stabilize the maxilla, and 2 more with 4 screws each are used for the mandible. Post-surgical orthodontics began 10 days after surgery and involved arch alignment and leveling, with decompensation of the lower arch. For this patient, the total orthodontic treatment lasted 185 days, after which an adequate Class I occlusion and an esthetically balanced profile was achieved.

Liou EJW, Chen PH, Wang YC et al (2011) introduced the concept of the surgery-first approach and reported the general and specific guidelines for orthodontic management of skeletal class II and class III malocclusions, transverse arch coordination and model surgery without presurgical orthodontic decompensation. The surgery-first approach uses osteotomy to solve both skeletal problems and dental compensation, and a “transitional” occlusion is set up postoperatively. Orthodontics in the surgery-first approach is a postoperatively adjunctive treatment to transfigure the transitional occlusion into the solid final occlusion.

Ching EW, Pin SS et al (2011) conducted a study to compare 1) progressive dental and skeletal cephalometric changes, 2) postsurgical stability, and 3) treatment efficacy of patients with skeletal Class III correction with and without presurgical orthodontic treatment. This study included 53 patients, divided into 2 groups according to the treatment procedure of presurgical orthodontics: the surgery first (SF) approach and the modified conventional (MC) approach. The SF group included 18 patients, consisting of 8 men and 10 women and the orthodontic treatment was conducted by C.S.H. The MC group included 35 patients, consisting of 19 men and 16 women. In the SF group, No active orthodontic treatment was performed. In these patients, the presurgical preparation included dental casts, accurate bite registration, and facial measurements.

In the MC group active orthodontic treatment was performed in all cases included leveling and alignment, space consolidation, and general coordination of both arches. The mandible in all the patients was corrected with BSSO. The single splint technique was conducted during OGS. The Class III pattern showed a similar initial status of skeletal and dental measurements (T1) in both groups, except for the increased vertical distance of the B point and pogonion in the MC group. The SNB in both groups was almost identical. The ANB was smaller in the SF group (_5.1°) without a statistically significant difference compared with the MC group (_3.8°). The authors concluded that class III OGS patients with or without presurgical orthodontic treatment showed no difference in the amount of skeletal correction and postsurgical relapse and treatment duration.

Pin Hsu SS, Singhal D, Xia JJ et al (2012) utilized computer-aided surgical simulation (CASS) to provide two planning methods for the surgery-first approach. The benefits of using CASS for planning include enhanced 3-dimensional visualization of treatment progression, the ability for surgeons and orthodontists to discuss and visualize in detail any potential treatment algorithm, and providing a more precise prediction for the surgeon, orthodontist, and patient in surgery first cases. The authors used one case of a female patient with obstructive sleep apnea to highlight two different planning procedures for the surgery-first approach in surgical orthodontic treatment. The major treatment goal is to open the airway by advancing the mandible by a minimum of 10 mm. The results demonstrated that the patient's mandible has been advanced thereby enlarging the airway after the orthognathic surgery. The orthodontic treatment will follow to address the post-surgical treatable malocclusion.

Leelasinjaroen p, Godfrey K et al (2012) reviewed the concept, indications, contraindications, the stages of treatment, advantages, and disadvantages of SFOA. In skeletal Class III cases without indication for needing extractions, Baek et al required at least three stable occlusal stops with positive overbite of six anterior teeth and existing arch coordination. The contra-indications for SFOA are severe crowding, arch in-coordination, severe vertical or transverse discrepancy, and patients with high expectations of treatment outcomes in terms of dental esthetics and stable occlusions.

Advantages include improves facial esthetics at the early stage of treatment, it can provide patient satisfaction, and shortened treatment time, after surgery, orthodontic tooth movement can be easily achieved because the teeth are usually not occluded. Rapid tooth movement can occur also because of the RAP effect. Disadvantages include the prediction of the final occlusion is most challenging and time-consuming, so the clinician's experience and skill are very important for achieving predictably satisfactory results.

Villegas C, Janakiraman N, Uribe F (2012) presented a case of class III malocclusion who had undergone combined orthodontic orthognathic surgical correction using SFOA. The age of the patient was 19 years. She had previously been treated orthodontically with four first-premolar extractions. presented with a skeletal Class III malocclusion was attributable to a retrusive maxilla with paranasal deficiency and a slightly prognathic mandible. Molar and right canine relationships are in Class III. Overjet and overbite were minimal because of the edge-to-edge occlusion of the incisors, she accepted a "surgery-first" approach that would achieve a normal occlusion, enhance facial esthetics. Surgery would consist of a high Le Fort I osteotomy that would advance and impact the maxilla by 3mm posteriorly, combined with a mandibular setback of 3mm. The clockwise rotation of the maxillomandibular complex was designed to address the retrusive maxilla, labially tipped maxillary incisors, paranasal deficiency, and prognathic mandible. Model surgery indicated a stable postsurgical cusp-to-cusp relationship. One day before the orthognathic surgery, .022" Roth prescription brackets are bonded in both arches. The .016" × .016" nickel-titanium archwires are placed in the operating room. After surgery, intermaxillary elastics (1⁄8", 3oz) are worn from canine to canine. One month later, .016" × .016" stainless steel archwires were placed and Class II elastics. The results showed that Rotation of the occlusal plane enhanced the maxillary projection in the middle facial third, improving the facial profile. The post-treatment molar and canine relationships are in Class I on both sides. Six months after debonding, the surgical corrections and occlusion had remained stable.

Ching ko EW, Chen YR Huang CS et al (2013) evaluated 45 consecutive patients to identify the parameters related to skeletal stability after orthognathic surgery in skeletal Class III malocclusion using a surgery-first approach and to analyze the factors correlated with surgical relapse. The subjects included in this study are 19 men and 26 women. No presurgical orthodontic alignment was performed in any patient. The mandibular surgical procedure was performed using a modification of the Hunsuck sagittal split ramus osteotomy. All subjects underwent combined Le Fort I and bilateral sagittal split osteotomy. Twenty-two of the 45 patients underwent genioplasty during OGS. Serial lateral cephalometric radiographs are obtained during initial examination (T1), 1 week postoperatively (T2), and after orthodontic debonding (T3). The average presurgical preparation took approximately 4 to 6 weeks before OGS. The mean B-point surgical setback was 11.19 mm, and the mean B-point relapse amount was 1.44 mm, representing a relapse rate of 12.46% in this group of patients.

Park KR, Kim SY, Park HS et al (2013) conducted a study on patients with the temporomandibular joint disease by intraoral vertical ramus osteotomy using surgery first approach. Two patients with mandibular prognathism underwent a jaw corrective procedure with SFA via IVRO. The surgical treatment objective (STO) was determined using 3D medical imaging software. The subjects included 1 male and 1 female (mean age 20 years). The age of the patient was 18 years presented with prognathic mandible, TMJ pain during mandibular function, revealed dental crowding and skeletal class III relationship. The surgery included the maxilla being repositioned to the STO and the maxillary osteotomy sites are fixed with biodegradable plates and screws. Also, the mandibular setback was performed using bilateral IVRO. Postsurgical orthodontic decompensation was performed to level and align the dentition. The labial brackets were removed 10 months postoperatively, and a well-aligned and leveled dentition with stable occlusion was obtained. Also, facial symmetry and normal facial profile were obtained. One-year postoperative, maximum mouth opening increased to 45 mm without clicking, TMJ symptom relief and facial esthetic improvement, as well as accomplishment of functional and stable occlusion within a 6-month period.

Aymach Z, Sugawara J et al (2013) presented a Non extraction “Surgery First” Treatment of a Skeletal Class III Patient with Severe Maxillary crowding. The age of the patient was 21 years. The patient had mandibular excess, Class III dental relationships, a deep anterior crossbite, and a severely crowded maxillary arch. The day before surgery, .022" preadjusted brackets are bonded to all teeth, and passive .018" × .025" stainless steel archwire is inserted. A bilateral sagittal split ramus osteotomy (BSSRO) was then performed to achieve the required mandibular setback. With the splint in place, the osteotomy was fixed with titanium miniplates.

The upper and lower third molars are extracted during surgery. Immediately afterward, the patient demonstrated a Class II profile and occlusal relationships, which are stabilized with the splint. Postsurgical orthodontic treatment was initiated one month after surgery. Postsurgical orthodontic treatment was initiated one month after surgery. After 14 months of orthodontic treatment, all brackets are debonded, and the titanium miniplates and screws are removed. A wraparound retainer was prescribed for the maxillary arch, and a lingual retainer wire was bonded in the mandibular anterior segment. Post-treatment records showed improved facial balance, with a symmetrical chin and enhanced lip posture. Class I canine and molar relationships were achieved, along with a level maxillary occlusal plane and proper overbite.

Uribe F, Janakiraman N, Shafer D et al (2013) presented a new approach with 3-dimensional cone-beam computed tomography-based treatment planning for the surgical correction of facial asymmetry in conjunction with the surgery first approach. The author documented the treatments of 2 female patients (mean age 24 years) with facial asymmetry who had orthognathic surgery with the surgery first approach with 3D computer-aided surgical planning based on CBCT scan procedure. The age of the patient was 22 years reported with a retrognathic mandible, vertical maxillary excess with an occlusal cant, transverse maxillary constriction, the facial asymmetry with the chin point deviated toward the left. Dentally, Class II molar and canine occlusion and excessive gingival display. 1, 4 weeks before surgery, the maxillary and mandibular teeth were bonded with 0.022-in slot pre-adjusted edgewise appliances, and the molars are banded. A CBCT scan (exposure time, 14 seconds) was taken for the construction of a composite skull model.

The surgical plan consisted of a LeFort I maxillary osteotomy with expansion, advancement, impaction, and bilateral sagittal split osteotomy for mandibular advancement with lateral sliding genioplasty. Postsurgical orthodontics duration was 12 months. The superimposition of the 3D virtual plan and the outcome shows the differences in the surgical movements. Three-dimensional superimpositions showed the initial images compared with the outcome CBCT images reflecting the movements of the maxilla and the mandible for correction of the facial asymmetry. The authors concluded that the Fusion of relatively new technologies and techniques such as 3D CBCT-based surgical planning, computer-aided splint fabrication, and the surgery first approach can make orthognathic surgery more efficient and effective.

Park HM, Lee YK, Choi JY et al (2014) investigated the differences in the amount and pattern of the maxillary incisor (MXI) inclination change in skeletal Class III patients treated with extraction of the maxillary first premolars (MXP1) and two-jaw surgery (TJS) between conventional orthognathic surgery (COS) and surgery-first approach (SFA). The sample consisted of 60 skeletal Class III patients (24 males and 36 females; mean age 5 22.4 6 4.4 years), who underwent one-piece LeFort I osteotomy and bilateral sagittal split ramus osteotomy and orthodontic treatment with MXP1 extraction. The mandibular arch was treated with non-extraction in both groups. and the MXP1s are extracted during surgery for all patients in group 2. The amount and pattern of MXI inclination changes are also measured and analyzed to evaluate the differences between the two groups. Lateral cephalograms were taken before treatment (T0), 1 month before surgery (T1), within 1 month after surgery (T2), and after debonding (T3).

The results showed that during T0–T2, the amount of MXI inclination change (DU1-SN) in group 1 was significantly larger than that in group 2 (212.8u vs 24.4u; P, .001). During T2–T3, DU1-SN in groups 1 and 2 occurred in opposite directions (3.8u vs 25.9u; P, .001). However, the total amount of DU1-SN during T0– T3 was not different between groups 1 and 2 (29.0u vs 210.3u). At T3 the U1-SN values for groups 1 and 2, respectively. The null hypothesis was that there was no difference in the amount and pattern of MXI inclination change between COS and SFA.

Huang CS, Pin Hsu SS (2014) presented a systematic review that aims to appraise the currently available evidence on the surgery-first approach and support its use in orthognathic surgery. A MEDLINE search was conducted using the subject headings "surgery first" and "orthognathic surgery" and 258 articles were obtained. Abstracts of these articles were reviewed to select the studies that used a surgery-first approach. The inclusion criteria were 1) human study and 2) orthognathic surgery using a surgery-first approach or its equivalent. Personal opinion was excluded. The search results indicated that a prospective cohort study or randomized controlled trial on the surgery-first approach has not yet been conducted. They concluded that the surgery-first approach offers an alternative to the orthodontics-first approach for the correction of the maxillofacial deformity. The final outcomes, in the way of facial esthetics, dental occlusion, and stability, are similar when using orthodontics-first and surgery-first approaches. Dental occlusion and facial esthetics can show immediate improvement after surgery when using a surgery-first approach; this almost eliminates the time spent on preoperative orthodontics.

Kim JY, Jung HD et al (2014) evaluated the postoperative stability of the surgery-first approach using intraoral vertical ramus osteotomy (IVRO) 12 months follow-up. They retrospectively studied 37 subjects who are diagnosed with mandibular prognathism with or without facial asymmetry treated by the surgery-first approach using a LeFort I osteotomy and IVRO for correction of class III dentofacial deformity. All subjects had surgical archwires placed 2–3 weeks preoperatively to be used for maxillomandibular fixation. After surgery, the mandible showed a mean (SD) anterior relapse of 0.6 (2.3) mm and superior relapse of 2.9(1.4) mm. There was no significant relapse of the mandible horizontally, but the vertical relapse was significant at all time intervals, particularly during the first 6 months postoperatively. Lateral cephalograms were taken preoperatively and 2 days, 6 months, and 12 months postoperatively are traced, and the skeletal and dental variables at different time points were analyzed.

Alfaro FH, Martinez RG et al (2014) managed 45 patients with a surgery first orthognathic approach. They may represent a reasonable approach for the expedited correction of a maxillofacial deformity. The studied sample consisted of 27 women and 18 men (mean age, 23.5 yrs.). Selected cases presented symmetrical skeletal malocclusions with no need for extractions or surgically assisted rapid palatal expansion. Periodontal or temporomandibular joint problems and management by an orthodontist without experience in orthognathic surgery is considered exclusion criteria. Diagnostic workup included routine clinical assessment by the combined orthodontic and surgical team and radiologic evaluation with cone-beam computed tomography. The necessary dental movements are anticipated by performing a 3D virtual orthodontic setup on the skull model.

The planned osteotomies were simulated too. Next Except for bracket bonding 1 week before surgery, no other preoperative orthodontic preparation was implemented. After corticotomies are executed in the maxilla and mandible to accelerate postoperative orthodontic movement according to the regional acceleratory phenomenon (RAP) theory, these corticotomies are performed with a piezoelectric micro saw. After a healing period of 2 weeks postoperatively, orthodontic treatment began. At 1-year follow-up, patient satisfaction with treatment outcome was assessed with a visual analog scale (VAS). Of 19 patients with Class II malocclusion, 6 had a long face (vertical maxillary hyperplasia) with bi-retrusion and open bite and 5 had a short face (vertical maxillary hypoplasia) with bi-retrusion, the remaining 8 patients exhibited mandibular hypoplasia with no associated vertical discrepancy. Twenty-two patients had Class III skeletal malocclusion owing to sagittal maxillary hypoplasia and mandibular hyperplasia. Of these, 9 had a long face (vertical excess of anterior mandible), 6 had a short face (vertical maxillary deficiency), and 7 had no vertical problems. Four patients presented with facial asymmetry. Orthognathic procedures included 1-piece Le Fort I + BSSO 24 Segmented Le Fort I + BSSO 3 1-piece Le Fort I + BSSO + mandibular front-block osteotomy 2 Segmented Le Fort I + mandibular front-block Osteotomy Maxillary surgery 11 1-piece Le Fort I 8 Segmented Le Fort I 3 Mandibular surgery 4 BSSO. The mean duration of orthodontic treatment was 37.8 Weeks. Orthodontic retention was followed in all cases.

Rhee CH, ChoI YK (2015) investigated skeletal and dental changes after application of a mandibular setback surgery-first orthodontic treatment approach in cases of skeletal Class III malocclusion. To test the proposed hypothesis, a retrospective study was conducted using data from 34 patients (23 men, 11 women; mean age, 26.2 ± 6.6 years) with skeletal Class III deformities, who underwent surgery-first orthodontic treatment, was conducted. Skeletal landmarks in the maxilla and mandible at three-time points, pre-treatment (T0), immediate-postoperative (T1), and post-treatment (T2), are analyzed using cone-beam computed tomography (CBCT)-generated half-cephalograms. All statistical analyses are performed using a statistical software package program. The significant T0 to T1 mandibular changes occurred −9.24 ± 3.97 mm horizontally. From T1 to T2, the mandible tended to move forward 1.22 ± 2.02 mm, while the condylar position (Cd to Po-perpendicular plane) shifted backward, and the coronoid process (Cp to FH plane) moved vertically. Between T1 and T2, the vertical dimension changed significantly ($p < 0.05$). Changes in the vertical dimension are significantly correlated to T1 to T2 changes in the Cd to Po-perpendicular plane ($r = -0.671$, $p = 0.034$), and in the Cp to FH plane ($r = 0.733$, $p = 0.016$), as well as to T0 to T1 changes in the Cp to Po-perpendicular plane ($r = 0.758$, $p = 0.011$). The authors concluded Greater alterations in the vertical dimension caused larger post-treatment (T2) stage skeletal changes. Studying the mandibular position in relation to the post-surgical vertical dimension emphasized the integral importance of vertical dimension control and proximal segment management to the success of surgery-first orthodontic treatment.

Marıa A. Peir_o-Guijarro, Raquel Guijarro-Martınez, and Federico Hernandez-Alfaro (2015) A systematic review of the scientific literature on surgery-first treatment (January 2000 to January 2015) was performed. The PubMed and Cochrane Library databases were accessed. Patient selection criteria, specific surgical orthodontic protocol, treatment duration, patient and orthodontist satisfaction, and stability of results were compared with a similar population treated conventionally.

The search yielded 179 publications. The application of strict selection criteria gave the final group of 11 articles. In total, 295 patients were managed with a surgery-first approach. A Class III malocclusion was the most prevalent underlying malocclusion (84.7%). Total treatment duration was shorter in surgery-first patients than in those treated conventionally. There was substantial heterogeneity among articles and high reporting bias regarding the inclusion and exclusion criteria, the orthodontic and surgical protocols, and the stability of results. A meta-analysis of combined data was not possible. The surgery-first approach is a new treatment paradigm for the management of dentomaxillofacial deformity. Studies have reported satisfactory outcomes and high acceptance. However, the results should be interpreted with caution because of the wide varieties of study designs and outcome variables, reporting biases, and lack of prospective long-term follow-ups.

Zingler S, Hakim E, Finke D, Brunner M, Saure D, Hoffmann J, Lux CJ, Erber R, Seeberger R (2017) The aim of this pilot study was to investigate psychological and biological changes after application of a surgery-first orthognathic treatment approach. A prospective cohort study of 9 patients (6 women and 3 men; mean age 26.7 years) suffering from skeletal Class II and III deformities was conducted. Skeletal changes from pre- to post-treatment were analyzed based on data acquired by use of cone-beam computed tomography (CBCT). Psychological changes were analyzed using the orthognathic quality of life (OQLQ) questionnaire, Sense of Coherence 29-item scale (SOC-29), and longitudinal day-to-day questionnaire. For biological evaluation, concentrations of IL-1β, IL-6, TGF β1-3, MMP-2 and VEGF were assessed in the crevicular fluid by bead-based multiplex assays at one preoperative and various postoperative time points. A significant improvement (P=0.015) in quality of life, as measured with the OQLQ, was observed between baseline and 3 months post-surgery. The most affected dimensions were: facial aesthetics (p=0.022), oral function (p=0.051) and social aspects (p=0.057). Sense of coherence (SOC) significantly improved after treatment by 9 points (P= 0.029). Despite the significant improvement in OQLQ and SOC during the study, the personal experience of appearance varied distinctly in course and intensity. In accordance with the temporal pattern of fracture healing, the analysis of crevicular fluid revealed an increase in proresorptive factors (IL-1 β, IL-6, and MMP-2) at early postoperative time points, while remodeling factors (members of the TGF-β superfamily) were detected at later postoperative time points.

Xiaotong He, Jiayi He, MS, Hua Yuan, Wenjing Chen, Hongbing Jiang, and Jie Cheng, (2017) The aim of this study was to characterize condylar displacement and surface remodeling after bimaxillary orthognathic surgery in adult patients with skeletal Class III malocclusion treated by the surgery-first approach (SFA) or the orthodontic-first approach (OFA). This retrospective cohort study recruited adult patients with mandibular hyperplasia treated with SFA or OFA. Simultaneous Le Fort I osteotomy for maxillary advancement and bilateral sagittal split ramus osteotomy for mandibular setback were performed in all patients. Original cone-beam computed tomographic data before surgery (T0), immediately after surgery (T1), and 12 months postoperatively (T2) were collected and reconstructed for 3-dimensional (3D) quantitative analyses. Three-dimensional condylar displacement and remodeling after SFA and OFA were characterized and statistically compared by Mann-Whitney U test and c2 test. The significance level was set at a P value less than .05. Twenty-four (male-to-female ratio, 1:2; mean age, 21.2 yr) and 20 (male-to-female ratio, 1:1; mean age, 23.1 yr) patients were enrolled in the OFA and SFA groups, respectively. Condylar inferolateral displacement with inward and anterior rotations from T0 to T1 and return movements from T1 to T2 were observed regardless of treatment approach. Significantly greater amount of 3D bodily shift immediately after surgery.

HISTORICAL BACKGROUND

Mandibular osteotomies

Orthognathic surgery was originally developed in the United States of America (Steinhäuser 1996). The first mandibular osteotomy is considered to be Hullihen´s procedure in 1849 to correct a protrusive malposition of a mandibular alveolar segment caused by a burn (Hullihen 1849). Osteotomy of the mandibular body for the correction of prognathism was first carried out in 1897 as the so-called ´St Louis operation´. The osteotomy was performed by Vilray Blair, who later described several methods to correct maxillofacial deformities and was the first to present a classification of jaw deformities: mandibular prognathism, mandibular retrognathism, alveolar mandibular and maxillary protrusion, and open bite. He was also the first to underline the importance of orthodontics in treatment. (Steinhäuser 1996). The first phase of development in the USA came to an end at World War I (WW I), when surgeons had to concentrate on trauma surgery.

Ever since the first orthognathic surgery procedure was performed by Hullihen[1] in 1848, many new techniques and methods have been introduced. The introduction of orthognathic surgery widened the possibilities for the treatment of severe malocclusions which could not be treated by orthodontics alone. During the early days of orthognathic surgeries were usually performed without any pre-surgical orthodontic treatment. In fact, when Hullihen performed the first mandibular sub-apical osteotomy on a burn victim, he could correct the prognathism but created an edge-to-edge occlusion anteriorly.

Not much progress was made in Europe during the first phase of orthognathic history. Berger (1897) described a condylar osteotomy for the correction of prognathism.

This technique was elaborated by others, but the results were not satisfactory due to problems of relapse and open bite. Only slight development took place between the two World Wars (second phase), and during WW II, surgeons were again committed to the treatment of facial injuries.

The concentration on trauma surgery was not, however, only a disadvantage to the development of orthognathic surgery, but also helped in many ways to apply these experiences to the principles of orthognathic surgery.

The third phase, which began in the early 1950s, was a period of rapid development in the whole field of orthognathic surgery. In 1954, Caldwell and Letterman developed a vertical ramus osteotomy technique, which had the advantage of minimizing trauma to the inferior alveolar neurovascular bundle. This method could be used instead of body ostectomy to correct mandibular excess.

Europe now became the center of progress. Pupils of the ´Vienna School´ of maxillofacial surgery, Trauner and Obwegeser (1957), introduced intraoral bilateral sagittal split ramus osteotomy (BSSO), although the first description was published as early as 1942 (Schuchardt). The technique was further modified by Dal Pont (1961), Hunsuck (1968) and Epker (1977) among others. It was a versatile procedure that allowed corrections in all three planes of space without a need for a bone graft. There were, however, still many problems and much hesitation before this procedure made a breakthrough in the late 1970s and now sagittal split osteotomy has become the most commonly performed mandibular procedure (Wyatt 1997). The risk of damage to the inferior alveolar nerve still remains. The introduction of an internal rigid fixation method bone screws and plates instead of 5 to 6-week intermaxillary fixation radically improved patient convenience (Steinhäuser 1996).

This new method was motivated by innovations within trauma surgery, from where it was gradually applied to orthognathic surgery. Biodegradable osteosynthesis material (Suuronen R et al. 1999) and application of the principles of distraction osteogenesis represent the latest innovations in orthognathic surgery.

Maxillary osteotomies

Although Cheever was the first to do down fracture of the maxilla as early as 1864 to resect a nasopharyngeal mass in two patients, it took decades until further maxillary procedures were attempted (Moloney & Worthington 1981). Between the World Wars in 1921, 72 years after Hullihen´s first mandibular osteotomy, Wassmund reported his initial attempt to perform a maxillary osteotomy. Wasmund did not mobilize the maxilla but employed orthopedic traction postoperatively to position the maxilla. (Turvey & White 1991). Again, it was not until the third phase of the development of orthognathic surgery in 1960 that Obwegeser started to perform maxillary surgery and described a large series of LeFort I osteotomies in 1969. That marked the beginning of a new era in the correction of maxillofacial deformities: before the mid-1960s, dentofacial deformities were treated by performing mandibular surgery, although the patient would also have benefited from complementary or exclusive maxillary surgery.

This technique was just as revolutionary in the maxilla as sagittal split osteotomy had been in the mandible: the maxilla could now be moved in all three planes of space. The major concerns had been intraoperative bleeding, revascularization, and healing of the maxilla. After studies of vascular perfusion and the anatomy and relevance of the maxillary artery, it was found that the most important thing would be to preserve a wide, intact palatal and maxillary soft tissue pedicle attached to the osteotomized segments.

This allows good healing and minimizes the risk of tissue necrosis. (Bell et al. 1975, Turvey & Fonseca 1980). The improvement of surgical techniques, and the progress in anesthesia, enabled surgery on two jaws, called bimaxillary surgery, and the introduction of rigid internal fixation made it more predictable and decreased morbidity. Köle had, as early as 1959, performed simultaneous segmental osteotomies on both jaws (Köle 1959), but the first total two-jaw operation was done by Obwegeser in 1970. This technique facilitates the correction of extensive dentofacial deformities in a single operation. [62]

In the 1960s, surgeons rarely depended on orthodontic treatment to move the teeth prior to surgery. They performed orthognathic surgery either before orthodontic treatment or after the removal of orthodontic appliances. During those years, surgeons, thus commonly used a surgery-first approach for orthognathic surgery. In 1963, Poulton *et al*[9] reported five cases of mandibular prognathism successfully treated with bilateral vertical osteotomy without any orthodontic treatment.

However, it was soon recognized that the amount of mandibular setback was limited by the overjet between the upper and lower anterior incisors. As most of the orthognathic treatments were performed without the concept of orthodontics, the skeletal relationship was not improved satisfactorily and teeth were not interlocked as they should be. The occlusal relationship was usually changed into an unfavorable one and the treatment was unstable.

In 1969 Converse and Horowitz[10] stated that preliminary orthodontic treatment is required for proper dental alignment and arch coordination before surgery. Surgeons started to use orthodontic appliances for post-operative stabilization, and the concepts of pre-operative and post-operative orthodontics were developed. Worms *et al*[11] explained this "orthodontics-first" concept to all orthognathic cases, including mandibular prognathism, mandibular retrognathism, and vertical skeletal discrepancy with the anterior open bite or deep bite, and emphasized that optimal surgical repositioning of the jaw is only possible following the removal of all dental compensation prior to surgery.

By this time the conventional OGS includes, the pre-operative orthodontic treatment for dental decompensation, the orthognathic surgery, and the post-operative final orthodontic treatment were settled as a set of the regular treatment program and are still being studied. At this period, surgeons started to use bilateral sagittal split osteotomy and it soon became a popular method in mandibular surgery. Edgewise orthodontic bracket and stainless-steel wire were used to fix the interarch relationship.

Wafer, which fills the gaps between each maxillary and mandibular tooth during the surgery, induced the movement of the maxilla and mandibular bone and it minimized post-op occlusal instability even though the occlusion might not be perfect. Later by the 1980s new method was introduced in fixing the bone segments, by using the metal plate or screw or positioning screw. This led to the abandonment of the post-operative intermaxillary fixation and the patient could live their daily life without much discomfort.

In 1988 Behrman and Behrman[6] introduced the concept of surgery first and Orthodontics second, which is defined as starting with the surgery with no presurgical orthodontic procedure, and the orthodontic treatment is performed postoperatively. Caution is important when embarking on a "Surgery First" course of treatment. Even for the highly experienced orthodontist and surgeon, it is difficult to identify the occlusal relationship that will accompany an ideal facial and functional result.

The planning process is time-consuming and requires choosing the desired appearance and skeletal relationships, mounting the casts in the position determined by the skeletal change, and then planning the post-operative orthodontic tooth movements. The surgical movement must be sufficient to allow dental decompensation after the surgical procedure. Generally, the teeth are bonded/banded and a passive archwire is placed pre-surgically. Active orthodontic tooth movement begins within a relatively short period of time after the jaws are repositioned to capitalize on the potential for accelerated tooth movement.

The surgery-first approach gained further support from Lee in 1994[12] emphasizing the early correction of skeletal and soft tissue problems, stating that orthodontic treatment is easier to perform following the achievement of a relatively normal skeletal and soft tissue environment after orthognathic surgery.

Later SFA was proposed by Nagasaka et al in 2003 at Tohoku University in Sendai Japan for patients with skeletal deformity[13,14]. This approach has two significant advantages immediate correction of soft-tissue deformities and reduced treatment time.

DIAGNOSIS AND TREATMENT PLANNING

In diagnosis and treatment planning, the orthodontist must

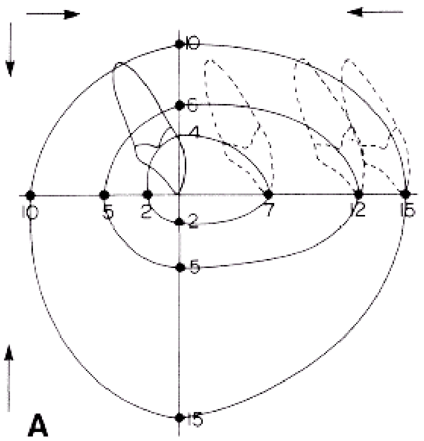
1. Recognize the various characteristics of malocclusion and dentofacial deformity.
2. Define the nature of the problem, including the possible etiology.
3. Design a treatment strategy based on the specific needs and desires of the individual.

The goal of the diagnostic process is to produce a comprehensive but concise list of the patient's problems and synchronize the various treatment possibilities into a rationale plan that maximizes the benefit of the patient.

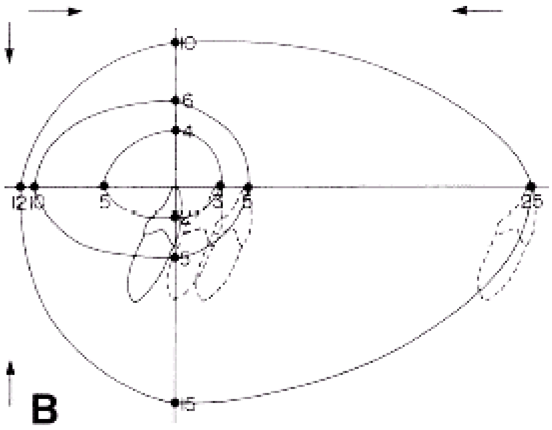
The 3 basic treatment modalities that the orthodontist can use (either separately or in combination) are as follows;

When a jaw discrepancy accompanies a severe malocclusion, there are three broad possibilities for correction: (1) growth modification, (2) camouflage (orthodontic positioning of the teeth to compensate for the jaw discrepancy), or (3) orthognathic surgery in conjunction with orthodontics to reposition the jaws and/or dentoalveolar segments.

Proffit and Ackerman introduced the concept of the envelope of discrepancy to graphically illustrate how much change can be produced by various types of treatment. This diagram helps simplify the relationship of the three basic treatment possibilities for skeletal discrepancies. The inner circle, or envelope, represents the limitations of camouflage treatment involving only orthodontics; the middle envelope illustrates the limits of combined orthodontic treatment and growth modification, and the outer envelope shows the limits of surgical correction.



Envelope of discrepancy; maxilla



Envelope of discrepancy; mandible.

Growth modification generally referred to as dentofacial orthopedics, is the most desirable approach to a severe skeletal problem when the potential for further growth exists.

When a moderate skeletal discrepancy exists and there is no potential for further growth (or if more change is required than can be accomplished through growth modification alone), orthodontic camouflage should be considered

The final treatment option for a severe skeletal discrepancy is orthognathic surgery. Once growth has ceased, surgery becomes the only means of correcting a severe jaw discrepancy. Although surgery may allow greater changes, there are still limitations to the surgical options. Depending on the type of problem and direction of desired jaw movement, certain problems are more receptive to surgical correction than others. When dental compensation is present, either naturally or previously produced by orthodontic treatment, these dental positions must be reversed before surgical repositioning of the jaws. The greater the dental compensation, the smaller the magnitude of jaw movement the surgeon has to correct the skeletal discrepancy.

The term *reverse orthodontics* is often used in reference to the deliberate movement of teeth in a direction that appears to make the worse initially when preparing the dentition for orthognathic surgery. When dental compensations exist, they limit the distance the jaws can be repositioned to achieve a desirable esthetic result.

When the diagnosis and treatment planning for the particular patient is being done, both orthodontist and oral and maxillofacial surgeons should take equal interest. The patient's expectations and chief complaint should be taken into consideration and after the detailed treatment plan is decided, the patient conference should be held with both the members of the team.

Database (case history, patient examination, radiographic and model analysis)

⇩

Problem list in priority order – Diagnosis

⇩

Possible solution to the problem – Tentative treatment plan

⇩

Discussed with the patient & modified treatment plan

⇩

Optimal treatment plan

⇩

Execution of treatment

The diagnosis and treatment planning and execution of treatment comprises four phases

Phase I

Includes assembling the database, synthesizing the problem list, diagnosis and team conference

Phase II

Includes developing interdisciplinary problem list with dentofacial problems in order of priority, and possible solutions, which forms the tentative treatment plan. A patient-parent-doctor team conference is arranged to discuss the tentative treatment plan with the patient and the family and a definitive plan is arrived at.

Phase III

Includes the preparatory phase (Restorative, endodontic, periodontic), the definitive orthodontic-surgical treatment, and continuous team monitoring, re-evaluation, interaction, and modification of the therapy.

Phase IV

It is the maintenance phase. It is extremely important that the clinician does not overlook the importance of including the patient and parents in the treatment planning process. Ackerman and Proffit suggested the clinician is generally more influenced by objective findings (i.e., the problem list), whereas patients are more influenced by subjective findings (i.e., their perception of their needs and values).

This dichotomy makes effective communication an essential tool when one is faced with the decision between orthodontic camouflage and surgical-orthodontic correction. The modern concept of patient autonomy versus paternalism in orthodontic treatment planning shifts the role of the doctor from the sole decision maker in the treatment-planning process toward inclusion of the patient as co-decision maker.

The patient-parent conference should include the following three components:

(1) A description of the problem list by the orthodontist. The patient should have input on the prioritization of the problem list,

(2) A review of the risk/ benefit considerations must be presented. The merits of each treatment alternative should be given, including the consideration of no treatment as an option because most orthodontic treatment is elective, and

(3) Consideration of the patient's expectations and values is of paramount importance.

Informed consent requires not only obtaining the patient's permission to treat after having explained the risks, but also a dialogue between the clinician and patient in deciding on the final treatment plan. It is important that the patient and doctor communicate openly about the decision-making process because the patient's perception of the problem is not always the same as the doctor's understanding of the issue.

Collection of Database:

Demographic data

History

Chief complaint

General evaluation

Family history

Medical history

Dental History

Esthetic facial evaluation

Functional Facial Evaluation

Intraoral examination

Radiographic examination

Lateral cephalogram

Orthopantomogram

Model analysis

Demographic data

Consists of basic chart information of name, address (home, work, or school), age, sex, marital status, and type of employment or school attended.

Chief complaint

The first goal of the interview is to establish the patient's major reason for seeking treatment, which is the chief complaint.

GENERAL EVALUATION OF THE PATIENT

Patient Evaluation:

Evaluation and proper diagnosis recognize the major functional and esthetic problems, reduce complications and improve the outcome of surgery.

Patient concerns: Attention should be paid to the chief complaint of the patient since the ultimate aim of orthognathic surgery is to satisfy the patient. A change in appearance, correction of the profile according to cephalometric standards may be undesirable to the patient. A surgeon should understand patient concerns, expectations, and motivation. This also gives the idea to the surgeon regarding the psychological health of the patient. Asking specific simple questions to the patient and preparing a preliminary problem list. The patient should understand his problem, all treatment options, anticipated outcomes, and potential risks and complications. The scenario in which patients are uninformed/patients with unrealistic expectations treated often leads to dissatisfaction, psychological and medico-legal problem.

PSYCHOLOGICAL IMPLICATIONS

Orthognathic surgery is a complex process leading to changes in the appearance and functions of dentofacial structures. These changes, take place in a single moment during the operation. This is totally unlike the traditional orthodontics seen in children which produce small changes during growth. It is a fine balance matching the patient's ability to adapt with the amount of change that is necessary. It helps considerably if the patient is thoroughly evaluated psychologically prior to treatment and during the pre-surgical phase.

Appearance is a major concern for many people seeking orthognathic surgery. There is a high value for cosmetic characteristics in the current society. The area of the body which maximally determines physical attractiveness is the face. It is a primary means of identification, expression, and non-verbal communication. Severe craniofacial deformities may cause significant psychosocial problems. In orthognathic surgery when compared with congenital deformities you will find that the changes in appearance are less dramatic but effects on personality are noted.

Motivation to Undergo Orthognathic Surgery

The majority of the patients seek an improvement in esthetics (approximately 65%) and the others an improvement in function and alleviation of temporomandibular joint problems, as well as motives external to the patients, e.g., an orthodontist's advice or family pressure.

The degree of effect frequently does not correspond to the degree of esthetic or functional deviation. Self-perceptions of the profile are more important than professional recommendations or cephalometric measurements in determining whether or not individuals choose surgery.

There are two types of motivation, external and internal. Of the two, internal motivation is the more valid form and includes long-standing inner feelings about deficiencies in appearance. These people are better candidates for surgery. External motivations include the need to please others, along with paranoid ideas and beliefs that one's career or social ambitions are being thwarted by physical appearance. Not all patients can be placed in a discrete category, and some patients will exhibit characteristics of both external and internal motivation.

Selection of appropriate patients for orthognathic surgery:

Psychological evaluation of a patient for surgery is recognized as being difficult but, nevertheless, very important.

1. Patients who have developed a good body image are better surgical candidates.
2. It is important to obtain specific answers to open-ended questions E.g. “What do you think is wrong”. Why do you want treatment”? A vague response is a negative sign.
3. Patients who have a long history of unhappiness about a specific feature are better surgical candidates than are patients who have only recently decided that they want treatment.
4. Patients with developmental deformities are usually better surgical candidates than are those with acquired defects.
5. Care should be taken with patients who want “secondary gain” from the operation e.g., they hope to achieve a better job or relationship.
6. Care should also be taken with patients who have “Subjective deformities” or dysmorphophobia. These are deformities that are minimal from an anatomic point of view and would be tolerated by most individuals.
7. There are also patients who seek surgery because of external pressure, e.g., to please a parent or spouse. Counseling of these patients, and the patients in the previous two categories, must be recommended.

