Surgery first approach in orthognathic surgery

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Abstract

Orthognathic surgery is a common method to treat dentofacial deformities. Combined orthodontic and orthognathic surgical treatment is necessary to treat severe deformities where only orthodontics cannot give an acceptable result. There are two approaches for orthognathic surgery: orthodontics-first and surgery-first approaches. The disadvantages of having orthodontic interventions both before and after orthognathic surgery include a long treatment time and temporary worsening of facial appearance. Nowadays, the concept of surgery first, followed by orthodontic treatment is applied to orthognathic surgery cases in different orthodontic centers in the world. This concept and technique is called "surgery–first–orthognathic–approach" or "surgery–first approach" (SFA) rigid fixation (skeletal anchorage system) of the bony segments and regional acceleratory phenomenon were keys to broad implementation of the SFA. This article is intended to review the concept, indications, advantage and potential problems of SFA.

Keyword: Orthognathic surgery, surgery first, approach, orthodontic first approach SFA, OFA

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Introduction

In 1849, Hullihen first reported the orthognathic correction of mandibular elongation.[1] After that there were many previous article about the numerous surgical techniques have been used for the dissection of the mandibular body or ascending ramus to correction mandibular prognathism.

In 1957, Trauner and Obwegeser[2] introduced bilateral sagittal splitting ramus osteotomy (BSSRO), which marked the beginning of the modern era of orthognathic surgery. This intraoral approach could move the mandible in three dimensions according to a designated surgical plan, keeping the condyle in the glenoid fossa, and, most importantly, maintaining sufficient bone contact area to allow primary bone healing after orthognathic surgery. After introducing osteotomy in the mandible, Obwegeser was also the first to develop Le Fort I osteotomy to move the maxilla in all three dimensions, reporting a large series of maxillary osteotomy cases in 1969.[3]

Pre-surgical orthodontic preparation was uncommon for patients requiring orthognathic surgery until the 1960s. The patients' and clinicians' desire for optimal esthetic and occlusal results led to the most common current treatment approach pre-surgical orthodontic decompensation of the occlusal relationships and attainment of normal dental alignment. The disadvantage of having orthodontic interventions both before and after orthognathic surgery include a long treatment time of 7–47 months, dental caries, gingival recession and root resorption.[4,5] Other complications associated with preoperative orthodontic treatment are temporary worsening of facial appearance and masticatory discomfort. When a patient refuses surgery after all the preparations have been made, the results can be catastrophic.

Brachvogel *et al.*[6] in 1991 proposed concept of "surgery-first and orthodontics second" with the goal of reducing some of the disadvantages and inconveniences of pre-surgical orthodontics. He claimed that the normalized surrounding soft tissues (lips, cheeks and tongue) settled teeth into better positions after surgery, facilitating remaining orthodontic tooth movement and reducing the total orthodontic treatment period.

Nowadays the concept of surgery-first followed by orthodontic treatment has been brought back to apply to orthognathic surgery cases in orthodontic centers in Korea, Japan and Taiwan. This concept and technique is called "SFOA" (Surgery-First-Orthognathic Approach) or "SFA" (Surgery-First Approach) which is defined as starting with the surgery with no pre-surgical orthodontic procedure and the orthodontic treatment is performed postoperatively[7,8,9]. The concept of this technique is for no prior tooth movement or minimal tooth decompensation for one to two months 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.[10] Daniel and Huang[11] reported that SFA could still have a minimum pre-orthodontic preparation period about two to three weeks for recording data, treatment planning, set-up model surgery, bonding and banding of orthodontic brackets and inserting surgical arch wire and hooks.

Surgery-first approach

A major driving motive for performing surgery-first orthognathics has been the reduced treatment time.[12-14] It has been shown that orthodontic treatment time decreases by using alveolar osteotomy procedures.

