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Current Approaches in Orthognathic Surgery

Mustafa Sancar Atac

Abstract

The orthognathic surgical procedures are performed for the correction of abnormalities of the facial skeleton that are present from the birth or arise during growth or acquired secondarily during lifetime. Due to the cover of this book as orthodontics, I would prefer to summarize some commonly used techniques to correct the dentofacial deformities. Even we have published all these techniques at their popular time with our orthodontist colleagues; skeletal anchor systems, some basic interdental osteotomies, or complex mechanics that are applying orthopedic corrective forces are currently being used by the orthodontists rather than surgeons. Le Fort I osteotomy in maxilla and sagittal split ramus osteotomies (SSRO) in mandible are commonly used techniques to solve the deformity problems of the facial skeleton; therefore, the scope of this chapter is going to be including my personal experience and some technical details with Le Fort I and SSRO.

Keywords: orthognathic, surgery, dentofacial deformity, Le Fort I osteotomy, sagittal split ramus osteotomy, maxillary osteotomy, mandibular osteotomy, airway, facial esthetics, genioplasty, facial harmony, piezoelectric surgery, piezosurgery

1. Introduction

The orthognathic surgical procedures are performed for the correction of abnormalities of the facial skeleton that are present from the birth or arise during growth or acquired secondarily during lifetime. The variety of the underlying reasons of the facial deformities would require different types of surgical strategies, but mainly orthognathic surgical techniques are preferred for the rehabilitation of the deformities. Due to the cover of this book as orthodontics, I would prefer to summarize some commonly used techniques to correct the dentofacial deformities.

Skeletal anchor systems, some basic interdental osteotomies, or complex mechanics that are applying orthopedic corrective forces are currently being used by the orthodontics rather than surgeons. Even we have published all these techniques at their popular time period with our orthodontist colleagues. Therefore in this chapter, I will focus on the most commonly used surgical applications to solve the skeletal discrepancies mainly called as Le Fort I osteotomy and BSSRO. These techniques can be applied as a single-jaw surgery or double-jaw surgery depending on the magnitude of discrepancy of the jaws to each other. Besides these basic techniques can also be preferred in association with distraction osteogenesis or orthodontic elastic traction forces for gradual and slow motions of the segments as well, but I think it is better to discuss the indication not in this chapter. Therefore the scope of this chapter is going to be including my personal experience and some technical details with Le Fort I and SSRO.

2. Bilateral sagittal split ramus osteotomy (BSSRO)

The history of orthognathic surgical techniques goes back to the mid-1800s. Both in Europe and the USA, the corrective jaw surgeries at their first steps begun to be heard by the population. Schuchardt was the author who first described the sagittal split in 1942 in German literature [1]. In English literature, Trauner and Obwegeser were the pioneers in 1957 who described and discussed the technique in detail [2]. Dal Pont [3], Hunsuck [4], and Epker [5] all added modifications to the technique such as to maintain more surface contact between bony segments at outer cortex, obtaining a minimal horizontal cut in the medial surface of ramus just beneath the lingula and minimal muscle detachment to avoid postoperative blood loss and hematoma.

2.1. Indications

BSSRO is a perfect option for surgical treatment of dentofacial deformities including the mandibular deformities. The mandible can be repositioned in three dimensions of the space such sagittal direction (as advancement, setback), transversal direction (asymmetries and shifting from one side to the other or transversal rotation), and axial plane (clockwise or counterclockwise rotation). For each movement a patient-specific osteotomy and muscle dissection should be kept in mind to avoid postoperative relapse and skeletal disfigurement. On the other hand, while planning such osteotomies, the facial harmony, speech, tongue size, esthetics, and most importantly the airway should be precisely evaluated. As an example huge magnitude of setback of the mandible would result as decreased airway volume and in advance as OSAS. The preoperative evaluation should include a 3D airway evaluation. If such compromise occurs, other osteotomy techniques should be analyzed such as mandibular ostectomy, IVRO. Also in macroglossia patients, tongue reduction surgery should be kept in mind before or during operation in setback surgeries to avoid dentoskeletal relapse. The incision would be placed on the ascending ramus in proximal segment and be carried inferiorly on the distal segment over the external oblique linea, while a mouth gag or a position stabilizator is placed on the opposite side with maximum mouth opening. Care must be taken to avoid dislocation