The surgeon must determine at an early stage exactly why the patient is seeking treatment and what the patient hopes to achieve. The surgeon must then decide whether this demand can be met surgically.

Level emphasized that satisfaction begins with the selection of appropriate patients. This selection can be represented by the acronym SAFE.

S- Self-assessment of attractiveness: How important is attractiveness to the patients? How does he or she perceive himself or herself in terms of attractiveness? If these questions are answered positively, the chances of postoperative success are higher.

A- Anxiety: The more relaxed the patient is the greater the chances of success and satisfaction.

F- Fear: Care must be taken with patients who have compulsive traits, especially those who seek multiple opinions or excessive detail. Postoperative satisfaction is frequently difficult to achieve.

E- Expectations: The more realistic the expectations, the more likely the patient is satisfied.

General Conclusions:

A primary objective of orthodontics and orthognathic surgery is to improve patients' quality of life. This includes correcting functional deficiencies and improving facial appearance so that individuals find relief from the physical deviations that distinguish them from others. Patients are motivated to seek treatment, however, not only to correct functional and esthetic limitations they also to have psychological and social goals. An understanding of the psychological benefits associated with treatment is essential.

Medical history

Patient's medical information must aim to obtain information regarding medical conditions like a history of medication, allergies to drugs, bleeding disorder, Respiratory problem, cardiac problem, asthma, diabetics, anemia, rheumatic fever, etc. that may complicate correction of skeletal deformities.

Family history

Includes information regarding the marriage of the parents, consanguineous/ non-consanguineous marriage, about the siblings, siblings' general and dental conditions, history of familial disease if any, and Parents' concern for treatment.

Dental history

The patient's interpretation of past orthodontic, periodontic, and prosthetic experiences will give some insight regarding his willingness to co-operate and personal motivation level. A previous history of periodontal disease should alert the surgeon to potential problems in hygiene and patient compliance. The incidence of TMJ dysfunction and the possibility of aggravating any problems makes pre-operative documentation essential. Knowledge about previous orthodontic therapy or existing active orthodontic treatment is important. Any previous records if available or narrative descriptions about treatment from the previous orthodontist regarding the nature of treatment and evaluation of results should be reviewed. Many maneuvers involved in orthodontic therapy can complicate diagnosis and if overlooked may result in unusual post-surgical results.

Esthetic facial evaluation

1. Clinical examination.

- Frontal face analysis
- Profile face analysis

2. Photographic evaluation.

- Frontal
- Profile
- Oblique 45°

The patient is asked to sit upright at the eye level of the clinician. The patient's head should be adjusted in such a way that the pupillary plane should be parallel to the floor. The plane of the ears also should be parallel to the floor. The patient should be examined with the teeth in a centric position. The patient's lips should be relaxed during the evaluation of tooth display, gum display, lip incompetence, and chin position. The patient is asked to look straight and remain steady throughout the evaluation of facial form and divergence.

A. Class I skeletal and dental (facial angle Class I)

1. Vertical maxillary excess

2. Vertical maxillary deficiency

B. Class II facial and dental (facial angle Class II)

3. Maxillary protrusion

4. Vertical maxillary excess

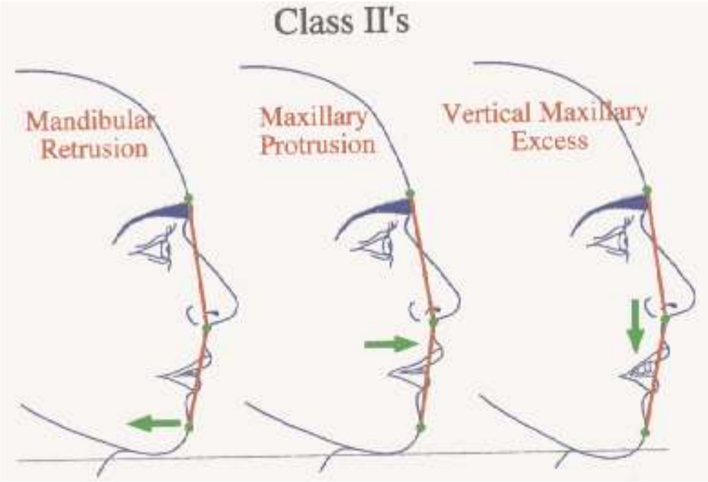
5. Mandibular retrusion

C. Class III facial and dental (facial angle Class III)

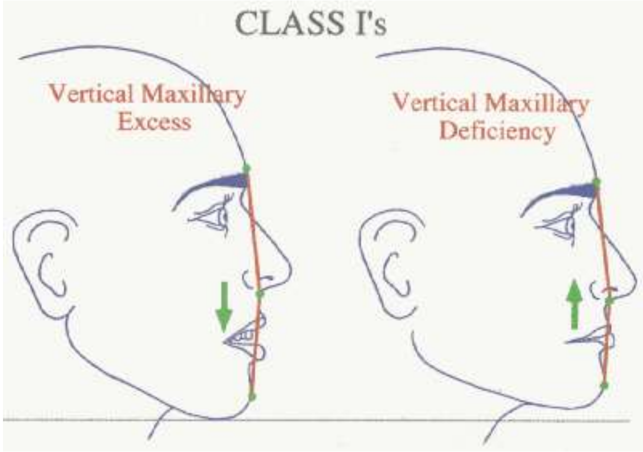
6. Maxillary retrusion

7. Vertical maxillary deficiency

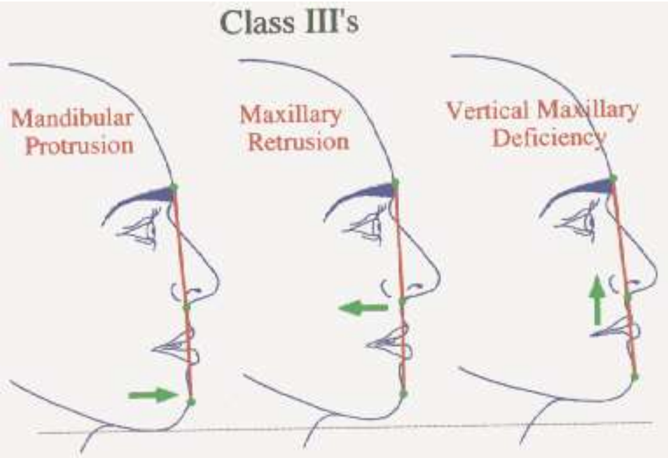
8. Mandibular protrusion



Class I facial and dental (facial angle Class I)



Class II facial and dental (facial angle Class II)



Class III facial and dental

(facial angle Class III)

Clinical photographs in frontal view

The face is divided into equal thirds. The upper third is from the hairline to the glabella. The middle third is from glabella to subnasale. The lower third is from subnasale to soft tissue menton. The lower third can be further divided from subnasale to upper lip stomion as one-third and lower lip stomion to soft tissue menton equaling two-thirds.

"RULE OF FIFTHS"

The Central Fifth:

Delineated by the inner canthus of the eyes

Inner canthal distance= alar base of the nose

The Medial Fifth:

Width of mouth= interpupillary distance

The line from the outer canthus should coincide with the gonial angles

The Outer Fifth:

Measured from the outer canthus to the ear helix


Larry Wolford and Fields analysis (frontal)

1. The forehead, eyes, orbits, and nose are evaluated for symmetry, size, and deformity.
2. Normal intercanthal distance is 35 ± 4 mm.
3. Normal interpupillary distance is 65 ± 4 mm.
4. The intercanthal distance, alar base width, and palpebral fissure width should all be equal.
5. The width of the nasal dorsum should be equal to the intercanthal distance and the width of the nasal lobule should be two-thirds the intercanthal distance.
6. A vertical line through the medial canthus and perpendicular to the pupillary plane should fall on the alar bases +_ 2 mm.
7. The upper lip length is measured from subnasale to upper lip stomion. The normal upper lip length is 22 +_ 2 mm for males and 20 +_2 mm for females.
8. A normal upper tooth to lip relationship exposes 2.5 ± 1.5 mm of incisal edge with lips in repose.

9. The facial midline, nasal midline, lip midline, dental midline, and chin midline all should be congruent and the face should be reasonably symmetric, vertically, and transversely.
10. Lip incompetence if present should be measured from upper lip stomion to lower lip stomion with lips in repose and teeth in centric occlusion (0-3 mm).
11. Smile line-during smiling, the vermilion of the upper lip should fall at the cervicogingival margin with no more than 1 to 2 mm of exposed gingiva. The patient should be asked to give full smile to detect a 'gummy smile'.
12. The distance from the glabella to subnasale and subnasale to mention should be in a 1: 1 ratio, providing upper lip length is normal.
13. The length of the upper lip should be one-third the length of the lower facial third.
14. The lower eyelid should be level with or slightly above the most inferior aspect of the iris.

Profile or lateral view analysis

1. Determining vertical and anteroposterior plane problems of the jaws.
2. Facial types - straight, convex, and concave.
3. The facial contour angles.
4. This angle is formed between the upper facial contour plane and the upward extension of the lower facial contour plane. Reference norm ranges between -8 and -11 degrees.
5. Lip position
6. The upper lip should protrude ahead of the lower facial contour plane by 3.5 mm. The lower lip should protrude by 2.2 mm.

7. Nasolabial angle.

8. The angle formed at the subnasale by a line drawn tangent to the base of the nose with a line drawn from the upper lip to the subnasale. The normal range is 100 to 110° in males and 110 to 120° in females. A large angulation is indicative of a convex face, generally associated with a recessive chin.

9. Lower lip, chin-throat angle

10. The angle between the line drawn from the lower lip to the soft tissue pogonion and a line drawn tangent to the soft tissue contour below the body of the mandible. The normal angulation is 110°± 8°. A large angulation is indicative of a recessive chin and a low angulation is indicative of excessive chin.

11. The chin to throat length- The distance between the angle of the throat and soft tissue menton. Norm is 51 mm ± 6 mm. An increased value indicates mandibular prognathism, concave face, acute lower lip, chin throat angle.

Evaluation of nose

Bell described three types of nose

Leptorrhine - long, high and narrow nostrils.

Mesorrhine - lack of dorsal height and columellar support.

Platirrhine - flat broad nose and wide nostrils

Alar base width is equal to the inter canthal width of the eye which is influenced by inherited ethnic characters.

Lefort 1 osteotomies affect the alar base width; superior repositioning is associated with widening of alar base. Simultaneous rhinoplasty is indicated if a significant change in alar base width is expected during surgery.

Functional Facial Evaluation

Includes the examination of occlusion, tongue, speech, TMJ, muscles of mastication, mandibular movements, respiration, deglutition, incisor exposure, and freeway space.

The TMJs are the foundation for orthognathic surgery. If the TMJs are not stable and healthy, orthognathic surgical results may be unstable, with increased TMJ dysfunction and pain as a result. The TMJs must be appropriately evaluated before surgery. The most common TMJ disorder seen in orthognathic surgery patients is the displaced articular disk. Significant problems can occur when orthognathic surgery is performed in the presence of untreated disk displacement.

TMJ pathologic conditions that may affect treatment outcomes include condylar resorption with the redevelopment of a jaw deformity and malocclusion; condylar hyperplasia, condylar hypoplasia, idiopathic condylar resorption, pain with increased intensity osteochondroma, reactive arthritis, rheumatoid arthritis, psoriatic arthritis, systemic lupus erythematosus, scleroderma, and ankylosing spondylitis.

TMJ pathology must be assessed and properly managed to provide healthy, stable TMJs for a sound foundation and the achievement of predictable results.

The tongue is an important factor in jaw growth and development. Microglossia can cause underdevelopment of the jaws with the lingual collapse of the dentoalveolar structures. Macroglossia can result in overdevelopment of the jaws, especially the dentoalveolus.

When the clinician treats mandibular hyperplasia, the patient's tongue size and its position must be carefully evaluated before surgery. The most common tongue-related factors affecting surgical results are macroglossia and habitual tongue placement. When the mandible is surgically moved posteriorly, the volume of the oral cavity decreases. An enlarged tongue or an abnormal tongue-posturing habit may create post-surgical relapse by causing forward posturing of the condyle in the fossa, forward protrusion of the mandibular dentoalveolus, or shifting between segments that are wire fixated. The use of a reduction glossectomy may be indicated in specific cases.

Intraoral examination

Soft tissue examination includes oral hygiene status, gingival texture, periodontium, frenal attachment, tongue, and oral mucosa. Ackerman and Proffit recommend that the clinician does not ignore the limitations of the soft tissues in guiding the treatment planning process. They suggest these soft-tissue constraints involve several areas of concern:

(1) The pressures exerted on the teeth by the lips, cheeks, and tongue are a primary determinant of stability,

(2) The periodontal attachment apparatus is a fundamental consideration in oral health,

(3) The temporomandibular muscular and connective tissue components have a major role in function, and

(4) The soft tissue integument of the entire face determines esthetics.

Cephalometric values guiding the position of the incisors are restricted by racial, ethnic, and pretreatment positions; thus, orthodontic treatment should reflect the amount of incisor change that would occur relative to stability because of the pretreatment position likely reflects the soft tissue influences. These investigators also suggest that anteroposterior expansion of the incisors by more than 2 mm or transverse expansion by more than 4 or 5 mm will likely be unstable. If macroglossia exists, there is a possibility that constriction of the lower arch to close spaces would not be maintained. Gingival recession and dehiscence of the alveolar bone may occur with orthodontic expansion when the attached gingiva is thin, especially when accompanied by plaque accumulation and inflammation. If there is inadequate attached gingiva, gingival grafting of the area is recommended to avoid recession.

Hard tissue examination

It includes the examination and recording of the number of permanent teeth and deciduous teeth, missing teeth, and supernumerary teeth if any. The texture of the teeth, occlusal wear caries, fillings, endodontically treated teeth prosthetic replacements if any should be recorded. Intra arch relations like Shape of the arch (V, Square), arch symmetry, arch alignment, crowding, spacing, rotation, the axial inclination of teeth and other individual irregularities are recorded. Inter arch relation like over jet, overbite, midlines are recorded.

DIAGNOSIS IN SURGERY FIRST ORTHOGNATHIC APPROACH

1. Conventional diagnosis
   a. Consultation
   b. Clinical examination
   c. Evaluation
2. 3D diagnosis

Conventional diagnosis in SFOA:

I. Consultation:

1) Chief complaint of the patients who visit the orthodontic clinic firstly:
   a. They mainly concern malocclusion.
   b. As having increased interest in malocclusion, they want to correct the malocclusion only with the orthodontic treatment, which means that they want to avoid the surgery.
   c. Their chief complaint usually includes the misfit between upper and lower teeth, inability to masticate the food, inability to pronounce, and pain at TMJ.
2) Chief complaint of the patient who visits the Oral and Maxillofacial surgery:

a. They mainly concern the skeletal problem.

b. As having increased interest in facial esthetics, they want to get treated the problem with the surgery.

c. They usually complain about their appearance such as mandibular protrusion, long facial profile.

d. Orthodontists need to check the patient's psychological state. In the case of skeletal class III dental class I, the fundamental skeletal problem should be solved even if the dental class I relationship is completed with orthodontic treatment. Otherwise, psychological disorders would be brought in.

e. As the statistic result shows that 25% of surgically treated patients require psychological treatment, it is important for orthodontists to find out the patient's fundamental chief complaint and correspond to that properly.

2) Why does the patient want to get surgery treated now?

- The motivation for treatment affects the attitude during treatment and result after treatment. Patients would get motivated for the treatment as their personal condition changes, and also that change sets forth various psychological changes. Therefore, orthodontists need to consider carefully what the actual motivation of the treatment is.

3) Expectation for the treatment result:

- The level of expectation of the treatment result might be different among the patients. Patients can be classified into two groups; patients who belonged to the passive expectation group want to remove skeletal problems only, but patients who belonged to the active expectation group want their facial esthetics to be improved.

- Orthodontists differently approach each group, and it leads to the difference in surgical technique and the amount of surgical correction. As patients would have different post-op psychological states according to their level of expectation, they need to consider this when they consult with the patients.

4) Expectation for improvement in TMD

- Many patients except that their TMD would be improved through orthognathic surgery. However, there is no evidence that orthognathic surgery can solve TMD. So, orthodontists should explain that to their patients.

II) Clinical examination:

1. **Photo taking:**

Before the orthognathic treatment begins, taking a photo of patients helps orthodontists plan the treatment. It's important when comparing the condition between the appearances, before and after treatment. To compare accurately, always need to take photos in a standard form and keep them in proper storage.

a. Facial photo: A front view of the face in rest; a front view of the face in a smile. 90^o lateral view (left, right), 45^o lateral view, submental view.

b. Intraoral photo: A frontal view, a lateral view (right and left), upper and lower occlusal plane.

2. **Radiograph taking:**

a. Orthopantomogram

b. Lateral cephalogram

c. P-A cephalogram

d. Submento-vertex

3. Intraoral dental model:

1) Evaluate the alignment of teeth, the state of the occlusal plane, the abnormality of the number of teeth such as missing teeth, upper supernumerary tooth, etc.

2) Evaluate the disharmony between the width of the upper and lower dentition by estimating the intercanine width and intermolar width etc.

4. Model mounting:

Model mounting is achieved by face bow transfer. In this plane, orthodontists evaluate the occlusal relationship between upper and lower dentition and whether the maxilla or mandible is canted.

5. Facial evaluation:

In clinical examination, orthodontists evaluate if the midline of the upper anterior teeth is aligned to the facial midline and how much the upper anterior teeth are shown in the resting position. Orthodontists also measure the extent of gingival exposure when the patient smiles, the symmetry of the mouth corner and the canting of the maxilla, etc., also let the patient bite the tongue depressor with their molars and measure the distances from mouth angle and upper canine to lateral canthus or medial canthus.

These values enable us to evaluate the occlusal canting of the maxilla. As a next step, orthodontists evaluate the anteroposterior Position of the maxilla and measure the nasolabial angle.

To evaluate the mandible, orthodontists measure how the midline of lower teeth is closely aligned to the facial midline, and the extent of mandible asymmetry and to figure out the relationship between upper and lower teeth, orthodontists measure the overjet and overbite.

6. Examination of medical history, growth, and sexual maturity:

In orthognathic surgery, its important to evaluate if the patient's growth is completed. Orthodontists must examine the growth and sexual maturity. There are two ways: one is to take a hand-wrist x-ray and examine it. The other is to refer to pediatrics.

III. Evaluation:

1. Evaluating the soundness of hard and soft tissues:

a. Dental sound: Check the existence of caries, cervical abrasion, fracture and determine if the treatment is needed.

b. Periodontal soundness: As bad periodontal status would make it difficult to cut incision, it is important to measure the amount of keratinized attached gingiva. The less the amount of attached gingiva, the more the recession of the gingiva postoperatively.

2. **Facial ratio and esthetics evaluation:**

1) Frontal view + vertical ratio:

a. Frontal view: evaluate the vertical and horizontal length of the face. Anthropometric facial measurement is used as a standard value.

Ex) zygomatic width (zy-zy) (mm): 137+/- 4.3 mm(M), 130 +/- 5.3 mm(F) gonial width (go-go) (mm): 97+/- 5.8 mm(M), 91+/- 5.9 MM(F) face height (N- Gn) (mm): 121+/- 6.8 mm(M), 112+/- 5.0mmm(F).

b. Vertical and horizontal length of the facial skeletal pattern: Facial index is used as a standard value.

c. Vertical ratio; upper: middle: lower: = 1:1:1

The recent ratio is changed to 1:1:0.9~0.85 and it reflects the trend that people prefer the shoreface.

d. Incisal showing

In a rest position, the optimal showing of upper anterior teeth is about 2.0~3.0mm. If the length is short or long, surgeons move the maxilla up and down so that the patient's gingiva and teeth are shown naturally.

2) Horizontal ratio

The degree of asymmetry and protrusion is also examined by photo view and tactile sensation.

3) Lateral ratio

a. Vertical ratio of the lateral lower face

The original ratio was 1:2 but it's been shortened. The recent ratio is 1: 9.

b. Protrusive ratio in lateral view:

The ideal protrusion ratio in lateral view varies with the researcher. Furthermore, eastern and western researchers have a conflict with each other in the thought of beauty and this might affect the ratio.

c. Natural head position is recommended as horizontal index line.

If the patient's dentofacial deformity is severe, the FH plane might coincide with the true horizontal plane. In forehead deformity, it would result in a different development between maxilla and mandible. In nasal deformity, it affects the shape of the lip.

3. Social – psychologic evaluation:

Kiyak[34], Cunningham[35] quoted that the social psychologic evaluation is most neglected when correction of facial deformities is considered. Psychologic make up of patient is important for 2 reasons:

A. Unrealistic patient expectations regarding the result of treatment.

B. Failure of the clinician to inform the patient realistically of problem treatment result.

- The patient must be made aware of and accept the fact that even with the most skillful therapy they will probably never look exactly like they did before as quoted by Steenbergen E.V. and Nanda R[36]
- Frequently it is best not to treat the patients who are not psychologically satisfied, since they are generally unhappy with the results achieved.

4. **Occlusal evaluation:**

There are two phases;

1. Functional
2. Static

1. **Functional evaluation:** It is done to determine the compatibility between centric occlusion (CO) and centric relation (CR) and to areas of tooth wear. Because of habitual occlusion, it is carefully evaluated. Failure to appreciate this may result in errors in treatment planning and surgery.

2. **Static evaluation:** It is done in 3 parts;

a. Intra-arch relations where midline of the arch relative to the skeleton and soft tissue of face noted. Arch form, symmetry noted, anomalies of occlusal plane, and curve of spee noted. Also crowding is measured.

b. Inter-arch relations exist in 3 planes of space. Anteroposteriorly Angle's classification is observed for both molar and canine and incisor overjet measured. In vertical incisor overbite noted. In transverse coordination of upper and lower midline and buccal or lingual crossbites are evaluated.

c. Tooth – mass relation is critical, such discrepancies must be taken into consideration to achieve good occlusion with normal overjet, overbite relations. The use of Bolton's analysis is recommended.

Masticatory muscles and TMJ evaluation before orthodontic surgical treatment, it is necessary to diagnose accurately the problems related to masticatory muscle and TMJ and should be treated earlier before surgical treatment.

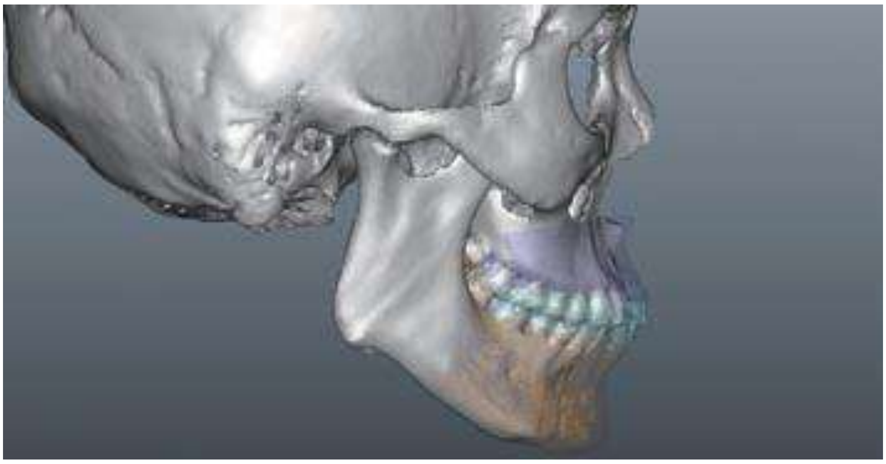
3D DIAGNOSIS IN SFA:

Conventional paper and model surgery remains the most widespread and standard method by which surgical planning is achieved. However, the limitation of these conventional techniques results from using 2-dimensional tools to attempt an accurate prediction of 3-dimensional surgical and orthodontic movements. Moreover, conventional planning techniques do not provide a final 3-dimensional visual treatment objective to further guide surgical and orthodontic precision. Computer-aided surgical simulation (CASS) utilizing 3-dimensional images obtained from multi-slice computer tomography (MSCT)/cone-beam computer tomography (CBCT) has been successfully performed previously to plan craniofacial surgery[37]. By substituting the dentition in MSCT/CBCT images with images acquired from surface laser scanning of dental models, we can virtually construct a composite skull model that can be used for accurate diagnosis, planning, and simulation not only of the facial skeleton but orthodontics as well.

Alfaro et al[25] initially described the utility of CASS for planning the surgery-first approach in surgical orthodontic treatment. However, this description did not detail the planning procedure.

Method A:

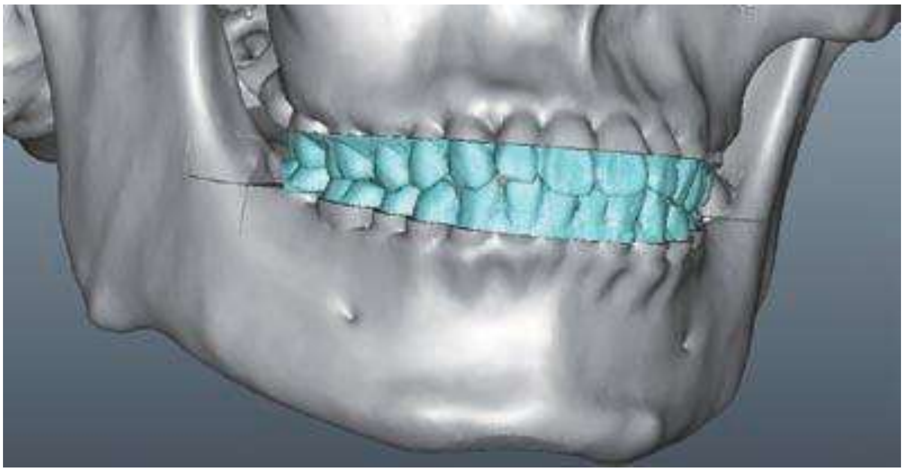
1. Construct a composite skull model in neutral head posture (NHP)[38]:



As has been previously being to collect preoperative records, including by Gateno and Xia[39], the first step is direct anthropometric measurements, clinical photographs, stone dental models, a patient-specific bite jig, an NHP recording, and a CT scan. The bite jig is connected to a facebow with fiducial markers. The patient then undergoes a CBCT scan with the bite jig in place. Simultaneously, the dental models are laser scanned (3D Scan Company, Atlanta, GA) with the bite jig in place. Fiducial markers, present in both images, can then be used for precise registration to construct a composite skull model.

The composite model consists of a skull model derived from the CBCT and dentition from the dental model image. The bite jig, attached to a gyroscope, (i.e. digital orientation sensor; 3DM, MicroStrain Inc, Williston, VA) allows for the patient's NHP to be recorded. Inputting the orientation setting to the computer-aided design (CAD) gyroscope, the virtual head (i.e., virtual head) can be aligned to the patient's actual NHP.

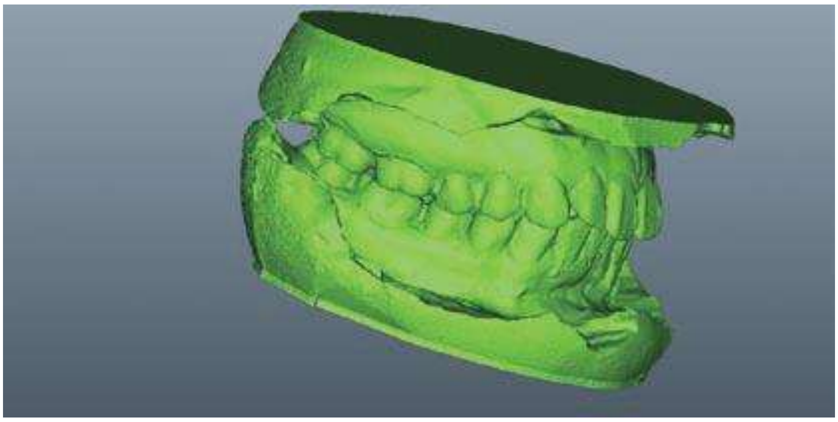
2. Separation of teeth into single units with associated dental roots that are ready for orthodontic assessment and simulation:



Utilizing Simplant OMS software, authors perform a segmentation for all the dental roots. The 3D rendition of the teeth is then cut into single crowns connected to their corresponding roots. In this format, the dentition is ready for simulating virtual tooth movement.

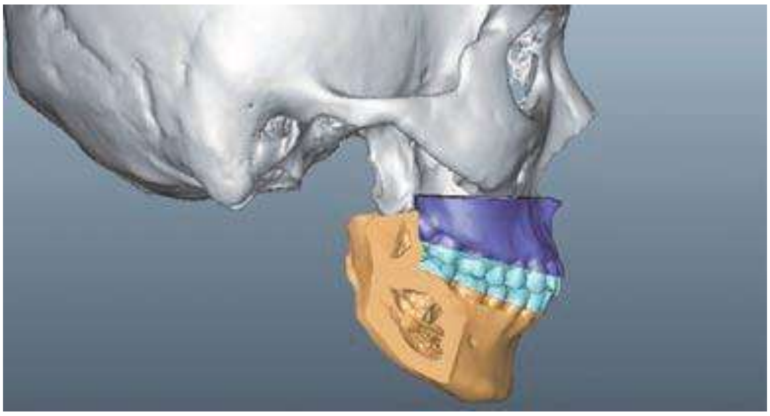
3. Set up a "treatable" post-surgical occlusion:

Determine a treatable post-surgical occlusion with the stone dental casts and transfer that arrangement into the virtual plan with surface laser scanning.



Using the virtual casts as a reference, the lower dentition, along with the distal segment, is brought into the post-surgical occlusion. The relationship between the maxillary dentition, mandibular dentition, Le Fort I, and distal segments (i.e., maxilla-mandibular complex, MMC) are then appropriately positioned[38].

4. Simulate orthognathic skeletal movement:

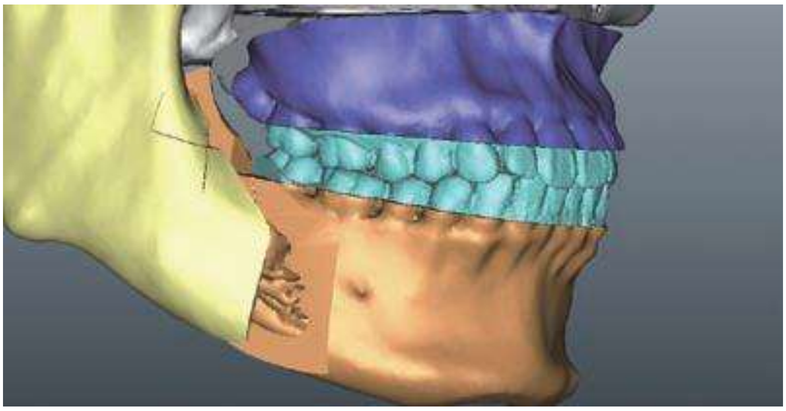


The MMC is now moved to achieve skeletal symmetry and all the cephalometric values are normalized. Utilizing a technique previously described by Gateno and Xia[39], created a triangle to represent the maxilla.

The triangle is bounded by the mid-point of the central incisors and the mesial-buccal cusp tips of the bilateral 1st molars. The triangle, along with the MMC, is then rotated to achieve a zero-degree roll (i.e. correction of any maxillary occlusal cant) and zero-degree yaw. The triangle is translated along the x-axis to coincide with the maxillary midline and midsagittal plane. Finally, we adjust the pitch (i.e. the maxillary occlusal plane angle), anteroposterior, and vertical position of the triangle, along with the MMC, to fit the 2D-cephalometric norms.

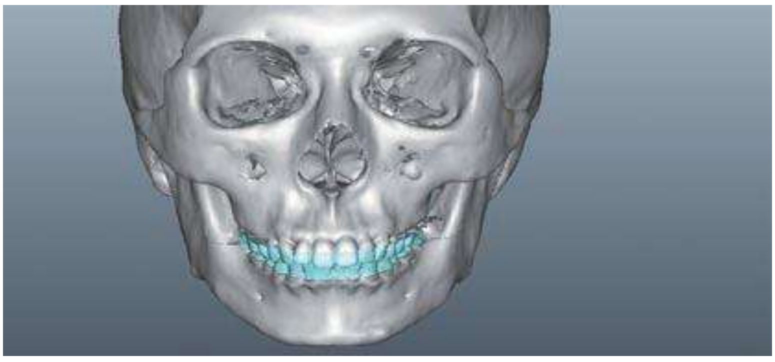
After finishing the aforementioned procedures, we complete the surgical simulation by obtaining the symmetry and averageness of the composite skull. In the present case, the mandibular advancement was achieved by advancement and counterclockwise rotation of the MMC.

5. Simulate post-surgical orthodontics with 3-dimensional tooth movement:



Move every tooth virtually to achieve the final occlusion in which all the cephalometric values are within the normal range. Compare the final and original position of the teeth and allow the orthodontists to evaluate if the planned tooth movement is achievable according to their treatment philosophy and ability. If so, the plan works and can be carried out accordingly.

Method B:

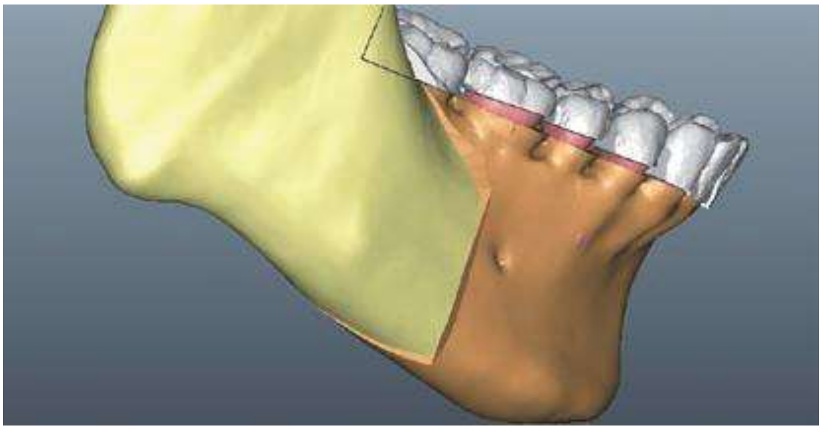


1. Construct a composite skull model in NHP24[38].

2. Separation of teeth into single units with associated dental roots that are ready for orthodontic assessment and simulation, as aforementioned and demonstrated.

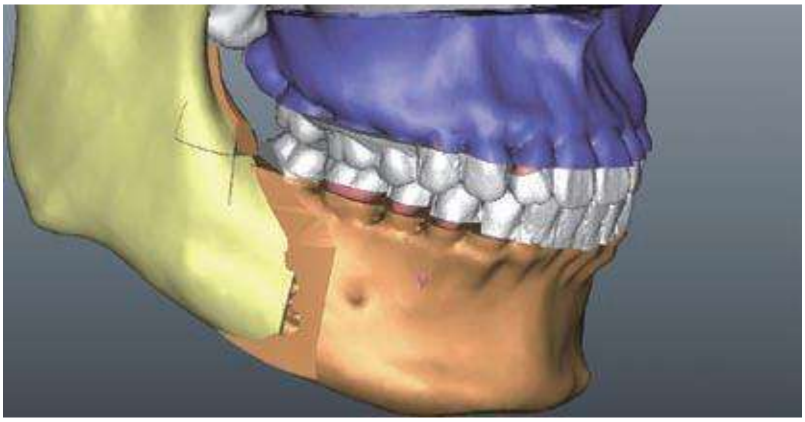
3. Simulate pre-surgical orthodontics:

Utilizing Simplant OMS software, the tooth movement is simulated according to the orthodontist's ability and treatment philosophy regarding pre-surgical orthodontics. In most of cases, the pre-surgical orthodontics is limited to leveling and alignment in relation to her alveolar base. For the maxillary dentition, authors[22] limited proclination of maxillary incisors by arch expansion and optional stripping of the anterior teeth because the upper incisor angle, with reference to SN, is at the upper limit of normal. For the mandibular dentition, the curve of Spee is leveled with proclination of the anterior teeth.



4. Simulate the skeletal movements of orthognathic surgery:

Set up the post-surgical occlusion as would be done with conventional techniques (i.e. with both jaws having finished pre-surgical orthodontics and having established a post-surgical occlusion.



The relationship between the maxillary dentition, mandibular dentition, Le Fort I, and distal segments (i.e., maxilla-mandibular complex, MMC) are then appropriately positioned and the MMC is manipulated to achieve skeletal symmetry and normalize cephalometric values.

5. Finally, the teeth are "reversed" to recreate the original dentition in the "post-surgical" skull model, allowing acquisition of the anticipated post-surgical occlusion. Afterward, the entire mandible (i.e., the distal segment and bilateral proximal segments) is rotated clockwise or counterclockwise to avoid collision or open contact, respectively. The orthodontist then evaluates whether or not the post-surgical occlusion is treatable. If so, the plan works and can be performed accordingly. This is the first article[38] to detail the procedures of planning the surgery-first approach in surgical orthodontic treatment with 3-dimensional images and CASS.

The described Method A is a modification of the planning protocol used at the Craniofacial Center in Chang Gung Memorial Hospital for many years. The original planning protocol was based on setting up an orthodontically treatable and stable occlusion with a minimum of 3 contact points between maxillary and mandibular dental casts. Paper and model surgery were then utilized to plan the skeletal movements and transfer the surgical plan to the operating room with appropriate splints. While this protocol has been executed for years with excellent results, a limitation that has always existed is the potential for minor occlusal interferences when establishing the post-surgical occlusion in cases without pre-surgical orthodontics. In most cases, model surgery could not depict the effects on the final surgical results with regard to skeletal symmetry and profile manifestation. By contrast, CASS allows for the depiction of the surrounding anatomic structures thereby providing more information on the final position of the craniofacial skeleton and is therefore superior when planning surgery-first approach cases in surgical orthodontic treatment. In addition, with accurate anatomic depictions, the rotational movement of the proximal segments (especially along the axial axis) is better controlled thereby preventing post-surgical stresses on the temporomandibular joint.

Method B, on the other hand, provides a more straightforward approach for individuals more comfortable with the conventional orthodontic-first treatment. By simulating pre-surgical orthodontic tooth movements and establishing a post-surgical occlusion, the sequence of events exactly mirrors those of the conventional orthodontic-first approach. After the "conventional procedures", the final surgical plan and respective surgical splints are determined by simply superimposing the original dentitions. However, method B does have its own limitations. The procedure could produce an unstable occlusion because there could potentially be less than 3 points in contact between maxillary and mandibular dentitions. In addition, the procedure does not adequately address cases that present with a difficult or even untreatable occlusion such as with a complete buccal crossbite of the posterior teeth or extreme midline discrepancies.

In cases of an unstable occlusion, a modified surgical splint can serve as a bite plate/bite stabilizer for 3 months after surgery, on the other hand, modifying the occlusion to a more stable and treatable condition could solve both aforementioned problems. The authors would recommend combining both methods A and method B for clinicians who are not familiar with planning the surgery-first approach. Method B allows the clinician to establish a temporary post-surgical occlusion using familiar conventional techniques. Method A is then utilized to check the post-surgical skeletal position. Another issue in planning the surgery-first approach with a CASS planning protocol is determining how to simulate orthodontic tooth movement? Many guidelines regarding orthodontic movement have been previously published. In most cases, the focus is to avoid exaggerated proclination of the upper incisors after surgical counterclockwise rotation of the MMC as the patient's initial upper incisor angle was already at the upper limit.

