Orthodontist's Role in Orthognathic Surgery

John O. Wirthlin, DDS, MSD¹ Pradip R. Shetye, DDS, BDS, MDS²

¹ Division of Plastic Surgery, Michael E. DeBakey Department of Surgery, Baylor College of Medicine, Houston, Texas

² Craniofacial Dental Center, NYU Langone Medical Center, Institute of Reconstructive Plastic Surgery, New York, New York

Address for correspondence John O. Wirthlin, DDS, MSD, Division of Plastic Surgery, Michael E. DeBakey Department of Surgery, Baylor College of Medicine, 6701 Fannin St., Suite 610, Houston, TX 77030 (e-mail: John.wirthlin@bcm.edu).

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Abstract

Keywords

- ▶ orthodontist
- ▶ orthognathic surgery
- ▶ collaboration

Orthognathic surgery can eliminate severe esthetic and functional deformities and be a life-changing event for a patient. An orthodontist's role in orthognathic surgery can be divided into several phases: the initial evaluation, presurgical orthodontics, surgical planning, and postsurgical orthodontics. At each of these phases, collaboration between the orthodontist and the surgeon is critical. The ability of an orthodontist and a surgeon to coordinate their efforts during this time is what will lead to a successful outcome.

Background

The close interaction of orthodontists and surgeons in orthognathic surgery goes back to the cradle of orthognathic surgery in St. Louis, Missouri, during the late-19th century.¹ At that time, Vilray Blair, the dominant orthognathic surgeon, worked with Edward Angle who is considered to be the Father of Modern Orthodontics. In close collaboration, these two performed the first described ostectomy of the mandible in a patient with mandibular prognathism in 1898.² In an early publication on orthognathic surgery, Blair concluded, "Treating of skeletal deformities is really surgical work, but the earlier a competent, congenial orthodontist is associated with the case, the better it will be for both the surgeon and the patient."³ Although much has changed in the field of orthognathic surgery since the early 1900s the role of an orthodontist in achieving an ideal result remains integral.

An orthodontist's role in orthognathic surgery can be divided into several phases: the initial evaluation, presurgical orthodontics, surgical planning, and postsurgical orthodontics. At each of these phases, collaboration between the orthodontist and the surgeon is critical. Orthognathic surgery is truly an interdisciplinary challenge and lack of coordination between the orthodontist and the surgeon will lead to a

compromised result. A broad overview of each of these phases, with particular emphasis on the initial evaluation, will now be explored along with selected specific illustrative examples.

Initial Evaluation

The goal of the initial evaluation is to define the deformity. This is done by careful collection and analysis of orthodontic records along with a thorough clinical evaluation. The minimum orthodontic records required for proper evaluation of a prospective orthognathic patient are standard orthodontic photographs, articulated or appropriately trimmed study models, a panoramic radiograph, a lateral cephalogram, and a posteroanterior cephalogram. Additional records that can provide critical information include three-dimensional (3D) photographic images,⁴ 3D cone beam radiographs,⁵ and video images of the patient.⁶ Accuracy and consistency are essential in the acquisition of each of these records.

Once these records are collected, they need to be analyzed and organized in a meaningful manner. When it comes to analyzing orthodontic records, there are enough different types of analysis to fill volumes of books. There are model analyses, space analyses, numerous lateral cephalometric analyses, photo analyses, soft tissue analyses, and countless

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combinations of the above. Each practitioner will develop his or her own system for analyzing orthodontic records. The method of analysis is of little importance as long as the deformity is thoroughly and accurately defined. Below are a couple critical points when analyzing orthodontic records in preparation for orthognathic surgery.

Posterior Transverse Dimension

In a traditional orthodontic patient, the posterior transverse dimension can be easily analyzed by a visual inspection intraorally or inspection of mounted or trimmed orthodontic models. In a prospective orthognathic surgery patient, the posterior transverse dimension must be analyzed in the proposed postsurgical position. In a patient with a class II skeletal malocclusion, this can be done by instructing the patient to posture their mandible forward into a position with a proper overjet. In a patient with a class III skeletal malocclusion, the transverse dimension must be analyzed using orthodontic models placed in the proposed postsurgical position.

