Aesthetic Orthognathic Surgery and Rhinoplasty

Edited by
Derek M. Steinbacher

with website

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Edited by Derek M. Steinbacher
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Foreword I

This book, *Aesthetic Orthognathic Surgery and Rhinoplasty* by Dr. Derek Steinbacher, masterfully considers the interface between the dentofacial, soft-tissue, and nasal elements of the face. The relationship between structure, osteocartilaginous vaults, and overall appearance and function is considered first-hand. The content of this book enables the reader and surgeon to understand, diagnose, and architecturally manipulate anatomical structures to optimize facial balance and aesthetics. When performed properly, repositioning and alteration of the facial skeleton and nasal anatomy can very positively benefit nasal form and function. Orthognathic manipulation improves not only the occlusion, but can optimize breathing, and incorporate complete aesthetic optimization.

The content covers all critical aspects of these topics, including analysis and planning, new concepts in treatment sequence and approach, and proper execution and technique to manipulate facial structures to achieve the best results. Importantly, adjunctive considerations and procedures to complement the jaw movements are considered in depth. These include fat grafting, soft-tissue augmentation and reduction, nasal changes incumbent on maxillary movements, and all relevant rhinoplasty aspects. The rhinoplasty perspective is critical to see how the nasal form and function can be optimized, and how a well-performed rhinoplasty is essential to achieve overall facial balance. The most aesthetic face incorporates well-balanced facial buttresses along with nasal form and function, together in harmony with the overlying soft tissues. The chapters take a unique bend and show how the entirety of the face is greater than the sum of its parts. This book is essential, and a necessary addition to the library of all providers, surgeons, and orthodontists who exhibit an interest in facial aesthetic, reconstructive, craniofacial, facial plastic, and rhinoplasty surgery.

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Foreword II

There has been a great need for a trusted reference source regarding orthognathic surgery and rhinoplasty. This truly is what this text, *Aesthetic Orthognathic Surgery and Rhinoplasty*, by Dr. Derek Steinbacher establishes. Dr. Steinbacher is uniquely qualified and experienced as a plastic and reconstructive, oral and maxillofacial, craniofacial, and rhinoplasty surgeon. He brings together the state-of-the-art in the scientific foundations, and blends the complex analytics of orthognathic surgery with the art of rhinoplasty. Not only has Dr. Steinbacher done a unique job in defining these deformities and their inter-relationships, but he has done so with clear images/depictions, state-of-the art 3D planning, and assessment of results. The management of skeletofacial deformities: Class II–III, mid- and lower-face discrepancies, and significant asymmetries, is elegantly illustrated. Dr. Steinbacher has uniquely been able to bring both the craniofacial and the plastic surgery vantage points to orthognathic surgery to provide for stable reconstruction of the face in an aesthetic manner.

Furthermore, because of his talent, experience, and background, as an orthognathic and maxillofacial surgeon and as an aesthetic plastic surgeon, he has been able to effectively blend the management of nasal deformities. Cosmetic rhinoplasty, together with functional improvement, is considered in either a simultaneous or a staged fashion. One of the most important aspects of this book is the chapter in which he addresses when to perform combination orthognathic surgery with rhinoplasty and when to adhere to a staged sequence. I have never seen a definition that is so well stated and well done. Traditionally, it has been that orthognathic surgery is done first, and a separate, staged rhinoplasty later. But there are reasons when one can and should perform both procedures simultaneously, such as in the setting of a significant nasal deformity and osseous nasal pyramid deformity. Dr. Steinbacher addresses this concomitantly with aesthetic correction of the chin and neck area.

The beauty of this book is that it truly balances the art, technique, and experience of an oral and maxillofacial and plastic/rhinoplasty surgeon to provide uniformly superb results. The management of these complex orthognathic and craniofacial deformities, especially in the setting of significant nasal deformities, is challenging. Dr. Steinbacher and his authors should be congratulated for this magnificent book which is a must read for all rhinoplasty surgeons, especially those who deal with significant craniofacial and orthognathic deformities. Clearly the application of both orthognathic surgery and rhinoplasty is one of the most powerful combinations to achieve optimal facial aesthetics and form.

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Foreword III

As the field of aesthetic and functional surgery of the face has evolved, it has been increasingly recognized that the face is more than just the sum of its parts. In the ideal functional and aesthetic state there exists a harmonious balance between not only the different facial regions, but between the hard and soft tissues. It is this dynamic interaction that is an absolute requisite for creating something that is maximally functional and aesthetically pleasing. Too often surgeons have focused regionally, ignoring the various other parts and, although the result in isolation may be acceptable, the overall improvement is less than ideal. The same is true for the hard and soft tissues: those with primary training in the hard tissues have been guilty of paying little attention to the soft-tissue mantle, while those with primary training in the soft tissues often ignore or minimize the contribution of the underlying bony framework.