Extraction therapy could be a solution to achieve normal incisor inclination in this case. Instead, the authors adopted arch expansion to relieve mild crowding of the patient's upper dentition (i.e., rotation of the upper right lateral incisor) in order to prevent proclination of her maxillary incisors in non-extraction orthodontics. This approach led us to investigate the extent to which we can perform arch expansion. The question was answered with generated 3D images of orthodontic tooth movement simulation. In the images, we were able to observe the relationship between the dental roots and the surrounding alveolar bone. After simulated arch expansion, dental roots angled outside the alveolar bone indicates a tooth movement beyond the biological limit. The CASS planning protocol is an excellent tool to facilitate and predict reasonable and an excellent tool to facilitate and predict reasonable and practical orthodontic treatment plans. When applying the CASS planning protocol, the skeletal movements can be transferred with the surgical splint that is output with the rapid-prototyping technique. Many methods exist to transfer the orthodontic tooth movements to patients.

One method is using Invisalign to cover the accuracy and esthetics in suitable cases. In addition, we can utilize 3D simulation for indirect bonding procedures on either the buccal or lingual sides. In this way, they can accurately transfer the virtual orthodontic tooth movement to the patient for pre-surgical and post-surgical orthodontics. Clinicians should be aware of the disadvantages[4] and limitations with regards to the surgery-first approach in surgical orthodontic treatment. First, patients with severe mal-alignment and exaggerated curves of Spee could present a contraindication to this approach because of unavoidable occlusal interferences in setting the post-operative occlusion that may result in skeletal deviation during surgery. Second, because occlusion cannot be used as a guide to determine the skeletal position, the surgical design could be quite different from that obtained using traditional techniques.

Nagasaka[21] and Sugawara[20] recommend using Wits appraisal and Craniofacial Drawing Standards (CDS) analysis to establish individual treatment goals. Third, immediate post-surgical occlusion could be unstable in the surgery-first approach because of no pre-surgical orthodontics. In such cases, wearing an occlusal splint while eating to stabilize the mandible[14] or considering an orthodontic-first approach should be entertained. Finally, any orthodontists undertaking this approach should be trained to handle an unexpected malocclusion immediately after surgery. In our protocol, unlike that of Nagasaka[21] and Sugawara[20] do not routinely utilize the TADs for the surgery-first approach. However, with the help of TADs, the orthodontist can have even greater more control on a dental midline deviation or to help solve a post-surgical anterior open bite.

CBCT ROLE IN SFOA:

Conventional surgical planning for orthognathic surgery involves the collection of data, including a clinical examination, extraoral and intraoral photographs, lateral and posteroanterior cephalograms, and plaster dental models. Dental models are mounted on an articulator, and the interdisciplinary team of the orthodontist and the oral-maxillofacial surgeon evaluates, simulates, and decides on a treatment plan. A surgical splint is fabricated to the newly determined dental occlusion[40]. The main limitation of conventional surgical planning is its 2-dimensional approach, a major handicap especially in patients with facial asymmetries when often the deformity involves all 3 dimensions.

Appropriate surgical treatment starts with an accurate diagnosis by evaluating all dimensions and determining the nature of the asymmetry because it might be a combination of hard-tissue and soft-tissue components. To overcome those shortcomings, cone-beam computed tomography (CBCT) for imaging the craniofacial region heralds a true paradigm shift from a 2-dimensional to a 3-dimensional (3D) approach.

CBCT allows a 3D display of the craniofacial anatomy with possibilities of image segmentation, thereby expanding the role of imaging from diagnosis to the simulation of the surgical procedures and fabrication of the surgical splints in craniofacial surgery. Three-dimensional computer-aided surgical planning techniques for craniofacial deformities introduced by Xia et al[41] and Swennen et al[42] allow 3D analysis and a virtual surgical plan and provide the information for fabrication of computer-manufactured surgical splints without conventional model surgery. This virtual planning allows for more thorough analysis and surgical planning, especially in patients with facial asymmetries. Peck and Peck[43] defined facial symmetry as the state of equilibrium, the correspondence in size, and the form and arrangement of facial features on the opposite sides of the median sagittal plane.

Severt[44] and Proffit[45] reported that the frequencies of facial asymmetry were 4.7%, 36%, and 74% in the upper, middle, and lower thirds of the face, respectively. In spite of the high prevalence, assessment of facial asymmetry, a complex 3D defect, is not accurate with 2-dimensional imaging such as posteroanterior cephalograms, panoramic radiographs, and submentovertex views. Several limitations include magnification, distortion, projection errors, and questionable width measurements. It is possible to overcome these shortcomings and acquire, diagnose, and produce a virtual surgical plan with 3D CBCT imaging. In corrective surgeries for facial asymmetry with conventional planning, it is not possible to visualize the condylar positional changes or bony interferences between the proximal and distal segments because of asymmetric surgical movements, which could compromise the stability and temporomandibular joint function.

With 3D surgical planning, it is possible to evaluate and perform relocation planning of the osteotomy cut to prevent bone interferences and to select the appropriate location and size of the fixation screws and plates.

Additionally, quantification of relocated bony segments can be done after simulated surgery, and measurements can be assessed in the x-, y-, and z-axes. According to Xia et al[46], relocation of osteotomized segments might not be sufficient to obtain facial symmetry not only because patients with asymmetry have asymmetrically displaced skeletal units, but also because of the morphologies of the bones and associated soft tissues can be different on the 2 sides. With a mirroring technique, it is possible to evaluate the symmetry during planning, and the differences between the 2 sides can help the surgeon to decide whether to use grafting, ostectomy, or repositioning of the segments. Once the 3D plan is finalized, it is absolutely important to accurately carry out the plan during the surgery. The surgical splint fabricated by the computer-aided design and manufacturing technique helps in accomplishing this purpose.

Gateno et al[47] assessed the precision of digitally generated surgical wafers with conventional splints and found a high degree of accuracy with the computer-generated splints. Furthermore, another pilot study[48] showed that surgical outcomes deviated statistically and clinically insignificantly from the planned surgical procedures using computer-aided manufactured surgical splints. The above authors concluded that splints generated by computer-aided design and manufacturing techniques had a high degree of accuracy, and the fit was similar to that of conventional splints. The orthognathic surgery first approach is becoming popular because of several advantages, such as reduced treatment times, efficient tooth decompensations, rapid improvement in facial esthetics, and greater cooperation from the patients after surgery.

At the Division of Orthodontics, University of Connecticut Health Center, approximately 30 patients have been treated successfully with the surgery first approach during the past 5 years, with an average treatment time of approximately 10 months. Although there are currently no set criteria for patient selection for this approach, recently Liou et al[8] described general and specific guidelines for successful orthodontic and surgical management of these patients. In general, most patients with dentofacial deformities undergoing orthognathic surgery can be treated with surgery first, including patients with severe crowding and rotations. With the aid of a skeletal anchorage system, arch length can be increased by postsurgical distalization of the posterior teeth to accommodate the crowded teeth and still achieve proper axial incisor inclinations, obviating the need for extractions. The primary indication, reflected in most publications on the surgery first approach, is the treatment of Class III malocclusions. Patients with the proper maxillary anteroposterior incisal inclination and mild to moderate mandibular crowding with retroclined mandibular incisors could be considered ideal for this approach.

The major contraindication would be any patient whose postsurgical posterior occlusal contacts would be prevented by the incisor inclination, resulting in a negative overjet after surgery. Such would be the case with excessive lingual inclination of the maxillary incisors in a Class II patient or excessive labial inclination of the mandibular incisors in a Class III patient. Combining the surgery first approach with 3D CBCT virtual planning enables us to obtain symmetry in the facial structures with great accuracy while significantly increasing treatment efficiency. The most complicated step with this approach is the determination of the transitional occlusion immediately after surgery. In essence, the surgery is planned to achieve skeletal symmetry in all planes of space, adequate facial proportions, and harmony. The occlusion resulting from the process is then evaluated, and an orthodontic setup is constructed.

The orthodontic setup serves to visualize the movements necessary to achieve an ideal occlusion after surgery. This is similar to the process that the orthodontist performs to correct any malocclusion. Based on the complexity of the movements, the orthodontist plans with the surgeon the addition of orthodontic miniplates to be used as skeletal anchorage after surgery to aid with specific tooth movements. Once the surgical movement and the transitional occlusion are planned virtually, they are replicated in hard stone models and sent to the company (Medical Modeling, Golden, Colo), which will use them as the reference for fabrication of the final surgical splint.

Recently, Hernandez-Alfaro et al[25] presented two patients treated by the surgery first approach using 3D CBCT and similar software for virtual orthodontic and surgical planning in bimaxillary surgery. They used an intermediate splint fabricated by a computer-aided design and manufacturing technique; the final surgical splint was fabricated from poured stone models in both patients. In their report, the software was used for treatment planning purposes in patients. The intermediate and final surgical splints were fabricated from stone models according to the virtual plan. On the other hand, one patient had virtual 3D planning and computer-aided manufacturing of the intermediate and final occlusal splints. The final surgical wafer was removed immediately after surgery as stable occlusion was obtained. Accurate surgical planning and a true team approach between the surgeon and the orthodontist are crucial when using the surgery first approach and virtual 3D planning. Probably, a greater level of planning is required when this approach is applied to patients with significant asymmetries. Although both patients[23] were asymmetric, they represented opposite ends in the spectrum of sagittal discrepancy (Class II vs Class III). Nonetheless, both treatment outcomes showed good occlusal and facial relationships in all 3 planes of space.

Thus, the Fusion of relatively new technologies and techniques such as 3D CBCT-based surgical planning, computer-aided splint fabrication, and the surgery first approach can make orthognathic surgery more efficient and effective for patients and the surgical-orthodontic team.

DIAGNOSTIC AIDS

CEPHALOMETRIC EVALUATION IN ORTHOGNATHIC SURGERY

Basic radiographs required will include Lateral cephalogram, orthopantomogram specialized views like IOPA, occlusal view, PA cephalogram in the case of facial asymmetry, transcranial or trans pharyngeal views for TMJ are requested if indicated. Specialized radiography e.g., computed tomography [CT] scans, magnetic resonance imaging [MRI], or nuclear scintigraphy are indicated in certain cases, especially for identification of TMJ pathology. Hand-wrist films may be useful in determining the growth potential in some patients.

Many analyses are available for diagnosis and treatment planning. COGS hard tissue analysis and Quadrilateral analysis are the two hard tissue analysis and COGS soft tissue analysis, Holdaway's and Arnette & Bregman's are the soft tissue analysis widely used.

COGS – Cephalometrics for Orthognathic Surgery

Developed by Burstone et al. Developed at the University of Connecticut, COGS can be the first step in diagnosis and treatment planning which determines the nature of the dental or skeletal defects. The COGS analysis describes the horizontal & vertical position of facial bones. The size of the bones is represented by direct linear dimensions & their shapes by angular measurements. The chosen landmarks and measurements can be altered by various surgical procedures. The COGS analysis describes dental, skeletal & soft tissue variation.

The baseline for comparison of most of the data in this analysis is a horizontal plane constructed by drawing a line 7º from the line Sella to Nasion.

Horizontal Skeletal Profile

Angle of skeletal convexity

The angle of skeletal convexity is measured by the angle formed by line N-A and a line A to Pog. The N-A-Pog (angle) gives an indication of the overall facial convexity, but not a specific diagnosis of which is at fault the maxilla or the mandible. A positive angle (+) of convexity denotes a convex face; a negative (-) angle denotes a concave face. A clockwise angle is positive (+) and a counter-clockwise angle is negative (-).

Point A to Nasion Perpendicular

The horizontal position of A is measured to this perpendicular line (N-A). This measurement describes the apical base of the maxilla in relation to N and enables the clinician to determine if the anterior part of the maxilla is protrusive or retrusive.

Point B to Nasion Perpendicular

N-B is also measured in a plane parallel to HP from the perpendicular line dropped from N. This measurement describes the horizontal position of the apical base of the mandible in relation to N. Therefore, the surgeon has a quantitative assessment of the anteroposterior position of the mandible and the degree of mandibular dysplasia.

Pog to Nasion perpendicular

N - Pog is measured in the same manner as NA and NB and indicates the prominence of the chin. Any unusually large or small value that is obtained must be compared with N-B and B-Pog (the distance from point B to a line perpendicular to MP through Pog to determine if the discrepancy is in the alveolar process, the chin, or the mandible proper.

Vertical Skeletal and Dental

A vertical skeletal discrepancy may reflect an anterior, posterior, or complex dysplasia of the face, so the vertical skeletal cephalometric measurements are divided into anterior and posterior components.

Vertical skeletal measurements of the anterior and posterior components of the face will help in the diagnosis of anterior, posterior, or total vertical maxillary hyperplasia or hypoplasia and clockwise or counter clockwise rotation of the maxilla and the mandible.

The typical surgical correction of these problems includes total maxillary vertical advancement or reduction, anterior maxillary vertical augmentation or reduction, posterior maxillary vertical augmentation or reduction, the combination of anterior and posterior maxillary vertical augmentation or reduction, and mandibular ramus rotation and ramus height reduction. The vertical dental dysplasia is also divided into anterior and posterior components.

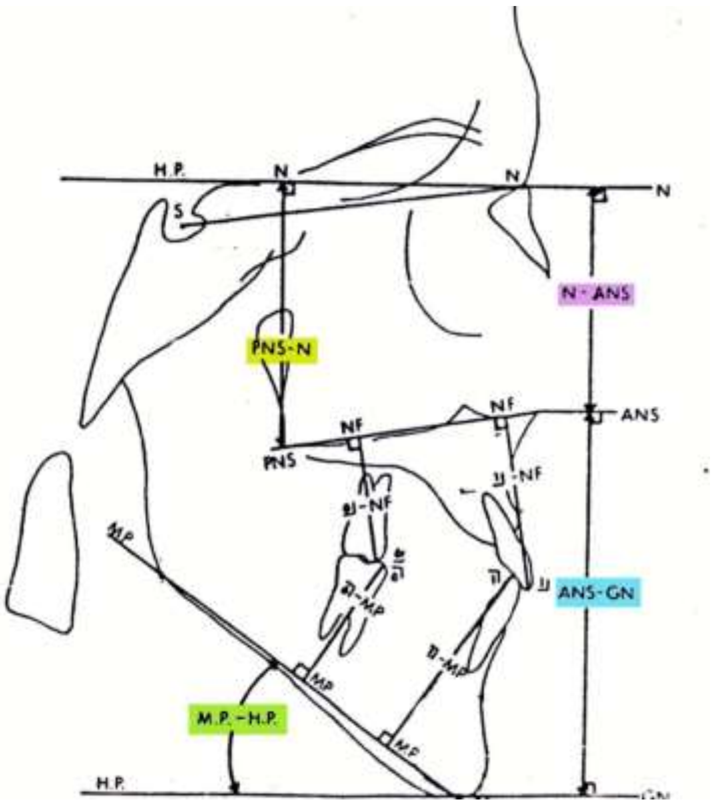
To measure the anterior maxillary dental height, a perpendicular line is dropped from the incisal edge of the maxillary central incisor to NF.

To measure the anterior mandibular height, a similar line is dropped from the incisal edge of the mandibular central incisor to MP. The total vertical dimension of the premaxilla from approximately the pyriform aperture perpendicular to the tip of the maxillary incisor crown is represented by 1-NF. The total vertical dimension of the anterior mandible from the MP perpendicular to the tip of the mandibular incisor crown is represented by $\overline{1}$ –MP.

The posterior dental measurement is subdivided into 6 – NF, which is t perpendicular length of a line through the maxillary first molar mesiobuccal tip of the cusp constructed to NF and $\overline{6}$ – MP, which is a similar line through the mandibular first molar mesiobuccal tip of the cusp constructed to MP. The posterior dental-mandibular vertical height or molar eruption is represented by $\overline{6}$ – MP.

Maxilla and Mandible

The total effective length of the maxilla is the distance from PNS to ANS that is projected on a line parallel to the HP. The ANS-PNS distance with the previous measurements N-ANS and PNS-N, gives a quantitative description of the maxilla in the skull complex.



Four measurements relate to the mandible:

A line from Ar to Go quantitates the length of the mandibular ramus. The linear measurement that establishes the length of the mandibular body is Go-Pg. The angle Ar-Go-Gn is the Go angle that represents the relation between the ramal plane and MP.

The final mandibular measurement is B-Pg, which is the distance from B point to a line perpendicular to MP through Pg. This short line describes the prominence of the chin related to the mandibular denture base. This measurement of the chin should be related to N-Pog to assess the prominence of the chin in relation to the face.

Dental

The occlusal plane (OP) is a line drawn from the buccal groove of both first permanent molars through a point 1mm apical of the incisal edge of the central incisors in each respective tooth. The OP angle is the angle formed between this plane and HP.

If the teeth overlap anteriorly to produce an overbite, the OP can be drawn as a single line. If an anterior open bite is present, two OPs must be drawn and measured separately to establish the angles formed with HP. Each OP is assessed as to its steepness or flatness.

The measurement AB-OP is constructed by dropping a perpendicular line to OP from points A and B respectively and then measuring the distance between these two linear intersections. This distance is the relationship of the maxillary and mandibular apical base to the OP. If the AB distance is large with point B projected posteriorly to point A (a negative number), mandibular denture base discrepancy that predisposes to a class II occlusion is present.

The angulation of the maxillary central incisor to the NF is represented by $\underline{1}$ –NF (angle). This angle is constructed from a line drawn from the incisal edge of the incisor through the tip of the root to the point of intersection with NF. The angulation of the mandibular central incisor to the mandible is represented by $\overline{1}$- MP. These angulations determine the procumbency or recumbency of the incisor and are vital in assessing the long-term stability of the dentition.

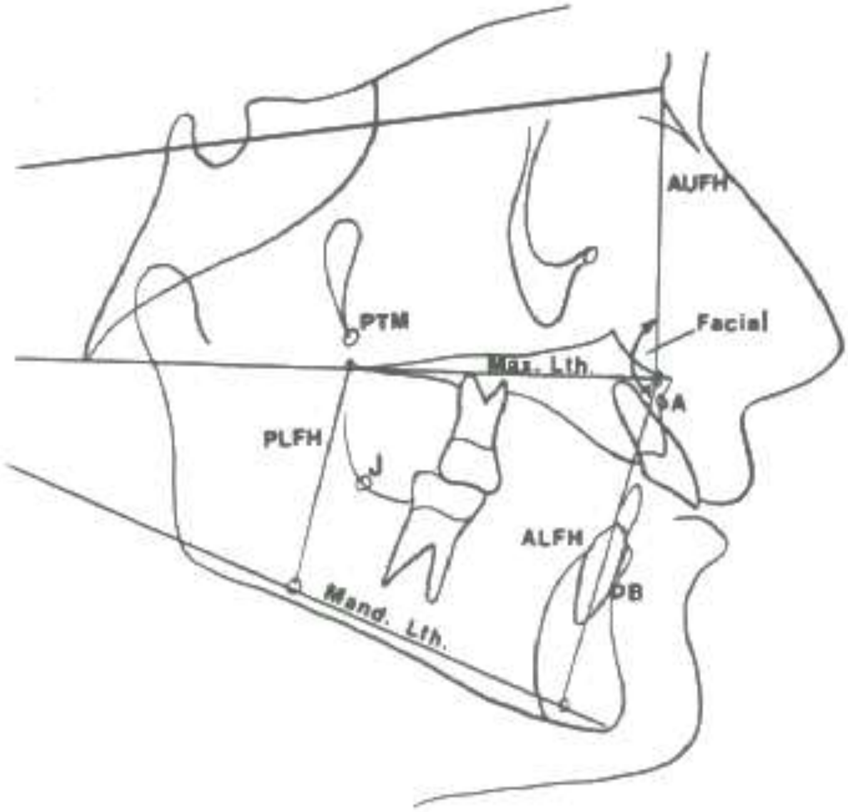
The Quadrilateral Analysis

The quadrilateral analysis, which was developed by Rocco J. Di Paolo is based on theorems in Euclidean geometry. The quadrilateral analysis determines the direction and extent of the skeletal dysplasia in linear measurement which is more understandable in surgical orthodontics than angular measurement. The location of the skeletal problem and its effect on jaw relations must be determined before proper orthodontic and/or surgical planning can be made.

According to him a proportionality of lower face existed in patients, regardless of the dental malocclusion, and Class I, II, and III open-bite dental malocclusions all existed within this proportional framework. When a specific malocclusion exists in an unbalanced quadrilateral (dental bases unequal), the malocclusion is skeletal and not dental in nature.

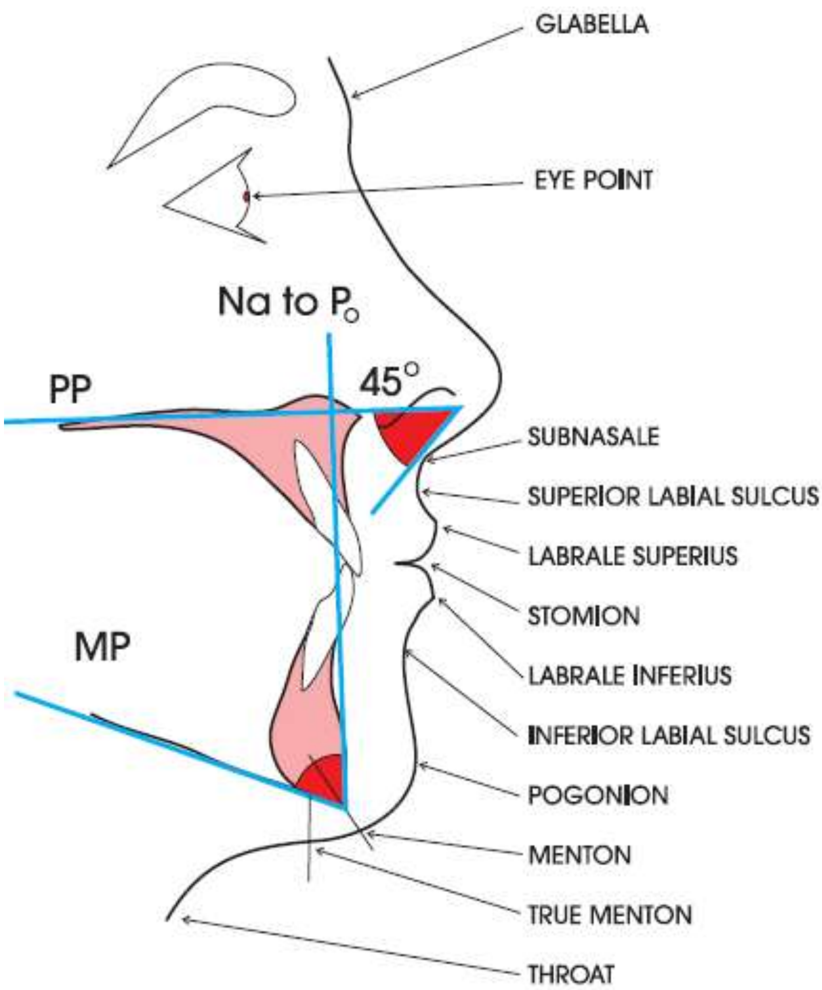
A normal proportionality, irrespective of the existing malocclusion, will suggest to the clinician that the growth pattern is and should continue to be favorable.

Existing skeletal excesses or deficiencies, horizontal and vertical, are also detected, indicating that the growth pattern is and should continue to be unfavorable.



Soft tissu

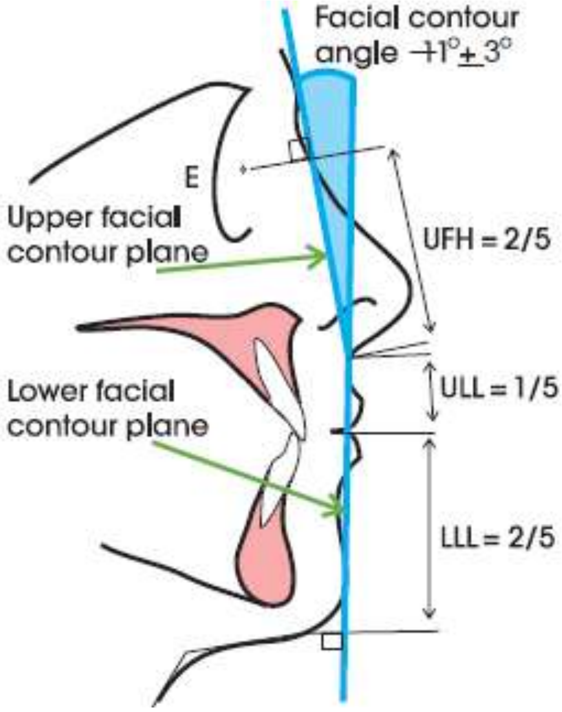
TOMAC (an acronym for the author’s name) is a surgical-orthodontic treatment planning and prediction system designed to identify the best possible soft-tissue profile by testing the effects of various orthodontic and surgical options. Although it was developed for orthodontists, oral surgeons will also find it useful. Landmarks used in this cephalometric analysis are shown below.



Angular Measurements

Facial Contour Angle

The facial contour angle (FCA) is highly relevant to the analysis because it measures the convexity or concavity of the face. This angle is formed by tangents to glabella and soft-tissue pogonion, intersecting at subnasale. The line from glabella to subnasale is referred to as the upper facial contour plane and that from subnasale to pogonion as the lower facial contour plane.

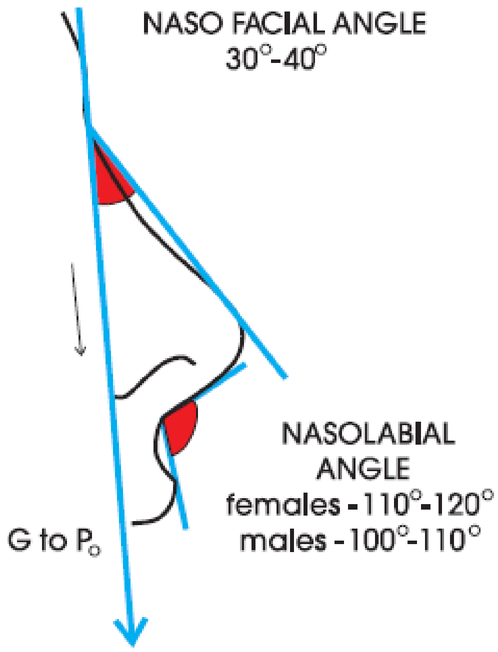


Nasolabial Angle

The nasolabial indicates the protrusion of the upper lip relative to the nose, but can also reflect the up or down tip of the nose.

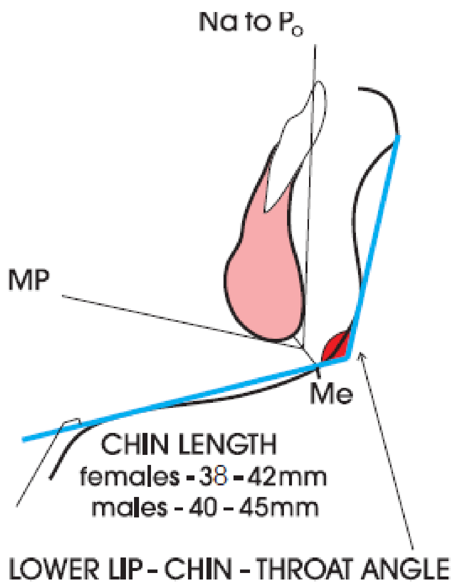
Nasofacial Angle

The nasofacial angle, formed by the intersection of a tangent to the radix and tip of the nose with a line drawn from glabella to pogonion, is important because it describes the protrusion and slope of the nose relative to the total facial profile. The norm is from 30-35°.



Lower Lip-Chin-Throat Angle

This angle is formed by a line drawn from labrale inferius and tangent to pogonion, intersecting with a tangent to the throat that passes through throat point and soft-tissue menton. It is helpful in determining the position of the lower lip in relation to the chin.



Linear Measurements

Lip Protrusion

Upper lip protrusion is an excellent measurement of lip protrusion or retrusion when used in conjunction with the nasolabial angle. The norm is +3.5mm ± 1.4mm. Lower lip protrusion should be used in conjunction with the lower lip-chin-throat angle. The norm is +2.2mm ±1.6mm.

Chin Length

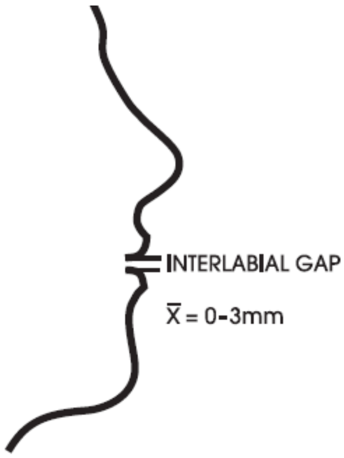
Chin length is measured from constructed soft-tissue menton to the intersection of tangents to the chin and the throat. It is a reasonable guide in treatment planning.

Facial Height

Upper Facial Height (UFH), measured from eyepoint to subnasale, makes up two-fifths. Middle Facial Height (MFH) or Upper Lip Length (ULL) is measured from subnasale to stomion and contributes one-fifth. The norm for females is 20mm; for males, 24mm. Lower Facial Height (LFH) or Lower Lip Length (LLL), from stomion to constructed menton, makes up the final two-fifths.

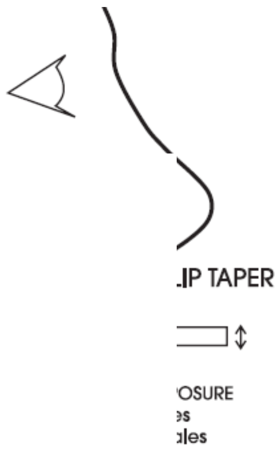
Interlabial Gap

The interlabial gap is the space between the upper and lower lips when they are relaxed. The norm is 1.8mm ± 1.2mm.



Maxillary Incisor Exposure

The maxillary incisor should be exposed below the relaxed upper lip by 1-2mm in males and 3-5mm in females. This is a critical measurement on which much of the vertical planning for surgical-orthodontic treatment depends.



Lip Taper

Upper lip thickness can be measured in both relaxed and lips-together postures. The measurement is made from the point of maximum thickness of the upper lip, just below the subnasale, to the underlying bone, usually about 3mm below point A. This measurement is compared with that from the incisor crowns to the vermillion border. The norm is 14mm for the upper measurement and 15mm for the lower, resulting in a 1mm taper.

Dental Model Analysis:

Important in understanding and development of orthognathic treatment planning. The basic dental model evaluations are as follows:

1. **Arch length:** Correlate the width of teeth to the relative amount of alveolar bone available. Helps to determine whether teeth need to be extracted/spaces need to be created, spaces need to be closed.

2. **Tooth size analysis:** Relations of the mesiodistal width of the upper teeth to that of the lower teeth. Used primarily to evaluate the relation of six upper anterior to six anterior lower teeth.

Usually **"BOLTON'S ANALYSIS"** is used.

3**. Tooth position:** Angulation of maxillary and mandibular anterior teeth with basal bone. The values were compared with cephalometric analysis.

4. **Arch width analysis:** Done between the maxilla and mandible. Assessment of the transverse relationship between malocclusion and expected occlusion.

5. **Curve of occlusion:** Has significant influence on treatment planning. It can be corrected orthodontically/if surgical interventions are necessary to level the occlusal plane. About 2 mm of lower incisors can be intruded orthodontically more than it becomes unstable. For every 1 mm of lower incisor leveling vertically it will move 0.6 – 1 mm anteriorly. Correcting the reverse curve of occlusion by extruding the incisors may not provide stable results. To correct the reverse curve surgical leveling of the arc is presented. Surgical leveling may be obtained by sub apical osteotomies/segmental procedure of maxillary/body osteotomies of mandible.

6**. Cuspid:** molar relationship

7. **Tooth arch asymmetry:** analysis to find left to right symmetry within each arch.

8**. Buccal tooth tipping:** (curve of Wilson) evaluates the position of the occlusal surfaces of the maxillary posterior teeth in a medial-lateral position.

9. Missing, broken down/crowned teeth may influence the treatment plan.

Buccal tooth tipping – If the occlusal surface of the maxillary posterior teeth is tipped buccally, it may be difficult to achieve a proper occlusal relationship. To correct this problem orthodontically, orthopedically, / even surgically assisted orthopedic expansion it is even difficult.

NEWER DIAGNOSTIC AIDS

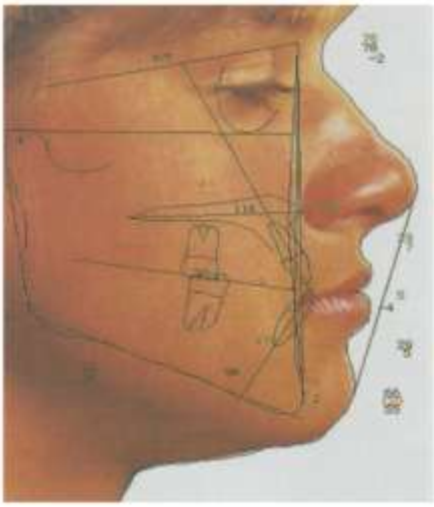
Video cephalometric diagnosis (VCD)

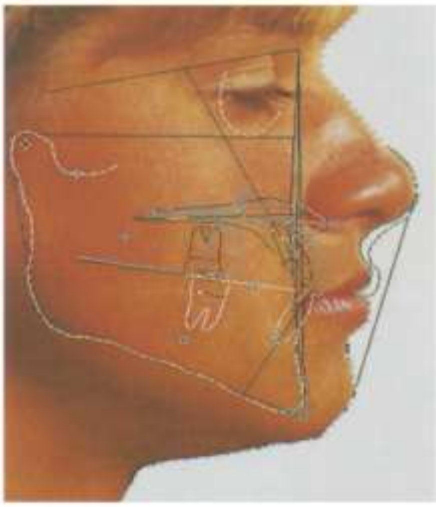
Video imaging has the potential to loach almost every aspect of the orthodontic practice: diagnosis and treatment planning, communications of consultations, database management, integration with practice management programs, communication with other offices, and many other areas that have not been fully realized yet. The current cephalometric analysis systems are supported by powerful software functions that allow possibilities for on-screen digital image acquisition either directly from cephalometric analysis or storage of data. The process is quick and accurate for the landmarks digitized. The digital photographic images taken in a standardized manner are calibrated and superimposed on the digital cephalogram image. This software facilitates on-screen mock surgery, movement of skeletal segments, and morphing of the soft tissue profile consequent to surgery. The soft tissue changes of patients are predicted and morphed based on the data provided from the research study. Dynamic smile analysis is done through video imaging techniques. The predicted image enhances communication with the patient who can visualize the outcome of the surgery and boost confidence. However, these systems have limitations of accuracy whereby, actual surgery outcomes may vary.

The pre-treatment image modification session may be done with the patient before full records are gathered. It is not uncommon for patients considering surgery to request a review of facial changes to be anticipated before committing to a full workup. A profile image is gathered and displayed on the computer screen and profile changes are expected with maxillary incisor. advancement before surgery is illustrated. Patients who require such decompensation are advised that they will “look worse before they get better”, to prepare them for the unmasking effect of decompensation. Further image modification then stimulates mandibular advancements and advancement genioplasty.

The treatment planning template is calibrated to the existing profile image. Profile projections are drawn from the computer database and are applied in an algorithmic mathematical fashion. The profile algorithmic may be user-defined so that the division has the capability to adjust the hard to soft tissue ratio to his or her own specifications.

Stimulation of the orthodontic decompensatory movement is accomplished by the uprising and advancing the upper incisor template. The upper lip soft-tissue outcome is automatically adjusted through the algorithmic response mechanism, and the anticipated facial response is produced as the software adjusts the video image to the prediction outline. Once the simulated orthodontic decompensation is complete, the mandibular advancement is then simulated by either a keyboard advancement of the mandibular template or via a click and drag feature.

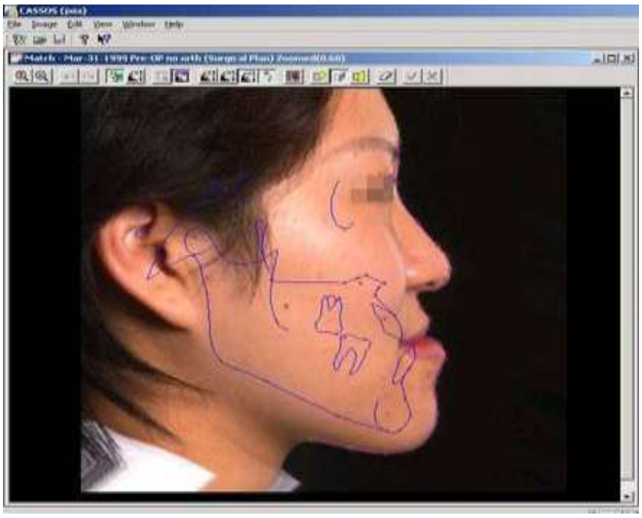




3D CEPHALOMETRY

Three-dimensional (3D) craniofacial imaging techniques are becoming increasingly popular and have opened new possibilities for orthodontic assessment, treatment, and follow-up. Recently, a new 3D cephalometric method based on spiral multi-slice (MS) computed tomography (CT) was developed and validated by our research group. This innovative 3D virtual approach is a bridge between conventional cephalometry and modern craniofacial imaging techniques and provides high-quality, accurate, and reliable quantitative 3D data.

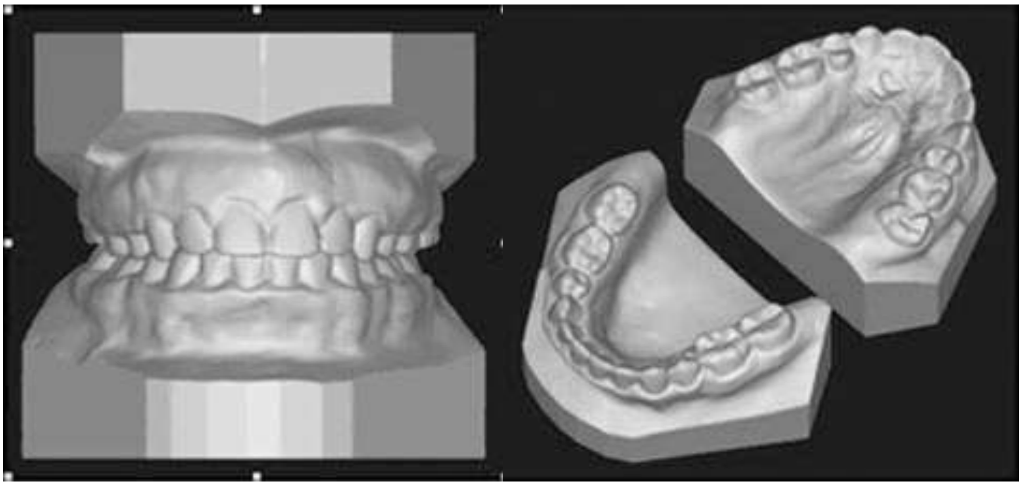
The patient's head is scanned in a horizontal position. The CT images are stored by using DICOM format. Then the DICOM files are converted into MXM files (Maxilim version 1.3.0, Medicim NV, Sint-Niklaas, Belgium). The bone and soft-tissue surfaces are segmented by applying a threshold on the acquired image volume of radiographic densities expressed in Hounsfield units (HU). To begin the analysis, the segmented hard- and soft-tissue surface representations of the skull are rendered in a virtual scene. After semiautomated virtual standardized positioning of the skull, high-quality virtual lateral and frontal cephalograms are computed as orthogonal projections from the single CT data set and linked to the 3D hard- and soft-tissue surface representations. This innovative 3D virtual scene approach allows the accurate and reliable 3D definition of various landmarks; the setup of 3D cephalometric planes; and an accurate and reliable 3Dcephalometric hard- and soft-tissue analysis.