Once a posterior transverse discrepancy has been identified, it must be determined whether the etiology of discrepancy is in the maxilla or the mandible and whether it is a skeletal or dental discrepancy. Although there is normative data for transverse skeletal dimensions of the maxilla and the mandible, the extreme variability that exists limits the value of this information.^{7,8} A reasonable and systematic approaches to delineate maxillary and mandibular skeletal and dental discrepancies is as follows:

1. Identify any transverse mandibular skeletal discrepancies. Although variance does exist in the transverse dimension of the posterior mandible, by convention the mandible is considered the diagnostic arch and its skeletal dimension is rarely questioned. Whether this is appropriate may not be of significance because the transverse skeletal dimension of the mandible is rarely changed surgically. If a transverse skeletal discrepancy is found in the mandible and its correction is planned, this should be done with model surgery on diagnostic casts.
2. Identify any transverse malposition of the mandibular molars. The lingual cusps of the mandibular molars should be at or slightly (~1 mm) below the level of the buccal cusps. If the lingual cusps are significantly below the buccal cusps, this represents constricted mandibular molars. If the lingual cusps are above the buccal cusps, this represents overly expanded mandibular molars. A common finding in a class III skeletal malocclusion is mandibular molars tipped lingually with their lingual cusps significantly below the buccal cusps. If a significant transverse dental discrepancy exists, model surgery should be performed on the diagnostic casts to place the molars in their correct position. If the discrepancy is only minor, the repositioning of the molars can be estimated on the study models.
3. Identify any transverse dental discrepancy in the maxilla by again comparing the buccal to the lingual cusps. In

the maxilla, the buccal cusps of the molars should be at or slightly above (~1 mm) the lingual cusps. If the buccal cusps are significantly above the lingual cusps, this represents overly expanded maxillary molars. If the buccal cusps are below the lingual cusps, this represents constricted maxillary molars. A common finding in a class II skeletal malocclusion is maxillary molars tipped palatally with their buccal cusps significantly below the lingual cusps. Again, if a significant transverse dental discrepancy exists, model surgery should be performed on the diagnostic casts to place the molars in their correct position. If the discrepancy is only minor, the repositioning of the molars can be estimated on the study models.

4. Once the mandibular skeletal, mandibular dental, and the maxillary dental discrepancies have been identified and either corrected on diagnostic casts or estimated on the original study models, any remaining transverse discrepancy between the maxilla and the mandible must be due to a skeletal imbalance of the maxilla. Assuming the orthognathic patient is at the age of skeletal maturity this maxillary skeletal discrepancy can be eliminated through surgically assisted rapid palatal expansion (SARPE), orthodontic dental compensation, or a multipiece LeFort osteotomy.

Vertical and Sagittal Skeletal Relationship

When analyzing orthodontic records for a prospective orthognathic patient, it is critical to appreciate the relationship between each dimension of space. The relationship between the transverse and the sagittal was highlighted in the above section. Another critical interrelationship occurs between the vertical and the sagittal dimension. This is best appreciated during cephalometric analysis.

The most commonly used cephalometric variable for representing the sagittal relationship of the maxilla to the mandible is the ANB (A point, nasion, B point) angle. In patients with normal vertical dimensions, the ANB is a robust measure; however, if there is a skeletal vertical discrepancy, the ANB can be misleading. Imagine a patient with a prognathic mandible and significant class III ANB angle. Now visualize the vertical dimension of the mandible increasing by rotating the mandible clockwise. As the mandible rotates clockwise, the B point moves distally. This would increase the ANB. The mandible is still prognathic, but the ANB could now be close to normal. Without careful review, this prognathic mandible could be disguised by the increased vertical dimension. The Wits appraisal is a powerful measure of the sagittal relationship of the maxilla to the mandible that should be used to cross check the ANB angle. The Wits appraisal is a linear measurement, not an angular measurement, and uses the occlusal plane as a reference. These characteristics of the Wits appraisal prevent a vertical discrepancy from disguising a sagittal discrepancy between the mandible and the maxilla (►Fig. 1).

