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Introduction to Aesthetic Orthognathic Surgery and Rhinoplasty

Graham Grabowski and Derek M. Steinbacher

1.1 Introduction

A dentofacial deformity exists when the teeth do not fit together due to incompatibility of jaw size and/or relationship. Functional and appearance issues accompany the dentofacial disharmony, including trouble with incising, chewing, breathing, speaking, smiling, closing the lips, and strong, weak, or asymmetric facial structures. This combination of functional and appearance concerns is bothersome, and motivates patients to seek treatment. The traditional focus of orthognathic surgery is to impart a normal occlusion to improve masticatory function, with possible secondary requisite benefits of other functional and aesthetic related enhancement. However, it is common now that patients are more driven (or at least as much) by the cosmetic opportunity that jaw surgery permits.

The first-level objective in orthognathic surgery is to achieve a stable, functional class I occlusion. However, this basic result, when straightening and aligning the jaws and teeth, can be achieved in any infinite vertical, sagittal, side-to-side, roll, and yaw positions in space. For instance, a class I occlusion can be achieved, yet the jaws still left deficient sagittally (with continued airway obstruction); or a class I with yaw or cant discrepancies can be present, which confers a significant and noticeable unaesthetic appearance. As such, the next-level objective in orthognathic surgery is to place the maxillomandibular unit not only in a class I, but in the most aesthetically optimized position in space. This also tends to incorporate proper functional improvement (e.g. airway), by facial skeletal expansion [1–4]. As in nature, the most balanced and appealing morphology is also frequently the most functional (form and function are intertwined) (Figure 1.1) [5,6].

Similarly, surgical stability and aesthetics are also complimentary. Rigid fixation, and liberal use of interpositional grafts, allow for practically any three-dimensional movement in space with enhanced stability [7]. The aesthetic-minded orthognathic surgeon has to be comfortable with large magnitude and complex movements, in order to achieve both a Class I occlusion, and also optimal facial balance, function, and harmony. The last level of intervention is attention to the shape and morphology of the maxillomandibular skeleton and the surrounding regions and tissues. Augmentation and/or reduction or other modification of the zygoma, orbits, nose, lips, mandibular angles, chin, and submental region need to be considered and incorporated into the treatment plan.

Levels of objectives in aesthetic orthognathic surgery

1. Class I occlusion[a]
2. Facial skeleton in aesthetically (and functionally) optimized position in space
3. Adjunctive facial hard and soft-tissue control, or modification, to optimize aesthetics

[a] Precise Class I occlusion may not be the immediate post-surgical goal in cases of "surgery-first" orthodontic/orthognathic surgery; but the orthodontist will create this by end-treatment.

Given the various objectives with orthognathic surgery, patients may present with different perspectives or chief complaints. When referred by an orthodontist, the goals are typically occlusion-centric (to "fix their teeth"). Some elements of facial balance may have been discussed, but chewing and occlusion are central. It then is incumbent on the surgeon to educate the patient regarding facial imbalance and the aesthetic benefits of surgery. The evaluation should focus on soft-tissue and facial harmony, in addition to occlusion. To formulate the treatment plan, aesthetic goals and objectives from the evaluation are critical. In the same vein, anticipated unaesthetic changes from the jaw surgery, and/or other facial regions requiring manipulation, should be discussed. 3D photos and simulations of the preoperative issues and surgical objectives are essential tools to planning and education (Figure 1.2) [8].

Increasingly, to the aesthetic-minded practice, patients may present first requesting cosmetic facial modification, not realizing that they have a dentofacial deformity.

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Figure 1.1 Form and function addressed in an aesthetically minded manner.

These patients have not recognized that their accommodated difficulty with biting and chewing (i.e. malocclusion) is in fact linked to jaw imbalance underpinning poor facial aesthetics. A complete occlusal examination is therefore part of the overall facial aesthetic evaluation, and, if indicated, orthognathic surgery is offered as part of the overall plan. Patients hoping for a single "makeover" surgery may then be surprised to learn of a need for orthodontics, and a dental component to their treatment plan. This highlights education as being of utmost importance, and clearly a comprehensive approach will result in the best function and appearance.

The compensated occlusion must be decompensated, which may worsen the occlusal discrepancy, but will facilitate a greater movement of the jaws to impart the most aesthetic result [9]. In patients who are older and/or impatient (wanting near-immediate results, with little time in braces), the "surgery-first" approach can be explored. This will be discussed later in this book, but seeks to limit the overall treatment time and eliminate the need for a prolonged pre-surgical orthodontic phase [10]. However, the orthodontic component is still required post-operatively and is a critical component of the overall treatment (Figure 1.3).

Concepts of aesthetic orthognathic surgery

Aesthetic	Orthognathic[a]
Balanced	Jaws aligned
Pleasing	Stable functional occlusion
Younger	Symmetric jaw outline
Well-proportioned	Optimized airway
Soft-tissue volume and support	

[a]Orthognathic surgery enables the aesthetic surgeon, to address skeletal, dental, soft-tissue relationships, improving balance, function and aesthetics.