of any condyle during this point (**Figure 1**). An electrocautery knife or a 15 blade would be preferable depending on the surgeon. My choice is the Colorado Needle which may help us for delicate incision without necrosis of the soft tissue with a good bloodless vision. The trick with the electrocautery is to perform repetitive coagulations on the same soft tissue plane to avoid tissue necrosis. A layer-by-layer dissection of mucosa muscles and periosteum is necessary. Adequate amount of soft tissue should be remained on the attached gingival side for wound closure. The mucoperiosteal full thickness flap is raised on the external oblique linea. If the temporal muscle tendons are identified, they can also be reflected. An Obwegeser ramus retractor or a curved hemostat is positioned on the tip of coronoid process. The anterior inferior border of the mandible which is close to the external oblique linea can also be reflected, and during bone osteotomies an Obwegeser channel retractor should be placed on the inferior mandibular border. The lingula and the mandibular foramina should be identified on the medial surface of the mandibular ramus and a Williger or Obwegeser raspatorium is used to protect the neurovascular bundle above its insertion to foramen mandibularis. This maneuver will guide to horizontal medial bone osteotomy just above the foramina. There is no need to perform posterior dissection to the posterior border of the mandible. It is better to create a soft tissue tunnel subperiosteally and keep it just to the posterior of the foramina. This will also reduce the possible intraoperative excessive bleeding arising posteriorly and medially from the adjacent muscle and vessel structures (**Figure 2**). Once all the bony aspects of the desired osteotomy lines have been approached, depending on the surgeon's preference, a cutting instrument like saws, rotary handpiece, or piezoelectric surgery handpiece can be used. If the patient has no cardiac disease like arrhythmias or is not a pacemaker user, my first choice is piezoelectric ultrasonic surgery. The piezoelectric ultrasonic surgery is a well-defined system, the first steps of which were discovered by Pierre and Jacques Curie Brothers in 1880. Piezoelectricity is the electric charge that accumulates in certain solid materials (such as crystals certain ceramics, and biological matter such as bone, DNA and various proteins) in response to applied mechanical stress. The first ultrasonic alveolar bone cut was performed by Horton on the dog alveolus in 1975 [6]. In piezoelectric surgery, the cavitation phenomenon

Figure 1. The incision line placed over the external oblique line and ascending ramus. Carrying it to high and medially will cause herniation of temporoparietal fat pad (Bichat's fat pad).
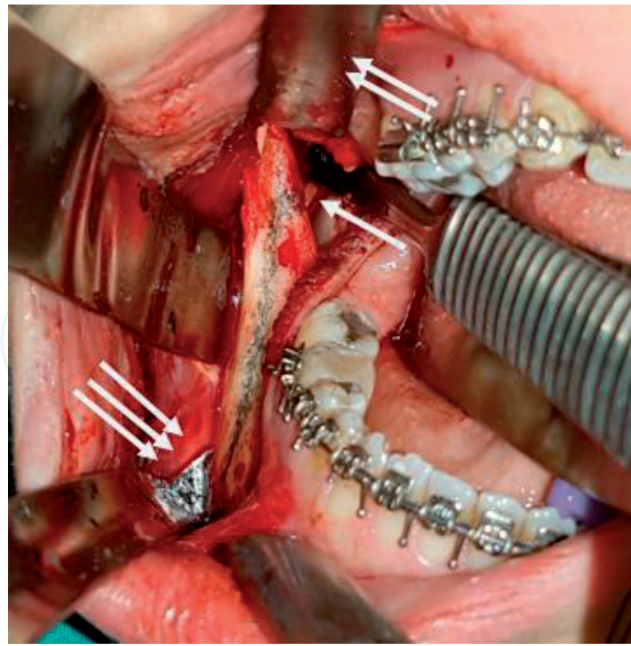
Figure 2. Ramus single white arrow: alveolaris inferior neurovascular bundle; double white arrow: Obwegeser ramus retractor; and three white arrows: Obwegeser ramus channel retractor. Please note that the Obwegeser periosteal raspatorium is placed above the foramina and protecting the neurovascular bundle. Also a sub periosteal dissection has been performed creating a tunnel to avoid haemorrhagia. Also pay attention to pencil drawing along the ascending ramus declining on the external oblique linea finalizing at the anterior most inferior edge of the linea. This cut will create a separation between distal and proximal segments.

describes the process of vaporization, bubble generation, and subsequent implosion (growth and collapse of bubbles) into many minute fractions of its original size (microscopic gas bubbles) that will occur in a flowing liquid because of the decrease and increase in pressure that is caused by the ultrasonic vibrations. In ultrasonic osteotomy, the cavitation phenomenon helps to maintain good visibility in the operative field by dispersing a coolant fluid as an aerosol that causes the blood to essentially be washed away. Furthermore, the cavitation effect will bring about hemostasis, which results in a bloodless surgery. Walmsley et al. have suggested that the cavitation effect fragments the cell walls of bacteria and therefore has an antibacterial efficiency [7]. Also, piezoelectric device has a selective cutting effect and has a sound alert warning system when the tip has reached to a nonresisting part such as neurovascular bundle or sinus membrane that avoids trauma to soft tissues. Therefore, hemorrhagic and neurosensory deficits are rare in piezoelectric surgery. Afterward Vercellotti published his experience with piezoelectric surgery [8]. In orthognathic surgery Landes et al. shared their experience with piezo-osteotomy feasibility as a substitute for the conventional saw in orthognathic surgery that was evaluated regarding operative technique, blood loss, time requirement, and nerve and vessel integrity. Fifty patients who had orthognathic surgery procedures using piezo surgical osteotomy showed that piezoelectric osteotomy reduced blood loss and inferior alveolar nerve injury at no extra time investment, compared with 86 patients who received conventional saw and chisel osteotomies [9]. We have also evaluated piezosurgery in PhD thesis and compared the conventional rotary instruments with piezosurgery. The aim of this study is to comparatively evaluate primary postoperative patient complaints such as