Fig. 1 The high mandibular plane angle of this patient is masking a severe class III skeletal discrepancy. The ANB (A point, nasion, B point) is only -1, a discrepancy some would consider within the realm of orthodontic correction alone; however, the Wits of -11 reveals the true severe skeletal discrepancy.

An increased curve of Spee is also vertical finding that can disguise a significant sagittal discrepancy. When the mandibular dentition exhibits a significant curve of Spee, the arch length of the mandible is shortened. If a significant curve of Spee were to be leveled, the arch length of the mandible would increase. This is often the case in skeletal class III

Fig. 2 The significant curve of Spee seen on this patient masks some of the true sagittal discrepancy. Once this curve of Spee is leveled, the negative overjet will increase significantly.

relationships. Initially, only a minor negative overjet may exist, but if there is a significant curve of Spee that is then leveled, the negative overjet can increase dramatically. If this relationship is unnoticed during the initial examination, the original treatment plan may need to be altered dramatically (► Fig. 2).

Clinical Examination

Although emphasis is often placed on collection and analysis of orthodontic records when evaluating a patient for an orthognathic procedure, the clinical exam often provides the most critical data. Ideally, the clinical evaluation is performed in conjunction with the orthodontist and the surgeon. Much of the information gleaned from the clinical evaluation can be confirmed by other records collected, such as photographs, study models, or lateral cephalograms, but there are several critical data points that can only be accurately obtained during the clinical evaluation. Four of these points include the presence of a mandibular functional shift, lip/incisor relationships, temporomandibular joint (TMJ) function, and the location of the facial midline.

Mandibular Functional Shift

The anteroposterior position of the mandible in relation to the maxilla is often the most obvious discrepancy that initiates the desire of a patient to seek orthognathic surgery. However, the malocclusion a patient presents with may not represent the true skeletal relationship of the maxilla to the mandible due to a mandibular functional

Fig. 3 A significant lateral function shift can be seen between the habitual occlusal seen below versus the centric occlusion in these photos. This functional shift creates a significant change in the dental midlines.

shift. A patient with a minor class III skeletal relationship can present with a severe class III occlusion if they are shifting their mandible anteriorly to avoid an uncomfortable edge-to-edge anterior occlusion. A patient with a severe class II occlusion may have formed a habit of posturing their mandible forward to camouflage their true mandibular retrognathia. A patient with an uncoordinated posterior transverse dimension may shift their mandible anteriorly and laterally that may appear as skeletal asymmetry when no such asymmetry exists (►Fig. 3). If a mandibular shift is present but not identified during the clinical exam, incorrect treatment plans and decisions will be made.

Over the years, the best method for detecting the true unstrained position of the mandible has been heavily debated with no universal consensus.^{9–11} In certain situations, a functional shift cannot be detected without a period of muscular deprogramming with an occlusal splint. It takes an experienced and detailed practitioner to ensure true mandibular position is being recorded during a clinical examination.

Lip/Incisor Relationships

During the evolution of orthognathic surgery, the goals of treatment have also evolved. At times, normalizing the skeletal discrepancy was emphasized; at other times, achieving ideal interocclusal relationships was emphasized. As the field of orthognathic surgery has become more refined, an increased emphasis has been placed on the interaction between the skeletal and dental units with the soft tissues. One of the most important of these interactions is the relationship between the maxillary incisors and the upper lip. This is a complex interaction and is affected by the position of the incisor within the alveolar bone of the maxilla, the position of the maxilla, and the length and thickness of the upper lip. Adding to this complexity is the large variance of lip/incisor relationships based on age and gender,¹² as well as different perspectives of what constitutes an ideal esthetic relationship.¹³

Although the ideal final lip/incisor relationship can be debated, the critical nature of recording the initial lip/incisor relationship cannot. The following measurements should be recorded during the clinical examination of a prospective candidate for orthognathic surgery:

- Incisal show at repose
- Incisal show at full smile
- Length of upper lip
- Sulcus depth

The measurement for incisal show at repose and at smile serves as starting points for incisor position. The final position must then be predicted based on anticipated orthodontic movements of the teeth, maxillary skeletal movements that will be performed during the surgery, and the predicted soft tissue response based on the soft tissue phenotype. Typically, the incisal show at repose and the incisal show at full smile and congruent. If one is excessive, the other will be as well. If one is deficient, the other is similar. In some circumstances, the incisal show at repose is within normal limits and the

Fig. 4 Sulcular probing of the anterior maxillary teeth is critical to determine the appropriate relationship between the incisors and the upper lip.

incisal show at full smile is excessive. This indicates an overactivity of the upper-lip musculature. In this situation, the only way to achieve ideal incisal show at rest and incisal show at full smile may be an application of Botox to the upper lip.¹⁴

The length of the upper lip is important in understanding the limitations that may exist in achieving an ideal lip/incisor relationship. If a patient has an abnormally long lip, it may be impossible to achieve an ideal lip/incisor relationship without surgical intervention to the upper lip.

The depth of the gingival sulcus surrounding the maxillary anterior teeth is a critical yet often overlooked variable when it comes to evaluating lip/incisor relationships. A typical and healthy sulcular depth is between 1 to 3 mm (►Fig. 4).¹⁵ Sulcular depths of more than 3 mm in a skeletally mature individual represent a condition known as a delayed passive eruption.¹⁶ In these situations, an excessive sulcular depth is associated with a short clinical crown. It is critical to factor in the additional incisor length that can and should be exposed by gingival recontouring when planning the final skeletal position of the maxilla and the final lip/incisor relationship. Simply using the clinical crown length measured on study models without factoring in an excessive sulcular depth will lead to a compromised result.

Temporomandibular Joint Function

A full TMJ exam should be performed at the initial exam. This exam should include an assessment of any pain, crepitus, or popping in the joint, any pain in the associated masticatory musculature, an evaluation of the path of opening, along with measurements of maximum opening and excursive mandibular movements.¹⁷ This exam serves primarily as a baseline for postsurgical comparison, but the path of opening can significantly impact surgical planning when using the mandible as a guide to position the maxilla.

In LeFort procedures and often in two-jaw orthognathic cases, the final position of the maxilla is established using the unoperated mandible as a guide. When positioning the maxilla, a mandible with a lateral path of opening can introduce a significant variable that must be accounted for. If the path of the mandible deviates laterally upon opening,

Fig. 5 A careful clinical examination is the best way to assess the facial midline of patients with significant skeletal asymmetries, dystopia, ear asymmetries, and unusual natural head positioning.

any vertical increase in the maxilla during surgery will also reflect this lateral movement of the mandible. If this is not identified during the initial exam, the transverse position of the maxilla will not be in the planned and desired location.

Facial Midline

Although the facial midline can be assessed from a frontal photograph, many subtleties can best be appreciated during a clinical exam such as dystopia, malalignment of the ears, subtle soft tissue asymmetries, and natural head position (→**Fig. 5**). Determining a facial midline from a frontal photograph also requires the photograph to be taken at exactly the correct angle. Any slight turning of the patient's head during the photograph can lead to an incorrect determination of the facial midline from a photograph. Advances such as 3D photography and gyroscopic natural head position systems can also be a valuable tool for assessing the facial midline of a patient, but ultimately the best determination of the facial midline comes from a detailed clinical evaluation.¹⁸

Organization of Findings

The collection of accurate data from orthodontic records and the clinical evaluation is of critical importance, yet the collection of this information is only as powerful and the ability to make decisions based on the information. Once this

information has been collected, it should be organized in a manner that allows for easy interpretation.