Consider if you would the rehabilitation of an older home, something many readers might identify with. One can see the promise of the space, but to realize that potential a series of organizational steps are necessary. First, it starts with what one likes about the space, such as an ornate fireplace or grand entryway, but then those things that are disagreeable must be addressed: small rooms, narrow passageways, limited windows, and the like, to name just a few. So an architect is hired, and working with you he puts together a set of plans and blueprints, both 2D and 3D, for the entire project that will include things such as combining small rooms to make a grander space and opening up the windows, walls, and passageways to let in more light. But he also retains that which is attractive and functional, such as the ornate mantle, a handmade door, or a grand stairway. The list is endless.

Construction follows, during which small modifications inevitably are added, but everything is done in a stepwise fashion beginning with the foundation and the "bones" of the structure – the walls, floors, windows, and doorways – and is followed in sequence by floor coverings, framing of doors and windows, the addition of electricity and plumbing, etc. Only when these elements are in place is the interior decorator invited in to add color, fabric, and furniture. This is the recipe for a successful renovation. Stepwise, and beginning at the beginning, with the foundation. Too often this is forgotten. We have all probably been in homes where a defined space or room as a standalone structure is elegant but just does not fit with the remainder of the space.

The management of appearance-related and functional deformities of the face is no different, especially those centered around the jaw, the nose, and the mouth. First you define what you like and do not like, then establish a normal or supranormal (aesthetic) skeletal foundation which takes into consideration the effect it may have on the related soft tissues, and finally you modify and adapt those soft tissues for the best possible fit, both aesthetically and functionally. You treat both the hard and the soft tissues and you do so in a logical and stepwise fashion.

Who better than Dr. Derek Steinbacher to bring these principles together? Trained in both the hard and soft tissues of the face with residencies in Oral and Maxillofacial Surgery, Plastic Surgery, and a fellowship in Craniofacial Surgery, he not only understands these concepts but puts them to practice, as this well-written and practical guide demonstrates.

Enjoy this book; you are in for an informative and practical journey.

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Foreword IV

Over the past 50 years, improved understanding of the biologic basis of orthognathic surgical procedures and technical, anesthetic, and pharmacological advances have resulted in improved outcomes and decreased morbidity. There has been a corresponding increase in the number of patients undergoing surgical correction of maxillofacial deformities and surgeons, orthodontists, and patients have higher expectations for the quality of the outcomes than they have had in the past. We currently define success not only as a corrected occlusion, but we also consider improvement in masticatory function, breathing, speech, and the patient's facial aesthetics. The relationship between the corrected dental occlusion and improved facial appearance has been evaluated and reported as an outcome. The contribution of chin morphology and position, the size, shape, and position of the nose, and the nasal septum are also critical to understand and to evaluate when planning orthognathic surgery. The nose, in particular, may change dramatically after maxillary surgery.

Aesthetic Orthognathic Surgery and Rhinoplasty therefore, will be of great interest to oral and maxillofacial, plastic, and ear, nose, and throat surgeons who perform orthognathic surgery and/or rhinoplasty. The book specifically addresses preoperative diagnosis, 3-dimensional and virtual preoperative planning, and operative techniques, all the while considering the aesthetic implications and interactions of changes in the dentition, the jaws, the chin, and the nasal architecture. The major strengths of this book are the excellent documentation, the consistency achieved in a single-authored text, and the specific focus and integration of ideas on this important aspect of orthognathic surgery. It is also refreshing to see a young surgeon's well-considered ideas on this subject.

I have known Dr. Steinbacher since he was an Oral and Maxillofacial Surgery Resident at Massachusetts General Hospital. It is a tribute to his hard work and dedication that he has been able to complete this ambitious book after a relatively short period in practice. I look forward to future editions of the book.

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Foreword V

Numerous books have covered various aspects of orthognathic surgery from the standpoint of malocclusion and skeletal dysmorphology to achieve aesthetic results. Often the emphasis in the past has been to describe various surgical techniques to correct specific problems. In contemporary concepts of aesthetics, it is important to have a targeted approach to correct skeletal dysmorphology with optimal soft-tissue results.

This book by Dr. Steinbacher is the first of its kind, and describes in 26 chapters a systematic and comprehensive approach to diagnose and devise an optimal treatment plan by including nasal and maxillofacial systems. Various chapters describe surgical management of nasal deformities, some of which often develop following certain surgical movements of midfacial bones. I personally find it an innovative approach to include the nose as an essential part of orthognathic surgical treatment planning. This complements our current emphasis in providing patients with a nice smile, balanced soft tissue, and skeletal results with optimal function.