edema, paresthesia, and pain and patient satisfaction and operation times of orthognathic surgical operations performed with conventional drills and piezoelectric surgery. A total of 200 patients with completed skeletal growth and malocclusion due to mastication dysfunctions were retrospectively evaluated. These patients were divided into two main groups named control group and piezo group. Each group was divided into three subgroups about the type of surgical procedure performed, which are, Le Fort 1 subgroup, bilateral sagittal split ramus osteotomy (BSSRO) subgroup, and bimaxillary subgroup. The evaluation between the groups is made at postoperative 1 day, 1 week, and 1, 3, and 6 months. To evaluate each subgroup, the data acquired from a specific subgroup was compared to the subgroup with the same name in the other main group. After piezoelectric surgery edema, neurosensory dysfunction and pain levels were found to be lesser than conventional techniques. Patient satisfaction was found to be higher in piezoelectric surgery patients. When operation times were compared, piezoelectric surgery was discovered to take longer to finish the osteotomy because of its lower cutting efficiency. This study shows that the selective cutting ability of the piezoelectric surgery device provides an extremely safe osteotomy for patients by performing a selective osteotomy, thus preserving critical adjacent soft tissues [10]. The piezosurgery begins with the medial aspect of the ramus just over the mandibular foramina, and the cutting tip of the handpiece will be directed 45° angle at posterior start point with around a depth of 2 mm and comes anteriorly. On the ascending ramus, the tip is applied without angulation as deep as possible through the cortex to reach the medullary bone and declines inferiorly on the external oblique linea. If the procedure is a mandibular setback surgery, it is better to extend the osteotomy till the anterior border of the external oblique linea which would help the removal of bony segment for desired positioning of the distal segment similar to Hunsuck-Epker modification. In my experience if a rotational or laterognatic corrective sagittal split osteotomy is going to be performed, the anterior vertical osteotomy on the lateral cortex would be like Obwegeser technique that goes posteriorly to the angulus of the mandible. Besides if the rotation amount is excessive, care must be taken not to dislocate the proximal segment laterally. If such situation occurs, a greenstick fracture must be performed on the posterior part of the distal segment distal to the last molar. In thin and small volumetric mandibles generally, piezoelectric ultrasound surgery is enough to complete the whole osteotomy running from the superior cortex border to the inferior bony cortex border through a fashion without chisel and hammer or separators. Also, this would avoid unfavorable fracture of the segments during rotation split maneuver of the osteotomes that are placed between proximal and distal segments. To avoid undesired inferior border, splitting piezoelectric surgical instruments tips can be directed to the inferior border to maintain a bone cut at the inferior border initiating from the end of the anterior vertical osteotomy back to the posterior end just inferior to orthogonal projection of the lingula. The osteotomy and separation of the proximal and distal segments will simultaneously be completed via this technique without chiseling and hammering. I personally call this technique as Piezotomy Technique®. If the osteotomes are needed to complete the osteotomy, thin osteotomes would be helpful to complete cortex osteotomies keeping them away from the neurovascular bundles. While osteotomizing the inferior border of the mandible, the Obwegeser channel retractor is essential to guard the underlying soft tissues and vital structures. It is better to use a thin osteotome to start separation of the segments seen in **Figure 3**. Completing the osteotomies bilaterally and
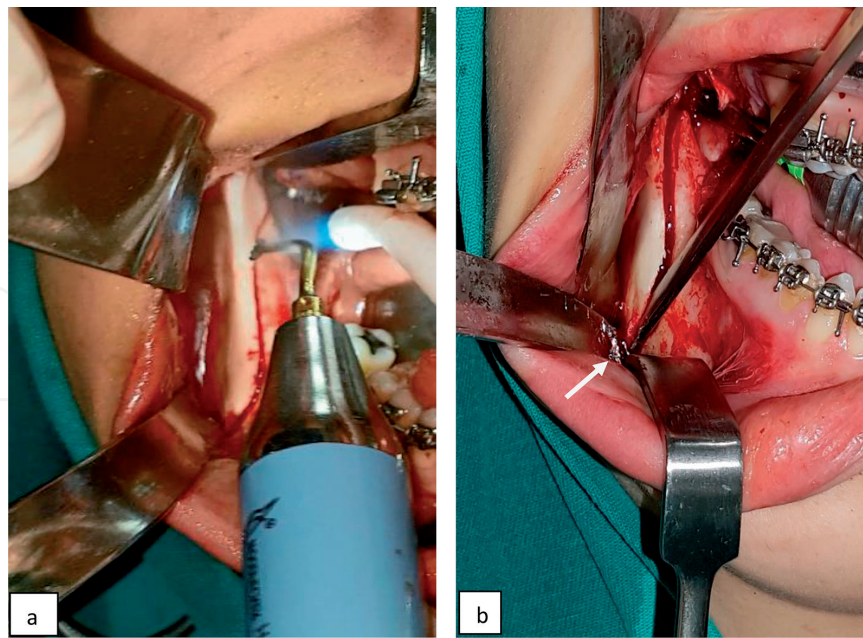
Figure 3. (a) Osteotomy line starting from medial surface of ramus down to ascending ramus to he external oblique linea inferiorly with ultrasonic surgery; (b) thin osteotome is placed for separation of outer cortex of the inferior border.
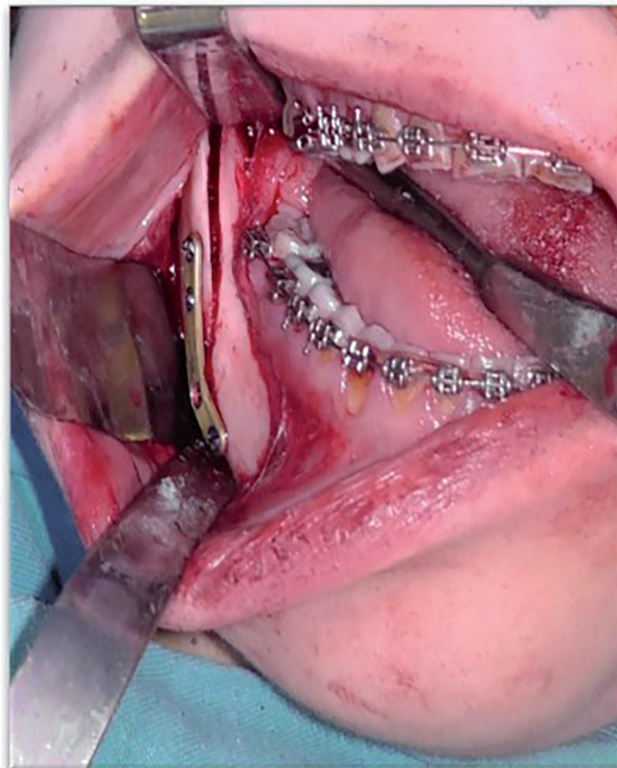