The proposed mechanism for this decrease in treatment time is the increase in cortical bone porosity that results in decreased resistance to tooth movement. It has been shown that during healing process after orthognathic surgery, there is an increase in blood flow above the presurgical levels which facilitates the healing process and stimulates bone turnover that can potentially speed up orthodontic tooth movement.[15,16]

Regional acceleratory phenomenon (RAP)

In 1977 Epker and Fish[7] described that bone turnover or remodeling in the entire bone area receiving operation greatly increases following osseous surgery. This facilitates orthodontic tooth movement. Frost further observed this RAP in long bone in 1989,[17-18] and Wilcko et al.[19,20] described similar observations in membranous facial bone in 2001 and 2003. The underlying biological mechanism might involve accelerated bone turnover and decreased bone density by way of a transient burst of localized severe bone resorption and remodeling.[17,18]

Liou et al.[21] hypothesized that the phenomenon of postoperatively accelerated orthodontic tooth movement might be related to increases in osteoclastic activities and metabolic changes in the dentoalveolus caused by the orthognathic surgery. Biomarkers of osteoclastic activity (such as C-terminal telopeptide of type I collagen) and osteoblastic activity (such as serum alkaline phosphatase) could increase 1 week (osteoclastic) and 1 month (osteoblabstic) after surgery, with elevated levels lasting for 3-4 months. Orthognathic surgery might, therefore, trigger 3-4 months of higher bone metabolism postoperatively, which might then induce accelerated orthodontic tooth movement.

Treatment time for postoperative orthodontic treatment

Because SFA improves facial esthetics at the early stage of treatment, it can provide patient satisfaction. It is claimed that this technique provides efficient and shortened treatment time[8-11,21-22] of around one to one and half years or less.[10] After surgery, orthodontic tooth movement can be easily achieved because the teeth are usually not occluded. The rapid tooth movement can occur also because of the RAP effect[10,21,23-24] noted previously. However, the treatment time varies depending on the complexity of remaining malocclusion problems and the orthodontist's experience.[22]

Liao et al[23] showed that a SFA group of patients required less treatment time than a pre-surgical orthodontic group (342 + 127 days versus 512 + 103 days, respectively). Yu et al[25] showed a treatment course for one patient of only four months. Some authors[9,26,27] reported total average treatment time approximately nine to twelve months. Villegas et al[8] found that they could complete correction of significant dentofacial asymmetry in as little as seven months.

The different total treatment times for SFA depend on the severity of individual dento-skeletal problems, techniques of surgery, orthodontic mechanics, cooperation and biological response as well as desired results for each patient.

Indications and contraindications for surgery-first accelerated orthodontic surgery

The criteria that are suggested for SFA[10] are:

- Well-aligned to mild crowding
- Flat to mild curve of Spee
- Normal to mild proclination/retroclination of incisors
- Minimal transverse discrepancy
- This approach is also indicated in cases in which decompensation is needed.

Decompensation is done by positioning the jaw bones properly. "Even though the surgery-first technique can be applied to Class II as well as Class III malocclusions, the majority of cases treated using this approach have been cases with Class III malocclusion meeting the above criteria."

The contra-indications for SFA 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.[28]

Treatment planning considerations

With conventional orthognathic surgery, the treatment plan for SFA must be considered whether the problems may be with the maxilla, mandible, or both jaws. Moreover, the antero-posterior correction can change vertical and transverse jaw relationships. A three-dimensional analysis using a study model setup can demonstrate and simulate pre- and post- treatment conditions to help surgeon and orthodontist plan proper treatment.

The treatment plan considerations should evaluate the upper incisor inclinations in order to determine how much decompensation is desirable and thus, whether or not premolar extractions for decompensation of upper incisors[23]; and whether or not posterior maxillary impaction while increasing occlusal plane, will improve incisor inclinations[29]; or whether to use skeletal anchorage after surgery to the posterior distal segments of maxilla in order to provide space for upright the incisors.[8,9,30]

Moreover, the degree of transverse discrepancy between the two arches can be corrected by planning segmental osteotomy in severe cases, or resolving by arch coordination and elastics in a post-surgical orthodontic phase[22]. The vertical problems are usually related with antero-posterior problems and should be corrected with posterior maxilla impaction or postoperative orthodontic treatment[26] depending on whether the problems are associated with dental interferences not corrected before surgery. However, the occlusal interferences derived from non-level occlusal plan, supra-erupted teeth and improper bucco-palatal inclination of posterior teeth will not be corrected simply by surgery.

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 to occlusal plane angulation is <53–55°, extraction must be considered.[23] Another possibility involves changing the position of the whole maxilla, so that the occlusal plane become steeper and producing more upright maxillary incisors. One might distalize the maxillary posterior segments using zygomatic plates as shown by Nagasaka et al.[9] and Villegas et al.[8] thus opening the space to retract maxillary incisors

The midlines must be coincident or close to it after surgery, and proper buccal overjet must be established bilaterally

Most challenging and time consuming step is the prediction of the final occlusion based on the current position of teeth. The term intended transitional malocclusion is used to describe the occlusion that is used to fabricate the surgical splint and surgeon's guide during surgery.[31] At least a three-point contact must be established between the upper and lower models. In cases where such temporary occlusion cannot be established, it is advisable to initiate some orthodontic movement in order to relieve some of the interferences.