1.2 Patient Education

Given the requirement for combined dental, orthodontic, and surgical intervention, the patient and their family must understand and embrace the sequence, time, and compliance needed pre- and postoperatively [11].

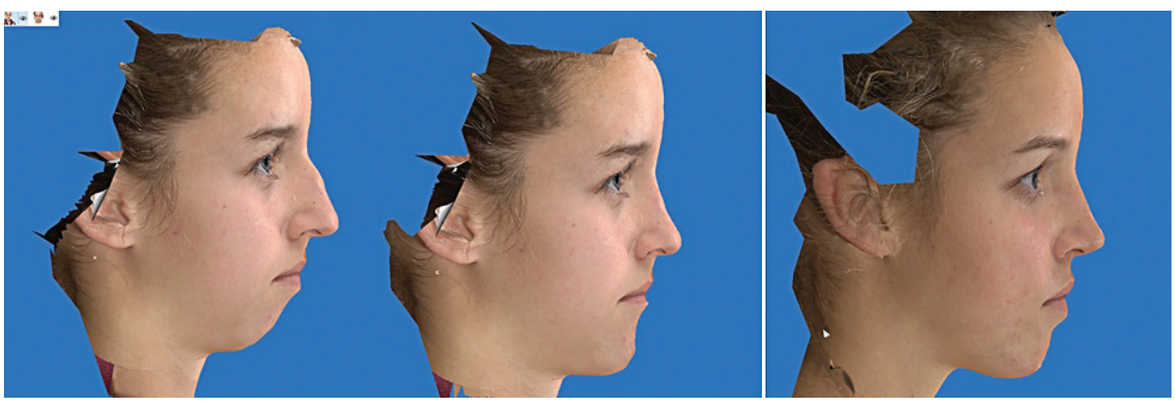

Figure 1.2 3D soft-tissue prediction used as part of patient education.

Figure 1.3 Example, pre and post- of orthognathic, rhinoplasty patient; addressing bone, soft tissue, and nasal regions.

Preparation for orthognathic surgery is a process – it is not simply a surgical procedure and then a recovery period. The period of presurgical braces is necessary to enable the surgery, as the teeth must fit together when moving the jaws. The aesthetic goals are factored into the orthodontic phase, and decompensation should be done in a way to optimize eventual aesthetics. During this phase, the appearance of the patient's dentofacial deformity will become worse. This can be challenging for the patient, as they were likely self-conscious prior to seeking treatment. Ensuring all members of the team (orthodontist, surgeon, other specialists, support staff) understand and support the plan allows for the proper explanation and support. Managing expectations is critical to a successful course and result [12].

The worsened facial appearance during presurgical treatment can be well explained using dental models, as well as 3D photos and simulation. This can then be contradistinguished to the surgical simulation of the desired result. The comparison of preoperative versus simulated result is also a powerful patient motivator. The next phase of understanding is that even after the surgery is successfully completed, there is a period of swelling and healing prior to the final aesthetic result being experienced. Additionally, postsurgical orthodontics will be needed to finalize the occlusion and to ensure a stable functional result. Then, once the braces are removed, retention of tooth position via bonded or removable retainers is recommended. Lastly, untoward impacts on facial appearance should be anticipated and explained preoperatively, and, if they cannot be addressed during orthognathic surgery, can be treated in a staged fashion several months postoperatively (e.g. rhinoplasty) (Figure 1.4).

1.3 Overview of Orthodontic Considerations

Orthodontic goals relate to dental relationships and recognition of skeletal position, but modern emphasis should also incorporate soft tissue and functional goals. The orthodontic aspects of aesthetic orthognathic surgery will be considered in depth later in this book, but some key points will be introduced now. A prerequisite for successful orthognathic surgery is the presence of healthy teeth that are centered in the alveolus, with adequate periodontal support (bone and keratinized tissue). Additionally, well-aligned and positioned teeth are aesthetic, and correlate with a pleasant smile and lip drape.

The classification of occlusal relationships was described by Edward Angle in the 1890s [13]. A Class I occlusion is the normal and most stable occlusal relationship. Angle developed the system based on the first molar relationship, although canine relationship is also described the same way. Overjet and anterior cross-bite relationships relate to the Angle classification as well. Asymmetries can also lead to a difference between the classification on the left and right sides of a patient. The transverse relationship is not well considered using this classification (Figure 1.5).

Class I occlusion	Mesiobuccal cusp of maxillary first molar is in line with buccal groove of mandibular first molar. Other teeth well-aligned, no rotations or malpositions.

Figure 1.4 (a and b) Facial appearance and overjet (occlusion) worsened with decompensation.

Class I malocclusion	Mesiobuccal cusp of maxillary first molar is in line with buccal groove of mandibular first molar. Other teeth rotated or with malposition.
Class II malocclusion	Mesiobuccal cusp of maxillary first molar is anterior to buccal groove of mandibular first molar. Lower molar is distally positioned relative to the upper molar. Maxillary canine anterior to groove between mandibular canine and first bicuspid. Excess overjet.
Class III malocclusion	Mesiobuccal cusp of maxillary first molar is posterior to buccal groove of mandibular first molar. Lower molar is mesially positioned relative to the upper molar. Maxillary canine posterior to groove between mandibular canine and first bicuspid. Anterior cross-bite.