Figure 4. The sagittal mini plate has been bended and passively adopted to proximal and distal segments with monocortical mini self-drive screws and let mandible for early functioning.

detaching the muscle attachments that are resisting for mobilization of distal segment, the surgical splint is placed, and an exact intermaxillary fixation is secured. In this period if it is a setback surgery, the excess bone is removed. At this point, for rigid fixation, the surgeon can prefer lag screws or miniplates with screws to stabilize the segments. My personal choice is to use sagittal plates with self-drive mono cortical screws for rigid fixation. This is essential to avoid condylar sag and distortion of proximal segments as well, especially in the laterognatic and asymmetric cases that require shifting or rotation of the mandible. Also bending the plates geometrically to create a step would stabilize the segments in passive but stable position avoiding the relapse phenomenon. The proximal and distal segments are rigidly fixated (**Figure 4**). After bleeding control the wound edges will be sutured with 3.0 resorbable sutures. Suctioning drains are placed if required.

3. Le Fort I osteotomy

The maxillary discrepancies and the midface abnormalities can easily be corrected by Le Fort I level osteotomy with variable surgical modifications. In 1927, Wassmund performed the first Le Fort I osteotomy for an open-bite deformity [11]. The advancement of maxilla was performed by Axhausen [12], and Bell was the first to show the vascular supply and safety of the procedure at this osteotomy level [13]. The quadrangular Le Fort I was first described by Obwegeser in 1969 [14].