Potential problems

While significantly reduce treatment time, the SFA has overall more limited indications. Even though the SF technique can be applied to Class II as well as Class III malocclusions, the majority of cases treated using this approach have been cases with Class III malocclusion. A possible explanation is that a Class III skeletal relationship results in a more pronounced soft tissue imbalance. Careful treatment outline and plan therefore, is of great importance, as was emphasized by Baek[26]. In the study, Baek concluded that the SFA requires accurate prediction of the postoperative orthodontic treatment for dental alignment, incisor decompensation, arch coordination, and occlusal settling at the very beginning of a preoperative treatment plan.

The prediction of the final occlusion is most challenging and time-consuming[28], so the clinician's experience and skill are very important for achieving predictably satisfactory results[14,25,28]. There are many factors that the orthodontist should consider, such as the skeletal discrepancy, limitations of tooth movement, prospective position of the teeth, treatment time require, complexity of passive surgical wire bending, and risk of bonding failure before and during surgery. Furthermore, after surgery-first correction, patients may not be enthusiastic to move on the second orthodontic phase, leaving an outcome that would not satisfy the important clinical goal of best possible conditions for orthodontic stability.

Also, because timing of surgical treatment relates to jaw growth, patients would have delay of correction until adolescent mandibular growth is considered to be complete, whereas pre-surgical orthodontics could be carried on during the final period of growth.[32]

Apart from certain advantages, some potential problems associated with SFA are the following:

- Predicting the final occlusion is the hardest challenge with SFA due to multiple dental interferences
- Cases requiring extractions are especially very difficult to plan when performing surgery-first
- Any minor surgical error can compromise the final occlusion
- The planning process is very time consuming in contrast to the total treatment time
- The increase in the number and complexity of osteotomy procedures poses a greater risk to the patient.

Treatment outcome

The group of Sugawara and Nanda published a series of case reports using a SFA approach to correct skeletal Class III[9] and skeletal Class II[27] malocclusion and dentofacial asymmetry. The results demonstrated entirely acceptable facial esthetics and dental occlusion, with total treatment time of less than 12 months. Their use of the SFA attracted attention to the paradigm shift from the traditional orthodontic-first approach (OFA). The authors documented that skeletal problems could be immediately corrected using orthognathic surgery without performing any preoperative orthodontic treatment. In their three case reports, orthognathic surgery was performed on the mandible only. A Class III malocclusion becomes Class II immediately after mandibular setback, and a Class II malocclusion becomes Class III immediately after mandibular advancement. The Skeletal Anchorage System (SAS) must then be used to correct the intentionally created Class III or Class II malocclusion by moving posterior teeth to achieve a final Class I relationship. However, the most common combination of variables for Class III malocclusion was a retrusive maxilla, protrusive mandible, protrusive maxillary incisors, retrusive mandibular incisors, and a long lower facial height. Previous reports on surgical correction of mandibular prognathism described the use of an isolated mandibular setback in fewer than 10% of patients, in favor of maxillary advancement or bi-maxillary orthognathic surgery.

In a retrospective study for transverse problems, Wang et al.[33] investigated 36 adult patients with skeletal Class III malocclusion, who underwent Le Fort I osteotomy and/ or mandibular BSSRO. All operations were performed by the same experience surgeon. The patient groups differed only in receiving the preoperative orthodontic treatment (6 months on average). Preoperative orthodontic treatment might involve the leveling and alignment of dental arches and elimination of major occlusal interferences. For maxillary canine inclination, the preoperative orthodontic treatment was successful in expanding inter-canine width. However, 1 year after surgery, there were no differences between the OFA group and the SFA group in inclinations of the maxillary canine, mandibular canine, maxillary molar, and mandibular molar. The authors concluded that the final outcomes of the transverse dental changes were similar irrespective of receiving preoperative orthodontic treatment or not.

In another retrospective cohort study, Kim et al.[34] investigated skeletal Class III patients who underwent only mandibular setback surgery. Of these 61 patients, 23 were in surgery-first group and 38 in orthodontics-first group. They concluded that mandibular sagittal split ramus osteotomy without pre-surgical orthodontic treatment was less stable than conventional orthognathic surgery for mandibular prognathism. Before performing a SFA, skeletal stability needs to be considered.