It is important to highlight that in certain circumstances a Class I molar occlusion may not be achieved. In this instance, a Class I canine relationship is the goal. This may occur in patients with a Class III malocclusion with adequate or slight labial inclination of the maxillary incisors and significant crowding. To be able to maintain the maxillary incisor inclination, extraction of the maxillary premolars may be in order. If no extractions are performed in the lower arch, the molar occlusion at the end of orthodontic treatment should be a Class II molar occlusion with a Class I canine occlusion. Likewise, in a Class II patient with a significant skeletal base discrepancy where the overjet is minimal, mandibular first premolar extractions are indicated to maximize the advancement of the mandible. In this patient, a Class III molar occlusion with a Class I canine occlusion is the objective of the end of orthodontic treatment (Figure 1.6).

In the initial patient evaluation it is important to discern previous treatment of their malocclusion. For instance, they may have undergone past orthodontic camouflage, and either declined a surgical option (aside from extractions), or not been offered a surgical solution

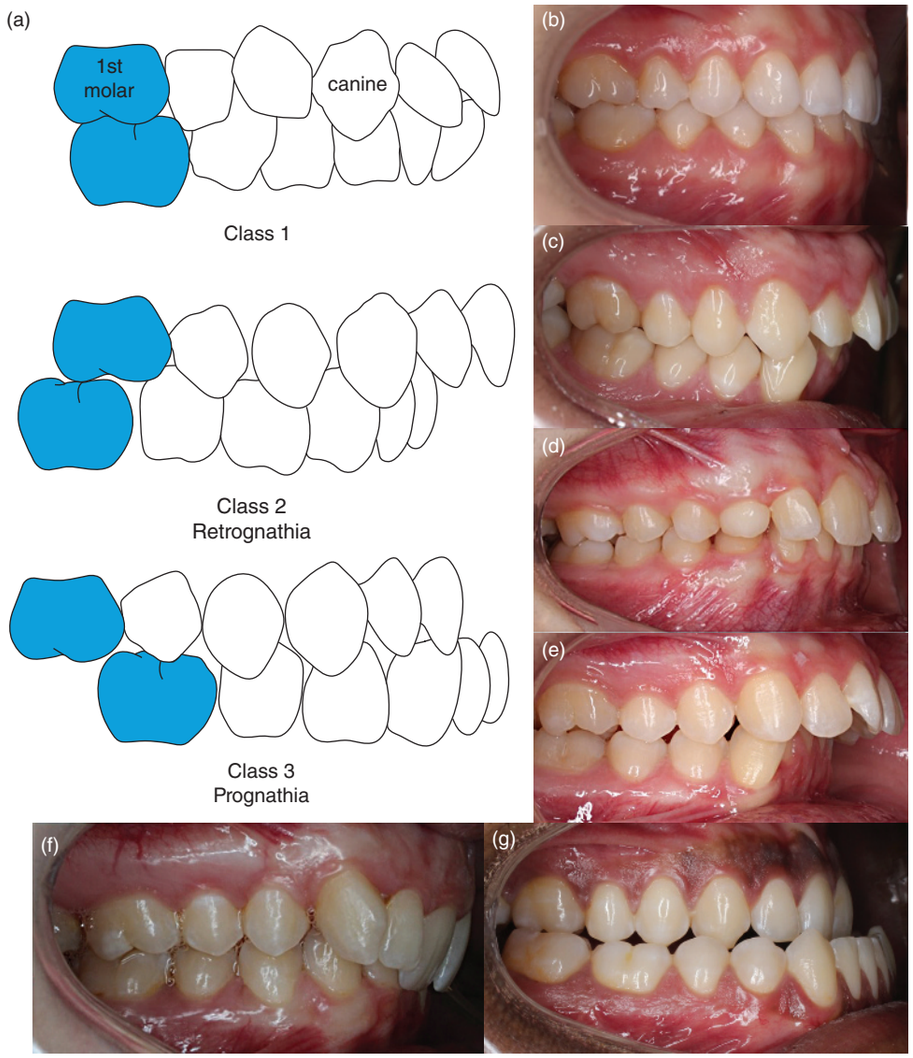

Figure 1.5 Angle classification of occlusion. (a) Overview of Angle classification; (b) class I occlusion; (c) class I malocclusion; (d) class II malocclusion; (e) class II division 1; (f) class II division 2; and (g) class III malocclusion.

in the first place. The orthodontic camouflage compensates the dentition, and may create a Class I relationship, but the jaw position is not altered. The aesthetic and functional compromise becomes apparent to the patient, initiating return for treatment (in the setting of a Class I occlusion). In some cases, the orthodontist goes to great lengths to avoid surgery, with extractions and prolonged period of braces, leading to patient treatment fatigue. The other issue with this is that the orthodontic forces for compensation need to then be reapplied later, in reverse, for decompensation (necessitating further, longer orthodontic treatment), risking root resorption and loss of support [14, 15]. A much better scenario is to identify the dentofacial deformity from the outset, and ensure the benefits and impacts of surgery are properly articulated and weighed by the surgeon, orthodontist, patient, and family. This will help limit a prolonged course of orthodontic therapy and "undoing" the attempted camouflage when the patient then later realizes that orthognathic surgery is needed/preferred.