Dr., Steinbacher has placed a special emphasis on enhancing soft-tissue aesthetics of the face by showing techniques of fat grafting, lipectomy, augmentation, and contouring with and without orthognathic procedures. This book also describes in a sequential manner orthodontic considerations, 3D planning and model surgery, 3D simulation, deformity-based targeted correction, and technical aspects of jaw osteotomies and rhinoplasty.

On a personal note, Dr. Steinbacher is one of the best surgeons I have come across over my five decades in academics. He has taken orthognathic surgery to a new level by considering the whole face. This is an ideal book for residents and practitioners of orthodontics, oral maxillofacial, and plastic surgery.

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Preface

Drawing by Brooke Steinbacher, 3rd Grade

Aesthetic orthognathic surgery and rhinoplasty are complementary procedures, which share in common a similar approach for assessment, diagnosis, and stepwise, targeted treatment, based on the existing deformity and cosmetic goals. Orthognathic surgery developed with emphasis on addressing malocclusion and jaw discrepancies, but it was quickly realized that these techniques are powerful tools to dramatically enhance facial appearance. Similarly, rhinoplasty has important functional and reconstructive aspects, but can very positively impact facial cosmetics. For the best, and most aesthetic result, the orthognathic (and adjunctive) procedures must be properly planned and executed.

Establishing the proper occlusion is only the first level in correction, and is necessary, but not sufficient alone in achieving the desired facial appearance. Function and aesthetics are both optimally improved, using orthognathic surgery and rhinoplasty, when performed correctly. This begins with sophisticated recognition and understanding of the imbalances, lack of facial support, and aesthetic compromise that exists at the initial presentation. A comprehensive understanding of what is normal, what is optimal, and what is cosmetic and aesthetic is of utmost importance.

Once the dysmorphology and imbalances are appreciated, a targeted treatment approach is developed to address the concerns, and to improve facial and nasal appearance. An engineering mentality and technical acumen are vital, but the subjective "difference-maker" is the keen artistic eye, appreciation for, and ability to create balance and beauty. This more qualitative and stylistic component cannot be taught, but rather is innate. Appreciation of subtleties, and the ability to modify requisite facial tissues, with anticipation and prediction of biological healing, is critical.

Both orthognathic surgery and rhinoplasty are technically challenging, and often considered among the most difficult operations in maxillofacial and plastic surgery. It is clear that the nasal form, function, and osteocartilaginous vault is intimately related to that of the jaws and maxillofacial skeleton. Aberration and deformity of either the nose or jaws can result in growth disturbances, malposition, and/or secondary sequela of the other. Additionally, change and alteration of one system will almost certainly impact the function and appearance of the other. Sometimes this is in a positive or beneficial manner; in other instances, surgical manipulation of one will negatively influence, or be detrimental, to the other. Occasionally, there is a neutral interchange. It is clear that the ability to manage one or both systems is required for the most optimal outcome.

The reason for writing this book is to focus on aesthetic optimization in orthognathic surgery in isolation (not often written about); to address the aesthetic aspects and recognition/improvement of nasal deformity in isolation (more frequently written about); and to consider, in detail, the interaction between the nasal and maxillofacial systems to most completely influence and impart positive aesthetic change and functionality to the face (almost never written about). Certainly too, focus on other adjunctive procedures (fat grafting, lipectomy, augmentation, contouring) are essential to the aesthetic approach, and must be implemented, without hesitation, when indicated.

The absence of dual consideration of both rhinoplasty and orthognathic surgery in the same setting results from lack of content overlap, and biases intrinsic to specific training. Frequently at rhinoplasty meetings, beautiful nasal results are shown, and elegant correction of the nasal deformity, with, expectedly, most/all emphasis placed on the interventions and maneuvers to achieve the desired nasal result. However, not infrequently, an obvious maxillofacial or dentofacial deformity is present in the same case examples, occurring concurrently, that was not mentioned, addressed, or managed (e.g. vertical maxillary excess, or retrognathia); or was glossed over and managed simply with camouflage (e.g. silicone genioplasty implant). Such camouflage may be appropriate at times, but indeed the most powerful facial result comes when all systems that need modification are appropriately addressed. Conversely, and similarly, at maxillofacial or orthognathic meetings, a complex jaw deformity or scenario is shown and managed exceedingly well; but a significant nasal deformity is missed (and/or not corrected), or at times actually created by the jaw surgery, without mention.