A useful framework found in the orthodontic literature is known as the 3D-3T (three-dimensional–three-tissue) analysis. This framework takes all the data from the orthodontic records and initial clinical evaluation and allocates them into one of nine sections based on whether the measurement is a skeletal, dental, or soft tissue measurement, and whether it is a measurement in the sagittal, vertical, or transverse dimension (→**Fig. 6**). This organization allows for the interactions between each type of tissue and each dimension to be easily assessed.

Another useful framework for organizing the information gleaned from the initial exam is described by Gateno et al.¹⁹ This framework is particularly useful for prospective orthognathic surgery patients. In this framework, the craniofacial complex is divided into three surgical subunits: the maxilla, the mandibular body, and the bony chin. The data collected in respect to each subunit is then defined as a measurement of shape, size, orientation, or position of the specific subunit. By organizing the data in this regard, the deformity is clearly defined.

Presurgical Orthodontics

The human body has an amazing ability to compensate. In low-oxygen environments, the blood adapts to carry oxygen more efficiently. It has been noted that individuals with vision impairment can sense pitch more accurately.²⁰ The craniofacial complex has similar abilities to compensate. In the presence of a skeletal imbalance between the maxilla and the mandible, the dentition will alter its position in an attempt to establish occlusal contact. The prime example of this is the retroclination of the mandibular incisors and the proclination of the maxillary incisors that occurs in a class III skeletal malocclusion (→**Fig. 7**). The overriding goal of presurgical orthodontics is to decompensate the occlusion. If the teeth are not decompensated prior to orthognathic surgery, dental interferences may occur that prevent ideal positioning of the skeletal subunits. Performing dental decompensation prior to surgery also has the benefit of creating a stable occlusion immediately postoperatively that is believed to aid in retention of the skeletal movements.

Decompensation of the dentition can be accomplished in many different ways depending on the initial deformity. At times, extractions of permanent teeth will be needed. A myriad of appliances can also be employed including expanders, headgear, and lip bumpers. Anchorage control is critical and may necessitate the use of Nance arches, transpalatal arches, or temporary anchorage devices. With patient compliance, interarch elastics can also be used to decompensate dentition prior to orthognathic surgery. To prepare a class III patient for orthognathic surgery, class II interarch elastics should be used and to prepare a class II patient for orthognathic surgery class III elastics should be employed.

Recent literature has been published that suggests certain advantages to foregoing presurgical orthodontics and

Diagnostic 3D-3T			
	AP	Transverse	Vertical
Skeletal	Skeletal Class I Convexity = 2 mm SNA = 81°, SNB = 78° ANB = 3° Wits = -1 mm	IMW = 32 mm	FA = 91° FMA = 22° SN-MP = 32° LFH = 40° Normal angle
Soft tissue	Convex profile LL-EP = -1 mm NLA WNL	Normal fifths Buccal corridors WNL	Normal thirds
Dental	RM: Class I LM: Class I RC: Class I LC: Class I OJ = 4 mm L1-APo = 3 mm L1-MP = 103° U1-SN = 110° U1-L1 = 115°	UDML = On LDML = 1 mm Right	OB = 2 mm
Other	UALD = 3 mm LALD = 5.5 mm		

Fig. 6 Example of the organization of a three-dimensional–three-tissue (3D–3T) table. ANB, A point-nasion-B point; AP, anterior-posterior dimension; FA, facial angle; FMA, frankfort mandibular angle; IMW, intermolar width; L1-APo, lower incisal edge to A point-Pogonion; L1-MP, lower incisor to mandibular plane angle; LALD, lower arch length discrepancy; LC, left canine; LDML, lower dental midline; LFH, lower facial height; LL-EP, lower lip to E-plane; LM, left molar; NLA, nasolabial angle; OB, overbite; OJ, overjet; RC, right canine; RM, right molar; SNA, sella-nasion-A point; SNB, sella-nasion-B point; SN-MP, sella-nasion to mandibular plane; U1-L1, upper incisor to lower incisor angle; U1-SN, upper incisor to sella-nasion angle; UALD, upper arch length discrepancy; UDML, upper dental midline; WNL, within normal limits.