3D MODELS

3D models with CBCT and digital construction are other technical advancements in this field. Here in digital CT images obtained through cone-beam computed tomography is used for the reconstruction of the patient's hard and soft tissues.

CBCT offers the distinct advantage of less radiation dosage than conventional CT. it offers a real-life view of bony structures, therefore allowing minute details of the surgical treatment plan. Bone thickness in relation to anatomical structures such as neurovascular canal and tooth-root can also be visualized. Stereolithography models can be generated using CT data whereby the surgeon can plan a mock surgery.



Stereo-photogrammetry

Stereo-photogrammetry is a technique for obtaining highly accurate 3d surface images using the principle of stereophotogrammetry. It can capture the object in less than 1.5 ms to generate a highly precise digital 3D model of human anatomy, which will soon replace traditional 2D photographs. The greatest advantage is that of its non-invasive nature. Secondly, very short capture speed is virtually instantaneous and especially suited for imaging young restless children. The images offer the possibility of analysis and landmarks on patient's surface data. It is easy to calculate and compare a number of parameters such as linear angular and complex surface distances, ratio, areas, volumes, etc. with 3dMD it is possible to obtain surface data from cross-sectional view on any plane or intersecting plane.

CONVENTIONAL v/s SURGERY FIRST ORTHOGNATHIC APPROACH

Conventional surgical orthodontics:

The conventional approach for correction of severe dentofacial anomalies in adults consists of presurgical orthodontic treatment, surgical treatment, and postsurgical orthodontic finishing. According to this approach, presurgical treatment is crucial for satisfactory surgical treatment and stable results. This Pre-surgical orthodontics is mainly aimed at removing the dental compensations of the malocclusion.

The goals of presurgical orthodontic treatment consist of [5]:

3. Dental decompensation for positioning the teeth over their basal bones without considerations for the bite relationship to the opposite arch;

4. Levelling and aligning of the upper and lower dentition, relieving any crowding;

5. Coordinating upper and lower dental arch forms;

6. Divergence of roots adjacent to surgical sites where interdental osteotomies are planned.

7. Avoid unstable expansion of the dental arches

8. Avoid class II and class III mechanics (unless required for dental decompensation correction in the arches)

9. Perform stable and predictable orthodontics

Presurgical preparation time varies according to the patient. If the patient is not properly prepared; Surgery cannot be carried out effectively, the Quality of the result is diminished, Post-surgical orthodontic treatment time increases.

Orthodontic treatment before orthognathic surgery reveals the true skeletal discrepancy preoperatively and helps to determine the required dental decompensations which would otherwise limit fully correcting the skeletal deformity. Presurgical orthodontic procedures usually produce satisfactory results and are considered routine.

However, this process can be time-consuming, taking as long as months, depending on the complexity of orthodontic treatment requirements. In addition, there are worsening lip profile, masticatory discomfort during preoperative orthodontic treatment, and psychosocial problems associated with delay in responding to the patient’s usual complaint concerning facial aesthetics treatment.

In the initial stages of treatment, orthognathic and conventional orthodontic mechanics have some similar objectives, like to position the teeth ideally relative to their apical bases through the establishment of correct torque, proper elimination of rotations, flattening of the occlusal plane, and eliminating tooth-size length discrepancies, but these procedures may temporarily accentuate the malocclusion, were demonstrating the true magnitude of the skeletal problem. However once accomplished, these objectives will allow the ideal class I anterior dental relationships and aesthetic facial balance to be attained at the time of surgery.

Intra-arch mechanics in orthognathic cases should be designed to achieve the ultimate desired postsurgical interdigitation and allow for the establishment of class I canine and molar relationships after surgical treatment.

If extractions are necessary to accomplish the desired objectives, then extraction sites should be closed unless segmentalized surgical closure is planned. In most of the malocclusions with severe underlying skeletal deformity, the dentition has often maintained some occlusal contact and interdigitation by the teeth compensating in their positions for the skeletal problems. These dental compensations are manifested in all 3 planes of space but are most apparent in the sagittal dimension.

The stepwise treatment procedure for patients with skeletal deformities in conventional orthognathic surgery:

Orthognathic surgery is indicated in cases of severe skeletal class II and class III malocclusion. In skeletal class II cases, the dental compensation occurs which includes a very protrusive mandibular incisor and upright maxillary incisor, conversely, in skeletal class III, the mandibular incisors are often found to be Retroclined while maxillary incisors are commonly flared forward. Our main aim is to decompensate nature's compensation, to position the incisors ideally to their apical bases. These "decompensations" by orthodontic mechanotherapy is usually achieved with inter-arch mechanics. Although this may worsen the apparent malocclusion and profile, increase the overjet, decompensating the dentition will afford a greater magnitude of surgical correction, and ensure the likelihood of post-treatment stability.

Decompensation in skeletal class II malocclusions:

In these cases, decompensation can be done by extracting the upper second premolars and lower first premolars followed by protraction of upper molars and retraction of lower anterior leads to worsening of profile and increase in overjet to advance the mandible to correct class II malocclusion. Even if little space is required then consider extraction of 2nd premolar which would avoid over retraction of anterior teeth and mandibular advancement would not be compromised.

Extraction patterns:

Camouflage treatment: Extraction of only upper 4s or Upper 4s and lower 5s

Surgical treatment: Extraction of Upper 5s and lower 4s, Upper 4s and lower 5s or all 4s.

Decompensation in skeletal class III malocclusions:

In these cases, decompensation can be done by extracting the upper first premolars and lower second premolars followed by retraction of upper anterior and protraction of lower molars leads to worsening of profile and increase in negative overjet, to setback the mandible for correcting skeletal class III malocclusion.

Extraction patterns:

Camouflage treatment: Extraction of only lower 4s or lower incisors.

Surgical treatment: Extraction of Upper 4s and lower 5s, Upper 4s and lower incisors.

Selection of the appliance:

Stability – It is important to stabilize the teeth against stresses encountered at surgery and during IMF [15,16]. Use of a pre-adjusted appliance is recommended due to the stability provided by a rectangular SS wire in a rectangular slot. Proffit does not recommend using a Begg's appliance for surgical patients, as he feels the stability provided by a round wire is much less. But surgical cases can be done with a Begg's appliance using a rectangular wire in the ribbon mode.

<u>Esthetics</u> – The most esthetic appliances today are lingual appliances. But these are not recommended for surgical patients due to the following reasons:

- Impossible to use the appliance for stabilizing the teeth during surgery or IMF.
- Post-operative patients have difficulty in mouth opening for the first few months.

If a lingual appliance is used, at least for some time pre-operatively a labial appliance will have to be bonded to overcome these limitations. Hugo et al[17] reported the use of a maxillary lingual and mandibular labial appliance in orthognathic patients. But they too mentioned the use of labial appliances just before the surgery and thereafter until the end of the treatment. The advent of bonding has made labial appliances more esthetically acceptable, but it is still advisable to band posterior teeth i.e.; the 2nd premolar or 1st molar back.

Tooth-colored brackets are of 2 types:

Plastic brackets – Not suited for surgery as they tend to fracture, and *the* bracket slot is not good enough to provide good torque control.

Ceramic brackets - Stronger than plastic brackets, and provide good torque control. But they are brittle and can fracture. Impacts should be avoided during treatment, especially during surgery. They are satisfactory for surgical treatment but should be limited to the upper anterior only, and the surgeon must be prepared to use alternative stabilizing methods (like arch bars) if the brackets fracture in the OT.

Slot Size:

Either slot size 0.018 or 0.022[18] – is good enough for surgery, as long as a full-sized wire is placed in the slot – 17x 25 SS for 0.018 slots, and 21x25 SS or TMA for 0.022slotst. But when segmented arch mechanics need to be employed, 0.022 slot[4,8] is preferable, as the individual segments can be well stabilized with 21x25 SS wires.

Bonding vs banding:

Bonding of anterior teeth, and banding of posterior teeth. When there are periodontal problems, banding should be avoided, due to difficulty in keeping the area clean.

Appliance modifications:

Although PAE brackets are recommended for surgery, a few things must be kept in mind:

1) All prescriptions cannot be used for surgical patients. **Extreme prescriptions must be avoided**. "Extraction series" brackets tend to have a high amount of tip on the canine and premolar brackets which result in roots converging into the extraction space. This can cause problems in the case of segmental osteotomies. Hence roots should not be converging in the extraction space. On the other hand, the opposite side bracket should not be placed, as it would cause too much root separation, and increase the time required for post-surgical orthodontics.

All teeth should be included in the strap-up. Mandibular second molars can be included before surgery, but it is better to include maxillary molars after surgery, as they tend to extrude. This can interfere with the surgical positioning of the jaw bases. If the maxillary second molars are included before surgery, they must be kept depressed using a step bend.

2) Auxiliary molar tubes and headgear tubes should be present, and molars should have lingual attachments to aid in the use of cross elastics.

3) Brackets with adequate mesiodistal and rotational control – twin brackets to be used (should be at least ½ the m-d width of the tooth), or single brackets with rotational wings.

4) Integral hooks in the brackets- these help in stabilization during surgery and for attaching elastics during post-surgical orthodontics. Long hooks should be avoided as they make oral hygiene maintenance difficult. Some surgeons however feel that the brackets may get dislodged if these hooks are used for stabilization, and prefer to use hooks on the archwire instead.

Final Presurgical Preparation: (Peterson's)

As presurgical orthodontic treatment progresses, new diagnostic records (lateral cephalograms, orthopantomograms, dental models) are taken to determine the feasibility and timing of surgical procedures[19]. This will also aid the orthodontist in identifying specific areas that may need to be addressed in completing the presurgical orthodontic goals (i.e., sectional leveling of the arch segments, marginal ridge alignment, vertical dental alignment, buccal surface alignment, additional TSD correction). During surgery, the jaws are usually wired together once or twice, as each jaw is independently mobilized and stabilized with rigid fixation. To facilitate wiring the jaws together as well as providing a means of using postsurgical elastics if required, fixtures attached to the brackets or archwires are usually necessary.

Fixtures attached to the brackets are dependent on the manufacturer but may include ball hooks built onto the brackets, T pins, and K hooks, Fixtures attached to the archwire include crimped-on hooks and soldered pins. Hooks built onto the brackets are preferred, followed by the other hooks placed on the brackets (T-pins, K hooks). The least preferred are the hooks on the archwire.

The reason is that if post-surgery elastics are required for an extended time, the elastics and hooks on the archwire will activate the archwire, possibly creating unwanted orthodontic forces and movements (i.e., tipping the crowns lingually and the roots buccally). This undesirable torquing occurs to a much lesser degree when the hooks are directly on the brackets.

When the maxilla or mandible is to be segmentalized, it may be better for the orthodontist to section the archwire and bend the ends inward at the predetermined osteotomy areas immediately before surgery, or the surgeon can cut the wire at the surgery.

Need for a face bow transfer – This depends on the type of surgery.

1. If the relation of the condyles and the mandibular dentition will be maintained during the surgery, and the mandible is required to auto-rotate to a new position, face bow transfer is needed.

2. In cases of 2 jaw surgeries, the mandibular position and rotation are important for positioning the maxilla. Hence face bow transfer is needed.

If the relation between the condyle and the mandibular dentition is to be changed during surgery, a face bow transfer is not needed. Mounting on a simple articulator will do. Facebow transfer is needed in Reposition of the posterior or entire maxilla, Segmental subapical procedures of the mandible, and 2 jaw surgeries.

Purpose of model surgery:

1) To verify that the planned movements are possible.

2) To relate the mandibular and maxillary dentitions in the position where the surgical splint will be made.

Model Surgery -2 jaw surgery

The patient's impressions are taken after the final rectangular wire is in place for at least 3 weeks so that it is passive and no further tooth movement will occur. This is important to ensure the proper fit of the splint during surgery. Once the impressions are taken, a wax bite is taken to record the occlusion of the patient. Then, the facebow record is taken, and the maxillary cast is mounted on the articulator. The mandibular cast is mounted using the wax bite.

For the mounting of the casts, a 5mm acrylic spacer is used. The maxillary model is mounted onto the mounting rings with the spacer interposed. The spacer is then removed. Grooves are created in the plaster and are coated with petroleum jelly, and another layer of blue-colored plaster is poured.

This can be easily removed subsequently. The advantage of the spacer is that it eliminates or at least reduces the surgery of cutting plaster to simulate maxillary impaction. Blue plaster is used for initial mounting.

First, the maxillary procedure is done. The vertical distance of each crown’s cusp tip to the mounting ring is marked and measured. This will later aid in determining the amount of movement carried out. The plate of the jig is then oriented to the maxillary occlusal plane and the maxillary cast is stabilized with putty consistency rubber-base material. The blue-colored plaster is then easily removed. This leaves a space above the maxillary cast to allow for impaction. The jig has anterior and posterior screws which help in impacting the anterior and posterior limits of the maxilla to the predetermined amount. Once the impaction is done, the vertical distance of the teeth to the mounting ring is again measured, to confirm the amount of impaction done.

With the maxilla and the jig still in this position, a layer of pink plaster is poured to stabilize the maxilla. After the plaster sets, the incisal pin loosened, and the maxillary cast drops till it touches the mandibular cast. This simulates auto-rotation. In this position of the maxilla and the mandibular casts, the intermediate splint is made.

If transverse stability of the arch is required after surgery, a TPA in the upper arch or a lingual arch in the lower can be fabricated just before fabrication of the splint. Also, a 40 mil (19gauge) wire can be fabricated to run from one headgear tube to the other. These are to be inserted after the expansion has been done. After the intermediate splint is ready, the blue plaster is removed from the mandibular mounting, and the mandible is repositioned to the desired position. The final splint is then made.

The splints are made with E links incorporated in them, to aid in intermaxillary fixation. The splint is used during surgery to help attain the planned occlusion and to stabilize the teeth during surgery. Without a splint, however, the surgeon has to decide the most stable position for the jaws, not being able to judge symmetry and midlines, etc. The splint should not be too thick, as this would increase the chances of error as the mandible rotates into occlusion after the splint is removed. At times, there may be some teeth contacting through the splint, but this is acceptable as long as the thickness between these areas is adequate to provide good strength. Otherwise, the splint should not be more than 1-2 mm thick. The splint should be in place until the start of post-surgical orthodontics.

If rigid internal fixation is used, IMF is relieved earlier, but the splint should remain tied into one of the arches, and the patient should continue to function into it, guided by elastics.

Requirements of the splint:

1. It should fit the teeth accurately, and there should be no distortion of the resin.
2. Should be of minimum thickness required for adequate strength. i.e. – thickness should not be more than 2 mm.
3. Excess acrylic should be trimmed off the buccal aspect, to allow for proper visual verification during surgery and oral hygiene maintenance.
4. Should allow for ease in IMF.
5. If rigid internal fixation is to be used, the patient will have to function into the splint soon after the surgery. They must be trimmed so that only the occlusal indentations of the teeth are present in it, permit lateral movements, and yet provide a stable occlusal relationship.

Postsurgical Orthodontics: (Peterson's)

In preparation for the post-surgery orthodontic phase of treatment, the surgical stabilizing splint, if used, is usually removed 4 to 6 weeks post-surgery[19]. If the palatal splint design is used and a large maxillary expansion has been performed, the splint can remain for a longer period and postsurgical orthodontics can be performed around it.

The maintenance of the splint will enhance the transverse stability and it can be left in for 2 to 3 months or longer if necessary. It can be made into a removable appliance. If rigid skeletal fixation is used, active orthodontics involving changing the archwires can usually resume 4 to 6 weeks post-surgery, when patients are usually comfortable enough to tolerate changing their archwires. The orthodontist can be fairly aggressive at finishing the occlusion because the osseous segments can still be moved slightly.

The teeth move much more rapidly for the first few months post-surgery because there is an increased bony metabolism as a result of the surgery. The orthodontist can therefore accomplish in 1 to 2 weeks what would normally take 4 to 6 weeks to complete. Applying active mechanics at this early postsurgical orthodontic phase of treatment and booking the patient for a routine orthodontic follow-up 4 to 6 weeks later could result in uncontrolled excessive orthodontic movements, resulting in an unfavorable outcome.

For most cases the orthodontist should see the patient once a week for the first month, then every 2 weeks for the next 2 months for adjustments so that orthodontic changes can be closely monitored. At the initial appointments root positions are checked, loose brackets and bracket positions are evaluated and corrected, and new archwires are placed if indicated. Interarch mechanics (i.e., class II or III elastics, vertical elastics, and/or cross-arch elastics) can be applied as necessary to finalize the occlusion.

Once the initial healing phase is completed (approximately 3 to 4 months post-surgery) and the occlusion is stable, the orthodontic appointment intervals can be extended to the more traditional time frame. The final positioning of the teeth usually takes from 3 to 12 months of postsurgical orthodontic treatment but could be longer depending on the postsurgical orthodontic requirements. Although reasonable stability from surgical healing occurs in approximately 3 to 4 months, the final post-surgical healing phase takes 9 to 12 months.

NEW TREATMENT CONCEPT

(SURGERY FIRST ORTHOGNATHIC APPROACH)

As a greater number of adult patients seek orthodontic treatment for their beauty, the number of patients who want to get orthognathic surgery has been increasing as well as their demand for aesthetics. Their characteristics include: Refuse to get reverse orthodontics, want to get least orthodontic device installation, want to shorten the overall treatment period, want to get surgery before improving the facial profile more rapidly.

Patients' esthetic demands have grown, but their compliance has diminished. From orthodontic treatment perspectives, the degree of pre-operative orthodontic treatments has become predictable and the range of orthodontic treatments has been broadened with the utilization of SAS and mini-screws. Furthermore, in the surgical treatment perspective, there has been a breakthrough development of surgical procedures and also dental compensation can be resolved with segmental osteotomies.

SFOA can potentially produce semi-stable postsurgical occlusion compared with the conventional orthognathic surgical approach because of its sequence without presurgical orthodontic treatment. Therefore, a rigid fixation after bilateral sagittal split osteotomy has been suggested for maintaining the occlusion stability postoperatively.

- Wafer: Even if the occlusion is not completely set, setting a wafer after operation minimizes the post-operative occlusion instability.

- Rigid fixation: Rigid fixation of bone segments minimizes the post-operative occlusion instability.

- Prediction: the final amount of dental decompensation can be predicted with the setup model.

However, in this new treatment concept, the need for some of the orthodontic procedures are eliminated; some are displaced by maxillary posterior impaction (MPI), occlusal plane rotation (OPR), anterior segmental osteotomy (ASO), or segmental surgery, and the other procedures are performed after orthognathic surgery. Moreover, to predict the degree of post-operative orthodontic treatment, a set-up model is fabricated at a dental lab.

Protocol in SFOA:

While the sequence of treatment is similar, different protocols are being used to prepare the patient for surgery, perform the surgical procedure, and initiate orthodontic treatment[4]. Orthodontists often have their customized preferences which have developed in their years of practice.

I. **Preoperative procedures:**

   A. Timing of bonding in SFOA

   B. Stabilizing/ Initial archwires in SFOA

   C. Splints in SFOA

   D. Laboratory procedures

II. **Surgical procedure**

III. **Post-surgical procedure**

   A. Intermediate transient malocclusion

B. Immediate post-operative stability

C. Timing of active orthodontic treatment

D. Active orthodontic treatment. (Levelling and alignment, decompensation, arch coordination, detailing of occlusion).

Preoperative procedures:

A. Timing of bonding in SFOA:

Various authors recommended the timing of bonding in SFOA at different times.

- Sugawara[20] and Nagasaka[21,22] recommended that fixed orthodontic appliances should be placed just before surgery even when using a surgery first approach.
    - But the problem is when brackets are attached immediately before surgery the bond strength of the bracket to teeth might be weak and fail to resist the force of intermaxillary fixation.
- Chung ChihYu[23] Villegas[24] recommended the brackets should be placed 1 week before orthognathic surgery.
- Ellen wen ching[13] recommended 1 month before surgery.
- Federico Hernandez[25,26] reported the total elimination of preoperative orthodontic treatment and the fitting of orthodontic brackets 10-14 days after surgery.

But generally, in most cases, the brackets and the wires are placed right before surgery. While some clinicians prefer to bond the wire directly to the surface of teeth, others choose to utilize the conventional orthodontic attachments. Although bonding the wire directly to the teeth is very fast, it makes post-surgical orthodontics a problem since teeth needs to be bonded at that point. Given the healing period after surgery, it is very difficult to place brackets on teeth while minimizing patient discomfort. While some clinicians prefer to bond the wire directly to the surface of teeth, others choose to utilize the conventional orthodontic attachments.

B. Stabilizing/ Initial archwires in SFOA:

Contrary to conventional orthognathic surgery cases, in surgery first treatments leveling and aligning have not yet been performed which makes it very difficult to place the wire. Most authors used Stabilizing wires before surgery. Some used NiTi wires and some used stainless-steel wire.

- Liou et al[27] did not place any orthodontic archwires before surgery.
- Ching et al[23] used 0.016x0.022" superelastic NiTi wire.
- Carlos et al[22] have opted to use 0.16" X0.16" nickel-titanium wires at the time of surgery.

The use of nickel-titanium wires translates into immediate tooth movement after surgery which can be an advantage. However, in doing so, the orthodontist loses the opportunity to observe the stability of the surgical correction before starting the tooth movement.

- Sugawara and Nagasaka[20,21] preferred 0.18"x0.25" SS wires and 0.19"x0.26"

SS wires in the 0.022 slot are adapted to all teeth for preventing any tooth movement. Full slot withstands the forces resulting from intermaxillary fixation.

Either brackets have hooks or brass wire (lugs) are soldered to the archwire for wiring fixation, Prefabricated ball hooks may also be used, Kobayashi hooks[24] can also be used. Occasionally, intermaxillary screws may be required.

- Alternatively, Baek et al[7] suggested the archwire can be bonded directly to tooth surfaces to function as an arch bar a few days before surgery. Although direct wire bonding is comfortable for the patient, it is difficult to remove the

  orthodontic preparation can also allow the use of active archwires when there are premature occlusal contacts derived from crowding.

C. Splints in SFOA:

The use of surgical splints during and after surgery also varies between different orthodontists. While some advocate the use of the splint only during surgery, other groups have advocated its use anywhere between one to four weeks after surgery.

- Nagasaka et al[21] have used removable Gelb–type splints postoperatively. Their preference is to leave the splint in for about 4 to 6 weeks after surgery and if an open bite is observed, to use elastic between the splint and the mini-screws or to leave the splint for a longer period.

- Sugawara et al[20] modified the surgical splint into a removable maxillary occlusal splint, which was used to stabilize the jaw position and masticatory function.

- Villegas et al[22,24] did not use a splint to stabilize the occlusion after surgery. Model surgery indicated that the occlusion would be stable in a cusp-to-cusp relationship, and the maxillary teeth could then be distalized to relieve the anterior crowding while maintaining the incisor positions and inclination.

The BSSO technique on SFA requires 1 to 2 weeks of occlusal splint postoperatively[28], the IVRO technique requires approximately 4 weeks of occlusal splint owing to the difference in the amount of bony overlap and healing process. The BSSO provides primary stability by rigid fixation of bony segments interfacing the marrow; in contrast, IVRO has overlapping bony segments interfacing cortices (cortex-to-cortex healing).

These bony becomes more rigid and muscular reattachment sequentially follows. Thus, it takes approximately 4 weeks for mandibular proximal and distal bony segments to heal and fuse, and the occlusal splint is used to stabilize the occlusion during this bone-healing period.

D. Laboratory procedures:

“Set-up models” are used to predict and simulate dental positions and arch coordination for the decision on surgical jaw movement[5]. Liou et al[8] suggested to set-up model surgery in proper molar relationships with a positive overbite that is opposite to the conventional approach which uses decompensated incisors as the guide to predicting the final occlusion. Moreover, they suggested how to set up models in various circumstances. For example[5], a non-extraction case could be set up with molar Class I relationship; in case of lower first premolar extractions, molars could be set up in Class III relationship; and set up molars Class II in cases of maxillary first premolar extractions.

Baek et al[7] reported a different and precise technique for setting up models in skeletal Class III with two jaws surgery cases.

This required use of a semi-adjustable articulator with separation of the dental and base sections of the study models for set-ups to take separate account of required dental alignments and skeletal changes, and preparation of intermediate and final surgical wafers. This enables the surgeon to determine the required skeletal base movements. However, orthodontists must have experience and confidence that they can move teeth after the surgery with the same results as the model set-up.

Surgical procedure:

In 2011, Liou et al[8] suggested specific guidelines for using SFOA to treat cases of skeletal Class III and skeletal Class II in three dimensions; vertical, sagittal, and transverse. There are clinical reports of SFOA being applied for treating bimaxillary protrusion[25] and asymmetry cases[24] but without extended clinical trials.

In vertical discrepancy, the deep curve of Spee can cause occlusal interference because there has not been a presurgical orthodontic correction. It has been suggested to treat some cases with deep bite with subapical osteotomy, anterior segmental osteotomy, or treat with a post-surgical orthodontic appliance for correcting dental interferences. However, in applying the SFOA approach, the correction of the vertical discrepancy by anterior or posterior maxillary impaction can create anterior or posterior rotation of the mandible that will improve or worsen the profile of skeletal Class II or skeletal Class III. However, Baek et al[7] suggested posterior maxilla impaction can decrease occlusal interference and increase the amount of mandibular backward rotation.

In most cases requiring correction of a transverse discrepancy, the SFOA and conventional orthodontics-before-surgery approaches are the same, both relying on maxillary segmental surgery. Some cases have negative buccal overjet more than a half molar width but coordinated arches are correctable because it is associated with large skeletal Class III discrepancy where combined maxillary advancement and mandibular set-back are required. If the crossbite discrepancy is more than a molar width on each side, they could be coordinated surgically by a three-piece Le Fort I osteotomy. Alternatively, the narrow maxilla could be treated by surgical assisted rapid palatal expansion. While bone plates are used for rigid fixation, the length of time that a surgical splint is used following surgery depends on the orthodontist. Some clinicians[24] use the splint only during surgery; other authors suggest leaving the splint postoperative 4 to 6 weeks[4,7].

Nagasaka et al[21] and Sugawara et al[20] used removable surgical splints which consist of a lingual bar and ball-end clasps. The splint can be designed for use in the upper or lower arch depending on the treatment objectives in the post-operative period. Grinding of the occlusal surface of splint while using intermaxillary elastics can allow opposing teeth to be extruded and uprighted. Whether the anterior part of the splint has acrylic coverage depends on the orthodontist's need to prevent extrusion of incisors or allow anterior teeth eruption. For example, the Gelb type splint is suggested to maintain intrusion of posterior teeth because it has acrylic coverage over occlusal of posterior teeth only. This design will lead to mandibular upward and forward rotation and chin advancement.

Postoperative procedure in SFOA:

The objectives of orthodontic treatment after surgery in the SFOA technique are dental alignment, arch coordination, and allow occlusal settling, which together might take another 6-12 months[5]. This period can speed up orthodontic tooth movement especially after orthognathic surgery because there is an increased alveolar bone blood flow during the healing process with stimulation of bone turnover called the Regional Acceleratory

Phenomenon (RAP).

- Leelasinjaroen et al[5] suggested postsurgical orthodontic treatment could begin as early as one week to one month postoperatively.
- Kim et al[16] suggested waiting four to six weeks. The surgical splint and intermaxillary fixations should be removed for tooth movement.

Orthopedic appliances, such as a facemask or chin cap for class III patients, could be applied for the maintenance of jaw bone position during the orthodontic tooth movement. Authors have experienced the phenomenon of postoperatively accelerated orthodontic tooth movement in patients having orthognathic surgery whose orthodontic alignment and anteroposterior, vertical, and transverse orthodontic tooth movement could be achieved easier and faster.

A possible explanation for this phenomenon is the improvement of dental and muscular function postoperatively or bone physiologic changes induced by orthognathic surgery. The shortest reported treatment time for postoperative orthodontic treatment was 4 months for the correction of skeletal class II or III malocclusions and dental crowding[25].

- Nagasaka et al[21] completed postoperative orthodontic treatment within approximately 1 year.
- Sugawara et al[20] removed the fixed orthodontic therapy after 9 months.
- Villegas et al[22,24] removed the fixed appliances 7 months after surgery. Treatment time was approximately 6-12 months shorter using a surgery-first approach compared with using a conventional orthodontics-first approach. Only one study[5] described similar treatment times (1.5 years) for both approaches.

The individualized acceptable functional occlusion after SFOA (Treatable malocclusion)

The goal of the orthodontic treatment is to develop the esthetically pleasing dentition sagittally to obtain angles class I occlusion and normal overjet as well as vertically to obtain positive overbite of six anterior teeth after SFOA. The surgery methods minimize the root resorption or gingival recession, which the excessive tooth movement brings about. In other words, individualized acceptable functional occlusion includes the alignment and leveling procedures that lead to the correction of dentition alignment and minimize the dental movement through the positional change of maxilla and mandible. Then, the tooth angulation of the maxillomandibular complex against the occlusal plane is changed into an esthetically desirable one.

Immediate postoperative stability after SFOA (Jin Young Choi[29]):

1) The period for post-op inter-digitation is about 2-3 months. During this period, Orthodontists rapidly set the occlusion between upper and lower molars and adjust the width of the molar areas.

2) Risk management:

   The removal of the wafer, immediately after orthognathic surgery may exhibit premature contact, the difference among molar width, etc. that might result in an open bite. Therefore, while the patient wears the wafer, Orthodontists perform the occlusal splint adjustment and elastic wearing to the patient.

3) Orthodontic treatment begins 2 weeks after the surgery:

   To adjust the differences among the molar width, Orthodontists cut off the mandibular buccal and maxillary palatal region of the wafer right before or right after the surgery. Crossbite elastic could be installed so that molar teeth move for occlusal stability.

***The following are clinical treatment suggestions**:*

1. Cases with severe dental interference between arches, such as a deeper curve of Spee and OB, might need to be corrected before surgery;
2. Overcorrection of the mandibular setback or a more clockwise rotation of the maxillomandibular complex may be required to prevent forward mandibular rotation and sagittal relapse after OGS in cases with an accentuated curve of Spee and a larger OB that are planned for the SFOA.
3. For some cases with a severe, accentuated lower curve of Spee, adding a lower anterior segmental osteotomy (Keole procedure) to intrude the lower anterior teeth might be required to improve treatment efficiency and surgical stability;
4. Cases with severe initial sagittal discrepancies between arches should be treated with caution because of the tendency of relapse after surgery. The horizontal stability of surgical outcomes in the mandible might be negatively influenced when the amount of surgical setback exceeds 15 mm, even with 2-jaw correction.

Use of skeletal anchorage in conjunction with surgery first approach:

In recent years[4], temporary anchorage devices have become very popular in orthodontics. The use of skeletal anchorage has provided for more predictable orthodontic movements while minimizing undesirable side effects. The surgery’s first approach requires meticulous treatment planning and collaboration between the orthodontist and the orthognathic surgeon. The model surgery is based on the orthodontist's vision on what is achievable post orthodontically based on previous experience. Hence, many uncertainties remain at the time the patient is sent to surgery. By utilizing the temporary anchorage devices, many orthodontists try to have a "back-up" system that can be used to help in the post-surgical orthodontic phase. These devices are anywhere from single mini-implants to titanium plates which can be placed at the time of surgery.

Nagasaka et al[21] used surgery first orthognathic approach combined with skeletal anchorage system mechanics provides significant benefits to skeletal class III patients compared with traditional surgical orthodontic treatment. They have advocated the use of zygomatic plates as temporary anchorage devices to aid in post-operative orthodontic movement. During orthognathic surgery, zygomatic plates were placed. The plates were then used to distalize the upper arch post-operatively to achieve Class I canines and ideal overjet. These temporary anchorage devices play a key role in anchoring orthodontic forces so that any required vector can be used. They also can help compensate for surgical error or skeletal relapse.

Aymach Z et al[14] combined bony rigid fixation for skeletal stability with the SAS and a splint to control and correct the postsurgical occlusion, thus expanding the range of "surgery first" candidates to include patients with jaw deformities and advanced malocclusions. The combination of "surgery first" treatment with the SAS has several advantages, including a notable reduction in treatment time.

Bone turnover after orthognathic surgery can significantly accelerate orthodontic tooth movement difficult movements such as intrusion and distalization can thus be efficiently achieved during this postsurgical phase. Another advantage lies in the normalized relationship between the jaws and orofacial muscles, which contributes to effective tooth movement and further expedites the postsurgical orthodontic phase. The SAS can be helpful in the postsurgical correction of any relapse tendencies or slight discrepancies between the planned and actual surgical outcomes. Finally, the percentage of non-extraction cases has increased significantly because the SAS permits distalization of the entire dentition, taking advantage of the spaces created by third-molar extractions during surgery, but the drawback is that the orthodontist must be skilled in the SAS technique, which is essential in achieving predictable three-dimensional molar movement.

Hence the use of temporary anchorage devices becomes more crucial in more complicated cases that are attempted with the surgery first approach. When extractions or segmented osteotomies are planned, prediction of the final occlusion is far more challenging and placement of mini-implants during the surgery allows for efficient mechanics post- surgically.

Regional Acceleratory Phenomenon (RAP):

The regional acceleratory phenomenon (RAP) was well described by Frost in 1989[30,31]. After an osteotomy, bone remodeling around the healing tissue facilitates the healing process. This regional acceleratory phenomenon can be utilized by the orthodontist following orthognathic surgery to accelerate tooth movement. By performing surgery first, this period of rapid metabolic activity within the tissues can be harvested for efficient orthodontic treatment. The extent and duration of this window of opportunity become an important issue in some cases.

To answer this question, the by-products of bone metabolism have been measured in patients' blood samples following orthognathic surgery. Serum alkaline phosphatase and C-terminal telopeptide of type I collagen are two bone markers that have been studied.

The former is associated with osteoblastic activity while the latter is a by-product of the osteoclastic breakdown of bone. The results of one such study show that orthognathic surgery triggers three to four months of higher osteoclastic activities and metabolic changes in the dentoalveolar.

This short period of the regional acceleratory phenomenon is a possible explanation for shortened treatment time in surgery first orthodontics. This effect can be seen up to 4 months post-surgically. The regional acceleratory phenomenon is not exclusive to the surgery first approach. In the conventional approach, this phenomenon is seen after decompensation has been accomplished and the patient has had the surgical procedure completed. The surgery first approach, however, utilizes this golden opportunity to speed up the decompensation process which occurs after the surgery, unlike the traditional approach.

Since the decompensation of the arches is the most time-consuming step of the way, the regional acceleratory phenomenon is used when it is needed the most. Despite the findings demonstrated as case reports on shortened treatment time, the actual duration of the window of time during which the regional acceleratory phenomenon can be utilized for orthodontic tooth movement is still unknown. Various studies have shown different lengths of accelerated tooth movement. Hence, more studies are required at the time being to give sufficient evidence on the actual molecular basis for the accelerated tooth movement as well as the duration of this phenomenon after surgical procedures. The fact according to Hernandez-Alfaro et al[25,26] that the orthodontic treatment is shortened to an average of 37.8 weeks implies that dental movements are significantly expedited. This improved efficiency of orthodontic forces is significantly related to the process of demineralization and remineralization consistent with the wound-healing pattern of the RAP.

Together with the orthognathic procedure, selective bone injury through the performance of buccal corticotomies enhances the activating stimulus for the RAP in the periodontium. As a result, orthodontic appointments must be scheduled more often than in a conventional treatment approach.

The phenomenon of postoperative accelerated orthodontic tooth movement could be caused by the improvement in dental and muscular function postoperatively or the changes in bone physiology and metabolism induced by orthognathic surgery. When the improvement in function is the cause, the phenomenon of postoperative accelerated orthodontic tooth movement should last throughout the entire treatment period because the dental and muscular functions are becoming better and better day by day.

RAP is a complex physiologic process with dominating features involving accelerated bone turnover and decreases in regional bone density[27]. RAP increases tissue reorganisation and healing by way of a transient burst of localized severe bone resorption and then the remodeling. Several mechanisms have been postulated and proposed for the osteopenic effect in RAP such as osteoclast and osteoblast cell population shift in number, neovascularisation and local and systemic mediators, and calcium depletion. RAP occurring in jaw bone could be induced by flap surgery, corticotomy, and even by a non-surgical procedure such as orthodontic tooth movement. In rats, evidence of RAP is first observed after 10 days of healing, and there is almost complete recovery after 120 days; it is suggested that RAP in humans begins within a few days of surgery, typically peaks in the first and second month and may take from 6 months to more than 24 months to subside. These authors characterized the initial phase of RAP as an increase in cortical bone porosity because of increased osteoclastic activity and speculated that bone dehiscence might occur after periodontal surgery in an area where the cortical bone is initially thin. They surmised that RAP might be a contributing factor to increased mobility of the teeth after periodontal surgery.

Frost in 1989[31] found that reorganizing activity of osseous hard tissue adjacent to injured surgical wounds is greatly accelerated. This phenomenon begins a few days after insult and reaches its peak in 1 to 2 months. it was also found that orthodontic tooth movement could be accelerated following selective labial and lingual decortication of alveolar bone. This new technique was called “accelerated osteogenic orthodontics” (AOO). Significant shortening of the treatment time for mandibular crowding was seen with AOO[32].

In 2001, Wilcko et al[33] suggested that rapid tooth movement in the context of corticotomy-facilitated orthodontics was the result of a demineralization–remineralization process consistent with the wound healing pattern of the regional acceleratory phenomenon. It seems that selective bone injury results in an overwhelming activating stimulus for both catabolic and anabolic responses in the periodontium. It is possible that the alveolar bone adjacent to the osteotomies performed during orthognathic surgery also undergoes increased bone turnover. This could account for the more efficient postoperative orthodontic movements and hence contribute to the total treatment time reduction in a “surgery first” sequence.

INDICATIONS

The surgery first approach can be used to treat a variety of cases depending on the specific characteristics of the malocclusion and the dentofacial deformity[4]. The SFOA is indicated in cases that do not need too much presurgical orthodontic treatment. Nonetheless, certain criteria can make a case the ideal surgery first case.

- Well-aligned to mildly crowded anterior teeth,
- Normal to mild proclined/retroclined incisor inclination,
- Flat to the mild curve of spee,
- Minimal transverse discrepancies.
- Pronounced soft tissue imbalance in skeletal class III patients.
- Severe skeletal Class II deformities.
- Cases in which decompensation is not required.
- Patients who want the immediate esthetic result or who want to improve both function and esthetic.
- At least three stable occlusal stops with a positive overbite of six anterior teeth and existing arch coordination.
- The patients should be of appropriate age to proceed with surgery.
- Patients with facial asymmetries
- Cleft lip and palate patients.