In some cases, the patient never underwent orthodontic treatment, but still present with natural dental compensations for their jaw positions. Generally, compensation entails moving the incisors/canines to minimize either the overjet or anterior cross-bite. By contrast, decompensation (to set up for orthognathic surgery), performed by the orthodontist, will consist of

Figure 1.6 Example of Class I canine and Class III molar following extractions and mandibular advancement. (a) Facial sequence and (b) occlusal sequence.

uprighting the incisors in the alveolus which tends to increase the magnitude of overjet or underbite [16]. In addition to creating a more ideal and supported position in bone, this allows the surgical movements of the jaws to be maximized. The arches are also coordinated to allow the creation of a stable (Class I) relationship on jaw movement. Postsurgically, if the cusp–fossa relationship of the upper and lower teeth is well interdigitated, analogous to a lock and key, stability is increased (Figure 1.7) [17].

Decompensation alone does not always permit enough of a jaw movement to achieve the aesthetic objectives. For instance, in a Class II patient with a convex profile, after decompensation the mandible may only be able to be advance 4–5 mm, still leaving the patient with a convex appearance. As such, additional movements or modifications may need to be incorporated. The overjet can be made greater, with further decompensation, following mandibular bicuspid extractions with anterior retraction. This may also be indicated for crowding and space concerns. A combined maxillary and mandibular advancement can help advance the mandible further, especially when a counterclockwise rotation is utilized. Additionally a genioplasty is at times indicated to achieve further chin projection, beyond the boundary of what can be achieved with the jaws themselves.

In order to make the arches compatible (i.e. fit together on moving the jaws), the orthodontist must also presurgically level and align the teeth. Leveling refers to reducing the height of the Curve of Spee so that when the jaws are antero-posteriorly normalized, there are no interferences or opening of the bite when placing a Class I occlusion. At times, this leveling is not possible, or will take too long (e.g. two planes with an anterior open bite), and a multi-piece Le Fort-I may be indicated to achieve proper occlusion [16]. This is preferred especially compared to extruding the anterior teeth, which traditionally is thought to relapse, though this is now a matter of debate (Figure 1.8) [18].

Alignment of teeth suggests elimination of crowding and rotations, such that the teeth create a smooth arc or parabolic curve. Again, unstable movements should be avoided (e.g. tipping to compensate for a transverse