3.1. Technique

The patient is intubated via nasotracheal preformed intubation tube (RAE tube) to avoid nasal deformation during the surgery. Prior the incision a circular infiltrative local anesthesia is administered with vasoconstrictor agent. A mucosal incision at the vestibular fornix region from one premolar to another is initiated with Colorado Needle electrocautery (**Figure 5a**). To avoid repetitive coagulation, layer-by-layer single application is essential for deeper soft tissue structures down to the periosteum. A mucoperiosteal flap is raised both on sagittal and vertical plans. Laceration of the periosteum would result in discomfortable bleeding and herniation of Bichat fad pad. Depending of the level of the osteotomy, the reflection of the flap may extend up to the infraorbital region. A curved periosteal elevator would be essential for the elevation of the nasal mucosa on the medial sinus wall and midpalatal suture for each side (**Figure 5b**). If a collective fashion of haemorrhagia occurs, a fine rat tail tamponade with tranexamic acid solution will control it. Using piezoelectric ultrasonic surgery device, osteotomy will be initiated at the apertura priformis back to the crista zygomaticus and through the tuberosity of the posterior maxilla. Also via the piezosurgery tip, the medial antral wall osteotomy may be completed. Thanks to its selective cutting effect with cavitation phenomenon, also the palatine bone can be cut via piezosurgery. Even in some cases, from anterior nasal spine to posterior nasal spine, septal separation from midpalatal suture can be performed via piezoelectric surgery (**Figure 5c**). For each maneuver special piezo cutting tips can be preferred even for the pterygomaxillary junction region (**Figure 5d**). When all the
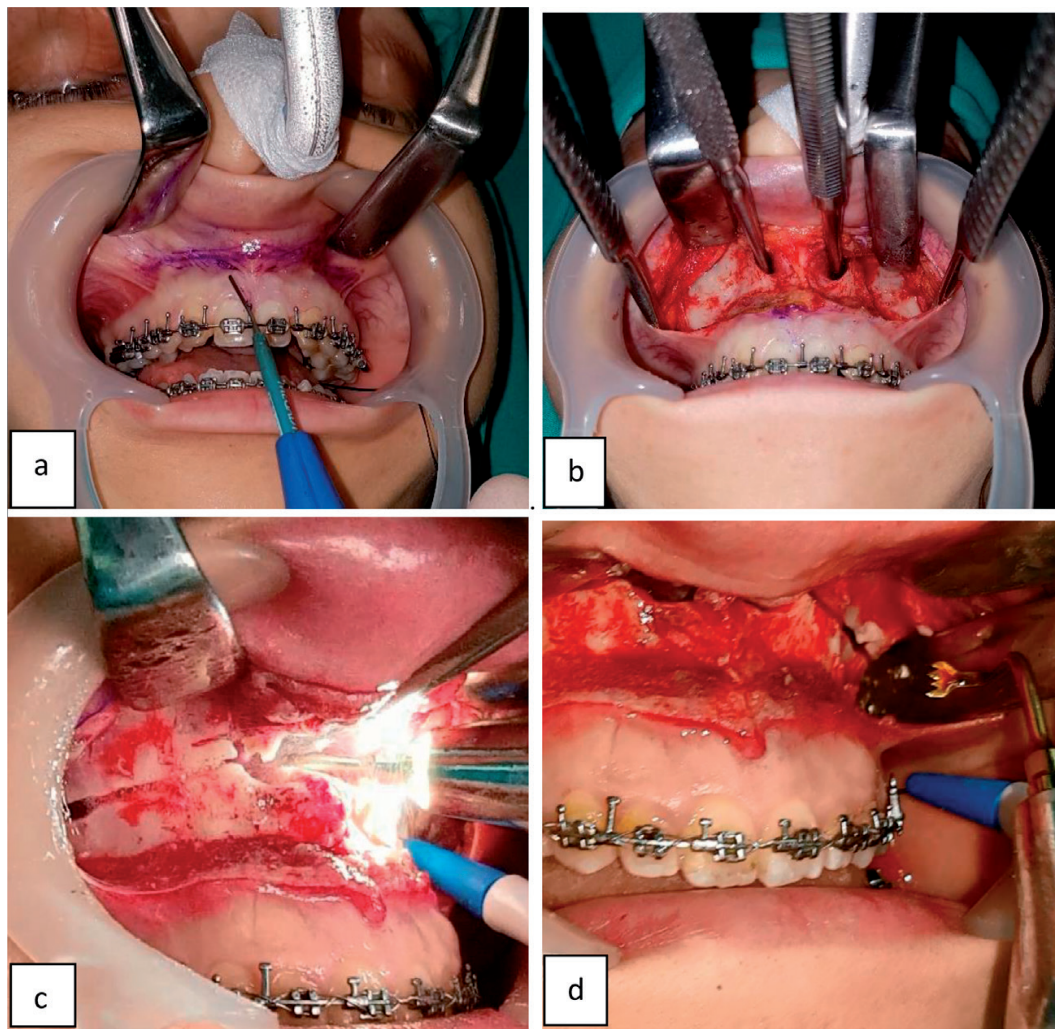
Figure 5. (a) Nasotracheal intubation via RAE tube, Colorado Needle for soft tissue incision, and the at very deepest sulcus, the incision is initiated between premolar regions; (b) soft tissue flaps created by subperiosteal tunneling; (c) anterior nasal spine to posterior nasal spine and also septal separation from mid palatal suture can be performed via piezo electric surgery; and (d) piezo cutting tips can be preferred even for the pterygomaxillary junction region.