CONTRAINDICATIONS

The SFOA procedure has the following disadvantages. Which includes:

1. Patient who require definite decompensation
2. Severe crowding
3. Arch-incoordination
4. Severe vertical or transverse discrepancy
5. Patients with high expectations of treatment outcomes in terms of dental esthetics and stable occlusions.
6. Severe proclination of upper and lower anterior.

ADVANTAGES

- Immediate change in the facial profile, having surgery first eliminates the unsightly pre-surgical profile and allows the chief complaint of the patient to be addressed at the beginning of treatment, this leads to improved cooperation of the patient during orthodontic treatment. The resolution of skeletal and soft tissue imbalance through surgery allows the orthodontist to move the teeth in a normal skeletal and soft tissue envelope which facilitates the orthodontic movement.

- Overall treatment period is reduced. Post-op orthodontic treatment can be progressed rapidly. Treatment times as short as seven months have been reported[16]. The pre-surgical orthodontic phase in conventional three-step orthognathic surgery cases is the most time-consuming step. Bypassing this step

- results in an overall shortened treatment time to 1 to 1.5 years or less. The main factor which is responsible for rapid tooth movement is the regional acceleratory phenomenon (RAP)[4].

- Decompensation can be performed effectively and efficiently. Because a class III malocclusion becomes a class II malocclusion after mandibular setback[21], the resulting improvement in the tone of the upper lip and tongue increases the force on the incisors of both arches, improving the efficiency of incisor decompensation. This phenomenon may be a factor in reducing the duration of orthodontic treatment time.

- Counter compensation of dentition is possible with the shortest period.

- In maxillary operation, the orthognathic surgery improves the counter compensation of upper anterior teeth and this makes the post-op orthodontic period be shortened.
- In maxillary operation, surgeons can set the midline of upper anterior teeth to the facial midline and shorten the post-op orthodontic treatment period.
- Treatment steps are simple: The surgery's first approach uses osteotomy to solve both skeletal problems and dental compensation so that the orthodontic treatment becomes less complex. As this treatment prefers non-extraction, orthodontists can set up a treatment plan strategically.
- The procedure can be instantly performed when the patient desires.
- Orthodontists can set up a treatment plan which fits to the soft tissue-centered concept.
- The result of treatment is stabilized. This treatment method can be aided by oropharyngeal function and post-op treatment result seems natural.
- If a surgical error or skeletal relapse occurs, compensation can be made with SAS mechanics[20,21]. In conventional treatment, because the decompensation is completed before surgery, it is difficult or impossible to recover from a surgical error during post-surgical orthodontic treatment.

DISADVANTAGES

Performing the surgical procedure prior to orthodontic treatment has multiple advantages, particularly the shortened treatment time. However, there are many drawbacks to this approach that should be taken into consideration[29].

1. Predicting the final occlusion is the hardest challenge with surgery first approach. In many cases, the upper and lower models cannot be placed in an ideal occlusion due to multiple dental interferences. If this occlusion is not achievable or is not planned accurately, the result will be far from ideal. The occlusion cannot be used as a guide for establishing treatment goals, unlike traditional surgical-orthodontic treatment in which decompensation of the incisors and coordination of the dental arches are performed before surgery. The skeletal disharmony must be accurately assessed to establish an effective treatment plan[4].

2. The requirement for more surgical movement to compensate for postoperative orthodontic movement, impacted lower third molars.

3. Without presurgical orthodontics, it is difficult to obtain a stable occlusion immediately after surgery. Therefore, the patient must wear an occlusal splint while eating. To overcome potentially unstable occlusion from SFA, precise and meticulous preoperative planning must be done through model surgeries, surgical simulation, interdisciplinary consultation between an experienced surgeon and orthodontist, and close follow-up visits.

4. Cases requiring extractions are especially very difficult to plan when performing surgery first. Thus, case selection is of utmost importance.

5. The planning process is very time-consuming in contrast to the total treatment time which is usually shortened. This becomes a financial issue for the treating orthodontist in many cases.

6. Increasing the treatment fee is one solution but it should be reasonable to the patient. When passive stainless-steel wires are placed prior to surgery each wire must be bent to rest passively on the surface of each tooth. This is also another challenging and time-consuming procedure for the orthodontist especially when teeth are severely rotated and misaligned in the SFOA procedure.

7. To simplify the pre-surgical bonding procedure, some orthodontists bond the wires directly to the surface of teeth without using any brackets. But the authors noted that there is a higher failure rate during surgery and the need for another bonding appointment at the initiation of orthodontic treatment.

8. To utilize the maximum potential of the regional acceleratory phenomenon, two jaw surgeries are preferred. Also, severe transverse discrepancies sometimes lead to a two-piece or three-piece Le Fort I osteotomies. But this increase in the number and complexity of osteotomy procedures poses a greater risk to the patient.

9. Complex treatment plan, because the dental compensation is achieved only with the changes of location or position of the skeleton and the goal of the treatment is to improve the facial esthetics, the treatment plan is complex.

10. In some cases, it is difficult to predict the result because the amount and direction measured on a setup model might be different from actual amounts and directions during surgery.

11. Bone healing process is progressed under an unstable occlusal state.

12. Because of premature occlusion between upper and lower teeth, the possibility of relapse is increased and it might be difficult to position the mandible as planned.

13. The treating orthodontist and orthognathic surgeon must be experienced enough to be able to know the limitations and possibilities.

TREATMENT PLANNING CONSIDERATIONS

Careful planning is the key to the success of any orthognathic surgery case especially when the surgical procedure is to be performed before orthodontic treatment [4]. As with any orthodontic treatment, obtaining high-quality records including intraoral and extra-oral pictures, models, and radiographs is the first step. Multiple treatment planning considerations must be taken into account when orthognathic surgery is being performed without prior orthodontic treatment. The orthodontist plans the surgery on the pre-operative models in such a way that a relatively stable occlusion can be achieved during surgery. The teeth will be decompensated to normal positions and angulations following surgery; therefore, the transitional occlusion must allow for post-surgical movement of teeth. Since the incisors cannot be used as a guide to predict the final occlusion in surgery first cases, the molar relationship can be utilized as a starting point to come up with a temporary occlusion.

The inclination of upper incisors is important in determining the need for possible extractions. If the upper incisor is excessively proclined, extractions may be considered to allow retraction of upper incisors post-operatively[49]. As a rule of thumb, if the upper incisor to occlusal plane angulation is less than 53 to 55 degrees, extraction must be considered. Another possibility involves changing the position of the whole maxilla so that the occlusal plane is steeper and producing more upright maxillary incisors. Also, one might distalize the maxillary posterior segments using zygomatic plates as shown by Nagasaka et al[21] and Villegas et al[20] thus opening space to retrocline the maxillary incisors.

When placing upper and lower models into occlusion, the transverse dimension of the arches in many cases does not allow perfect interdigitation.

Hence, the transverse dimension often poses a special challenge when performing model surgery in surgery first cases. The midlines must be coincident or close to it after surgery and proper buccal overjet must be established bilaterally. Depending on the degree of discrepancy between the two arches, the orthodontist can resolve this issue by planning for segmental osteotomies in more severe cases or possibly plan on resolving the issue post-surgically by arch coordination and elastics.

The most challenging and time-consuming step in preparing for surgery first orthodontics is the prediction of the final occlusion based on the current position of teeth. The experience of the orthodontist plays a very important role in the process. The term intended transitional malocclusion (ITM) is used to describe the occlusion which will be used to fabricate the surgical splint and is the surgeon's guide during surgery, Park et al[50]. The ITM must be stable enough to allow predictable splint fabrication and skeletal movement. Therefore, at least a three-point contact must be established between the upper and lower models when deciding on the ITM. In cases where such temporary occlusion cannot be established, it is advisable to initiate some orthodontic movement to relieve some of the interferences and allow for a more stable transitional malocclusion to be established.

The vertical problems[4] are usually related to anteroposterior problems and should be corrected with posterior maxilla impaction or postoperative orthodontic treatment depending on whether the problems are associated with dental interferences not corrected before surgery. However, the occlusal interferences derived from a non-level occlusal plan, supra-erupted teeth and improper buccopalatal inclination of posterior teeth will not be corrected simply by surgery.

Treatment considerations in skeletal class II in SFOA:

In class II division 1 malocclusions:

In conventional surgical orthodontics, presurgical orthodontics includes levelling, alignment, relief of crowding, decompensation which results in worsening of the facial profile. This presurgical orthodontics takes approximately one to one and half years depending on the severity of malocclusions. Skeletal class II malocclusion typically involves proclination of mandibular incisors and upright/mild proclination of maxillary incisors. SFOA may be particularly beneficial for a class II patient with a retrusive mandible. Immediately after surgery, the Class II malocclusion becomes a superclass I or Class III relationship following mandibular advancement[8], with an edge-to-edge incisor relationship or bimaxillary dentoalveolar protrusion. This situation, therefore, requires the use of class III orthodontic mechanics or it can also be corrected by extracting all first premolars followed by retraction as in class I bimaxillary protrusion cases. Thus, the resulting improvement in the tone of the lower lip and tongue increases the forces acting on the incisors in both arches.

In class II division 2 malocclusions:

In this type of case, it is difficult to perform SFOA as there is less overjet. In such cases, surgery can be performed after proclination and aligning the upper anterior and after getting the sufficient overjet for the advancement of the mandible for the correction of skeletal deformity or SFOA procedure can also perform directly without presurgical orthodontics in these cases by getting reverse overjet, and levelling and alignment can be done after surgery.

Anteroposterior and vertical decompensation in class II cases:

10. For a moderate to the deep curve of spee and proclined lower incisors in class II mandibular retrognathism, the anterior segment of the mandible could be levelled and intruded surgically through anterior segmental osteotomy so that the mandible could be advanced properly[8].
11. Alternatively, the mandible could be surgically advanced to an edge-to-edge incisor relationship and without occlusal contact in the posterior teeth and then postoperatively, the mandibular anterior teeth could be orthodontically intruded so that the mandible rotates upward and forward for posterior occlusal contact and a better chin projection.

In class III malocclusions:

In the traditional combined orthodontic and surgical treatment of dentofacial anomalies, pre-surgical orthodontics is aimed at relief of dental crowding and decompensation[23]. Its purpose is to provide stable occlusion, a proper position for the teeth and arch coordination after the operation. Pre-surgical decompensation takes the most time in the total treatment course, roughly around 6 months to 2 years, and varies among patients and orthodontists. During this period, patients may experience deterioration of both the facial profile and function. In skeletal class III cases, the lower incisors are usually crowded and retroclined while the maxillary incisors are commonly flared out. One of the goals of presurgical orthodontics is to position incisors in a proper angulation to the jaw bone, so the surgeon can set back the jawbones to their maximum.

Sometimes extraction is required for retraction of the upper anterior teeth and relief of lower crowding. This also increases the time needed for pre-surgical preparation.

Therefore, when surgery is performed first, a class III malocclusion always become a class II relationship immediately after mandibular setback which should be maintained with a surgical splint and requires class II orthodontic mechanics after surgery and adjustment of the anterior teeth can be managed postoperatively. In these malocclusions, occlusion cannot be used as a guide for establishing treatment goals, unlike traditional surgical orthodontic treatment, in which decompensation of the incisors and coordination of the dental arches are performed before surgery.

Anteroposterior and vertical decompensation in class III cases:

1. The anteroposterior decompensation[10] for proclined maxillary incisors in a class III case could be achieved by extraction of the maxillary first premolars and anterior segmental osteotomy or by clockwise rotation of the maxilla by Lefort 1 osteotomy to upright the upper incisor inclination[8]. The second approach is recommended because the first approach might have the disadvantage of the lack of an occlusal antagonist in the mandibular second molars.

2. The anteroposterior decompensation for moderately retroclined and crowded lower incisors in a class III case could be achieved by setting up the molars in a class I relationship with an excessive incisor overjet, and then the lower incisors could be aligned postoperatively to obtain a normal overjet.

3. The anteroposterior decompensation for severely retroclined and crowded lower incisors in a class III case could be achieved by extractions of the lower first premolars and anterior segmental osteotomy, setting up the molars in a Class III molar relationship with an excessive incisor overjet, and then the lower incisors could be aligned postoperatively to obtain a normal overjet.

4. A moderate to the deep mandibular curve of spee in a class III case is better levelled preoperatively or surgically by anterior segmental osteotomy to avoid the upward and forward rotation of the mandible postoperatively.

A forward and upward rotation of the mandible improves the chin projection in the case of class II mandibular retrognathism, however, it worsens the chin projection in the case of class III mandibular prognathism. To avoid the upward and forward rotation of the mandible postoperatively, alternatively, the lower incisors could be intruded and the upper incisors at the same time could be extruded postoperatively.

5. A chin cap could be applied to prevent mandibular skeletal relapse in the first 3 months postoperatively.

The MEMO strategy (Jin Young Choi)[29] consisted of minimum preoperative orthodontic treatment, preparation for surgery and postoperative orthodontic treatment. Cases with premolar extraction and severe vertical and transverse discrepancy should be treated with caution. In most cases, for treatment efficiency, the orthodontist suggests a minimum pre-operative orthodontics treatment approach for a couple of months before surgery for levelling and alignment, decompensation and arch coordination can be achieved. In addition, occlusal prematurity can also be removed by this procedure. The rest of the procedure after minimum preoperative orthodontic treatment is almost the same as the SFOA procedure.

With the MEMO strategy, rough correction of the anterior crowding (especially in the upper arch), coordination of the intercanine and intermolar widths, elimination of premature contact in the posterior teeth, slight incisor decompensation and resolution of occlusal plane discrepancy can be performed. In addition, troublesome bonding and removal of the surgical wire process can be avoided. Therefore, the MEMO strategy is a time-saving procedure because it can avoid complex surgery and reduce surgical morbidity and unpredictability. SFA or MEMO strategy can be a more accurate and predictable procedure than the current state.

Transverse arch coordination:

In the conventional approach[8], the intercanine and intermolar widths of the upper and lower dentitions are coordinated preoperatively or surgically, whereas, in the surgery first approach, they are coordinated by either surgery or postoperative orthodontic tooth movement.

1. For a wide maxilla with a transverse discrepancy of more than a molar width on each side, they could be coordinated surgically by a 3-piece Lefort 1 osteotomy of the maxilla.

2. For a wide maxilla with a transverse discrepancy less than a molar width on each side, they could be coordinated by postoperative orthodontic tooth movement. This can be done by setting up the buccal slope of the palatal cusps of the maxillary molars occluding on the lingual slope of the buccal cusps of the mandibular molars on both sides.

The excessive buccal overjet would be solved postoperatively by the occlusal force or vertical chin cap or orthodontically by an O. O32 inch beta-titanium constricting trans palatal arch in a short period because of the phenomenon of postoperatively accelerated orthodontic tooth movement. For a narrow maxilla, surgically assisted rapid palatal expansion could be the treatment of choice.

In most situations, the transverse discrepancies between the maxilla and the mandible result from dental, but not from skeletal, origins and reveal extreme buccolingual tilt of posterior teeth in patients with skeletal Class III malocclusion[51]. To prevent occlusal interferences after placing the basal jawbones to a new position after surgery, some proponents have emphasized[25] the importance of presurgical orthodontics to decompensate tooth alignment, inclination and especially to achieve a compatible arch width between the jaws. They also have advocated that maximum intercuspation after surgery enhances postsurgical stability. Thus, orthodontic appliances such as transpalatal arches, various palatal expanders, lingual arches, and heavy rectangular wires have been used to adjust the arch width and form before surgery. The adjustment of arch width and tooth movement could be accomplished more easily and quickly during or after orthognathic surgery. However, after surgery, the maxillary canines were lingually tilted to be compatible with the mandibular canines. Results interpreting overexpansion of maxillary intercanine width before surgery may be unnecessary because the over expanded maxillary canines still needed to be narrowed again after surgery owing to the concomitant lingual tilt of mandibular canines.

In cases without presurgical expansion of maxillary intercanine width, regular orthodontic treatment after surgery still could attain a compatible arch width between the jaws by expanding the maxillary canines and constricting the mandibular canines after application of orthodontic forces.

Wang et al[51] investigated the differences of transverse dimensional change of dental arches in patients with surgical skeletal Class III with and without presurgical orthodontics. In the OF group, the maxillary molars (1.3°), maxillary canines (3.4°), mandibular molars (1.5°), and mandibular canines (0.8°) showed buccal tilt during the period of the presurgical orthodontic treatment. After surgery in the SF group, the maxillary canines (0.8°) and mandibular molars (3.7°) were buccally tilted.

The maxillary molars (2.4°) and mandibular canines (2.5°) were lingually tilted. The results also agreed with the statement of the inefficiency of presurgical orthodontics before surgery. Although there is no exhaustive explanation of the inefficient tooth movement before surgery, it is generally considered that the occlusal interference acting as the "locking force" might be one of the factors interfering with presurgical tooth movement. One reason for a surgery-first sequence is based on possibly improving the patients' facial profile earlier in the treatment, thus improving self-image and cooperation. One other claimed reason is that the orthodontic tooth movement is more rapid for about months after surgery. From the viewpoint of achieving the compatible transverse dimension at the end of treatment, the present results indicated it was unnecessary to precisely coordinate the arch width between the jaws before surgery. Alternatively, postsurgical application of coordinated archwires (progression toward full-dimension rectangular wires) and inter-/intra-arch elastics could provide a more efficient way.

Treatment considerations in asymmetric malocclusions using SFOA

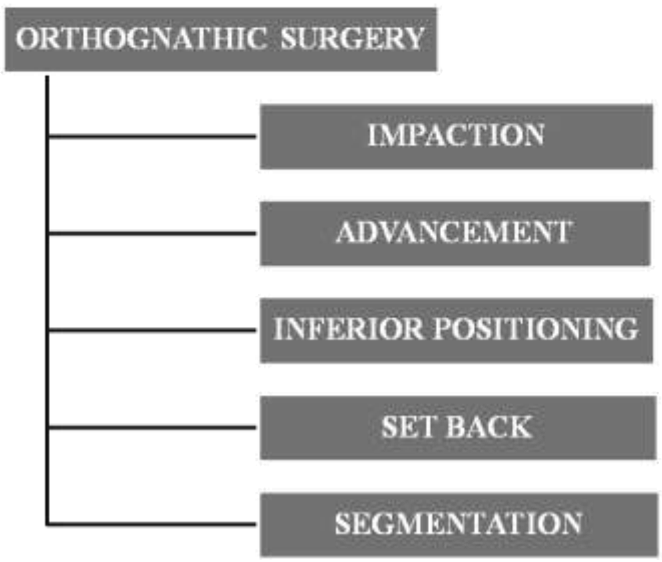
Symmetry is considered a hallmark of facial attractiveness. Skeletal asymmetries generally require surgical intervention to improve facial esthetics and correct any associated malocclusions[24]. The classic approach involves a presurgical phase of orthodontics, during which dental compensations are eliminated, and a postsurgical phase to refine the occlusion. The presurgical phase can be lengthy, involving tooth decompensations that often exaggerate the existing dentofacial deformities. SFOA now makes it possible to eliminate the presurgical orthodontic phase to correct minor surgical inaccuracies and esthetically benefit the patient. In these cases, SFOA includes bilateral sagittal split osteotomy with asymmetrical single-jaw surgery, with the mandible set back 7mm on the left and 3mm on the right, to address both the prognathism and the asymmetry.

SURGICAL PROCEDURES

Successful surgical procedures depend on strict adherence to surgical principles. In orthognathic surgery management of patients before, during, and after a surgical procedure is as critical to a satisfactory outcome as are the details of surgical technique. Important aspects of patients' management include psychological preparation of the patient; preservation of blood supply to the mobilized teeth and jaw segments; proper wound management; protection of teeth, bone, and neurovascular tissues; fixation methods for bony segments, proper occlusal control, and rehabilitation to full jaw control. The use of appropriate anesthesia, blood products, and bone grafts also is important to surgery.[47]

It consists of surgeries involving

- Maxilla alone
- Mandible alone
- Combination of maxilla and mandible



The spectrum of surgeries can be broadly summarized as:

a. Osteotomies (some procedures are Ostectomies involving removal of part of the bone) of the entire jaws - with or without bone grafts. The commonly practiced surgeries are Le fort I, (Le fort II, or III in some cases) Osteotomies and anterior segmented osteotomy in the maxilla; and sagittal split osteotomy and osteotomy of the ramus (trans-oral or extraoral, vertical or inverted L) in the mandible. Body ostectomy in the mandible is not as popular as it used to be some years ago. These procedures are useful in attending to the sagittal problems and some of them can also address the vertical problems.

b. Surgically assisted expansion or contraction of the maxilla (and to a lesser extent the mandible).

c. Subapical surgeries in both the jaws including the Segmental surgeries involving Dento-alveolar segments.

d. Chin Surgeries

e. Cosmetic surgeries involving the nose, ears, cheekbones, etc., and soft tissue surgeries of the lips, cheeks, and gingivae are often carried out as an adjunct to the above surgeries simultaneously or as secondary procedures.

f. Distraction osteogenesis. This is a major development in recent times.

Anterior maxillary subapical osteotomy

Anterior subapical osteotomy is a reliable surgical technique especially for maxillary protrusion if the vertical excess of the maxilla is minimal. This procedure is used in conjunction with anterior subapical osteotomy of the mandible in cases of bimaxillary protrusion.

It is not possible to advance the anterior segment due to the lack of soft tissue coverage but, the posterior and superior repositioning of the anterior maxilla is possible by these techniques. In the Wassmund technique more soft tissue pedicle is maintained thereby ensuring blood supply. In the Wunderer technique, the palatal flap is reflected making it is easier to perform surgery.[64]

Wassmund Technique:

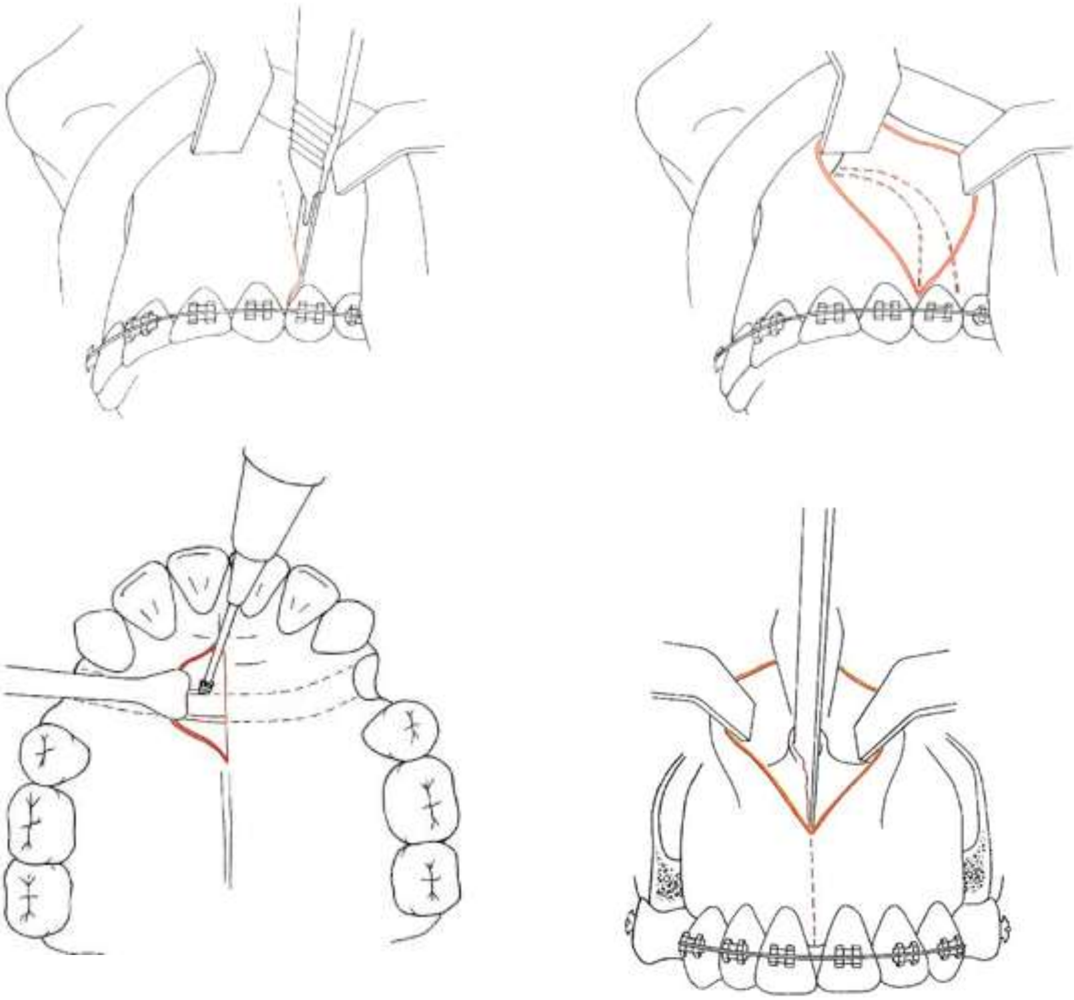
The buccal sulcus is infiltrated with lignocaine with 1:100,000 epinephrine. The palatal side is not infiltrated. A vertical incision is made between the canine and premolar extending to the nasal floor and the mucoperiosteum is reflected posteriorly and superiorly while reaching the apical region of the canine, the reflection is carried out to the inferolateral border of the nasal pyriform aperture. The mucoperiosteum of the pyridine aperture is reflected using a freer elevator.

If planned, the first premolar is extracted at this stage. The palatal mucosa is reflected by tunneling past midline and care is taken not to injure the anterior palatine vessels.

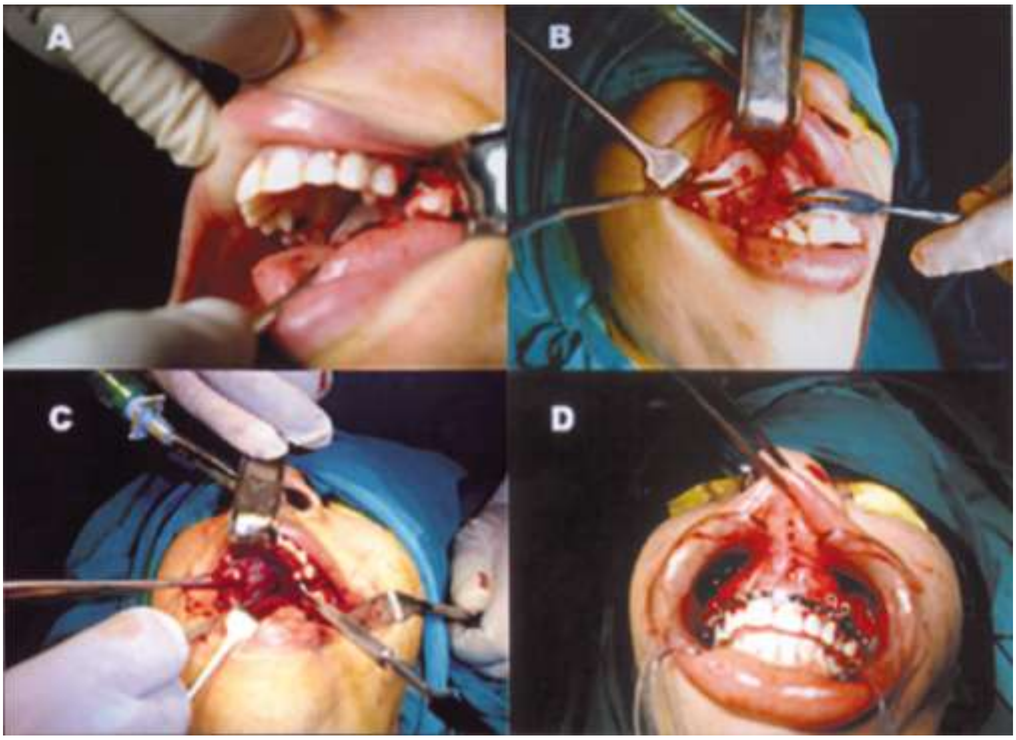
The bony cut is made on the buccal aspect of the alveolus using the bur or reciprocating saw. The cut is taken vertically upwards and turned medially to the piriform aperture so that 3 to 5mm of intact bone remains above the apex of the canine tooth.

Another important factor is leaving 1 to 2 mm of bone around the adjacent teeth. Throughout bony cut-ting, saline irrigation is provided to prevent thermal injury. No more than the required amount of bone should be removed.

The next step is the removal of the palatal bone from the alveolus to the midline. This is using the bur or saw. Care should be taken not to injure the palatal soft tissues. Towards the midline, the palatal bone is hard to cut due to difficult access and increased thickness of the bone. This region can be cut through a mid palatine incision in the anteroposterior direction (blood supply is not compromised by these incisions)[65]



A similar osteotomy/ osteotomy is performed on the opposite side. The attention is now directed to the separation of the nasal septum from the segment occasionally this can be disarticulated by finger pressure. A vertical incision is placed over the anterior nasal spine. The mucoperiosteum is reflected from the septum is separated from the anterior maxillary segment.



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A similar osteotomy/ osteotomy is performed on the opposite side. The attention is now directed to the separation of the nasal septum from the segment. Occasionally those can be disarticulated by finger pressure. A vertical incision is placed over the anterior nasal spine and the inferior aspect of the cartilaginous nasal septum. Using a nasal osteotome the septum is separated from the anterior maxillary segment. The dentoalveolar segment can be split in the midline, if required, at this stage. This is done by tunneling and using a straight fissure bur and an osteotome and is useful in case of closure of diastema and minor adjustment in the apposition for the canine and the premolar.

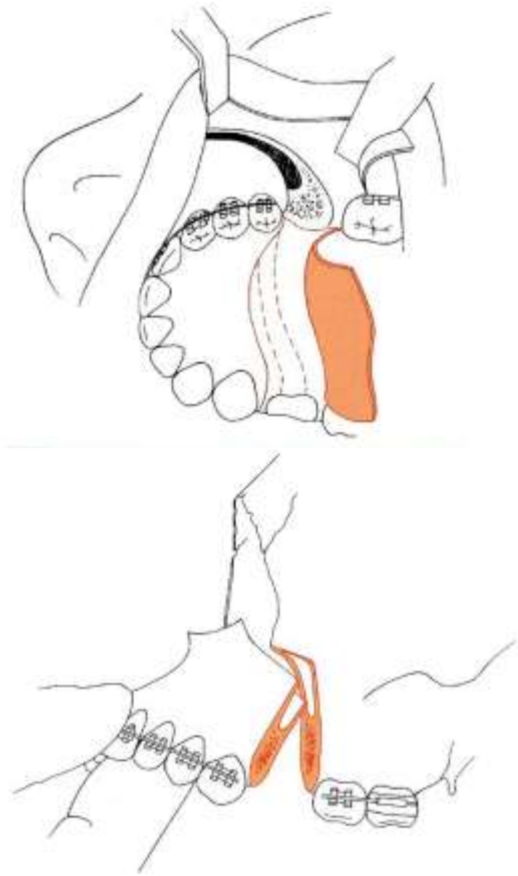
Now, the dental component has to be fitted into the occlusal splint. Any bony hindrances should be removed. The teeth are fixed to the splint. The folds on the soft tissue are checked to ascertain that there is no hindrance to proper blood flow. The soft tissue is closed using 3-0 catgut or vicryl.[66]

Wunderer Technique

Wunderer technique is suitable especially when the second premolar tooth is the one to be extracted. The labial approach for the surgery is the same as that of the surgery done in the Wassermond approach, the palatal surgery is started. Instead of tunneling the palatal soft tissue, in the Wunderer technique, a transverse cut anterior to the planned osteotomy site is made. Before this procedure is started the surgeon should make sure that the labial pedicles are intact and sufficient to impart a proper blood supply to the osteotomized segment. The soft tissue is raised posteriorly, a little behind the planned osteotomy site.

The osteotomy/ ostectomy is now performed. In the midline, the bone is a little harder. In this technique access to the palate is very good and the cut can be done as far posteriorly as the second molar.

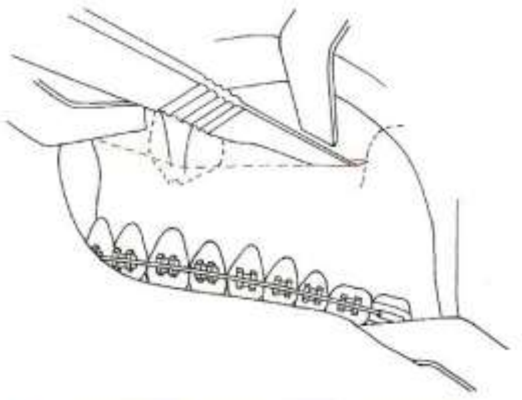
Once the bony cuts are completed, the anterior segment can be mobilized and separated from the nasal septum. It is positioned and fixed using a prefabricated occlusal splint, and soft tissue closure is done.[67]

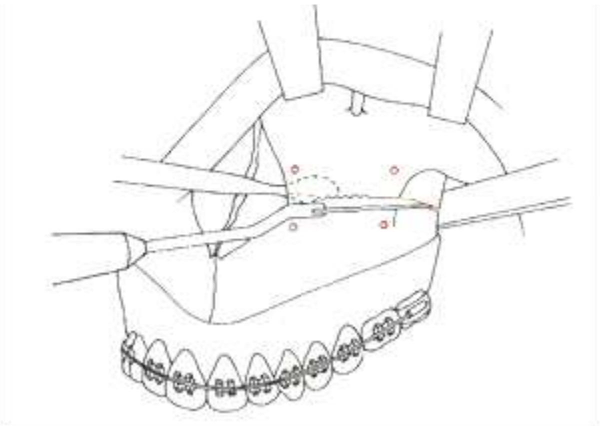


THE LEFORT I OSTEOTOMY

The Lefort I osteotomy is another versatile procedure, used frequently to resolve many functional problems. This is a very dependable, predictable procedure with a low complication rate. Understanding the biological basis of bony osteotomies is very critical. The revascularization studies of bell indicated that the maxilla can be mobilized and repositioned and the healing continues as long as the mobilized maxilla is pedicled on a broad soft tissue base. Excellent healing is observed even if the maxilla is segmented into multiple pieces. The soft tissues of the palate, lateral pharyngeal walls, buccal mucosa provide the vascular channels for healing. There is a rich, anastomosing collateral vasculature present in the facial area which results in excellent repair and healing.[70]

Indications: The deformities of the maxilla co-exist in multiple planes. Therefore, Lefort I osteotomy can be used to tackle the multifold problems either as a single procedure or in conjunction with mandibular osteotomy procedures. Whenever required multiple segmentalizations of the maxilla, also can be done. This procedure is used for surgical repositioning of the entire dentoalveolar segment of the maxilla superiorly, inferiorly anteriorly and posteriorly while simultaneously segmentalizing it to widen narrow, level, or improve arch symmetry. Essentially the operation involves the dentoalveolar complex and sometimes nasolabial areas and is used for low midface hypoplasia and some maxillary hyperplasia. The Le Fort I osteotomy has applications notably for patients with long and short face syndromes where either superior repositioning or inferior repositioning is appropriate, but also for altering the cant of occlusion. The Le Fort I osteotomy is commonly used for cleft patients and it is modified to correct the various aspects of the deformity present. [71]





DIFFERENT SURGICAL PROCEDURE

Maxillary Advancement

Indications: Post-trauma patients' cleft lip and palate patients nasomaxillary hypoplasia, in severe mandibular prognathism to reduce the amount of severe mandibular setback. This can be done along with the simultaneous expansion of the maxilla or narrowing of the maxilla by doing an additional midpalatal split of the maxilla.

Inferior positioning of Maxilla

Indications: In cases of the vertically deficient maxilla (VMD) cases cleft palate cases bone grafting is necessary after down fracturing of the maxilla. Bone grafts are secured with circumferential wiring or bone plates.

Leveling of Maxilla

Vertical maxillary asymmetry may be idiopathic but can be also seen associated with hemifacial microsomia, Romberg's disease, unilateral condylar hyperplasia, TMJ ankylosis, etc. The occlusal plane in these conditions is canted transversely, because of either a lack of vertical growth on one side or excessive vertical growth on the opposite side.

The leveling of the maxilla can be done by:

- Raising of one side of the maxilla.
- Lowering one side of the maxilla.

Simultaneously lowering one side and raising the other side of the maxilla. The degree of leveling necessary is determined by the clinical evaluation and the posterior, anterior and lateral cephalometric analysis. In adults, it is always necessary to simultaneously reposition the mandible, when the maxilla is being leveled.

Superior Repositioning of the Maxilla

Vertical maxillary excess or VME cases with typical gummy smiles' and over-exposure of anterior teeth will require superior repositioning of the maxillary dentoalveolar segment. VME cases are usually presented with coexisting other deformities of the maxilla or mandible or both, including AP (class II malocclusion), transverse (posterior crossbite), and a vertical (open bite) component. The unique features of total maxillary surgery or Le Fort I osteotomy is that it permits the simultaneous correction of the vertical, A-P and transverse deformities via appropriate repositioning and segmentalization of the maxilla.[72]

Superior positioning of the entire maxilla-LeFort I osteotomy

Indications:

- Superior movement less than 5 mm (minor movement)
- Existing functional nasal septal deviation or excessively large inferior turbinates.
- Movement of the maxilla as a single unit or minor movement of multiple segments.

Superior positioning of the maxilla leaving the nasal floor intact

Horseshoe-shaped osteotomy – Modification of LeFort I Osteotomy

Indications:

- Superior repositioning of 5-15 mm (major movement)
- Pre-existing decreased nasal airway function not related to nasal septum deviation
- Segmentalization of the maxilla into three to four pieces with the considerable movement of the individual segments.

Whenever more than 5-6 mm of superior positioning of the maxilla is required, the nasal cavity size will be this undesirable outcome, whenever a large amount of superior positioning is required, modified LeFort I osteotomy is carried out. [73]

Horseshoe-shaped osteotomy of the palatal vault, including the dentoalveolar segment and sparing the central palatal vault intact, will allow the maximum amount of superior positioning of the maxilla. Here telescoping of the posterior of the maxilla into the maxillary sinus can be done. The nasal floor is kept intact despite maximum superior positioning of the maxilla. Surgical planning for VME, cases Depending on the severity of the deformity, the surgical planning of VME cases needs different procedures to be carried out. They are as follows.

a. Superior positioning of the maxilla via total maxillary osteotomy.

b. Superior positioning of the maxilla via segmental maxillary osteotomy. Autorotation of the mandible brings the chin forward and upward (no need for mandibular surgery).[74]

Two-Piece Le Fort I Osteotomy

Following the regular procedure for a conventional Lefort I osteotomy wherein the maxilla Is stabilized in a down fractured state, the two-piece Lefort I osteotomy proceeds with the osteotomization of the midpalatal suture or the parasagittal plane. The osteotomy proceeds from the planned anterior interdental space posteriorly to and through the horizontal plate of the palatine bone. The line of planned osteotomy is angled laterally to an area midway between the mid palatal suture and the juncture between the horizontal and vertical parts of the maxilla.