For vertical problems, Liao et al.[23] evaluated skeletal Class III open bite patients using a surgery-first or orthodondics-first approach at four different time points (before treatment, 1 month before surgery, 1 week after surgery, and at orthodontic bonding). During 2002-2005, 33 consecutively operated patients received LeFort I posterior impaction osteotomy and BSSRO to correct skeletal Class III open bite. Of these 33 patients, 13 received an orthodontics-first approach and 20 a SFA. The SFA was associated with a significantly shorter treatment time than the OFA (342 days vs. 512 days). Both groups displayed similar maxillary stability in the horizontal and vertical directions and similar mandibular stability in the horizontal direction. The only detectable difference was increased upward mandibular movement following surgery in the SFA group compared with the orthodontics-first approach group. This upward mandibular movement could help to prevent relapse of the anterior open bite. For surgical orthodontic correction of skeletal Class III open bite, the OFA doesn't offer greater benefits in the way of facial esthetics, dental occlusion, or treatment stability than the SFA.

Ko et al.[35] conducted a prospective clinical study, investigating 53 skeletal Class III patients receiving Le Fort I osteotomy and bilateral sagittal splitting osteotomy of mandible between 2003 and 2007. The same experienced surgeon performed all operations. Of these 53 patients, 18 underwent a SFA and 35 an orthodontics approach. The final outcomes, in the way of skeletal correction and postsurgical relapse, displayed no differences between the two approaches. Upon the completion of treatment, the preoperative orthodontic work on the incisor proclination had returned to the original incisor inclination. Lengthy preoperative orthodontic preparation for dental decompensation is, therefore, not necessary prior to the surgical correction of skeletal Class III malocclusion.

Discussion

During the last 40 years, investigators have placed sporadic emphasis on the SFA in orthognathic surgery. In 1977, when the OFA showed popularity, Epker and Fish suggested that for the surgical repositioning of skeletal and/or dento-osseous segments, the surgical procedure should be performed prior to the orthodontic treatment.[7] This surgical procedure prior to the orthodontic treatment would ensure esthetically pleasing results and safely and easily accomplish tooth movement.[7]

Many authors described several advantages offered by the SFA: (1) Improvement in patient's facial esthetics and dental function early in treatment, rather than following a period of possible years, (2) improvement in patient's swallowing and speech functions after surgery,

(3) the proceeding of orthodontic tooth movement at a much faster pace following surgery, thus reducing the overall treatment time, (4) improved cooperation of the patient during orthodontic treatment, (5) easier orthodontic tooth movement following restoration of the normal functional and anatomic relationships of the bony skeleton and surrounding soft tissues, and (6) stability of results equal to, or in some cases superior to, those achieved using the more traditional OFA.

Epker and Fish described postoperatively accelerated orthodontic tooth movement in patients receiving orthognathic surgery in 1977; this was almost 23 years before the reporting of the regional acceleratory phenomenon (RAP) in orthodontic treatment by Wilcko *et al.*[19]

The SFA gained further support from Lee in 1994.[36] He emphasized 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. The described clinical benefits of a SFA included shorter overall treatment time, more biologically favorable tooth movement, more predictable occlusal results, more rapid tooth movement achieved postoperatively, improved coordination of the upper and lower dental arches, and earlier musculature adaption to maintain the altered arch relationship. Although this article provided no solid clinical data to support the claimed advantages, the described clinical phenomena remain valid presently.

The study of Sugawara and Nanda published a series of case reports using a SFA to correct skeletal Class III[9] and skeletal Class II[27] malocclusion and dentofacial asymmetry. The results demonstrated entirely acceptable facial esthetics and dental occlusion, with total treatment time of less than 12 months. They used of the SFA attracted attention to the paradigm shift from the traditional OFA. The authors documented that skeletal problems could be immediately corrected using orthognathic surgery without performing any preoperative orthodontic treatment. In their three case reports, orthognathic surgery was performed on the mandible only. A Class III malocclusion becomes Class II immediately after mandibular setback, and a Class II malocclusion becomes Class III immediately after mandibular advancement. The Skeletal Anchorage System (SAS) must then be used to correct the intentionally created Class III or Class II malocclusion by moving posterior teeth to achieve a final Class I relationship. However, the most common combination of variables for Class III malocclusion was a retrusive maxilla, protrusive mandible, protrusive maxillary incisors, retrusive mandibular incisors, and a long lower facial height. Previous reports on surgical correction of mandibular prognathism described the use of an isolated mandibular setback in fewer than 10% of patients, in favor of maxillary advancement or bimaxillary orthognathic surgery.