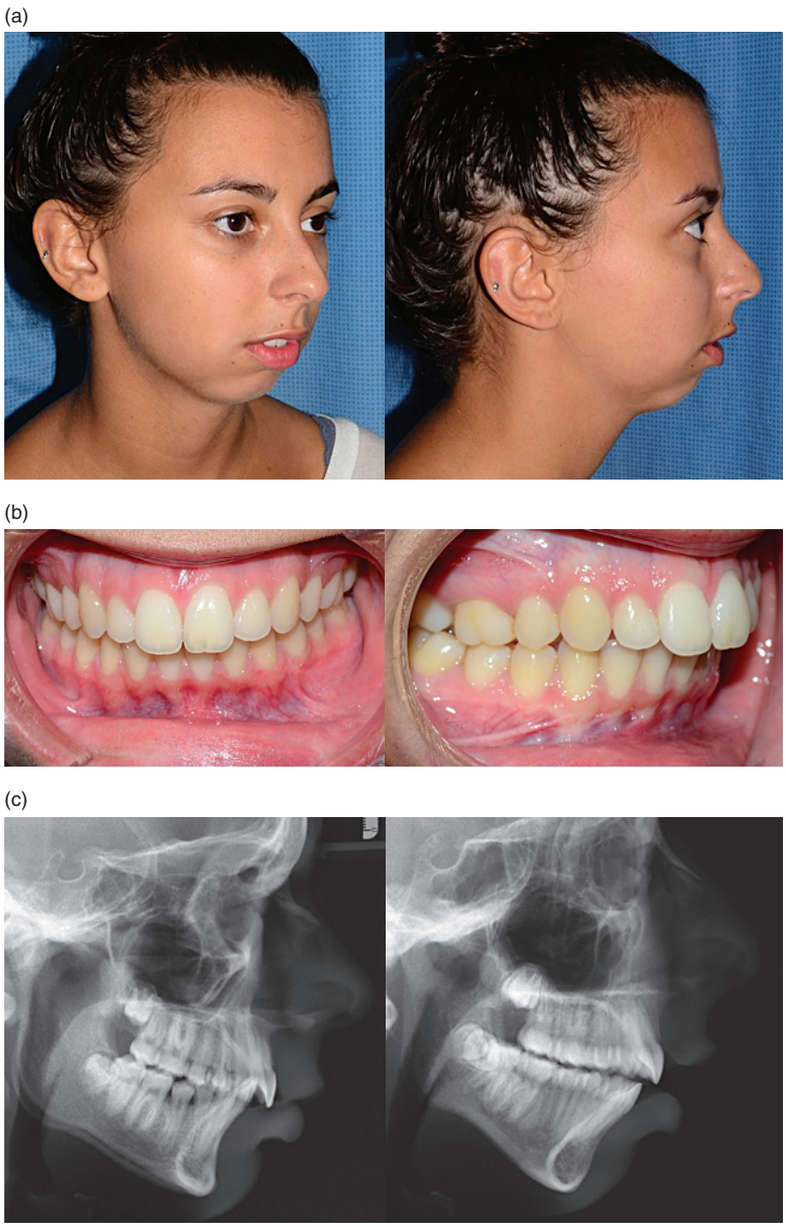

Figure 1.7 Compensated occlusion in the presence of a class II convex facial appearance. (a) Convex facial appearance with mandibular retrognathia and a short cervicomental distance; (b) occlusion is compensated (due to extractions) to a class I; and (c) lateral cephalogram shows before and after extractions, to lessen the overjet and compensate (note there is an anterior open bite following decompensation and the retruded skeletal/mandibular position still exists).

cross-bite or significant extrusion for open bites), as these teeth positions can relapse post-operatively, negatively impacting the surgical result. Such movements and understanding must be communicated effectively between the surgeon and orthodontist.

A Bolton discrepancy refers to a mismatch in the size of the maxillary and mandibular teeth. In such cases, even with appropriate decompensation, leveling and aligning, the upper and lower teeth may not appropriately interdigitate without accounting for the difference. Most commonly this is done by stripping mesial-distal width from the lower incisors, or increasing the mesial-distal width of the maxillary lateral incisors [19].

Bolton Analysis

$$\frac{\text{Sum mesio-distal width all 12 mandibular teeth (1st molar} - \text{1st molar)}}{\text{Sum mesio-distal width all 12 maxillary teeth}} = 91.3\%$$

One final consideration, which will be addressed in more detail later, is the "surgery-first" approach to combined orthodontic and surgical treatment. This entails

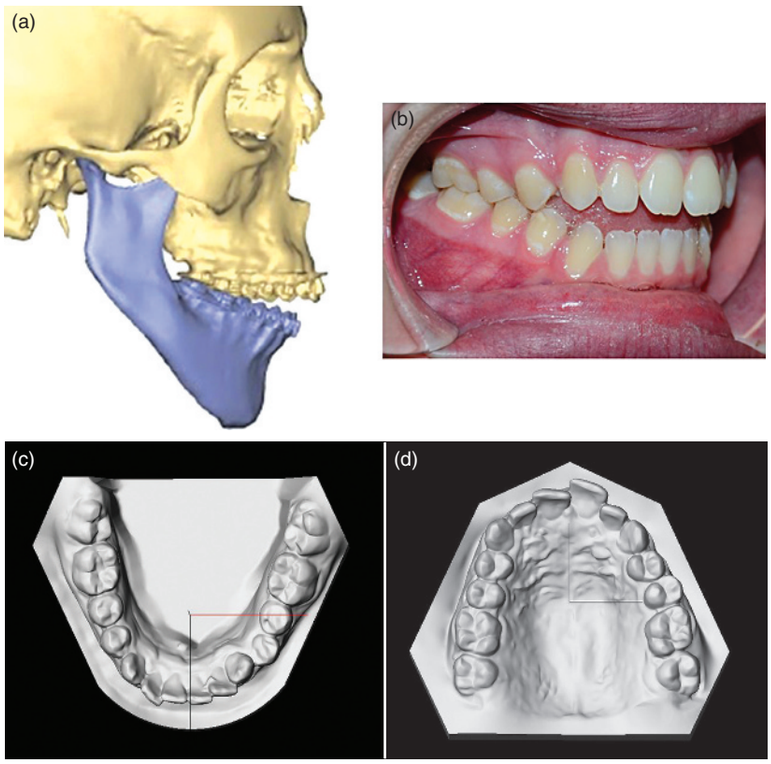

Figure 1.8 Apertognathia with two planes of occlusion. (a) Lateral 3D CT view with discrepant maxillary and mandibular occlusal planes and an open bite; (b) clinically, the presence of an anterior open bite. Digital models, to assess and measure a Bolton discrepancy; (c) lower model; (d) upper model.

minimal or no presurgical orthodontics. The needed amount of decompensation, retractions, alleviation of crowding, and so forth, are all factored into the surgical plan, frequently with jaw overcorrection to give space for these changes. The principal orthodontic phase is then performed postoperatively. The premise is surgically establishing a malocclusion that the orthodontist could normally treat in a nonsurgical manner. The overall treatment time is less for the patient, as they avoid the presurgical orthodontic phase, and the rapid acceleratory phenomenon (RAP) immediately following surgery seems to enable faster orthodontic tooth movement. Additionally, the soft-tissue is not working against the mechanics of the orthodontist as they are removing dental compensation [20, 21]. The most aesthetically driven patients offer a high degree of acceptance and preference for the "surgery-first" approach, as their jaws are positioned into a more harmonious position earlier in treatment.