The maxilla is divided into two segments by a sagittal osteotomy through the midpalatal suture by cutting through the relatively dense bone that is covered by thin mucosa. The margins of the incised palatal mucosa are carefully undermined to facilitate lateral maxillary movement without tearing the palatal soft-tissue pedicle.[83]

Three-pieces or four-pieces Le fort I osteotomy

Maxillary expansion is frequently achieved using a three-piece or four-piece Le fort osteotomy with or without extraction of premolar teeth. This versatile procedure allows simultaneous three-dimensional movement of the anterior or posterior segments into the desired occlusal relationship.[84]

LE-FORT II OSTEOTOMY

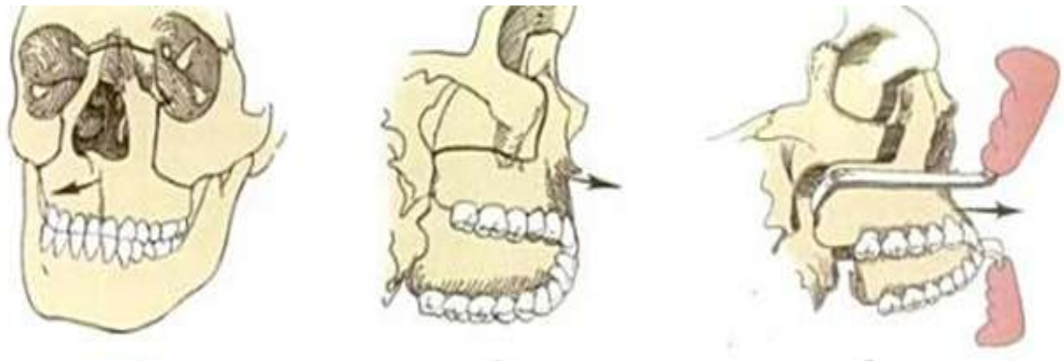
The most common indication is naso-maxillary dysplasia (e.g., binder's syndrome). Incisions can be bilateral paranasal incisions that can be connected through the natural skin creases of the glabella. However, a bicoronal flap is preferred since it avoids the facial incision. Width of 3 to 4 cm of hair is shaved off from the scalp, about 8 cm posterior to the natural hairline. The area is infiltrated with a local anesthetic containing epinephrine. The incision is extended from ear to ear, deep to the periosteum. Bleeding is controlled. Supraperiosteal dissection is carried out up to 3 to 4 mm of the supraorbital rim towards the scalp. (The dissection is above the temporal fascia). In this area, the periosteum is cut at the anterior region of the temporalis muscle and carried to the opposite side. subperiosteal dissection is done to expose the nasoethmoid and the orbital area. The medial canthal tendon is identified. The lacrimal sac is usually visible behind the tendon. The tendon is either left intact or separated and tagged.[90]

Osteotomy is started just below the frontonasal suture, extended posteriorly to the orbits, curved down to the superior aspect of the lacrimal fossa, turned inferoanteriorly anterior to the attachment of the tendon, and taken posteriorly downwards anterior to the anterior lacrimal crest and along the anterior aspect of the infraorbital rim. The procedure is repeated on the opposite side and the area is packed for hemostasis and the bicoronal flap is temporarily replaced.

Now a circumvestibular incision is made high in the vestibule. Subperiosteal dissection is made separately to expose the infraorbital nerve and the anterior and lateral walls of the maxilla.

The incision is taken to the inferior orbital rim to the previous osteotomy cut. This osteotomy is carried down through the lateral wall of the maxilla, below the zygomatic buttress (about 4 to 5mm of bone margin should be left above the root apices). The maxilla is separated from the pterygoid bone using a curved pterygoid chisel. The next step is to separate the midface from the cranial vault. An appropriately sized osteotome is malleted from the horizontal glabellar cut inferiorly and posteriorly.[91]

The cut is directed to the postnasal spine of the maxilla. It passes through the perpendicular plate of the ethmoid bone and the vomer. A Disimpaction forceps is used to down fracture the nasomaxillary complex. The force is applied first downwards and then anteriorly. The mobilization is continued until the complex can be placed anteriorly without tension. The occlusal splint is secured in position and intermaxillary fixation and infraorbital suspension wiring are done. Autogenous blocks of cortical cancellous bone grafts are placed over the lateral wall of the maxilla and the osteogenesis and rapid union. Closure of the wound is done according to basic surgical principles. Care should be taken to maintain the lip and nose harmony while closing the intraoral wounds.[92]



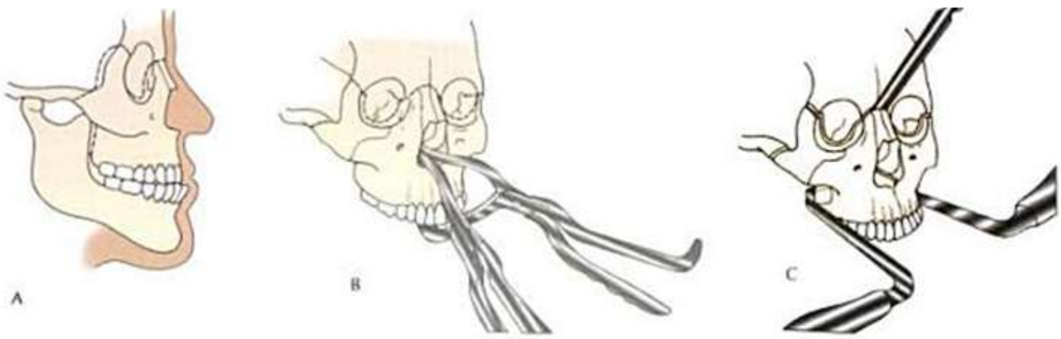
LE-FORT III OSTEOTOMY

Le Fort III osteotomy is indicated in patients with nasomaxillary and malar deficiency. In such cases, the nasal bones and infraorbital and lateral orbital rims are retruded into the eyeballs. The maxilla is retruded about the mandible. Pre-surgical orthodontic treatment, prediction tracing, model surgery, occlusal splint fabrication, etc. are completed as per the principles decried earlier.

Surgical technique

The bicoronal flap is reflected as described earlier in Le- fort II osteotomy. The areas to be exposed are the frontonasoethmoidal region infratemporal area, lateral orbital rims, infraorbital rims, and orbital floor. These are exposed sequentially.

The infratemporal space is exposed by reflecting the temporalis muscle inferiorly. The lateral orbital rim is also exposed subperiosteally and the dissection is taken down to the infraorbital area. The anterior aspect of the zygomatic arch is also exposed as the infraorbital rim and anterior orbital floor. The medical aspect of the orbital floor is tunneled by checking with a finger. The medial canthal tendons are detached and tagged with suture.[95]



Osteotomy starts a little below the frontonasal suture and is taken posteriorly to the orbit, distal to the lacrimal fossa superiorly. It is the extended inferiorly in the medial orbital wall passing through the lacrimal and ethmoid bones and carried to the orbital floor with the small curved osteotome.

Now the lateral orbital wall is approached. The site of the osteotomy is determined depending on the area of deficiency. The osteotomy is taken from the lateral orbital rim inferiorly just behind the zygomatic eminence. This passes to the inferior aspect of the malar bone. The osteotomy from the lateral orbital rim is taken to the lateral orbital wall and the inferior orbital fissure. From the anterior aspect of the inferior orbital fissure, the osteotomy is carried to the osteotomy at the medical aspect. This connection is made using a small osteotome rather than a bur.[96]

Now the pterygomaxillary junction is exposed through an intraoral incision. A pterygoid chisel is used to separate the maxilla from the pterygoids. This is extended superiorly to the orbital fissure. The nasal septum is separated. The osteotomy is from the horizontal cut in the nasal bone the osteotome is directed to the posterior nasal spine. The cut passes through the perpendicular plate of the ethmoid and the vomer. At this level, bleeding is less, and injury to the olfactory nerve is eliminated. Mobilization of the osteotomized part is done using Disimpaction forceps first, a downward force is applied followed by forwarding pressure. By this means, the orbital rim and nasal bones can be advanced to about 2 cms. Rocking movements should be minimized while applying the forward force. The mobilization is complete when the required position is achieved passively. As mentioned earlier, due to the chances of relapse and to accommodate the growth of mandible, the occlusal splint as to be constructed with the teeth in an over- corporate position.

Bone grafts are placed on the osteotomy gaps and wired to secure them into position. However, the orbital floor is not usually grafted. The medial canthal tendons are reattached by a 2-0 nonabsorbable suture in a figure of eight fashion. Only grafts are also used for augmenting the infraorbital rims, frontal area, etc. The bicoronal flap is repositioned and closed. Intermaxillary fixation is maintained for 6 to8 weeks.

Unplanned orthodontic treatment for severe skeletal problems results in unsuccessful functional or aesthetic results. Referral for surgery thereafter ends in compromised results. Only desired presurgical orthodontic preparation before surgery should be undertaken. Extensive pre-surgical conventional orthodontics is unnecessary and contraindicated.

Orthodontics should be planned to coordinate with specific surgical procedures. This practice (a) minimizes total treatment time (b) prevents relapse. Inadequate presurgical orthodontics jeopardizes the quality of post-surgical results. The mechanotherapy and treatment objectives are opposite of normal orthodontics treatment plan in presurgical orthodontics (Reverse orthodontics).[97]

POSTERIOR MAXILLARY SEGMENTAL OSTEOTOMY

Posterior maxillary segmental osteotomy (PMSO) was described in the year 1959 by Schuchardt as a two-stage procedure.

Indications

- Posterior maxillary hyperplasia
- Distal positioning of posterior maxillary alveolar fragments to provide proper eruption of impacted canine and bicuspid tooth.
- Total maxillary hyperplasia
- Transverse excess or deficiency
- Vertical excess or deficiency

A vestibular incision is placed in the upper left vestibule extending from the distal of the second molar region to the distal of the first premolar region. The mucoperiosteal flap was elevated to expose the supra erupted dentoalveolar segment. The necessary access was achieved.

The horizontal osteotomy cut was placed about 5 mm above the apices of the supra erupted teeth. This was done with the fine taper fissured bur. The cut was made deep enough to almost reach the palatal aspect of the maxilla. vertical cuts Lateral cuts were then placed again with the thin bur. The anterior cut was easily accessible and visible and was placed around 2 mm anterior to 2nd premolar. The distal cut was just posterior to the 2nd molar without separating the pterygoid plates. The fragment was then down fractured with the digital pressure and was separated from the maxilla.[99]

MANDIBULAR SURGERIES

SEGMENTAL SUBAPICAL MANDIBULAR SURGERIES

Segmental subapical mandibular surgeries can be used to reposition the anterior, posterior or entire mandibular dentoalveolar segment.

Anterior Subapical Mandibular Osteotomy

Anterior subapical mandibular osteotomy is a very popular technique. It can be used as a single procedure for:

- Correcting mandibular dentoalveolar proclination.
- Closing mild anterior open bite.
- Leveling an accentuated curve of Spee.
- Correcting mandibular dental arch asymmetry.

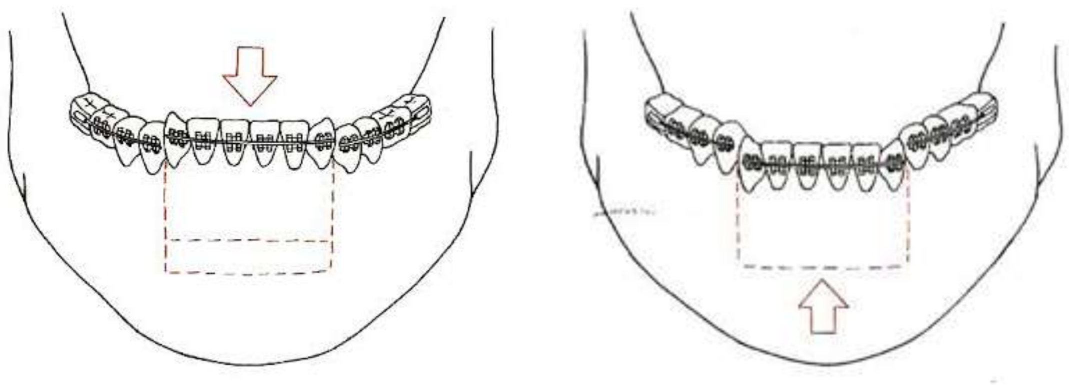
It can be used as an adjunctive procedure with other surgical procedures such as

- With anterior maxillary osteotomy to correct bimaxillary protrusion.
- With mandibular advancement to level the curve of speed.
- With genioplasty procedure.

Following extraction of premolars on either side, a circum-vestibular incision is taken from the canine-to-canine area. The incision is made into the lip and carried tangentially down to the bone. While making the incision the finger is placed on the cutaneous side of the lip to appreciate the depth of the incision, which should limit itself without cutting through the entire lip. Care is taken to locate the mental nerve and protect it. A subperiosteal dissection is carried to the inferior border and the symphysis region is degloved. [100]

A periosteal elevator is placed on the lingual side of the extraction socket and a vertical cut is made from the alveolar crest to the level of premolar root apex through both the cortices. The same procedure is repeated on the other side. Then both the vertical cuts are connected by the horizontal subapical osteotomy made about 5 mm below the anterior teeth apices.

The segments are mobilized by using an osteotome. An attempt is made to place the teeth into the prefabricated occlusal splint. Bony interferences are removed if necessary and the final fitting of the splint is checked and the osteotomized fragment can be stabilized by using miniplate fixation. The incision is closed in two layers, the muscular and the mucosal layer, and a pressure dressing is given externally. If anterior subapical mandibular surgery is to be used only for leveling the curve of Spee, then there is no need to extract the teeth. Vertical interdental osteotomies are done between canine and first premolars on either side, using a fine tissue bur and fine osteotome or a saw. A horizontal wedge of bone is removed to depress the anterior fragment.[101]

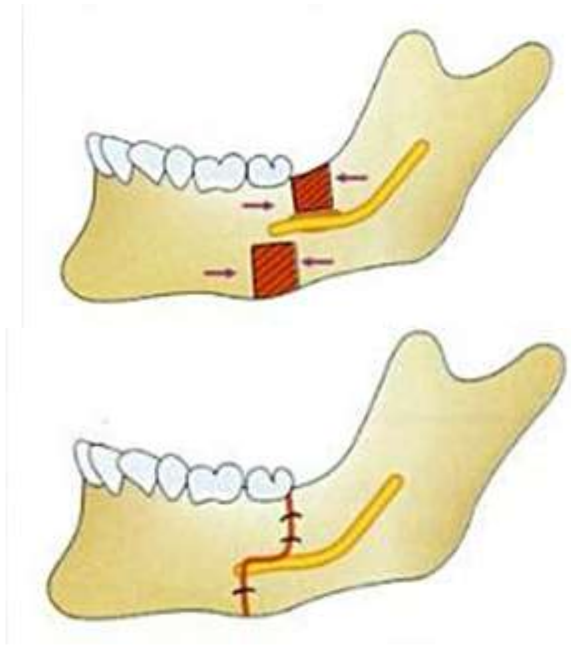


Subapical Mandibular Osteotomy Procedure

Used rarely, as it is technically difficult and there is a high risk of injury to the inferior alveolar neurovascular bundle.

But with the proper skill, it can be used successfully for:

- Uprighting the posterior segment which is in extreme lingo-version or Bucco – version.
- Closing a premolar or molar space.
- Leveling of supra erupted posterior teeth.[102]

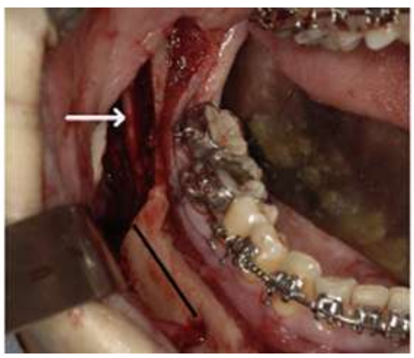


A horizontal vestibular incision is taken and the mucoperiosteal flap is reflected downwards till the inferior border of the mandible. Here the anterior vertical cut is taken in the area of missing first premolar or first molar and the second vertical cut is placed behind the last existing molar and the horizontal cut is taken below the apices of the teeth, protecting the neurovascular bundle. Both the vertical cuts are carried out from the alveolar crest up to the level of the neurovascular bundle. The portion of the buccal cortex that overlies the nerve bundle is removed. This window should extend several millimeters posteriorly to the distal vertical cut. The window is made in such a way that the cut extends only in the buccal cortex and the bone is removed with an osteotome and saved. After the identification and protection of the nerve bundle, the lingual cortex is osteotomized. Both vertical cuts are also completed till the horizontal cut level and the entire segment is mobilized with the osteotome in the desired position.

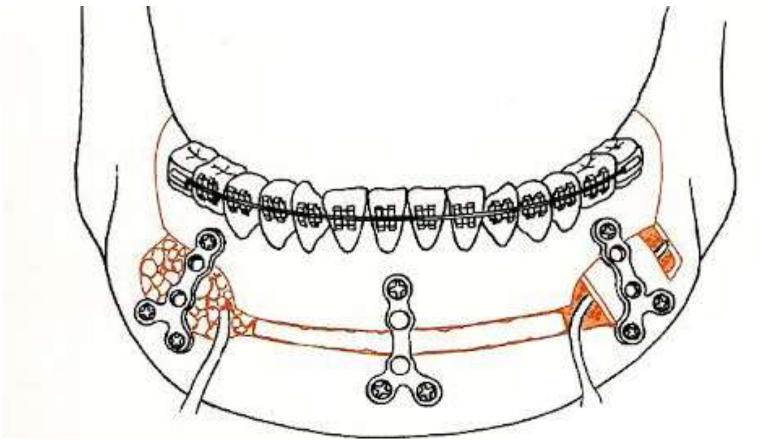
The segment can be stabilized by fixing the occlusal splint and by placing a circum mandibular wire over the splint. The outer cortical bony plate, which was saved should be fitted back before suturing.

Total Subapical Mandibular Osteotomy

Again, not performed routinely, as technically difficult and high-risk damage to the neurovascular bundle. It can be used to reposition the entire mandibular dentoalveolar segment anteriorly, posteriorly, or superiorly. For lengthening of the lower third of the face or for advancing the mandibular dentoalveolar segment, etc. Here the location of the horizontal subapical osteotomy is done below the level of the inferior alveolar neurovascular bundle. The level is determined by radiographs and the actual osteotomy location is marked by taking direct measurements from the occlusal plane.

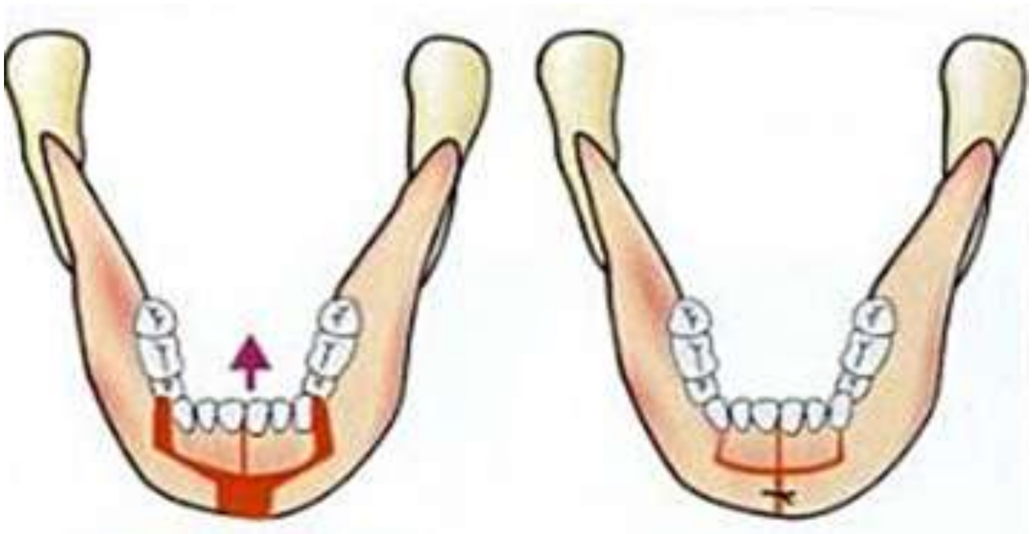


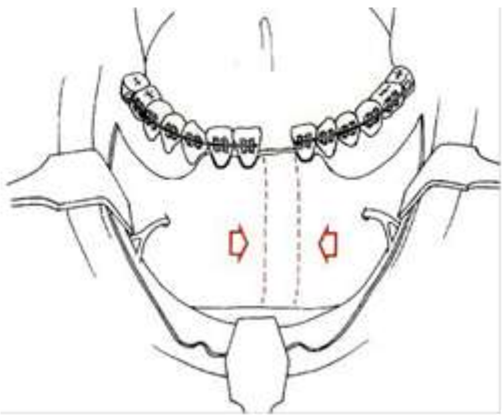
The horizontal osteotomy is started initially anteriorly in the symphysis region and proceeds posteriorly. The horizontal osteotomy cut is completed through the lingual cortex by placing the guiding finger on the lingual side and the bur is directed at the angle of 45^{o} from buccal to the lingual cortex. The entire horizontal cut is carried just posterior to the last molar. Then a vertical osteotomy is made approximately 5 mm posterior to the last tooth. This cut begins superiorly and is carried through and through to the level just above the nerve bundle. The buccal cut is then completed through only the outer cortex and the remainder of the lingual cortex adjacent to and below the bundle, which is fractured with the osteotome. In advanced cases, care should be taken not to overstretch the nerve. It can tolerate 3 to 6mm of stretching.[103]

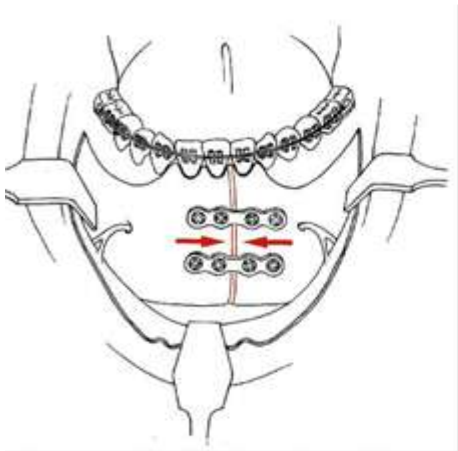


MID SYMPHYSIS OSTEOTOMY

If it is combined with posterior or anterior body osteotomy, then a complete vestibular incision can be planned. Thin tapering bur or saw can be used for cutting in between two mandibular incisors from the alveolar crest to the inferior border. Care is taken to place the osteotomy cuts, without damaging the roots of the teeth.







SAGITTAL SPLIT OSTEOTOMY

The most versatile mandibular osteotomy.

Historical review

Trauner and Obwegeser (1957). Horizontal cut just above mandibular foramen on the medial side of the ramus. A vertical cut took down the anterior border of the ramus. An oblique cut is made through the lateral cortex towards the angle of the jaw. A good technique for mandibular set-back but poor bone contact with mandibular advancement. Aseptic necrosis of angle due to extensive stripping of the pterygomasseteric sling.

Dalpont (1961) modified the sagittal split by advancing the oblique cut towards the molar region and making the vertical cut through the lateral cortex. The main problem with set-backs was interference between the main retro positioned proximal fragment and the mastoid process where occasional pressure on the facial nerve may occur as well.

Hunsuck (1968) Shortened the cut through the medial cortex of the ramus by taking it only as far as the mandibular foramen which prevented the occasional shattering of the ramus in mandibular set-backs.

Bell and Schendel (1977) *and* ***Epker et al***. (1978). In the anterior vertical cut, the whole of the lower border is sectioned through and through. The split is kept more laterally by directing fine osteotomes down the inner surface of the lateral cortex to produce easier splitting and greater protection for the inferior dental nerve. Blood supply to the ramus is preserved as elimination of the need to strip the pterygomasseteric sling.[104]

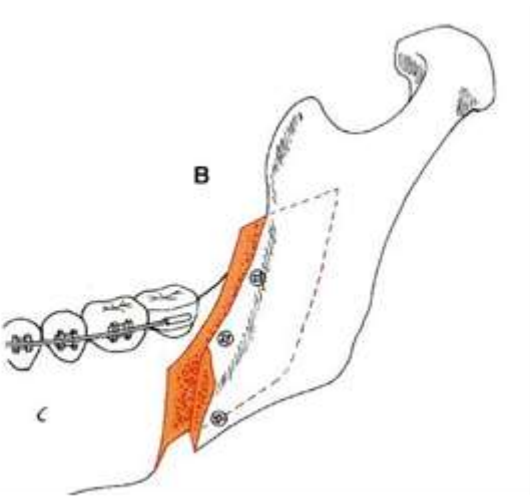
Surgical technique

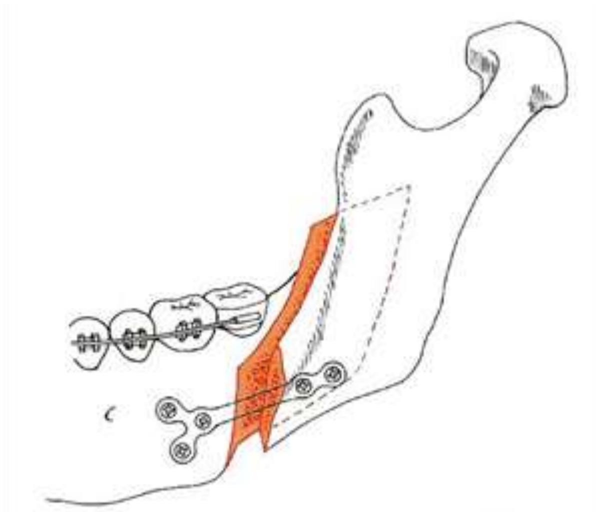
Incision.

Lateral crest of the alveolus. Extended up the anterior border of ramus and anteriorly along the external oblique ridge as far forward as first or second molar. Subperiosteal exposure laterally over the body of mandible to lower border. Medially just beyond the lingula and superiorly to expose the coronoid process. The lingual cortex of ramus - from the anterior border of ramus, passing backward to just reach superiorly and posteriorly to lingual.

External oblique ridge cuts made down along anterior border of ramus, medial to the external oblique ridge then forwards to about the 2nd molar tooth

Vertical cut lateral cortex of the body down to and through lower border of the mandible. Begin from the lower border of the vertical cut then proceed to insert fine osteotomes along the alveolar cut to gently pry the two fragments apart. The neurovascular bundle must always lie on the medial side in the distal segment otherwise it should be repositioned there.[105]





Fixation options

Upper border transosseous wires 4-6-week period of inter maxillary fixation required.

Lower border transosseous wire 4-6-week period of inter maxillary fixation required.

Bicortical screws - inserted transbuccally via trochar and cannula or transorally in an oblique (fashion in selected cases. The best biomechanical advantage is obtained with three screws placed in a triangulation pattern.

Monocortical plates and screws - one or two plates may be used and often placed transorally.

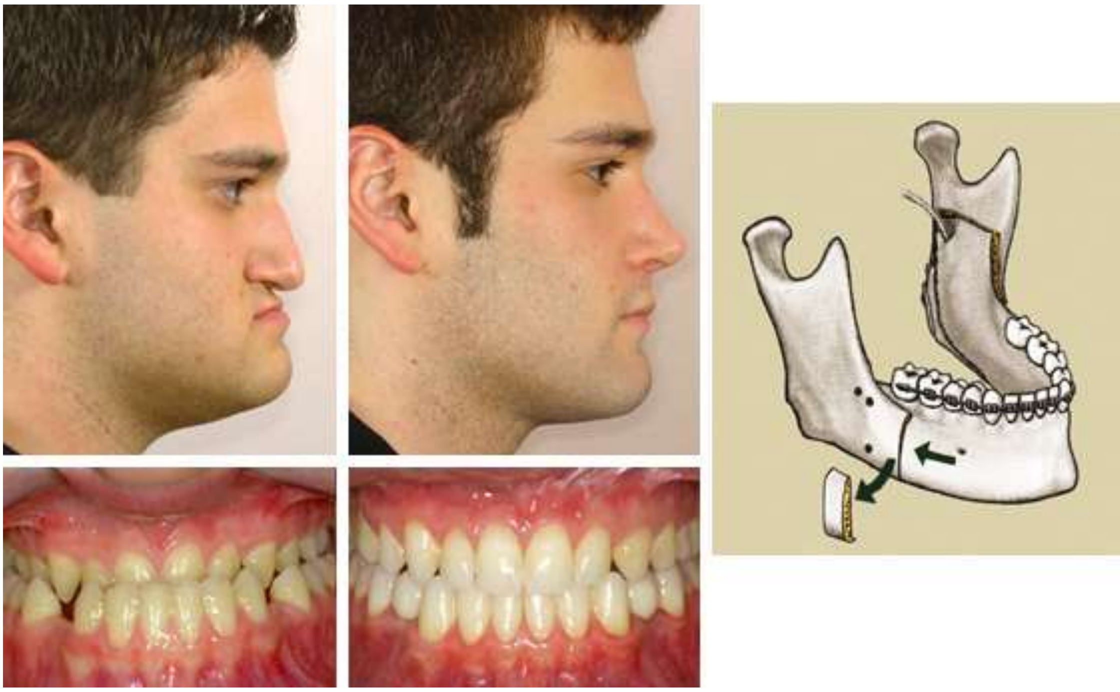
Rigid Internal Fixation utilizes compression screws or plates which allow the surgical team to avoid wiring the teeth together.[106]

Postoperative

Drain tubes are optional and often unnecessary. Wire fixation - MMF for 6 weeks

Screw fixation - training elastics for a few days

Bilateral Sagittal Split Osteotomy with mandibular advancement



Bilateral Sagittal Split Osteotomy with mandibular setback

Relapse is more likely to occur if there is the rotational movement of the proximal fragment particularly with the setback. To prevent relapse in mandibular setback procedures the medial pterygoid muscle attachment may be partially stripped off.

Occasionally the sphenomandibular ligament prevents large advancement of the mandible and may need to be stripped off the lingual. For large advancements (> 8 mm) additional measures such as skeletal suspension wires should be considered even when rigid internal fixation is used.[107]

Limitations of the sagittal split procedure

1. Relapse is common in cases of

a. Anterior open bite - not appropriate to use sagittal split alone particularly with short ramus height, where the inverted 'L' osteotomy is better suited. The sagittal split may be used in conjunction with maxillary osteotomy

b. Mandibular asymmetry - rotatory movements predispose to poor contact between the fragments hence careful trimming minimizes angle flaring

2. Thin/abnormal ramus structure - better to use inverted 'L', 'C', or arcing osteotomies

3. Split is occasionally unpredictable.

VERTICAL SUBSIGMOID (OR RAMUS) OSTEOTOMY (VSS)

Developed by Caldwell and Letterman (1954). Mainly for set-back procedures and mandibular asymmetries. Not recommended for correction of anterior open bites.

Extraoral approach (for unusual cases only)

1. Easiest and safest method is to utilize Risdon (submandibular) approach

2. Whole lateral surface of the ramus is stripped of periosteum and masseter muscle

3. Medial pterygoid muscle insertion is reflected off the deep surface

4. Rayne sub sigmoid retractor with fibreoptic light attachment is inserted

5. Position of lingula identified by a small bony thickening on the lateral surface of the ramus. A vertical bone cut is made a few millimeters posterior to this landmark with a slightly oblique angle Anteroposteriorly

6. Mandible is set-back so that the proximal fragment overlaps the distal fragment on the outer aspect. Lateral surface decortication may be required on the distal fragment to establish good bony contact and healing and on the proximal fragment to prevent deformity at the angle. Trimming of the angle from the proximal fragment may also be necessary to prevent flaring. Transosseous fixation mayor may not be used although Epker and Wolford (1980) advocate wiring to ensure the condyle is carefully seated in the fossa.

7. Where setbacks are greater than 1 cm, a coronoidectomy may be necessary to prevent excessive tension on the temporalis muscle.

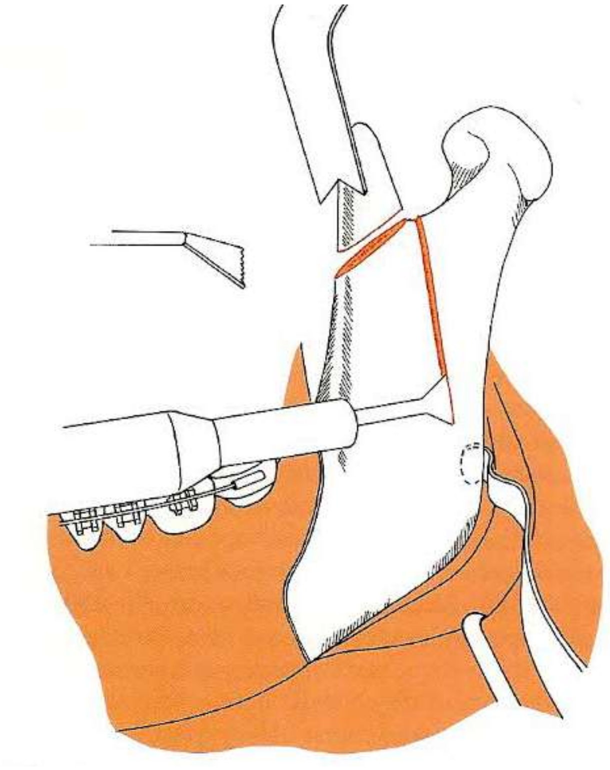
8. Closure in layers - muscle, deep fascia, platysma, and skin

9. MMF = 6 weeks

Disadvantages

a. External scar

b. Occasional damage to the mandibular branch of the facial nerve



Transoral approach

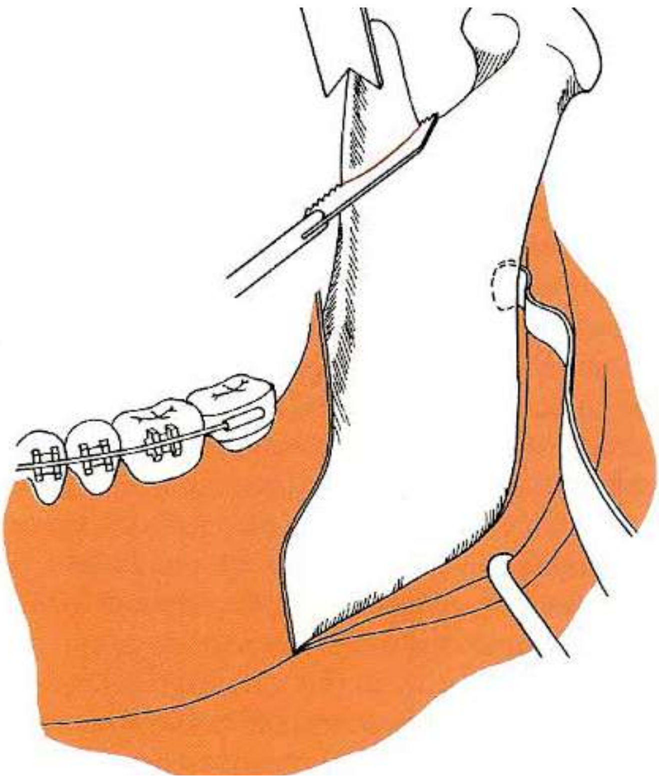
1. It has become a more popular approach since the introduction of specially designed retractors, oscillating saws, fibreoptic illumination, irrigation, and suction.

2. Submentovertex X-ray may occasionally help to assess the amount of outward flaring of the rami to establish the feasibility of the transoral approach, since the more parallel the rami, the less direct vision available to the surgical sites

3. Extended 3rd molar incision up the anterior border of ascending ramus and forwards to 1st molar similar to the sagittal split osteotomy incision.

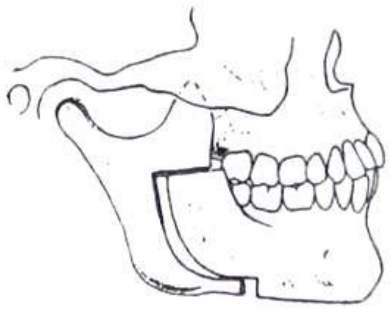
4. Extensive muscle stripping from ramus may result in aseptic necrosis of bone fragments and condylar sag. However, if inadequate muscle stripping occurs then there is an increased risk of relapse. Bell *et al.* (1980) recommend that medial pterygoid muscle should not be stripped off since it maintains the blood supply to the proximal fragment and helps keep the condyle in place although some believe this leads to greater relapse

5. Osteotomy begins halfway, first up then down from sigmoid notch to angle using an oscillating saw with 1200 blade angle. Depth of cut should be no greater than 6 mm to avoid the risk of damage to medial tissues



'C' OSTEOTOMY

Modification of the inverted 'L' osteotomy devised by Caldwell *et al.* (1968).



<u>Indications</u>

Mandibular advancement in patients with a high mandibular plane angle often without the need for bone grafting although a defect remains posteriorly.

Surgical technique

1. Vertical cut is brought forwards just below the level of the inferior dental nerve in a horizontal direction towards the third molar tooth.

2. Osteotomy is completed by making a short vertical cut anteriorly through the lower border

3. Fixed with lower border wiring or plates

With any of the above mandibular ramus procedures, the preoperative rate of growth can be expected to be maintained after surgery. Mandibular growth should not be affected by any of these techniques, provided that the condylar head is not damaged during surgery. The vector of facial growth, however, may be altered by a change in the orientation of the proximal segment and thus the condyle, like the molding of regenerate in Distraction osteogenesis. The use of rigid fixation will improve long-term stability.

SUBCONDYLAR VERTICAL OSTEOTOMY

Sub condylar vertical osteotomy was first proposed by Caldwell-Letterman in 1954. The indications for extraoral subsigmoid vertical ramus osteotomy are as follows:

- The major setback of mandible more than 10 mm
- The asymmetric setback of the mandible.
- Reoperation of previously operated case.

In this procedure, the ramus is approached through extraoral post-Ramal or submandibular incision and is sectioned from the sigmoid notch to the lower border of the mandible just ahead of the angle, the mandibular foramen remains on the distal fragment, thereby avoiding injury to the nerve, and the condyle attached to the proximal segment. After cutting through the pterygomasseteric sling, the angle and interior border of the mandible is exposed. A periosteal elevator is utilized to subperiosteally reflect all the tissues from the lateral aspect of the ascending ramus. The sigmoid notch and coronoid processes are also exposed. The hook or curved instrument is engaged at the sigmoid notch and the ramus is pulled slightly downwards. A bony prominence corresponding to the lingual and mandibular foramen is located on the lateral surface of the ramus. This is called Behrman's bump. The vertical line going from the sigmoid notch to the inferior border is scratched just posterior to the mandibular foramen with the bur. The cut is started from the sigmoid notch to the level of mandibular foramen through both the cortices. Care is taken to protect the medial tissues. Then the cut is started from the inferior border going up to the level of the mandibular foramen. Then both the cuts are joined together. This way if there is any inadvertent injury to the neurovascular bundle, which causes hemorrhage, then the two fragments can be quickly separated and the vessel is identified and ligated. A similar procedure is carried out on the opposite side. After both side osteotomies are completed the proximal fragments are placed over distal fragments and the assistant temporarily locks the mouth in the desired occlusion by carrying out temporary Inter Maxillary Fixation (IMF). The decortications of the distal segment are carried out on the lateral aspect of the overlap area and the proximal segment is decorticated on the medical aspect. The proximal segment is then fixed laterally to the distal segment is decorticated on the medical aspect. The proximal segment is then fixed laterally to the distal segment overlapping it with intraosseous wiring or bone plates. There can be variations of this basic osteotomy procedure. Sub sigmoid oblique sub condylar osteotomy is advocated by Robinson and Hinds in 1955. The cut is extended from the sigmoid notch to the posterior border. C-shaped or arching osteotomy can be done by curving the bony cut above the level of mandibular foramen extending it to the anterior border of the mandible, instead of going straight to the sigmoid notch. These procedures can be also used for the advancement of the mandible along with the use of bone grafts fitted between the distal and proximal segments.