performing orthognathic surgery first.²¹ In doing the orthognathic surgical procedure, first the skeletal deformities are corrected a transitional occlusion is established. Orthodontic appliances are then placed to establish the final

Fig. 7 Retroclined mandibular incisors and proclined maxillary incisors represent dental decompensations that can be seen in this patient with a severe class III skeletal malocclusion.

occlusion. Advantages of this “surgery first” protocol include

- Ability to address the patient's chief complaint early
- Immediate improvement of dental function and facial esthetics
- Possible shorter overall treatment times
- Faster dental movement due to the phenomenon of postoperatively accelerated orthodontic tooth movement
- Ability to achieve difficult dental movements, such as torque of the maxillary incisors, through segmental osteotomies and repositioning of the skeletal segments

Undoubtedly, the ability to perform orthognathic surgery first is in part due to the increased stability of rigid fixation. With rigid fixation, dependence of orthodontic elastics postoperatively to stabilize the skeletal movements is reduced. However, this protocol does require meticulous coordination between the orthodontist and the surgeon. “Surgery first” orthognathic surgery represents a promising new frontier.

Surgical Planning

In the initial evaluation, the deformity was defined. Surgical planning attempts to correct the deformity. Unfortunately, surgical planning is rarely a matter of simply moving the

skeletal units to a normalized position. The essence of orthognathic surgical planning is compromise. Although a 20-mm advancement of the maxilla may be needed to normalize the sella-nasion-subspinale (SNA) angle, this movement due to its magnitude and the resulting pull from the soft tissue would undoubtedly be unstable. A 12-mm maxillary advancement may be needed to create a maxillary position comparable to a Bolton template, but the amount of maxillary advancement may be limited due to a repaired cleft palate and a two-jaw procedure may be required to correct the sagittal discrepancy between the maxilla and the mandible. A patient with excessive overjet may need a maxillary setback to normalize the skeletal units but an obtuse nasolabial angle may require mandibular advancement. A patient with mandibular prognathism may not tolerate a mandibular setback due to sleep apnea. A patient with a long lower facial third may not tolerate maxillary impaction due to a long lip and the poor lip/incisor relationship that would result. The amount of maxillary advancement may be limited in a patient with a history of velopharyngeal insufficiency.

When performing orthognathic surgical planning the limits of skeletal movement must be defined for every patient based on their unique characteristics. The goals of the surgery must then be prioritized. Rarely will every goal of treatment be realized, and as suggested above compromises must be made. When prioritizing these goals it is most often appropriate to place an increased emphasis on soft tissue parameters such as lip/incisor relationship, nasolabial angle, facial convexity, and the mentolabial angle. Although every goal may not be fully realized, a balanced harmonious facial appearance should always be the goal.

Postoperative Orthodontics

The two primary goals of the postoperative orthodontic phase of orthognathic surgery are to stabilize the skeletal movements and detail and finish the dental occlusion.

Prior to orthognathic surgery full-dimension stainless steel orthodontic arch wires should be placed. These arch wires will withstand the use of heavy interarch elastics. Interarch elastics can be used in the postoperative period to refine any minor skeletal movements that need to occur and counterbalance the soft tissue pull that may lead to relapse.

As was highlighted above, the amount of presurgical orthodontics can be extremely variable. The amount of preoperative orthodontics will obviously influence how long the postoperative orthodontic period will last. In traditional orthognathic surgery where the majority of dental decompensation occurs before surgery, the postoperative orthodontic period usually lasts between 6 to 12 months. This time is used to refine the occlusion but can also serve as a time to evaluate relapse potential and support the skeletal movements with interarch elastics. The longer this period lasts, the more time the skeletal changes will have to fully consolidate, but a lengthy post-

operative orthodontic phase can also lead to patient burnout.

Conclusion

Orthognathic surgery can eliminate severe esthetic and functional deformities and be a life-changing event for a patient. A successful orthognathic surgery is not an event, but rather a program—a program that spans the time from the initial evaluation to the postsurgical orthodontics. The ability of an orthodontist and a surgeon to coordinate their efforts during this time is what will lead to a successful outcome.

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