In 2010, Baek *et al.*[26] emphasized that the SFA requires accurate prediction of the postoperative orthodontic treatment for dental alignment, incisor decompensation, arch coordination, and occlusal settling at the very beginning of a preoperative treatment plan. Their studies reported 11 cases of skeletal Class III malocclusion treated using a SFA and the observations included increased patient cooperation, efficient and effective decompensation, and shortened treatment time compared to using an OFA. They applied two-jaw surgery using Le Fort I osteotomy to impact the posterior maxilla and bilateral sagittal splitting osteotomy for mandibular setback. However, the authors mentioned some disadvantages of using a SFA, such as high bonding failure, difficulty in bending the surgical wire to fit into unleveled dentition, the requirement for more surgical movement to compensate for postoperative orthodontic movement, impacted lower third molars, and postsurgical occlusal instability. Surgical orthodontic teams applying a SFA could encounter all these problems. These should, thus, be resolved prior to its application.

Hernández-Alfaro *et al.*[37] reported two skeletal Class III anterior open bite cases receiving bimaxillary orthognathic surgery using a SFA. The total treatment time was 264 days (8.8 months) for first patient and 195 days (6.5 months) for second patient. Both patients were satisfied with the results of rapid facial changes and shortened treatment time. The authors emphasized that providing precise diagnosis, detailed treatment planning, and skillful orthodontic treatment is more demanding using a SFA than a traditional OFA.

Grubb and Evans described that using an OFA for skeletal Class III malocclusion,[38] any transverse maxillary width discrepancy should be corrected by preoperative orthodontic expansion, or by surgically assisted rapid palatal expansion, before or during orthognathic correction of Class III sagittal discrepancy. Maxillary expansion should be performed before orthognathic surgery.[15,16,38]

However, even without preoperative maxillary expansion, the maxillary molar width should be sufficient to allow coordination with the mandibular molars after upper and lower dental casts are brought into a Class I position. Irrespective of the approach that was taken, the molar width decreased continuously after orthognathic surgery.[33] Eventually, both maxillary and mandibular molar widths did not differ significantly between the surgery-first and orthodontics-first groups 1 year after the operation. Why should the molar width be increased prior to the operation, as proposed by the OFA?

The long-term outcomes of SFA provided in vertical,[23] transverse,[33] and sagittal[35] dimensions had shown the same or better skeletal and dental stability, as compared to that in OFA. Why do you need to spend 12-18 months of preoperative orthodontic treatment for gaining nothing in final skeletal-dental stability? Certainly, the patients would appreciate immediate improvement in facial esthetics and dental function right after the surgery, in addition to RAP frequently observed in postoperative orthodontic treatment.

Computer aided surgical simulation utilizing three-dimensional images obtained from multi-slice computed tomography/cone beam computer tomography has been successfully performed to plan orthognathic surgery.[39] Virtual planning appears to be an accurate and reproducible method for treatment planning that can reliably be transferred to the patient by means of surgical splints or intraoperative navigation. This may greatly benefit SFA in the future.

In conclusions, the SFA offers an alternative to the OFA for correction of maxillofacial deformity. The final outcomes, in the way of facial esthetics, dental occlusion, and stability, are similar when using orthodontics-first and SFA. Dental occlusion and facial esthetics can show immediate improvement after surgery when using SFA; this almost eliminates the time spent on preoperative orthodontics. The phenomenon of postoperatively accelerated orthodontic tooth movement also reduces the difficulties associated with and the time spent on postoperative orthodontics. Both the surgeon and orthodontist using a SFA should be experienced and should cooperate closely to achieve predictable and satisfactory outcomes. Orthodontists should be aware of the orthognathic principles and limits in orthodontic movement, and plan postoperative orthodontic treatment to include dental alignment, incisor de-compensation, arch coordination, and occlusal interdigitation. The surgeon should be capable of performing designated osteotomy and inter-maxillary fixation with occlusion bite plate on malaligned dental arches and providing the stability after skeletal reposition. Further studies, especially prospective cohort studies or randomized controlled trials, are needed to provide additional clinical evidence to support the SFA.

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