Advantages of sub sigmoid vertical and oblique osteotomy

- Adequate direct access.
- Adequate control of bony fragments.
- Good surface contact between the bony fragments.
- Minimal relapse tendency.
- Gonial angle contour can be changed.
- No loss of teeth or arch size.

Disadvantage: It is because of an extraoral incision, there is an external scar formation. If the patient has a keloid tendency, then this approach is contraindicated. Otherwise, careful planning of the post-Ramal incision gives a minimum amount of scar, which is hidden behind the shadow of the posterior border of the mandible, and over the years, the scar diminishes.

INVERTED 'L' OSTEOTOMY

Devised by Pichler and Trauner (1948).

Indications

1. Mand advancements >/= 12 mm

For increasing height (length) of ramus which also requires an Interpositional bone graft

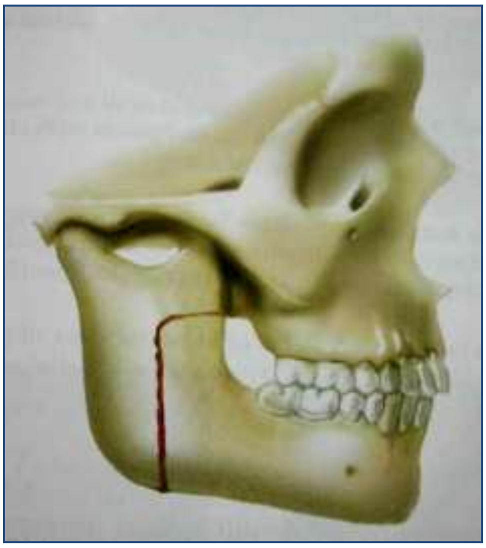
3. Mandibular set-backs 10 mm or more - provided the proximal fragment is carefully trimmed back

Surgical technique

1. Submandibular approach similar to VSS but the incision is made further down in the neck

2. Vertical cut made above and behind the lingula

3. Horizontal cut above lingula may be more easily executed via a transoral approach



Surgical technique:

It's a blend of IVRO & SSRO.

Medial exposure & dissection are done as per SSRO.

Exposure of lateral ramus & completion of inferior vertical osteotomy is the same as for IVRO.

Contraindication:

Abnormal posterior location of the mandibular foramen and mandibular advancement without grafting.

Advantages:

- Can correct mandibular prognathism/asymmetry
- Coronoid process and temporalis muscle remain basically in their original position.
- Can set back mandible a great distance
- Can lengthen ramus/ advance the mandible when used with bone/synthetic bone grafting
- Maybe also able to use rigid skeletal fixation.

Disadvantages:

- Usually requires bone/synthetic be grafting for mandibular advancement
- Increased-healing time

Limitations

The inverted "L" osteotomy (ILO) can be used to advance the mandible and vertically lengthen the ramus, but it may require bone or synthetic bone grafting to control the positional orientation of the proximal segment and to fill the bony voids between segments. The use of rigid fixation is recommended.

Age of surgery:

Surgery was performed from the age of 12 years and older. Sagittal split osteotomy, it is best to use it after the second molars erupt so they are not injured before the eruption.[117]

GENIOPLASTY

Genioplasty is the procedure used to correct the deformities of the anterior part of the mandible that is, the chin. It is possible to reposition the chin in all three dimensions of space. The chin can be moved in anteroposterior, vertical, and or horizontal directions. Genioplasty can also be used in widening and narrowing the chin in the widening and narrowing of the chin in the horizontal direction. Stabilization and fixation are usually done using a figure of eight transosseous wires. The use of plates and screw for fixation is superior to traditional transosseous wires.

Cephalometric Evaluation

- **Down's, Steiner's, and Tweed's analyses**
- **Gonzales-Ulloa and Stevens**, in which a line is constructed perpendicular to the Frankfort horizontal and passing through the soft tissue nasion. The soft tissue chin should be tangent to this line.
- **Merrifield's "Z" angle** is a line from the soft tissue chin tangent to the most procumbent lip, which forms an angle with the Frankfort horizontal. The upper lip should fall on the profile line, with the lower lip tangent to or slightly behind the profile line.
- **Ricketts's aesthetic plane** is a line from the tip of the nose to the chin. He found that in aesthetically pleasing profiles, the upper lip was 4 mm and the lower lip 2 mm behind the aesthetic plane.

- **Holdaway** suggested a line tangent to the chin and upper lip. This line forms an angle with a line between the nasion and basion and should be about 7 to 9 degrees. [119]
- **Zimmer** proposed a line from the anterior nasal spine to Down's "B" point and demonstrated that the nose and lips, as well as the chin, were almost identical in thickness when compared with this plane and that the nose had an approximate ratio of 2:1 to any of the other soft tissue structures.
- **Steiner** also used soft tissue components to define pleasing profiles. He constructed a plane from the middle of the columella, midway between the curves of the upper lip and nasal tip. The lips should fall on this line.

Surgical procedure

The incision is made on the facial mucosa on the lower lip after routine infiltration of lignocaine hydrochloride 2% with 1: 100,000 epinephrine. It is extended from the anterior part of the mental foramen to the opposite symmetrical site. The incision is taken to the periosteum which is cut to expose the bone. Subperiosteal dissection is done to expose the inferior border of the mandible.

Osteotomy/ostectomy

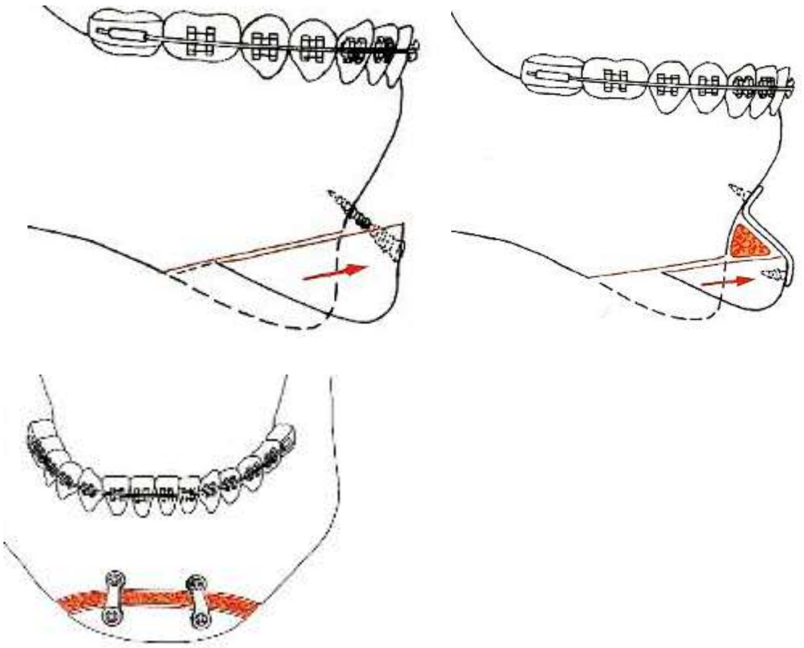
The bony cut is made above the inferior border. The posterior end of the cut should taper to the inferior border. The segmented portion is freed from the rest of the mandible but remains pedicled to digastric and geniohyoid. For vertical reduction, another horizontal cut is made above the original cut and the segment of the bone between the two cuts is removed.

Increasing the height of the chin can be achieved by bone grafting and doing internal rigid fixation using plates. Unilateral height increases can be done in asymmetry. The chin can be augmented (augmentation genioplasty) by bringing the cut inferior segment anteriorly and fixing it by the use of wires. Rigid fixation or use of semirigid plates is better than wiring techniques.[120]

Various techniques are available for altering the dimensions of the chin by osteotomies, including sliding horizontal osteotomy and the tenon and mortise technique. Bone segments may be fixed with wires, bone screws, or bone plates, and may require bone or synthetic bone grafting, as in the case of vertical lengthening. These procedures have no significant effect on subsequent facial growth, except affecting appositional bone growth at pogonion, or if developing dental structures are injured, which may lead to dentoalveolar ankylosis and decreased vertical alveolar growth.

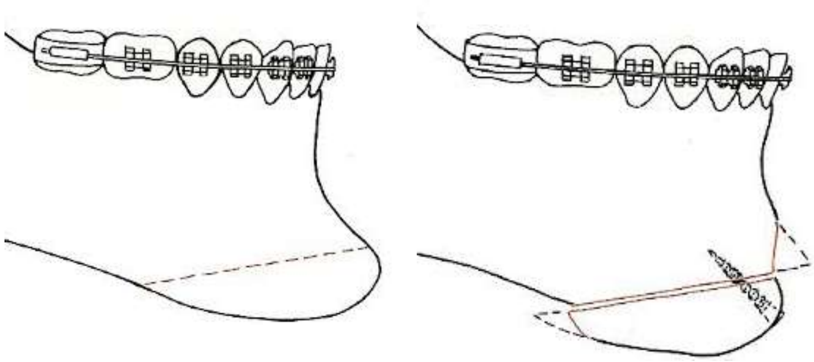
ANTEROPOSTERIOR AUGMENTATION

The usual limiting factor for chin advancement is the anteroposterior dimension of the symphysis unless the osteotomized segment is tied surgically. If the chin is narrow transversely, advancement tends to make the face appear even more tapered. Soft tissue change is approximately 80% to 85% of the amount of bony augmentation. Over time anterior bone resorption can occur with an osseous result of 80% compared with the original amount of advancement. Soft tissue also may regress posteriorly. [121]



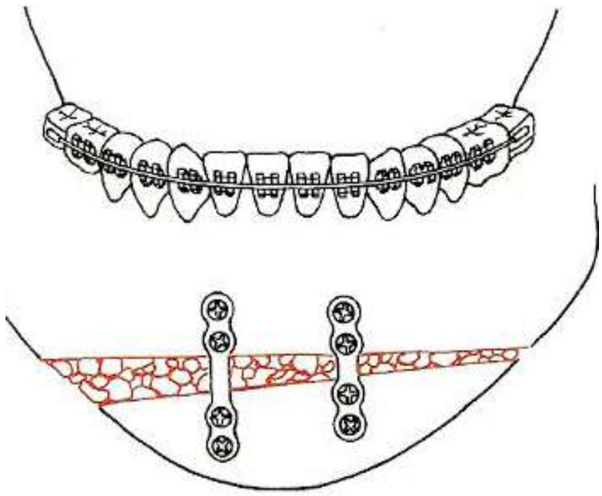
ANTEROPOSTERIOR REDUCTION

Optimal soft tissue change is achieved by performing a horizontal sliding osteotomy and moving the chin and attached soft tissue posteriorly. The chin usually appears wider after this procedure, and the labiomental fold decreases. Soft tissue change, if soft tissue remains attached to the anterior and inferior aspect of the chin, is usually 90% of the anteroposterior bony reduction. Shaving of the anterior aspect of the bony chin may result in only 20% to 30% posterior movement of the soft tissue about the amount of bone removed. Take care to ensure the soft tissues “follow” the hard tissue. Not infrequently, failure to do so leaves a mobile soft tissue mass that may be pulled inferiorly by the mentalis to produce unattractive ptosis of the chin.[122]



VERTICAL AUGMENTATION (DOWNGRAFT)

Vertical augmentation is accomplished best with a horizontal osteotomy and inferior repositioning of the chin segment. This technique usually requires bone or synthetic hard tissue grafting. Soft tissue change is approximately 100% of the osseous change.

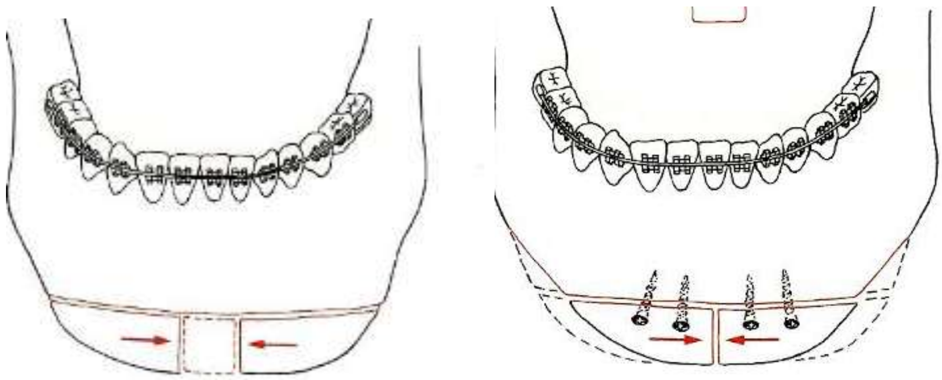


VERTICAL REDUCTION

The most predictable vertical reduction is with wedge resection and rotation of the inferior chin segment superiorly. When soft tissue remains attached to the inferior. When soft tissue remains attached to the inferior border, the soft tissue change is approximately 90% of the vertical osseous change. If the inferior border is resected and removed, then the vertical soft tissue change is only 25% to 30% of the amount of bone removed.[123]

TRANSVERSE REPOSITIONING

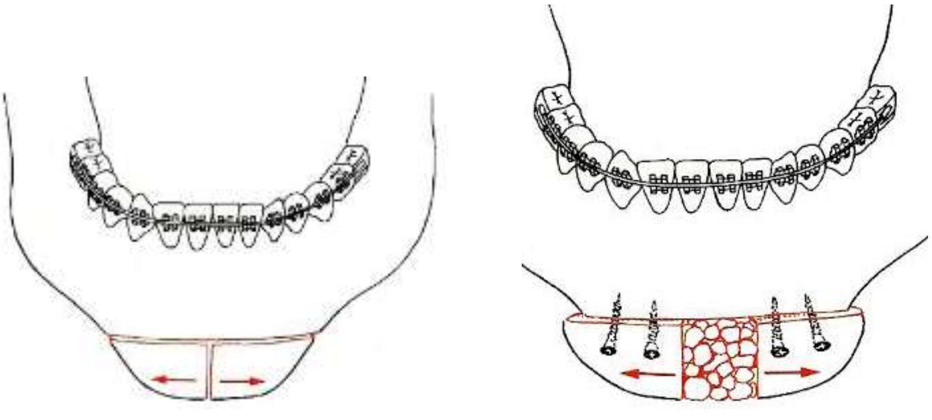
Transverse repositioning is used to correct asymmetrical chins. A horizontal osteotomy is performed, and the chin is shifted, and sometimes rotated, transversely, and is stabilized. Narrowing of the chin can be accomplished by rotating the segments medially, but the effectiveness of this technique is limited.



Transverse reduction

LATERAL AUGMENTATION:

By splitting the chin segment in the midline, the segments can be expanded and stabilized. If a large expansion is planned, the midline defect may require bone or synthetic bone grafting. [124]



Transverse expansion

AUGMENTATION GENIOPLASTY WITH IMPLANT

Augmentation genioplasty can serve as a valuable adjunct to orthodontic treatment. The borderline extraction patient with a good nasolabial angle, protruding lower incisors, and a deficient chin often can be treated better by non-extraction Orthodontics followed by advancement of the chin than by any regimen involving orthodontic extraction. Alloplastic that is proved not to cause bone resorption can be placed in patients as early as age 8 or 9 to the early teens, provided they can be fixed to the bone without damage to underlying dental or neurovascular structures. Appositional growth at pogonion will be eliminated after the placement of these implants. Certain alloplastic materials, (Protoplast-Teflon [Vitek, Houston, Texas], Silastic [Dow Corning, Midland, Mo], and acrylic), have been documented to cause resorption of the underlying bone, and their use is discouraged. Although certain alloplastic implants can be placed when the patient is 10 years old or younger, it is best to wait until the patient is at least 12years to minimize the risk of damage to underlying teeth and neurovascular structures.

- Implants can be used to lengthen the anterior mandibular dimension by extending them below the anterior mandibular border, as well as to augment the Para symphyseal region to a greater extent than the single-piece osseous genioplasty.
- Implants should be stabilized with transosseous wires or position screws to ensure immobility.
- Bony resorption under alloplastic has been seen in patients with hyperactive mentalis muscles and lip incompetence. Great care should be taken to diagnose these problems before implant placement to avoid future complications.[125]

Soft Tissue Closure

- Redistribution of soft tissues may cause chin ptosis if at least a two-layer closure is not performed. The mentalis muscle must be accurately reapproximated.
- In general, the incision should be closed in two to three layers and a pressure dressing applied to minimize hematoma formation and facilitate soft tissue reattachment

Soft Tissue Changes

- Soft tissue changes associated with genioplasty are highly variable.
- Reports in the literature range from 0.6:1 to 1:1 change in soft tissue compared with bony advancement/setback or implant thickness.
- Vertical and horizontal reduction genioplasty appears to have the most variability in osseous to soft tissue change.

Several surgical considerations will ensure a greater and more stable magnitude of bone-to-soft tissue change, the most important appears to be limited periosteal stripping and meticulous layered soft tissue reapposition, including reconstruction of the mentalis muscle.

The following recommended technique is safe and provides good long-term stability.

1. Perform the chin implant as the last step, after all, other orthognathic procedures are completed and the associated incisions are closed.
2. After exposure and preparation of the implant area, thoroughly irrigate it with sterile saline.

3. Change gloves and wash off glove powder before handling the implant.

4. Stabilize the implant to the mandible to eliminate mobility and migration by using bone screws, plates, or intraosseous wiring.

5. Close the incision in two layers with reapproximating of the mentalis muscle layer and tight mucosal closure.

Complications:

Several potential complications are associated with osseous and alloplastic augmentation.[126]

- Loss of osteotomized bone segment
- Bone resorption and infection
- Displacement malalignment
- Paraesthesia of lower lip and chin
- Lower lip ptosis
- Mentalis muscle dysfunction
- Unsatisfactory aesthetic outcome

SURGERIES FOR BIMAXILLARY PROTRUSION

Bimaxillary protrusion may be complicated in the adult patient by large diastemas, periodontal problems (especially moderate to severe bone loss), vertical maxillary excess, or mandibular dentoalveolar vertical hyperplasia, symmetrical or asymmetrical transverse deviations, or any sagittal skeletal discrepancies. In such cases the possibilities of obtaining successful results from the standpoints of both esthetics and stability through orthodontic treatment alone greatly diminish. Therefore, in many nongrowing patients, a combined orthodontic-surgical treatment alternative should be considered. This article intends to outline some basic considerations in planning treatment of this nature for those patients who exhibit bimaxillary protrusion with or without complicating dental or skeletal manifestations in other dimensions.

In those non- growing persons who exhibit bimaxillary protrusion with otherwise normal sagittal, vertical, and transverse skeletal relationships, treatment alternatives may involve the extraction of premolars and orthodontic treatment alone or extraction of premolars and surgical retraction of both maxillary and mandibular anterior segments with subapical osteotomies and osteotomies in the extraction sites. This combined surgical and orthodontic approach accomplishes virtually the same treatment objectives as does orthodontic treatment alone.

Considering the lack of growth, it may be necessary to augment the soft-tissue chin in these patients when it is anticipated that the surgical endoskeletal retraction and resultant anteroposterior reduction of labial soft tissue will not satisfactorily achieve the esthetic objectives of a straighter, more pleasing profile.[130]

Another consideration in these patients is the tonicity of the labial soft tissue. In cases of extremely hypotonic lip musculature or excessive tissue thickness, the lips may not retract adequately when the anterior teeth are moved posteriorly. This manifestation may be remedied with a secondary cheiloplasty to further reduce lip procumbent, eversion, or excessive tissue thickness.

In the absence of a vertical jaw dysplasia, the procumbent anterior maxillary and mandibular teeth can be retracted and raised or lowered by the anterior maxillary and mandibular subapical osteotomies in the first or second premolar regions. The step defect which is commonly produced in the interface between the proximal and distal segments may be corrected by interdental osteotomies to allow transverse movement of the two halves of the maxilla, the mandible, or both. In clinical practice, when surgery is performed without preliminary orthodontic procedures, model surgery will frequently indicate that better alignment can be achieved by maxillary or mandibular ostectomies in the second premolar sites than in the first premolar areas.

Bimaxillary dentoalveolar protrusion associated with anterior open-bite, excessive tooth exposure, and lip incompetence, has frequently been managed solely by the anterior maxillary and mandibular osteotomies. When treatment is planned in all three dimensions of space, however, relatively few patients with bimaxillary protrusion and anterior open-bite will be treated by isolated anterior maxillary or mandibular osteotomies. When an anterior open-bite is closed and facial convexity is reduced by the anterior maxillary and mandibular osteotomies, excessive tooth exposure and lip incompetence remain uncorrected.[131]

Bimaxillary protrusion and open-bite associated with minimal to no tooth exposure, lip competence, and adequate lower anterior facial height may be treated by anterior maxillary subapical osteotomy or extraction of first premolars and orthodontic extrusion of maxillary incisors. When the maxillary incisors are positioned too high and concealed above and behind the upper lip, the anterior maxilla may be lowered by anterior maxillary osteotomy to close the open-bite, reduce facial convexity, and improve the lip-to-incisor relationship.

Devascularization and devitalization of a repositioned segment may be produced by excessive stretching or detachment of the soft-tissue pedicle. Such complications are avoided by careful model surgery to determine the three-dimensional positional changes of the segments. In principle, surgical repositioning of single-tooth dentoalveolar segments is biologically and clinically sound.

In clinical practice, treatment can be planned to improve the tooth alignment by one or multiple interdental osteotomies to reposition dentoalveolar segments that include one or more teeth. Any combination of one-, two-, three-, or four-tooth segments, however, may be simultaneously mobilized and repositioned to achieve the desired alignment.

Simultaneous tipping and retraction of proclined maxillary or mandibular canines or premolars by segmental surgery tend to raise the canine teeth of the occlusal plane and tip the canine or premolar roots forward. This can be foreseen by careful study of preoperative cephalometric planning and model surgery. The elevated teeth can be brought down into occlusion by postsurgical orthodontic treatment. Alternatively, the improved axial inclination of the anterior teeth can usually be achieved by presurgical orthodontic correction after extraction of the first premolar teeth to avoid the need to upright the segment at the time of surgery.

When severe bimaxillary protrusion is treated by surgical means alone, however, segmentalization of the maxilla or mandible is usually necessary to improve either the alignment and/or the anteroposterior and axial inclination of the maxillary and mandibular anterior teeth. The planned changes must be carefully simulated by correlative model surgery and cephalometric planning studies. If interdental osteotomies between closely spaced teeth are calculated to produce large spaces between the apices of the teeth, particulate marrow or local bone grafts are placed between the margins of the sectioned bone to stabilize the segments, facilitating the consolidation of the margins of the osteotomy sites, and obviate periodontal complications. Interdental osteotomies can usually be made in the canine-lateral incisor, first premolar-second premolar, second premolar-first molar, and central incisor interspaces with relatively little risk to the contiguous teeth. When osteotomies are performed in these areas, vertical ostectomies are usually accomplished in the second premolar sites.

When the objectives of maxillary surgery are a posterior movement of the maxilla, concomitant alteration of the transverse dimension, or segmentalization to close edentulous spaces created by the extraction of the premolar teeth or prematurely lost molar teeth, the entire maxilla is usually repositioned by LeFort I osteotomy. This surgical procedure, involving simultaneous movement of anterior and posterior maxillary dento-osseous segments, affords maximal versatility to improve the canine-premolar relationship, alter the axial inclination of the anterior teeth, and achieve the desired transverse dimension. Segmentalization of the anterior maxilla to improve the axial inclination of the anterior teeth without ostectomy or extractions may be the surgical treatment of choice in selected cases, the desired anterior-posterior position is achieved by LeFort I osteotomy. When the maxilla is repositioned posteriorly and/or superiorly and narrowed, there are a distinct possibility of telescoping of the anterior and posterior maxilla into the nasal cavity or maxillary antra and of osseous instability and difficulty in stabilizing the repositioned maxilla by interosseous fixation. Improved stability of the repositioned maxilla can be achieved by Interpositional autogenous bone grafts, suspension wires, or small bone plates. The clinician must foresee the possible consequences of the planned positional changes of the maxilla. Based on the probable results of surgery, he may opt to alter the geometric design of the osteotomies to obviate undesirable consequences and improve the juxtaposition of the margins of the proximal and distal segments.[132]

Patients who manifest severe facial convexity and bimaxillary protrusion frequently require augmentation of the chin in addition to anterior maxillary and mandibular osteotomies. By a precise surgical technique, advancement of genioplasty can sometimes be accomplished simultaneously with anterior mandibular subapical osteotomy. Subapical osteotomies may be made within 3 mm. of the anterior teeth apices. A 5 mm. or larger "island of bone" should be maintained to preserve the vertical continuity and adequate strength of the anterior portion of the mandible. The osteotomy of the inferior border of the mandible should be performed 10 mm. or more above the inferior border of the mandible.

When insufficient chin height precludes simultaneous advancement genioplasty and anterior mandibular osteotomy, both secondary advancement genioplasty by osteotomy of the inferior border of the mandible are feasible options. Advancement genioplasty12 has been quite predictable, stable, and relatively problem-free.

The mandibular intercanine and intermolar width may be decreased by symphyseal ostectomy and subapical osteotomy. The versatility of various combinations of mandibular ramus osteotomies, anterior subapical osteotomies and osteotomies, and interincisal osteotomies allows for virtually any combination of vertical, transverse, and anteroposterior positional changes of the anterior and posterior teeth to achieve the desired and planned alignment of the anterior and posterior teeth. mid symphyseal ostectomy may also be combined with subapical osteotomy or ostectomy to narrow the posterior part of the mandible. Cephalometric planning studies and clinical analyses may indicate the need for intraoral vertical ramus osteotomies to retract the entire mandible or sagittal split ramus osteotomies to advance the mandible.

DISTRACTION OSTEOGENESIS

Distraction osteogenesis is a biological process of new bone formation between the surfaces of bone segments that are gradually separated by incremental traction. Specifically, this process is initiated when distraction forces are applied to the callus tissues that connect the divided bone segments and continue as long as these tissues are stretched. The traction generates tension that stimulates new bone formation to parallel to the vector of distraction.

Techniques

Halitosis– stretching of reparative osteotomy or fracture line --- has three stages

Latency—The waiting period during which new bone formation starts.

Distraction—The period during which the bone ends are stretched or distracted over many days.

Consolidation—The period during which bone maturation occurs and continues throughout one to two years and soft tissue adaptation also occurs.

Physeal distraction

Distraction epiphysiolysis—rapid 1—1.5mm per day—growth plate fracture

Chondrodiastasis—slow .5mm per day chondrocyte activity-induced and no fracture occur.[133]

Types of Appliances

Can be classified based on design construction such as:

1. Tooth borne
2. Bone borne
3. Hybrid

Based on the direction of distraction mechanisms such as:

1. Unidirectional (One plane of space)
2. Bidirectional (Two planes of spaces)
3. Multidirectional (All planes of spaces)

Based on the fixation mechanism

1. Internal
2. External

Based on the area of distraction

1. Alveolar Distractors
2. Symphyseal Distractors
3. Anterior maxillary Distractors

Events in Distraction Osteogenesis

- Initiation with incremental traction to the reparative callus.

- Tension within the callus stimulates new bone formation to parallel to the vector of distraction.
- Tension is created in the surrounding soft tissues leading to Distraction Histogenesis (active histogenesis in the skin, fascia, blood vessels, nerves, muscle, ligament, cartilage & periosteum.). The adaptive soft tissue changes allow larger skeletal movements hence minimizing potential relapse.

CLINICAL APPLICATIONS:[134]

i. Mandibular Lengthening

- Surgical Technique for Multiguide Mandibular Distraction
- The Frankfort Craniofacial Distraction System
- Osteodistraction Of Hypoplastic Mandible
- Single Vector Mandible Distractor
- Distraction Using Intra Orally Applied Devices
- Intra – Oral Submerged Mandible Distractor
- Bone Borne Dyna Form Distraction Device
- Modular Internal Distraction Device
- Rod – 1 Distraction Device
- Rod -2 Distraction Device
- Independent/Simultaneous Distraction Device

ii. Mandibular Widening

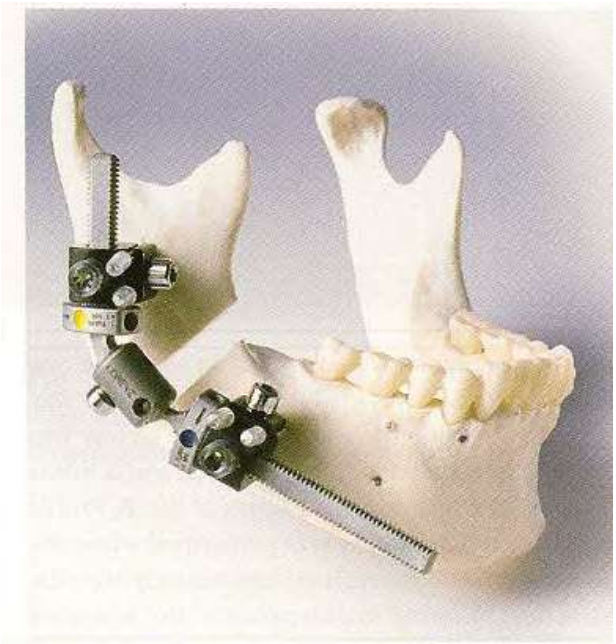
➢ Lingual Tooth Borne Distraction Device

iii. Mandibular Bone Transport

➢ Reconstruction of Mandibular Bone Defects

Iv. Alveolar Distraction Osteogenesis

- Principles of Alveolar Distraction
- Alveolar Distraction Osteogenesis
- Maxillary Alveolar Distraction Osteogenesis
- Leibinger Alveolar Distraction Device
- Intraoral Vertical Bone Distraction




Possible complications

Intraoperative complications:

These are similar to those experienced during Orthognathic surgical techniques such as bleeding problems, neurosensory deficits, less than optimum bone split encountered. Device–associated complications include improper Placement of device and orientation of both device and fixation pins

Intradistraction complications:

Pin infections, Pin loosening, Device loosening, and dislodgment, Device failure, Pin tract formation with subsequent scarring, Inappropriate distraction vectors, Premature consolidation, Dentigerous cyst formation, Coronoid process interference, Fibrous pseudoarthrosis, Paraesthesia, and Trismus are some of the intradistraction complications:

Post distraction complications

Failure to achieve a planned result, relapse, Poor growth after distraction, the appearance of new malocclusion, and distraction undone by unfavorable growth are some of the Post distraction complications

Although the above complications are common to both craniofacial as well as limb distraction procedures, the abundant blood supply of the craniofacial region, makes these complications top less severe than those occurring during the application of distraction osteogenesis to the axial skeleton.[135]

ADJUNCTIVE SURGICAL PROCEDURE

RHINOPLASTY

The nose is one of the most important elements in facial esthetics. This is supported by the fact that in our society the most commonly requested esthetic surgery is rhinoplasty. Many of the patients encountered by the oral and maxillofacial surgeon present with multiple functional as well as esthetic concerns, and simultaneous orthognathic and rhinoplastic surgery can be accomplished with favorable results. Surgical correction of functional or cosmetic defects in the shape or structure of the nose is an increasingly common procedure. It is important in these situations that the surgeon understand the possible changes in the nasal configuration secondary to orthognathic surgery. Because nasal dorsal deficiencies are minimally affected by maxillary surgery, simultaneous surgical correction can be accomplished. Patient selection should be performed with particular care as this is one cosmetic operation that is a potential source of disagreements and litigation. The preoperative psychological status of the patient should be assessed carefully to screen out those for whom surgical correction of their nose is unlikely to answer their expressed unhappiness with face or bodily form. Frank dysmorphophobia is a contraindication to surgery.[136]

Indications for Rhinoplasty

- **Post-traumatic-** After nasal or midface fracture the form of the nose is often unsatisfactory. Early correction of obvious deformities at the time of trauma obviates the need for later revision.

- **Orthognathic-** During maxillary orthognathic surgery changes in nasal shape occur. During the planning phase of midface surgery, the likely effect of surgery on the nasal form should be considered and appropriate steps to correct any predicted iatrogenic problem should be incorporated in the planned procedure.

- **Cleft palate-** Associated Palatal clefts are almost always associated with major functional and cosmetic defects of Eustachian tube function and nose shape. During the adolescent years, the need for orthognathic surgery in cleft palate patients is common. Rhinoplasty may be performed in conjunction with the orthognathic correction or later as a separate procedure.
- **Pure cosmetics**- The nose is often the focus of a patient's unhappiness with their body image and as such the subject of requests for surgical alteration. There is a significant risk of the surgeon becoming the focus of the patient's unhappiness in place of their dissatisfaction with the pre-operative appearance of their nose.

Preoperative assessment and surgical planning

Precision in diagnosis will improve subsequent surgical planning and outcome. Age and race are important factors and racial norms should be respected in treatment planning but severe age-related changes in the nose are rare. Only limited reversal of age-related changes in facial appearance should be attempted in a single operation.

Records are essential and full documentation of all planning and treatment stages is mandatory. A complete collection comprises comprehensive notes, X-rays, clinical photographs, and plaster casts.

Facial analysis

I. Frontal. Clinical and radiographic assessment of intercanthal distance (normal 35 -c 2 mm) for telecanthus and the presence of uncorrected dysmorphic syndromes is essential.

2. Midline relationships. The relationship to other facial structures such as chin and vertex should be assessed and the degree of septal deviation recorded. The coincidence of the centrelines of the nose, philtrum, dental arches, and chin allows determination of the degree of nasal skeletal and cartilaginous nasal tip deviation.

3. Facial 'thirds'. The height of the nose about the upper lip and forehead is important and lower facial height assessment will allow variation from the 45%:55% ratio of the classical facial norm to be determined.

4. Profile planning and lateral relations. The nasofrontal angle (N = 30 2 5") and the nasolabial labial angle (N = 90 f 3" in men and 105 -c 3" in women) are important. If the nasofrontal angle is > 105" a previous nasoethmoid fracture should be suspected and if the nasolabial angle is < 90" a history of previous septal surgery should be sought. If the nasal defects are part of a larger midface disproportion, full profile planning is required.

5. Cleft-related nasal problems require particular attention to both profile and frontal appearance. Maxillary retrusion, nasal 'beaking', shortening of the columella, and lip to nasal sill distance may all require correction.

6. Sub nasal or basal X-ray views. Clinical and photographic views allow alar anatomy and septal deviation to be documented.

7. Skin and subcutaneous tissues. A realistic assessment of the likely outcome of skeletal surgery on the overlying soft tissues must be made. Preoperative tissue expanders may be of use in some patients. [137]

Upper airway function

1. Assessment of the upper anyway function by pathology examination and fiber-optic nasoendoscopy to determine nasal deviation, rhinorrhoea, and sinus-related symptoms is required.

2. Pre-rhinoplasty correction of the nasal airway may be required if there is a risk that the rhinoplasty may compromise the volume, and pattern of an airflow across the nose. Where compensatory turbinate hypertrophy has occurred, turbinectomy may be required. Polypectomy and control of allergic symptoms are undertaken where required before nasal cosmetic surgery.

3. Lesions such as sarcoidosis, Wegener's granulomatosis, and syphilis are sometimes associated with nasal deformity.

Psychiatric assessment

Dysmorphophobic patients' assessment, clinical neurosis, family pressures, and frank psychosis all require an appropriate psychiatric referral before the surgery at least in the first instance. Such patients can present very severe problems postoperatively.

Surgery

There are several classical operations described with many modifications and eponymous variations. However, there are several distinct surgical elements to each of these operations.

Surgical elements.

I. Incisions. The commonest approaches in rhinoplasty use one of intercartilaginous, transcartilaginous, rim, Hemi, and full transfixion incisions. Septal incisions, either of Killian or Freer patterns are well described and an alar rim approach is favored by some surgeons. External or open rhinoplasty involves an incision in the columellar skin in addition to the mucosal incisions and permits wider soft-tissue degloving.

2. Nasal tip surgery. Tip lowering is achieved by separation of medial and lateral crura from the septum and upper lateral cartilages respectively. Nasal ridge augmentation will simulate a tip reduction operation.

Medial scoring of the dome cartilage may be a useful adjunctive technique.

Elevation of the tip is often best simulated by the reduction of a dorsal hump. An interpositional cartilage button graft to provide a columellar strut may aid in tip elevation. Shortening of the nasal tip is achieved by rotation after separating upper and lower lateral cartilages and excising a margin at the contacting edges. Lengthening a nasal tip that has been shortened by previous surgery or by naso-ethmoid fracture is simulated by dorsal grafting and broadening a narrowed tip using a cartilage graft may overcome notching and alar contraction.

3. Septal surgery. If the cartilaginous deviation is present, septoplasty via a Hemi transfixion incision is the operation of choice. Where cartilage ridges or spurs are present, they are almost always the result of a previous nasal fracture. Therefore, the severe nasal fracture should be considered for septal surgery in the acute stage.

4. Dorsal ridge surgery. Reduction or augmentation is commonly required. Simple reduction using scalpel or scissors or rasp is effective. Where augmentation is necessary, there are many options for implantable materials. Tragal cartilage, bone, or alloplastic materials such as Silastic and hydroxyapatite have all been used with varying success.[138]

5. Nasal osteotomy. Immediate reduction of nasal fractures is important. Late residual deviations require osteotomy performed narrowing or broadening can be achieved with the correction of any bony displacements from an earlier trauma.

6. Alarplasty. Wedge excision of alar cartilage will narrow the ala margin but Z-plasty allows greater reduction if required. Ala widening can be simulated by tip lowering procedures and Le Fort I maxillary advancement.

7. Nasal angles. These angles can be altered significantly by augmentation bone grafting and maxillary or premaxillary osteotomies.

8. Associated skeletal surgery. Genioplasty may improve apparent nasal prominence in microgenia.

Orthognathic correction of jaw disproportion or asymmetry usually has consequences for the nasal form and these changes are predictable. Orthognathic surgical planning should account for the need for rhinoplasty either at the time of the facial operation or a later stage. Cleft palate patients have functional and cosmetic problems in proportion to the severity of their original cleft and the method of its closure. Rhinoplasty is often required as part of the late corrective surgery in these, usually teenage patients.

9. Soft tissue surgery. Blepharoplasty, procerus muscle repositioning to alter the nasofrontal angle, upper lip augmentation, implant placement to correct nasolabial angles, and dermabrasion of facial skin may all have their place in the correction of poor facial aesthetics in association with rhinoplasty. Approximately 10% of all patients undergoing rhinoplasty present with complications. These include acute septal hematoma, tip irregularities, and persistent deformities in the later postoperative period.[139]

The outcome showed reduced lower facial height and improved upper lip esthetics with improved philtrum height with the refinement of the nasal tip.