1.4 Growth Evaluation

Anticipated jaw growth or change in position must be considered prior to orthognathic surgery. There are two principal scenarios: (i) the adolescent patient, and, (ii) the patient with changing occlusion, asymmetry, and temporomandibular joint (TMJ) pain. In the adolescent, the history should include age at first menarche, and change in shoe size and height. If growth is still active, then it should be followed for cessation. Perhaps the easiest way is simply through height. Cessation of vertical growth does not indicate facial growth has ceased, but facial growth is unlikely to cease until vertical growth is complete. Skeletal growth does not need to be complete to operate in a class II deformity (e.g. mandibular advancement ± maxillary surgery) or a case of vertical maxillary excess. However, a class III deformity should be delayed until growth is complete, as continued forward growth of the mandible (following maxillary advancement and/or mandibular setback) will serve to recreate the class III deformity, anterior crossbite, or contribute to perceived relapse of the positive overjet achieved.

Serial cephalometric films can be traced and superimposed to analyze for continued versus completed jaw growth. No change in serial cephalometric films over a six-month or year period implies that jaw growth has ceased. Similarly, the cervical vertebrae can be evaluated for signs of growth completion (deep concavities of the inferior borders of C2, C3, and C4, the height greater than width for C3 and C4) [22, 23]. Lastly, a hand–wrist X-ray can be obtained and fusion of the ulnar growth plate typically implies completion of maxillomandibular skeletal growth (the mandible being the last jaw to finish growth) [15].

Figure 1.9 Hand–wrist film can be used as a guide to skeletal growth completion; bone scan can be obtained to give information about an active condylar growth center. (a) Hand–wrist film with growth plates still open; (b) hand–wrist film with growth plates closed; and (c) bone scan showing increased uptake on the right (right condylar growth hyperactivity).

Patients presenting with a new onset asymmetry or occlusal change, especially in the face of TMJ symptoms, create concern for condylar or hemimandibular hyperactivity. This will be discussed in greater detail later in the book, but must be evaluated and treated if indicated. If objective measures of the ramus condyle unit on a plain film or panorex, and/or the presence of a double inferior border and evidence of a double occlusal plane on a lateral cephalogram worsen with time, this implies a progressive change or active growth center. Volumetric assessment on CT scan is also valuable and permits inspection for a pathologic process that may account for the change. A change in cant, occlusion, open-bite, or midline discrepancy can also be documented clinically, and documented over time. A bone scan can be used to reveal higher uptake (metabolic activity), pointing to an active condylar hyperplasia or an asymmetric growth process. In these asymmetric processes orthognathic surgery is typically performed after "burnout" of the growth process or a growth-arresting procedure (e.g. high condylectomy) is performed either in advance or concurrently with orthognathic surgery. Patients exhibiting these issues should also always be advised of the possibility, despite surgery, of future growth activation or resorption (Figure 1.9) [24].

1.5 Timing

Female patients reach skeletal maturity earlier than male counterparts, and therefore, on the whole, can undergo orthognathic surgery at a younger age. However, as mentioned above, it depends on the jaw discrepancy present, and any patient (both male and female) with a class II can undergo orthognathic surgery at a time prior to skeletal maturation. The minimal requirements are typically presence of the permanent dentition (third molars not withstanding) and having undergone orthodontic decompensation (unless "surgery-first"). In these class II patients a further impetus to early intervention is the

presence of obstructive sleep apnea (OSA). For instance, an adolescent who had Pierre Robin sequence as an infant, can undergo two-jaw advancement (mandible being advanced further) as soon as they are dentally able. As far as the mandible is advanced with surgery, if postoperative growth occurs, this will only help to maintain the advancement (or stave off relapse). A class III will not develop in a class II orthognathic patient who has undergone advancement prior to growth cessation.

In contradistinction, the class III patients are of greater concern, and need to be carefully evaluated and timed for surgery. Late mandibular growth, especially in male patients, can cause the patient to redevelop mandibular prognathism (and an underbite) and undo their surgical correction (maxillary advancement and/or mandibular setback). In the class III patient it is critical to wait until all markers suggest that maxillomandibular growth is completed. This provides the greatest chance for surgical stability and a long-term, robust result. In some instances, however, surgery may be considered early on Class III patients. This is especially the case for syndromic patients (Crouzon, Apert) who have significant psychosocial limitation, and/or functional (speaking, eating, OSA) issues interfering with their quality of life (Figure 1.10).