osteotomies are performed via piezoelectric surgery, a bi-digital mild pressure on the anterior incisors is applied by the surgeon in vertical and sagittal directions for down fracture of the maxilla. In cases that osteotomies are performed by rotary handpieces or saws, the osteotomy lines are quite similar to piezosurgery, but care must be taken while malleating curved pterygoid osteotome to separate the pterygomaxillary junction. The surgeons' eye should follow the upper occlusion, and the osteotome should be parallel to this line to avoid directing it cranially. One should place the point finger of the assisting hand to the pterygoid hamulus intraorally to feel the tip of the pterygoid osteotome (**Figure 6**). If such malpositioning occurs, there is the risk of laceration of maxillary artery close to the posterior region. Also during medial antral wall osteotomy, care must be taken not to go so far posteriorly due to laceration risk for descending palatinal artery. Because around 3.5 cm posteriorly, the sound will change and a resistance will occur during chiseling. This means that one has reached to the perpendicular lamina of the palatine bone that descending palatine artery is
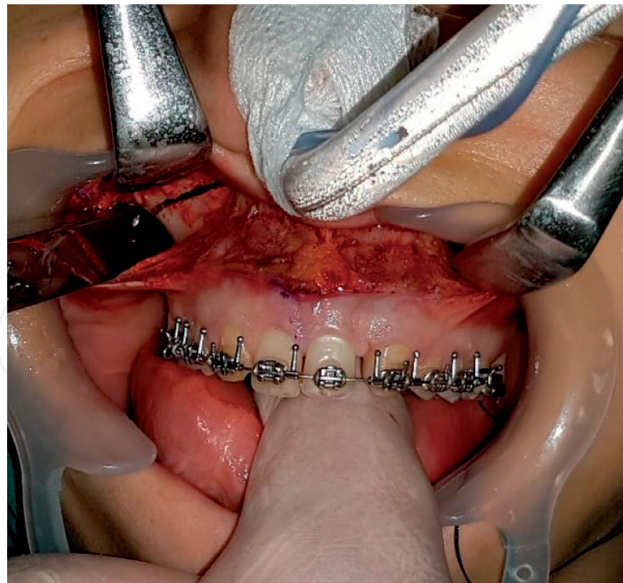
Figure 6. Pterygoid osteotome placed at the pterygomaxillary junction, and the assisting point finger is positioned on the hamulus pterygoideus to feel the disjunction and the tip.

running inside of it. If the surgeon is inexperienced, it is so easy to face an aggressive hemorrhage from the palatine artery. It can be controlled easily by direct packing with a immediate down fracture procedure to isolate the bleeding source. The septal cartilage and midpalatal bone would be separated using nasal septal osteotome. The assisting hand's point finger should be placed posterior-to-posterior nasal spine to feel the tip of the septal osteotome at the end (**Figure 7**). After the down fracture, Tessier mobilizers or Rowe forceps are used to mobilize the maxilla freely. At this point the lacerations on the nasal mucosa is sutured, and posterior reflection of the soft tissues was completed (**Figure 8a**, **b**). If the maxilla is going to be impacted, the septal cartilage would be trimmed as required to avoid deviation of the septum. If the anterior nasal spine is problematic for columella or nasal shape, it can also be removed till the desired level. If the magnitude of the advancement, impaction, or rotation is quite much, surgeon will face resistance; then decompression of the palatal artery and removal of the palatal bone around are necessary. These risky maneuvers can easily be done via piezoelectric surgery without bleeding. As an alternative, a round diamond rotatary burr can be preferred. Surgical saws may lead to hemorrhage. The maxilla will be repositioned with a surgical prefabricated splint followed by intermaxillary fixation. The bone edges are controlled, and interference of excessive bones is removed. When maxilla and mandible act as one unit due to intermaxillary fixation, rotation is completed by gentle force application on both sides of the mandibular premasseteric notches, and rigid fixation is performed (**Figure 9**). If regular micro- or miniplates are going to be used for rigid fixation; I suggest to use two plates on each side in inferior repositioning and advancement surgeries. If the maxilla is impacted, one four-hole L-shaped plate is adequate on each side. For the first time in the literature in 2008, I have published stress distribution both on plates (single- or double-plate fixation on each side) and facial skeleton after rigid fixation in Le Fort I osteotomies for all scenarios, and since 10 years, I clinically follow the guidelines of my publications to choose the number of the plates for each case [15–17].Also as an alternative, I
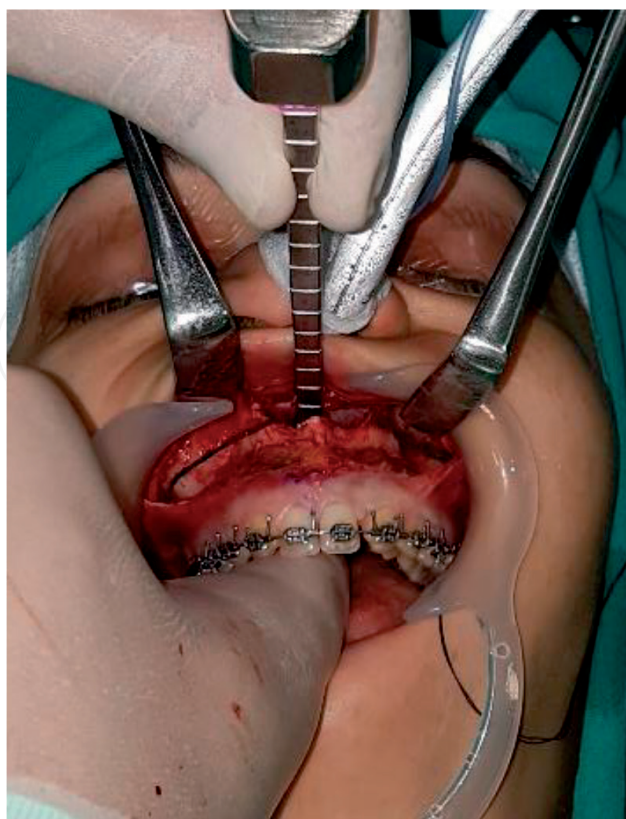
Figure 7. Nasal osteotome is placed on the midline just below the septum to separate the septal cartilage and the mid-palatal bone junction. Assisting point finger placed on to the posterior nasal spine.
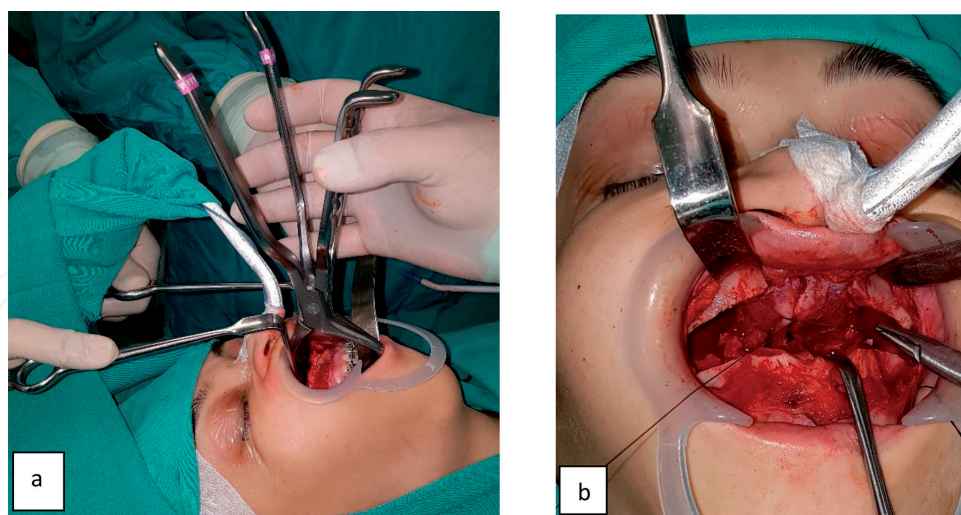