LIP PROCEDURES

Lengthening of the philtrum

The height of the philtrum of the upper lip should be equal to the height of the commissures. When the philtrum more than 2-3 mm shorter than the commissure there is an excessive display of maxillary incisors at rest and excessive display of gingiva on smile. Correction of short philtrum can be accomplished by V-Y cheiloplasty in combination with rhinoplasty

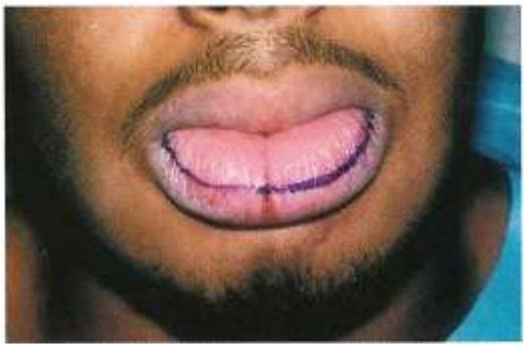
Lip augmentation

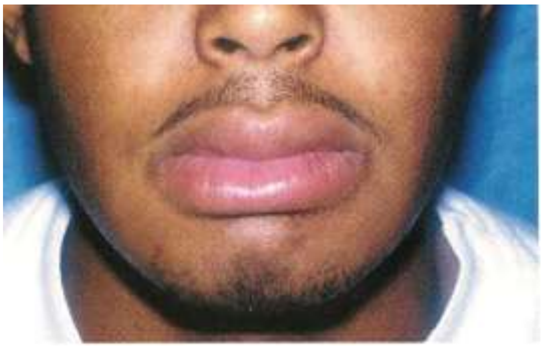
An increase in the bulk of lips is obtained by the addition of a variety of materials to the lip tissue either by injection or by the placement of implants. Lip augmentation injection procedures include injections and collagen, dermologen, cymetra, and fashion. Implant possibilities are alloderm or synthetic materials such as gore-tex.

In alloderm augmentation, small incisions are made at the oral commissure and the submucosal tunnel is created connecting two incisions. A sheet of alloderm is rolled into the desired diameter, passed through the tunnel from end to end, and cut to length. The incisions are then closed.[140]

LIP REDUCTION: REDUCTION CHEILOPLASTY

Reduction cheiloplasty is not frequently performed as in passed because lip fullness is now fashionable. Excision of a portion of one or both lips can be quite effective in reducing the soft tissue mass of the lips. In reduction, cheiloplasty incisions are made inside the oral commissures parallel to the vermillion border. The desired amount of lip including the submucosal gland is excised and the incision is sutured together thus reducing the vermillion is and lip size reduction is obtained.





SUBMENTAL PROCEDURES: SOFT TISSUE REDUCTION

An increased cervicomental angle creates unesthetic throat form and correction often is needed as an adjunct to the treatment of dentofacial problems. With aging, soft tissue sag contributes to a less-than-ideal submental form.

Double chins may be treated by lipectomy, platysmal manipulation, rhytidectomy (facelift) with the posterior subcutaneous musculoaponeurotic system (SMAS), and sometimes chin augmentation.

Aesthetic adjunctive surgical procedures maximize the beneficial outcome for patients treated for dentofacial deformity. A comprehensive treatment plan based on more than skeletal dental relationship should be presented to each patient and if adjunctive aesthetic procedures would improve the outcome, they should be discussed.[141]

LIP LIFT

The lip lift procedure which improves the appearance of thin lips by increasing the amount of vermillion display of the upper lip is an augmentation of vermillion but does not improve the total bulk of the lips. It can be performed in two ways. The first is to make the incision at the base of the nose and excise enough tissues to lift the vermillion so that it is more prominent. The second involves a direct incision on the lips. The new vermillion border is outlined and the tissue between the outlined and existing vermillion is excised. The edges of the incision are sutured together which elevates the superior border of the upper lip.

Complications of lip lift procedure include:

- Possible scarring
- drooping of lips

POST-SURGICAL ORTHODONTICS

The goals of the post-surgical therapy are surgical fixation, restoration and rehabilitation of neuromuscular function, occlusal stabilization, selective grinding of teeth, and final occlusion retention. The postsurgical phase has to achieve the restoration of a good neuromuscular function through a progressive reprogramming of the muscular and dental periodontal proprioception adequate to the new spatial situation of the maxillary and mandibular skeletal bases.

- Upon removal of fixation and the splint, the patient should be seen by the orthodontist immediately (that day or within 24 hours).
- At this time, he should superimpose the cephalometric head films taken before surgery, immediately after surgery, and at the release of fixation. Analysis of the changes seen will enable the clinician to identify precisely what surgical change occurred and also the nature and extent of relapse during fixation. This knowledge is vital in planning the postsurgical phase of treatment.
- In most cases, after the removal of fixation, the patient should be placed on full-time elastic therapy and seen frequently (at least weekly) until healing allows the use of normal orthodontic mechanics to be resumed.
- Light elastics should be placed in triangular or box formation with only a slight, if any, Class II or Class III vector.
- The use of these "short" elastics will minimize the tendency to cause molar extrusion and hence open the bite or cause a CO-to-CR discrepancy while affecting maximum occlusal interdigitation.[142]
- During the immediate post-fixation period attention should be directed toward rehabilitation procedures. Patients should be instructed to exercise the jaw-

opening muscles within painless limits so that they can ultimately return to maximal opening. These exercises should be carried out with the elastics removed if maxillary surgery has been performed.

- Lateral and protrusive movements should also be practiced as the patient progresses through what is normally a 2- to 3-week exercise period.

In operating room to 7 days after surgery.
1. Release IMF
2. Light Elastics
3. Voluntary opening.

↓

1 to 2 weeks after surgery Passive exercises.
1. nonpainful opening.
2. Gentle excursions and protrusions.

Comfortable, opens to 20 mm.

2 to 4 weeks after surgery continue passive-opening exercises.

↓

4 to 8 weeks after surgery.
1. Continue opening and excursion exercises.
2. Gentle isometric exercises.

↓

8 weeks after surgery and on
1. Aggressive maintenance of opening and excursions
2. home exercises.

Restricted or painful opening.

2 to 4 weeks after surgery.
1. Physical surgery.
   a. Ultrasound.
   b. Gentle voluntary muscle stretch.
   c. Muscle massage.
2. Home exercise programme.
   a. Heat application.
   b. Opening and excursions.

↓

4 to 8 weeks after surgery.
1. Continue physical therapy and home exercises.
2. Consider studies for TM joint problems.

↓

8 weeks after surgery and on
1. Continue physical therapy
2. Aggressive investigation of TM joints.

- Once the patient can comfortably open wide enough, procedures such as rebonding and rebanding of any loose attachments should be carried out. A continuous light archwire should be placed in the maxilla if segmental surgery has been performed. In addition, one can ligate the teeth together across the osteotomy site, particularly if any mobility remains in the segments. Where cross arch stability is required following expansion, a transpalatal arch in the maxilla and a lingual arch in the mandible have proved useful.
- Orthodontic objectives following surgery are generally similar to those considered in finishing a conventional orthodontic case. Final tooth alignment, maximum interdigitation, finalizing torque, and artistic positioning are all completed at this time. One should strive for an ideal overjet/overbite relationship compatible with a mutually protected occlusion where CO equals CR. The establishment of correct root parallelism is important, particularly in segmental cases where the roots of the teeth adjacent to the osteotomy sites should have been kept divergent to provide additional interdental space for the surgical cuts.

The postsurgical treatment time needed to reach such objectives varies according to the type of patient. Those cases in which anterior face height has been decreased (open bites or open-bite tendency) should have been treated virtually to completion before surgery. Therefore, a minimum (often no more than 3 to 4 months) of postsurgical treatment should be required. [143]

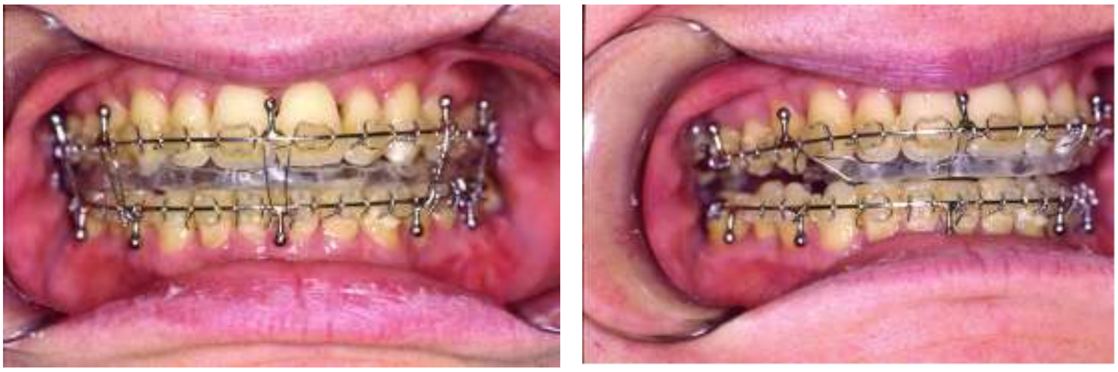
Lengthy postsurgical orthodontic treatment in these cases can lead to compromises in stability and function if the surgical results are disrupted. It is vital to customize the patient's retention plan according to the characteristics of the original malocclusion and the features of any relapse patterns seen after surgery. The use of a positioner, preferably employing a hinge-axis face-bow recording, is effective in obtaining close occlusal interdigitation and is thus ideal in cases in which originally there was an open bite. For long-term retention in these cases, removable retainers of the Hawley type can be used in the maxilla. Care must be taken not to allow retainer wires to pass across the occlusion or through extraction or osteotomy sites. To avoid potential occlusal interferences, circumferential (wrap-around) retainers with additional soldered "C clasps" are advocated. In cases in which relapse may be expected or has already occurred, attachments may be placed on the retainers to counteract these detrimental factors. Small cleats can be welded to the buccal surfaces of the bands of a mandibular canine-to-canine retainer, enabling the patient to wear Class III elastics to small hooks soldered to the buccal wire of a removable maxillary retainer. Similar procedures can involve the use of box elastics for open-bite cases and Class II elastics to a removable lower retainer for a relapsing mandibular advancement.

In cases that involve increasing lower anterior face height (deep bites), most of the orthodontic tooth movement should be accomplished post-surgically. This may take several months, and there need be little concern about untoward orthodontic effects causing relapse or a compromise of the surgical correction.

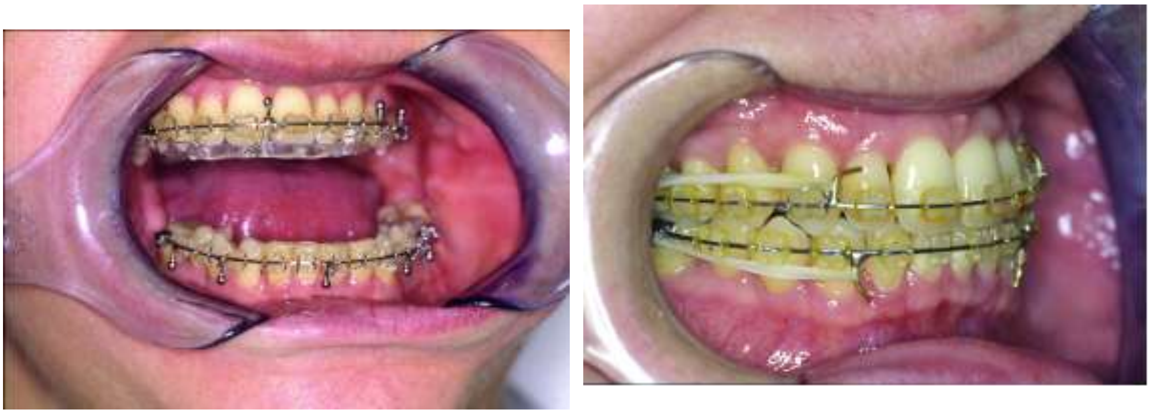
Such cases should be retained using a removable maxillary retainer with a small anterior bite plane if some relapse is expected. A fixed mandibular canine-to-canine retainer provides adequate support to prevent retroclination of the lower incisors.[144]

In surgical-orthodontic treatment, the correct control of the postsurgical orthodontic phase is as important as the presurgical orthodontic phase. A good final result depends not only on the initial diagnosis but also on the exact planning and execution of the orthognathic surgery. Postoperative orthodontic therapy is used to finalize and perfect the dental occlusion relative to the new skeletal relationships. In the post-surgical phase, it is important to restore neuromuscular function through progressive reprogramming of muscular and dental-periodontal proprioception that is adequate for the new spatial situation of the maxillary and mandibular skeletal bases. Finally, the orthodontic and prosthodontic treatment permits correct occlusion, which will be stabilized by a good spatial jaw relationship, correct neuromuscular function, and the prevention of parafunction. Aesthetics, function, stability, and treatment time have to be considered for the decision-making process.

The treatment of these serious anomalies must be neither orthodontic nor surgical alone. Orthognathic surgery is important when it is considered as part of the therapeutic method. A different treatment approach leads to poorer functionality and the problem of relapse.[145]



Postsurgical intermaxillary fixation



Mouth opening width on the removal of the occlusal stabilization intermaxillary fixation.

selective grinding of teeth to finalize the occlusion

STABILITY OF SURGICAL CORRECTIONS

The stability of orthognathic surgical procedures depends on the following

- Direction of movement
- Type of fixation used
- Surgical technique employed. – In the same order of importance.

The hierarchy of stability for different types of movements is as follows

Maxillary impaction

↓

Mandibular advancement (short and normal face)

↓

Genioplasty

↓

Maxillary advancement

↓

Max. up + Mand forward

↓

Mandible back

↓

Maxilla down

3 Basic principles that influence postsurgical stability

1. Stability is greatest when soft tissues are relaxed during surgery and least when they are stretched. Hence the stability of maxillary impaction, and instability of maxillary expansion.

2. Neuromuscular adaptation is an essential requirement for stability. When the maxilla is moved upwards, there is an adaptation in the mandibular position, and occlusal forces tend to increase. (Proffit et al 1989). The tongue is repositioned forward to maintain airway dimensions. Adaptation in lip pressure also occurs. These tend to stabilize the maxilla in the new position.

   But neuromuscular adaptation does not occur when the mandible is rotated upwards to close an open bite. The pterygomandibular sling is stretched as the gonial region moves downwards. Similarly, when the maxilla is moved downwards, the muscles and other soft tissues stretch. Even if the muscles adapt to an extent, the stretch of other soft tissues tends to cause relapse.

3. Neuromuscular adaptation affects muscle length and not muscle orientation. This is important for the stability of mandibular surgeries. If the initial orientation of the ramus is not maintained, there is a tendency for the muscles to revert to their original orientation, and hence cause a relapse.[151]

Maxillary impaction

- Most stable procedure. – Even though the maxilla is moved up, there is no reduction in the freeway space as the mandible auto-rotates to maintain the freeway space. This physiologic adaptation helps in stability.

- Comparing wire stabilization & IMF (wire/IMF) with rigid internal fixation (RIF), it is seen that for this procedure, both showed equally good results.
- Wire/IMF – 6 weeks after the surgery, about 20% of patients showed 2-4 mm of change in the maxilla in the upward direction.
- 6 weeks to 1 year – the same patients showed that much downward movement of the max.
- Therefore, 1-year post-surgically, up to 90% of patients had the maxilla within 2mm of the post-operative position.
- RIF – 6-week radiographs were not taken for RIF patents, but the 1-year radiograph shows that the results were similar.
- Hence in the case of Max. impaction, RIF, or wire/IMF seemed to make no significant differences in stability.[152]

Mandibular Advancement (BSSO)

- Mandibular advancement in patients with normal or short face height is considered. In these patients, the face height post-surgery remains the same or is slightly increased.
- Wire/IMF – during the first 6 weeks post-surgery – the mandible tended to move slightly back.
- But from 6 weeks to one year, the changes seemed to be recovered – once the function was started – indicating the influence of muscles on mandibular position.
- RIF – showed a much smaller tendency to move back, but a greater chance of slight forward movement.

- Overall, there was a better than 90% chance that the mandible would be within 2 mm of its post-surgical position.
- In the case of patients with increased face height, and open bite, if the mandible is advanced, and rotated to close the open bite, the procedure is not very stable. The stretching of soft tissue caused by this procedure causes instability. As the anterior part of the mandible is rotated upwards, the ramus seems to move downwards, increasing the length of the masseteric sling, and leading to instability.

For such cases, RIF is more stable than wire/IMF. Interpositional bone grafts and heavy bone plates are required to hold the correction. (Ritzik et al 1990)[153]

Mandibular advancement combined with superior repositioning of the maxilla

Wire/IMF – like the individual procedures, the maxilla moved slightly superiorly after surgery, and the mandible moved back. But *unlike* the individual procedures, there was no recovery between 6 months to 1 year and relapse continued in 1/3rd of the patients.

By the end of 1 year, only 60% of the patients were judged to have excellent clinical results.

- Also, a post-surgical bite opening tendency is seen.
- RIF - If RIF was used in the mandible, if it was used in the maxilla, stability seemed to improve. Despite the relapse of the mandible between 6 weeks to 1 year, over 90% of patients were judged to have good clinical outcomes. No bite opening tendency is seen.

Maxillary advancement

- In the anterior-posterior plane of space, there was an 80% chance that the maxilla would stay where it was placed post-surgically and a 20% chance of modest relapse. RIF and wire/IMF showed no significant difference in stability.
- Proffit et al – 1991
- Bishara, Chi - 1992
- But if the movement of the maxilla is such that it moves downward as it is advanced, there is a tendency for relapse as the mandible rotates in a counter-clockwise direction.

Mandibular Setback

- 2 procedures are mainly used for setting the mandible back – BSSO and Trans-oral vertical ramus osteotomy (VRO).
- Although mandibular setback was the original orthognathic surgical procedure to be performed, its stability remains a problem.
- Overall, VRO seemed to be more stable than BSSO.
- After VRO – there was a chance of further backward movement of the mandible post-surgically, but forward relapse also occurred in some patients.
- With BSSO, there was almost no post-surgical backward movement, but forward relapse was quite frequent. RIF with BSSO seemed to make relapse tendencies worse.
- Posterior displacement with the VRO seems to indicate that the condyles are not seated in the fossa very well during surgery, and it highlights a limitation of this procedure. After function resumes, the condyles go back into their original position, and the mandible slips back.

- Forward relapse in both cases is due to a controllable factor. If the ramus is pushed to a more vertical inclination when the chin is moved back, the mandibular musculature tends to return the ramus to its original inclination when function resumes, and this carries the chin forward. If care is taken to maintain the original inclination of the ramus, this forward movement should be reduced.[154]

Inferior repositioning of the maxilla

- When the maxilla is moved down, it has a strong tendency to move back up again. With wire/IMF almost all the inferior movement is lost. Wit RIF there is still a strong relapse tendency.
- The inferiorly positioned maxilla is unstable due to occlusal forces when the function is resumed. Ways of maintaining the correction are – use of heavy fixation bars from the zygomatic arch to the maxillary posterior teeth, the use of interposition bone grafts or simultaneous ramus osteotomy to minimize stretching of the elevator muscles, and the decrease occlusal force, Proffit et al 1991.

Widening of the maxilla

- This procedure shows the highest relapse tendency. The immediate post-surgical width is obtained by placing the maxillary segments in the splint. 1 year later, almost 50% of the expansion was lost in the second molar region (the area which was expanded the most), and there was a reduction in post-surgical width of about 2 mm in 2/3rd of the patients.
- The major cause of rebound appears to be stretching of the palatal mucosa, which tends to return to its original dimensions.

- Modest overcorrection and stringent retention are advised to stabilize the palatal expansion after surgery.[155]

POST-SURGICAL COMPLICATIONS

Dissatisfaction with outcome

At times, the orthognathic surgery may go well but the patient may still feel unhappy with the outcome. Some of the factors for such an outcome include

1. Patient-related factors: Unrealistic expectations, external motivating factors, unknown psychological problems.
2. Team dependant factors: Lack of proper understanding of patient's expectations, needs, and psychology. The situation could result from a hurried approach by the team during the patient's evaluation.
3. Poor communication: Poor doctor-patient interaction or personality conflict. Short-term patient dissatisfaction and depression may be associated with pain and discomfort caused by surgery, use of drugs and sedatives, and insufficient preoperative information about the immediate consequences of surgery. Lack of family support may also be a predisposing factor.

Complications related to procedures of orthodontic treatment, anaesthesia, or surgical procedures.

Pain. Usually most intense during the first two or three days after surgery, but is controlled with pain relief medications, which may be required for seven to ten days.

Swelling. Can be expected to peak after 48 hours. Most swelling will subside after 14 days with residual swelling usually resolved after three to four weeks.

Bruising. Can occur over the face, neck, and chest as swelling subsides, and usually disappears after seven to ten days.

Nasal sinus. Will be affected or congested for several weeks after maxillary surgery. surgery due to swelling and mainly involves restricted mouth opening. Elastic bands are used for support and to guide the lower jaw into occlusion. Jaw function will usually return to normal after four to six weeks.

Fixation. Loose or prominent bone screws or plates used for rigid fixation do very occasionally occur and may require removal and further surgery.

Bone healing. Delayed union or non-union of bone is rare in healthy patients and these problems can normally be corrected using bone grafts. Smoking increases the risk of poor bone healing. Rare instances of maxillary bone necrosis have been reported when the maxilla has undergone multiple sectioning as well as down fracturing.

Relapse: Relapse occurs by postoperative settling of the maxilla back toward its original position. Relapse occurs in patients who have a thin maxillary bone or in patients in whom stabilization is inadequate. Relapse is an unpredictable risk of orthognathic surgery. Many of the studies reporting relapse have limitations of sample size or the duration of follow-up, involving different surgical techniques being applied in the same sample, or suffer from limitations in the application of cephalometric measurements.

Relapse may be dental or skeletal or both. mandibular advancement appears to be stable, if rigid internal fixation is used (Van Sickels & Richardson 1996, Dolce et al. 2000, 2002) and if anterior facial height is maintained or increased (Proffit et al. 1996). Several factors may affect relapse in mandibular advancements: the surgeon´s skills; proximal segment control, including condylar positioning and prevention of proximal segment rotation; prevention of counterclockwise rotation of the distal segment in cases with a high mandibular plane angle; the degree of mandibular advancement; and stretching of the peri mandibular tissues, including skin, connective tissues, muscles, and periosteum. (Will et al. 1984, Smith et al.1985, Phillips et al. 1989, Moenning et al. 1990).[160]

The mandibular setback is not always stable, and the inclination of the ramus at surgery appears to have an important influence on stability (Proffit et al. 1996). The stability of maxillary osteotomies is affected by the magnitude of the anterior movement and the magnitude of the inferior repositioning of the maxilla, the adequacy of mobilization of the down fractured maxilla at surgery, the extent of bone contact in the newly established position of the maxilla and the type of fixation (Proffit et al. 1991a,b, 1996, Baker et al. 1992). Louis et al. (1993), on the other hand, did not find any correlation between relapse and the magnitude of maxillary advancement. The most stable maxillary procedure is superior repositioning, and forward movement is also reasonably stable. Inferior repositioning is less stable, especially if it causes downward rotation of the mandible and stretching of the elevator muscles of the jaw. The least stable orthognathic procedure is a transverse expansion of the maxilla. (Proffit et al.1996).

Condylar distraction: Condylar distraction occurs most often when there are interferences in the tuberosity or pterygoid plate.

Bleeding: Bleeding can be a significant problem in orthognathic surgery. With maxillary surgery the most common bleeding areas are the following:

i. Descending palatine vessels and the anterior or posterior palatine vessels
ii. Posterior superior alveolar vessels
iii. Pterygoid plexus

iv. Internal maxillary artery

v. Periodontal Defects

Uncontrolled haemorrhage in the jaws may result from either a mechanical disruption of blood vessels or congenital or acquired coagulopathy (Christiansen & Soudah 1993). The most common cause of haemorrhage in association with orthognathic surgery is a lack of surgical haemostasis (Lanigan et al. 1990a, 1991a). Variations in the bony or vascular anatomy or inadvertent handling of tissues with normal anatomy, hypotensive anaesthesia, or infection may be causes of immediate or secondary haemorrhages. If a major haemorrhage can be avoided, recovery is quicker (Neuwirth et al. 1992).

Maxillary osteotomies, especially LeFort I and II osteotomies, have the potential for the most serious bleeding sequelae in orthognathic surgery. These complications may present as immediate intraoperative bleeding or as postoperative swelling or epistaxis.

The most common sources of hemorrhage are the terminal branches of the internal maxillary artery, especially the descending palatine or sphenopalatine arteries. Bleeding from these may be caused by a curved osteotome, drilling, an oscillating saw, or a down fracture of the maxilla. The down fracture may even damage the internal carotid artery, if a basal skull fracture ensues that involves areas such as the foramen lacerum and the carotid canal. Even arterio-venous fistulas are possible. (Lanigan 1988, Lanigan et al. 1990a, 1991b, Mehra et al. 1999).

Most bleeding associated with mandibular osteotomies tends to be intraoperative and occurs rarely compared to maxillary osteotomies (Lanigan et al. 1991a). If the soft tissues are retracted properly to allow the operation to be done completely in a periosteal envelope, the risk for significant hemorrhage is small. Severe, prolonged disturbances in blood circulation may lead to avascular tissue necrosis, which may cause tooth devitalization, periodontal defects, or even loss of major bone segments. Due to the dense network of anastomoses in the face, this is a rare event but may manifest both in the maxilla and the mandible, especially in association with segmental osteotomies.

The anterior part of the maxilla is a special risk zone. (Epker 1984, Lanigan et al. 1990b, Lanigan & West 1990, Lanigan 1995). Although, in animal studies, preservation of the descending palatine artery was not found to be critical for maintaining blood flow to the down fractured maxilla (Bell et al. 1975, 1995), Lanigan et al. (1990) recommended that the artery should be preserved whenever possible and the segmentalization of the maxilla should be minimized. A wide, intact soft tissue pedicle is important for the circulation of the down fractured maxilla. In the mandible, avascular necrosis can be largely avoided by minimal stripping of the mucoperiosteum and muscle attachments (Bell &Schendel 1977).

Periodontal problems usually are caused by one of the following factors:

- Tearing of the interdental soft tissue
- Trauma to adjacent soft tissue and bone
- Vertical incision at interdental areas
- Damage to palatal tissues

Nerve Injury The infraorbital nerve frequently receives trauma primarily from retraction. One of the more damaging types of injuries is the severe stretch injury. If the anterior, middle, and posterior branches of superior alveolar nerves are cut, numbness to the teeth and buccal gingiva may remain for a considerable time. Nerve injuries in orthognathic surgery can be caused by indirect trauma, such as compression by surgical edema, or direct trauma, such as compression, tear, or cut with surgical instruments or stretching during manipulation of the osteotomized bone segments (Ylikontiola 2002). Seddon (1943) classified neurosensory and motor deficits into three categories to characterize the morphophysiological types of mechanical nerve injuries: neuropraxia, axonotmesis, and neurotmesis.

Neuropraxia is the mildest form of injury, and it is described as slight localized myelin sheath damage without continuity defect. Most inferior alveolar nerve (IAN) injuries following bilateral sagittal split osteotomy of the mandible (BSSO) are neuropraxia and may be due to nerve manipulation, traction, or compression. Normal sensation or function is usually recovered within two months.

Axonotmesis is characterized by disruption and damage to axons and the myelin sheath without disruption of the perineurium or epineurium. This is due to greater or more prolonged injurious forces, and a longer and more profound neurosensory deficit follows than in neuropraxia.

Neurotmesis is a severe disruption of the nerve trunk, which may cause a profound and possibly permanent neurosensory deficit.

The incidence of neurosensory deficits in IAN after BSSO has been reported to vary from 0% to 85%. This wide range of incidence may reflect the variation in the number of subjects in the study groups, the follow-up times, and the sensibility testing methods. (Westermark 1999). Several factors have been proposed to predispose neurosensory injury to IAN: the patient´s age; the surgeon´s skills; the magnitude of mandibular movement; additional genioplasty; and the degree of manipulation of the IAN

(Westermark 1999, Ylikontiola 2002, Van Sickels et al. 2002). Even after perfectly performed sagittal splitting, there may sometimes occur sensibility disturbances, which have been proposed to be caused by manipulation of the IAN during the soft tissue dissection in the initial phase of BSSO (Jones & Wolford 1990, Jääskeläinen et al. 1995, Westermark 1999). Due to the common use of BSSO, further studies to develop the dissection techniques are indicated.[161]

Reports on lingual nerve (LN) sensory deficits are fewer than reports on IAN sensory disturbances. The initial postoperative incidence has varied from 1% to 19% (Schendel & Epker 1980, Jacks et al. 1998), but according to most reports, the sensory deficit of LN tends to resolve over time. The proposed mechanism of injury to the LN appears to be associated with the fixation methods, either bone screws or wires, or with medial side tissue retraction.

Facial nerve injuries in orthognathic surgery are rare, but the consequences of such injuries may be devastating to the patient. Damage to the marginal mandibular branch of the facial nerve is a well-known complication of extraoral approaches to the mandibular ramus or angulus, but these approaches in current orthognathic surgery are rare. The facial nerve has been reported to be damaged in intraoral vertical sub condylar osteotomy and BSSO setback procedures with an incidence of less than 1%. The presumed trauma mechanisms have been compression caused by retractors behind the posterior ramus, fracture of the styloid process, and direct pressure as a result of distal segment setback.

Neurosensory impairment in the greater palatine and infraorbital nerves may be encountered after maxillary osteotomies. The incidence of prolonged sensitivity disturbances has been reported to be less than 4%, and they do not seem to bother the patients (De Jongh et al. 1986, Karas et al. 1990, De Mol van Otterloo et al. 1991).

TMJ complications: TMJ fibrous ankylosis or hypomobility following orthognathic surgery has been proposed to be caused by several factors: immobilization of the TMJ by intermaxillary fixation (IMF) (Ellis & Hinton 1991), iatrogenic displacement of the condyle posteriorly, and intra-articular hematoma (Nitzan & Dolwick 1989) or excessive stripping of the periosteum and muscle attachments in the ascending ramus, resulting in scar contraction and my fibrotic tissue formation (Storum & Bell 1984).

Fibrillation and erosion of condylar cartilage may be consequences of these factors, resulting in hypomobility or even condylar resorption.

Idiopathic progressive condylar resorption is a rare condition that has been considered to be caused by factors that diminish the normal functional remodelling capacity (age, systemic illnesses, hormones) or increase the biomechanical stress on the TMJ (occlusal therapy, internal derangement, parafunction, microtrauma, unstable occlusion). As a consequence of these, a decreased condylar head volume, ramus height, growth rate (juvenile), progressive mandibular retrusion or retrognathia, and a limited mandibular range of motion may occur. (Arnett et al. 1996a). The incidence of idiopathic condylar resorption is unknown. Arnett and Tamborello (1990) found 10 cases (1.2%) of condylar resorption in a population of approximately 800 dentofacial deformities examined over 10 years. Condylar resorption has been associated with orthognathic surgery. Several risk factors have been proposed. Preoperative morphological or functional factors include radiological signs of osteoarthrosis, TMJ dysfunction, condyles with a posterior inclination, a high mandibular plane angle, and a low posterior-to-anterior facial height ratio (Kerstens et al. 1990, Moore et al. 1991, Merkx& van Damme 1994, Bouwman et al. 1994, Arnett et al. 1996 Hoppenreijs et al. 1998, Hwang et al. 2000).

Contributing surgical factors include major mandibular advancement, counterclockwise rotation of the mandibular proximal fragment, IMF, rigid internal fixation, bimaxillary osteotomies, and avascular necrosis of the condyle (Schellas et al. 1989, Kerstens et al. 1990, Moore et al. 1991, Merkx& van Damme 1994, Bouwman et al.1994, Cutbirth et al. 1998, Hoppenreijs et al. 1998). Young females (15–30) have a higher risk for condylar resorption than males and older females (Kerstens et al. 1990, Moore et al. 1991, Merkx& van Damme 1994, Arnett et al. 1996 Hoppenreijs et al. 1998). The incidence of postoperative condylar resorption has been reported to vary from 1% to 31%.

This is probably partly due to the great variation in the study populations (Kerstens et al. 1990, Moore et al. 1991, Bouwman et al. 1994, De Clercq et al. 1994).

Infection Infections can occur in the maxilla around bone plates, interosseous wires, hydroxyapatite grafting. Infection after orthognathic surgery may be acute or chronic, local or general. Most postoperative infections are caused by endogenous bacteria, most likely aerobic streptococci (Peterson 1990). Infection is initiated if the equilibrium between the host's defense system and bacterial virulence is lost. Factors contributing to this in orthognathic surgery populations may be the usage of steroids, the duration of the surgical procedure, the patient's age, interference with the blood supply to the bony segments, dehydration of the wounds, presence of foreign bodies or sequestrum, hospitalization in large wards, nutrition, hematomas, and smoking. The surgeon's experience, a good aseptic technique, and gentle tissue handling are also relevant factors. (Peterson 1990). In the classical wound cleanness classification, normal orthognathic surgery wounds fall into the Class II category (Clean Contaminated Wound). An infection rate of 10% to 15% can be expected without the use of antibiotics, in comparison to Class III with an expected infection rate of 20% to 30%. In a Clean Wound (Class I), the probability of infection is approximately 2%. (Peterson 1990).

Studies dealing with infection after mandibular osteotomies report infection rates ranging from 0% to 18% (White et al. 1969, Guernsey &DeChamplain 1971, Willmar et al. 1979, Martis&Karabouta 1984, Buckley et al. 1989). In maxillary osteotomies, infection rates lower than 6% are mostly reported (Kufner 1971, Perko 1972, Kahnberg&Enström 1987), but in the study of Zijderveld et al. (1999), a 52.6 % infection rate was found in a placebo medication group with bimaxillary surgery.

There is some controversy concerning the need for prophylactic antibiotics (Peterson 1990, Martis & Karabouta 1984, Zijderveld et al. 1999), and many different practices exist. The operator must assess dosage, timing, duration of therapy, and side effects when considering antibiotic prophylaxis. [162]

Peterson (1990) has outlined the following principles for rational use of antibiotic prophylaxis in orthognathic surgery: (1) the surgical procedure should involve significant risk for infection. Wound Cleanness Class II includes an increased risk for infection (10–15%), as do bone grafts; (2) correct antibiotics should be selected; (3) the antibiotic level should be high; (4) the antibiotic must be administered in a correct time sequence; (5) the shortest effective antibiotic exposure should be used.

Non-union. usually occurs because of the lack of a bony interface, excessive mobility, or infection.

Other Complications: Fractures of the osteotomized segments in BSSO, i.e., bad splits, have been reported to occur in 3% to 23% of cases (Van Merkesteyn et al. 1987, Ylikontiola 2002). Ophthalmic complications are rare sequels of maxillary osteotomies. They include decreased visual acuity, extraocular muscle dysfunction, neuroparalytic keratitis, and nasolacrimal problems (Lanigan et al. 1993). These injuries appear to be caused by indirect trauma to the neurovascular structures during the pterygomaxillary dysfunction or fractures extending to the base of the skull.

Other problems, such as endotracheal tube damage (Thyne et al. 1992), tympanometric changes (Baddour et al. 1981), and prolonged dysphagia (Nagler et al. 1996), have been reported. Even life-threatening events may occur (Edwards et al. 1986).

Periodontal problems and tooth damage may be encountered, especially in segmental osteotomies. Problems are probably mostly caused by errors in the surgical technique. The design of the soft tissue incisions is critical: vertical incisions in the area of osteotomy will predictably create periodontal problems. Trauma to the palatal mucoperiosteum is a risk. Excessive heat generation with oscillating or rotating instruments, soft tissue injury, or excessive interdental bone removal may result in compromised vascular supply to the area, as does also marked repositioning of the segment. (Wolford 1998).

PATIENTS SATISFACTION

According to a news report, nearly 20% of women in Seoul now undergo cosmetic surgery procedures, and it is an increasingly dominant practice among young people. Twenty years ago, nobody could imagine that orthognathic surgery would be one of the most popular local clinic-based operations in our country. Amid such a boom of orthognathic surgery, there is the concept of surgery-first approach (SFA)[53]. The shortening of the total treatment period and immediate facial change would be the most powerful advantages of this approach. Since patients do not need to wait long for orthognathic surgery, the emotional barrier for surgery became attenuated.

The innovative improvement in orthodontic treatment also supported the success of this concept considerably. Similarly, the author selectively performs mandibular setback surgery using SFA or minimal pre-surgical orthodontics. The definition of real success in the medical field first started from the recognition of the problem and strong will to overcome such a problem. In this perspective, SFA was successful in terms of focusing on the patients' chief problem. Nonetheless, another condition for real success in the medical field - "accountability" - needs more attention. "Accountability" means the surgeon's ability to explain clearly the specific reason and course of treatment in a predictable, measurable way.

It might be attributed to the lack of consensus in indication/contraindication and long-term follow-up data. Nowadays, all practitioners and patients are exposed to mass media and high-speed Internet.

Every patient can compare the interior/exterior of the clinic, service fee, and reputation of the surgeon easily via the web community. Even with scarce scientific data, however, some operation techniques were exaggerated by aggressive advertisements in mass media.

Our surgeons encounter many patients with hot tempers and high expectations. Moreover, it is difficult to find room for accountability of the new surgical concept in the middle of the battle of priority in orthognathic surgery. Let's reflect on one example of accountability of the surgical concept. The mortality rate of wounded soldiers was 42% in the late 18th century in the US, 30% in the 2nd world war, and 25% in the Vietnam War. It remained at 25% for 25 years until the Gulf War.

Today, it is lower than 12% in the US army in the late 2000s. What was the main reason? It was very simple; surgeons tried to treat patients not more than 6 hours in the emergency unit near the battlefield. After the short, fundamental life-saving procedure, patients were immediately transferred from Afghanistan or Iraq to the US. Sometimes, the surgeon taped the opened abdomen and transferred the patients to a comprehensive surgery center in the US. Before transferring the soldiers, every primary care surgeon wrote the record very precisely and attached the documents to the soldier's body. This successful new attempt was based on a thorough investigation of the experience in the Vietnam War. Following a meticulous analysis of the outcomes of this attempt, the US surgeons finally established the new treatment concept for war casualties. Going back to orthognathic surgery, we know that orthognathic surgery has a certain amount of relapse, instability, and unpredictability. Of course, nearly every patient is satisfied with the surgical outcomes of orthognathic surgery.

Still, can we determine the exact number of percentages of long-term relapse in our operations? Can we explain the improvement of stability of the recent 5 years of operations compared to 5 years before that? This fundamental question concerning “accountability” can improve our practice and can make a breakthrough in our field. As for the conventional orthognathic treatment procedure, SFA needs to show scientific evidence as to whether this procedure can have a definitive advantage in terms of accountability.

We need to go beyond patients’ satisfaction. If SFA would be a paradigm shift in the orthognathic surgery field, investigation of the scientific basis and objective review of the outcome would be essential. Otherwise, this might be one of the faddish trials. True, we do not have enough time to spend just for evaluation in this fast-changing environment. Nonetheless, we need to take note that surgeons in other countries did just that under the most challenging situation.

CONCLUSION

Performing orthognathic surgery before orthodontic treatment has multiple advantages like shortened treatment time, increased patient acceptance, and the utilization of the regional acceleratory phenomenon. If the cases are selected carefully, the orthodontist and the surgeon are experienced enough to predict the final occlusion, and the level of cooperation between the clinicians is high, the results are very promising. However, even the slightest error during the treatment planning, surgical, and post-surgical orthodontic steps can be very difficult to correct. By utilizing the principles of surgery first technique, the pre-surgical orthodontics period can be shortened even if it is not eliminated.

As with any other surgical procedure, the patient's well-being and chief complaint should always be the first priority. The future of orthognathic surgery is geared toward minimizing the overall treatment time without compromising the final results.

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