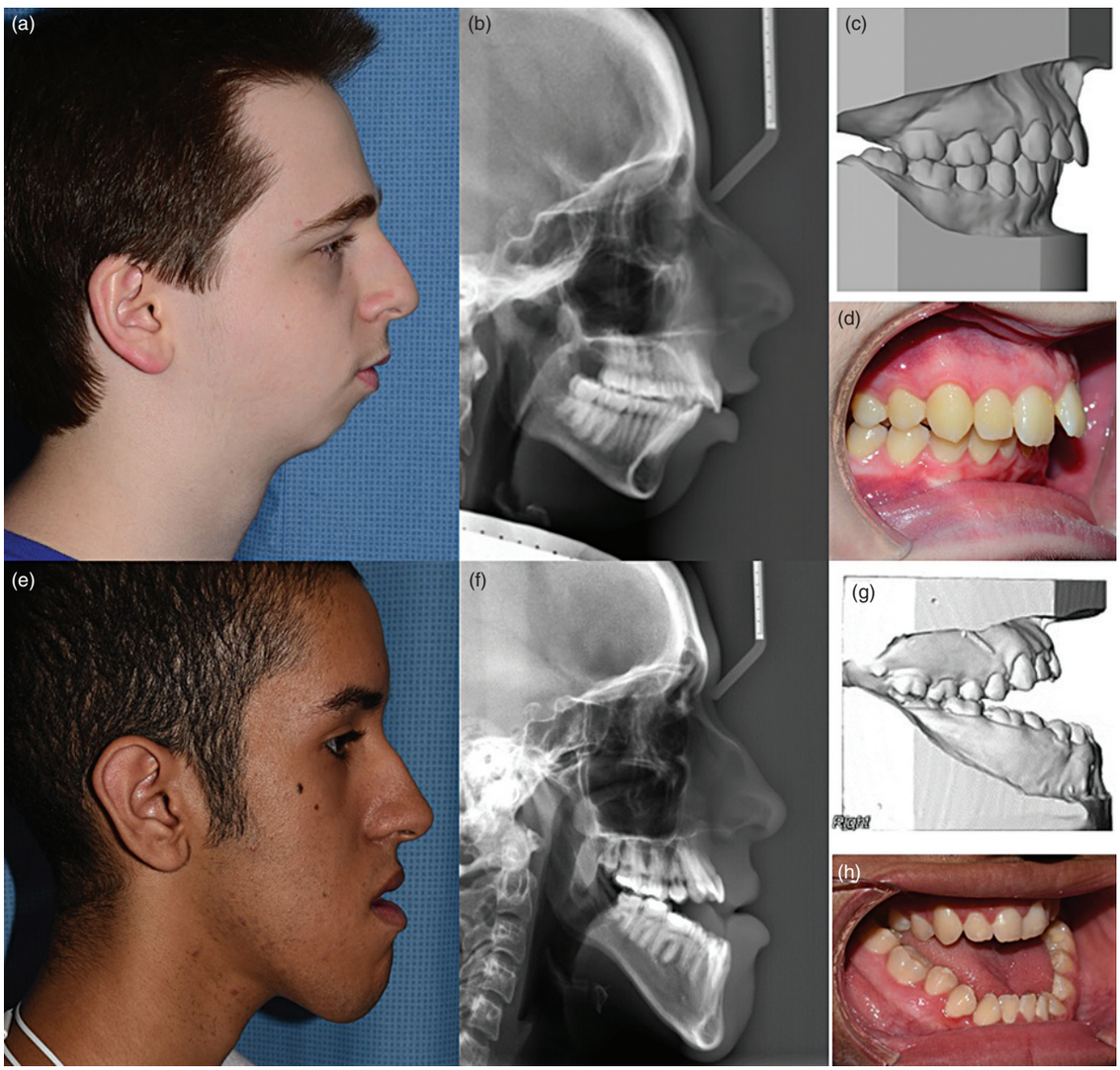

Figure 1.10 Class II v. III and when to proceed with treatment based on growth and deformity type. (a) Class II convex scenario, can operate prior to growth cessation; (b–d) class II occlusion (with excess overjet), models, cephalogram; (e) class III, wait until growth is fully complete prior to a mandibular setback and/or Le Fort I advancement; clinical photo; and (f–h) occlusal image; models, lateral cephalogram.

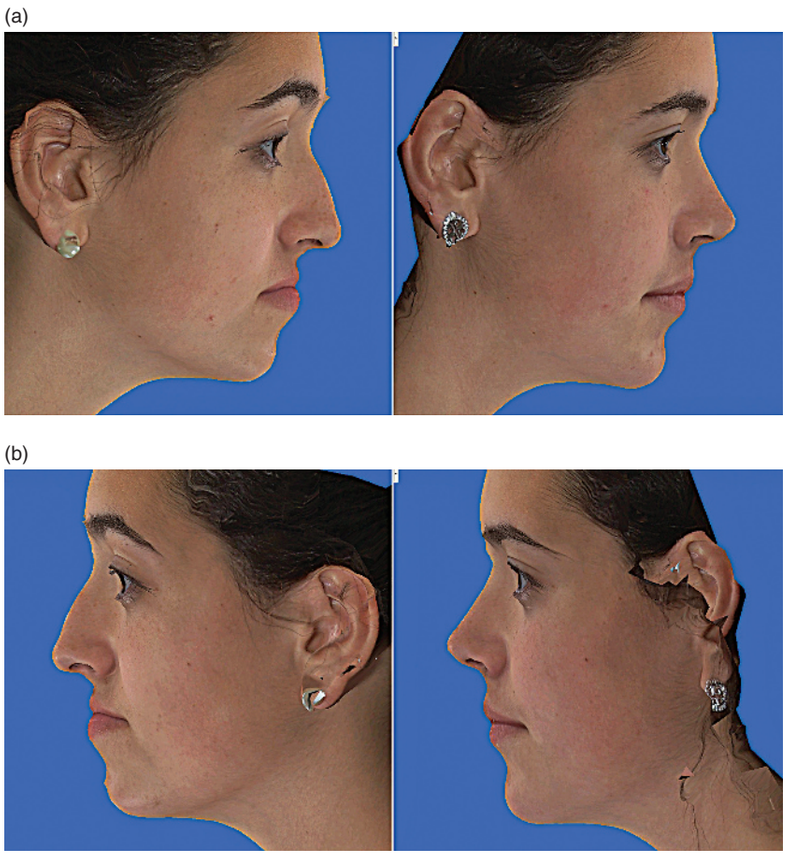

Figure 1.11 Example of orthognathic, rhinoplasty and facial aesthetic optimization. (a) Right lateral and (b) left lateral views.