Figure 8. (a) Rowe forceps placed bilaterally on the down fractured maxilla to complete the disjunction, (b) suturing the nasal mucosa ruptures.

suggest to use preformed Le Fort microplates that are currently available on the market with different shoulder sizes (**Figure 10**). Another current advancement in rigid fixation materials is the patient-specific titanium miniplates that are manufactured via 3D printers. The use

Figure 9. Intermaxillary fixation with a surgical splint, and superior repositioning of the complex with gentle pressure that has been applied bilaterally on both premasseteric notches.
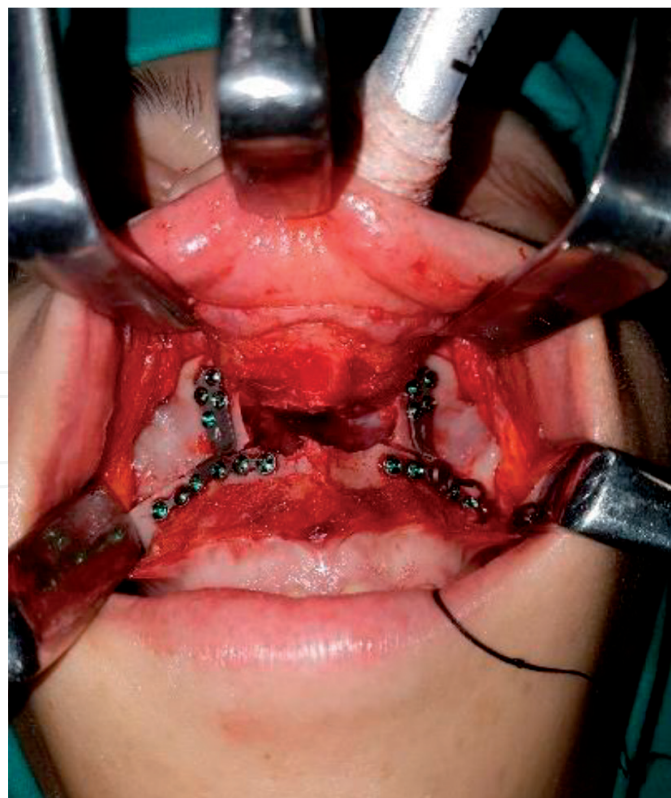

Figure 10. Preformed Le Fort miniplates and self-drive screws used for rigid [18] fixation. This special form supplies enough rigidity with just one plate and there is no need to place posterior plates around zygomatic buttress.
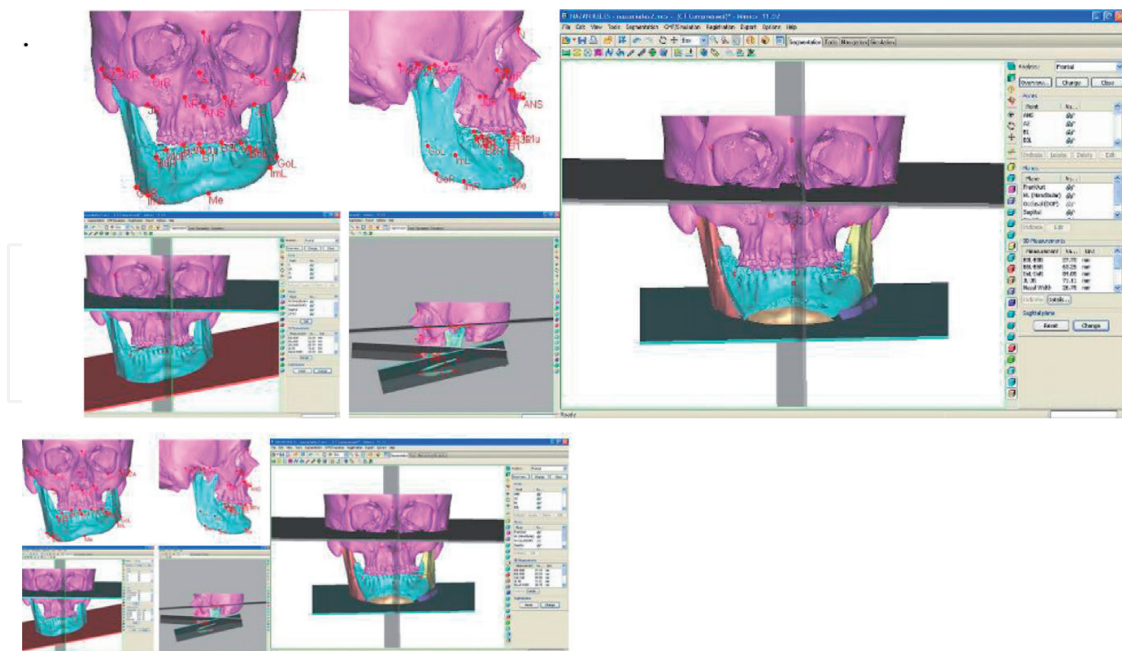
Figure 11. 3D evaluation and planning of a hemimandibular hyperplasia case using DICOM data with a surgical software, published in Journal of Cranio-Maxillofacial Surgery in 2009.

of 3D surgical planning in orthognathic surgery cases is on the market more than 10 years. Meanwhile we also published a paper with 3D tomographic DICOM data transferred to software and completed the operation virtually in 2009 (**Figure 11**) [18]. Depending on surgeons and orthodontist's choice, currently there are many alternatives to each other starting from conventional cast model articulating and model set up on casts, to 3D analyze and 3D printing of surgical splints and titanium fixation plates. On the other hand, higher technology for planning and manufacturing with 3D printers increases the financial expenses. After rigid fixation of the maxilla, the alar wings, nasal tip, and nostril symmetry and projection of the upper lips and the gums should all be evaluated. If the maxilla has been impacted, the nostrils and the nasal soft base will be wider, and alar chinch suture is essential to control the width. Also, a V–Y closure will help to improve the philtrum projection.

4. Bimaxillary surgery

The sequence of these surgeries may vary from surgeon to surgeon. My traditional way to do double jaw is to start with the maxilla first then complete the mandible. But in one indication, one should always start with mandible first which is the double-jaw counterclockwise surgery. Especially Class II with maxillary excess with gummy smile cases associated with OSAS or airway limitations, there is indication for counterclockwise double surgery. The surgical strategy should be mandibular advancement surgery with posterior inferior repositioning and anterior superior rotation. The space created at posterior occlusion is then filled with inferior rotation of the posterior maxilla with anterior maxillary impaction with Le Fort I osteotomy. The pivot point to perform this maneuver is premolar and zygomatic buttress region.

5. Conclusion and the future

As I have briefly explained the basic techniques that are commonly used in orthognathic surgery, for 5 years we are already beyond the future. The current advancements are tomographic evaluation including 3D reformatted frames integrated to advanced software programs with facial scanning to analyze the facial proportions rather than 2D cephalometric radiographs and 3D scanning of the teeth integrated with tomography that let to us perform operation in virtual environment and print out 3D splints. Besides other advancements are; 3D printing of the individual titanium plate screw fixation systems will avoid producing surgical splints, as well as using piezoelectric surgery rather than burs and saws supplies for bloodless and neuro-sensorial deficit-free operations, finally last but not the least, a totally robotic guided surgery will take place within a couple of years.

Conflict of interest

I declare that there is no conflict of interest.

Author details

Mustafa Sancar Atac

Address all correspondence to: msatac@gmail.com

Faculty of Dentistry, Gazi University, Department of Oral and Maxillofacial Surgery, Ankara, Turkey

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