1.6 Nasal and Adjunctive Procedures

In many orthognathic patients a nasal deformity may be causative, or contribute to the dentofacial deformity, and should be recognized. Additionally, the aesthetic optimization of the entire face, not only the jaw and maxillofacial region, may be an important treatment objective. Nasal considerations and timing of rhinoplasty are considered in great detail later in this book. Certain procedures to optimize nasal function, and mitigate adverse effects of orthognathic surgery, can be undertaken during the jaw surgery procedures (turbinectomy, septal repositioning, piriform contouring, alar repositioning). Formal rhinoplasty can be performed in either a simultaneous or staged manner, with advantages and disadvantages to each.

Bony augmentation or reduction, and soft-tissue modification (liposuction, fat grafting), may be also be indicated as adjuncts to orthognathic surgery. 3D photography and other bone and soft-tissue simulation tools are effective to develop and finalize the treatment plan and for patient/family communication. Longitudinal imaging should also be performed to follow results and changes over time. The cornerstone to achieve a balanced, aesthetic face is appropriate orthognathic planning and movement of the maxillomandibular complex to set the foundation. However, a comprehensive understanding of the entire facial, nasal, and dentoalveolar complexes, with referral for or performance of adjunctive procedures, will enable the ideal result to be achieved (Figure 1.11).

1.7 Summary of Goals: Guiding Principles for Aesthetic Orthognathic Surgery

Aesthetic orthognathic surgery is not simply treating the occlusion, nor treating an X-ray or cephalometric value. As we develop these concepts throughout this book, establishing a "normal" cephalometric value or occlusal relationship does not always, in itself, impart the most optimal aesthetic result. There is a subjective, artistic component that entails consideration of the entire face and facial regions. The goals in aesthetic modification are beyond restoring "normal." Aesthetic optimization entails achieving supranormal attractiveness.

Figure 1.12 Pre- and postoperative comparisons of aesthetic and orthognathic procedures, where the above tenets were implemented. (a) Preoperative oblique view (concave, prominent nose, asymmetric prominent chin, poor lip posture); (b) lateral, preoperative; (c) postoperative, with improvement of facial and nasal balance, following three jaw orthognathic, malar augmentation, rhinoplasty, fat grafting; and (d) lateral postoperative view.

General principles in "aesthetic" orthognathic and facial surgery include

a) *Expand the facial skeleton* (*when possible*)
   i) Provides additional facial volume
   ii) Improves skeletal support of the face and allows the face to age more gracefully
   iii) Expands the volume of the airway
b) *Remove all dental compensations*
   i) Allows larger magnitudes of skeletal movement
c) *Evaluate soft tissue imbalance, poor support, asymmetry*
   i) Orthognathic movements alone may address these issues
   ii) Adjunctive techniques may be required to address the remaining imbalance
   iii) Condylar growth disturbance may need to be dealt with
d) *Execute skeletal moves to enhance aesthetic goals – not just the occlusion*
e) *Harmonize soft tissues*
   i) Ensuring balance in the upper, middle, and lower thirds on both lateral and profile view
f) *Recognize when skeletal moves may worsen an aesthetic aspect*
   i) Prevent or address these changes now/later (e.g. A maxillary advancement may cause widening at the alar base. This could be minimized by employing counterclockwise rotation of the occlusal plane, possibly a cinch suture, or addressed secondarily with Weir/alar base or sill excisions.)

g) *Consider occlusal plane*
   i) Alteration of the occlusal plane via counterclockwise rotation can allow for increased chin projection while minimizing the advancement at the level of the alar base
   ii) Clockwise rotation (steepening) may be indicated for the overclosed mandible or buried maxillary incisors on vertical dimension

h) *Augment or reduce hard or soft tissues when needed*
   i) Orthognathic movements alone should be planned to optimize facial symmetry, balance, and support
   ii) However, at times intrinsic discrepancies, or areas remote to the jaw movement, require additional hard or soft-tissue modification (Figure 1.12)

i) *Optimize aesthetics through adjunctive procedures*
   i) Additional procedures for facial aesthetic optimization may be indicated either simultaneously or staged; depending on training paradigm, either you or a member of your treatment team/referral network should be enlisted to aid in such comprehensive treatment (e.g. rhinoplasty, genioplasty, submental lipectomy, malar/midface augmentation, chemodenervation, alteration of the nasolabial or labiometal folds, and skin resurfacing, among other procedures).

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