The purpose of this book is to connect these two areas that are most often disconnected, and bring them together with other facial aesthetic maneuvers to create the entire picture for facial cosmetic improvement. The best results are achieved when nasal, maxillofacial, skeletal, and soft tissue are all handled and addressed appropriately. This may mean a staged or simultaneous rhinoplasty; an orthognathic procedure performed which improves or obviates need for rhinoplasty; or anticipating and predicting when orthognathic surgery will worsen the nose and create a nasal deformity (requiring an interval rhinoplasty). Of course in some instances, orthognathic surgery is performed when no nasal deformity exists; and still no nasal deformity exists postoperatively. Similarly, there are many occasions (perhaps the majority of rhinoplasties) when a rhinoplasty is indicated and performed when there is no jaw or chin discrepancy. This book is also intended to ensure that: (i) It is recognized that a myriad of deformities occur in concert, or have causation, and the surgeon should not focus only on a single system; (ii) That each respective deformity should be examined for, exonerated, or managed; and (iii) The best result occurs (producing the most well-satisfied patient and surgeon) following comprehensive recognition and treatment of all concurrent facial and nasal issues (= optimal aesthetics [and function]).

This book is intended to comprehensively review the diagnoses, workup, planning, and execution of patients with facial and nasal imbalance, who can be optimized aesthetically (and functionally). This includes: orthodontic considerations; 3D planning and model surgery; 3D simulation; deformity-based targeted correction; goal-based modification; technical aspects of jaw osteotomies and rhinoplasty; and adjunctive procedure considerations (lipectomy, augmentation, soft-tissue alteration, and so forth). Critically, several chapters are dedicated to the interface between nasal deformity/rhinoplasty and jaw discrepancies/orthognathic. There currently exists a paucity of literature discussing these inter-relationships and intersection between jaw and rhinoplasty; and it is critical to know which jaw patients need or will need a rhinoplasty, under what circumstances a Le Fort will improve the nose; which nasal deformity patients exhibit a complementary jaw problem; and when/how to organize and stage the procedures. Concepts will be discussed and developed, and the content will be solidified with significant emphasis on a variety of case presentations and selected video content. I hope you enjoy reading this first edition of *Aesthetic Orthognathic Surgery and Rhinoplasty*.

Derek M. Steinbacher, DMD, MD, FACS

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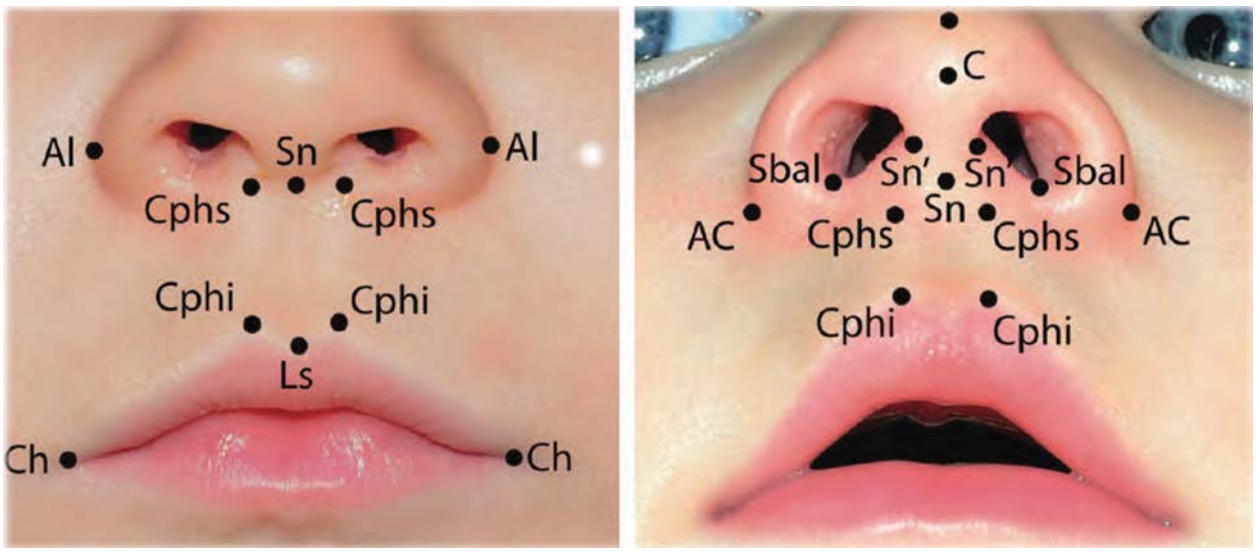
– **Mentors** in orthodontics, dentistry, oral and maxillofacial surgery, craniofacial surgery, rhinoplasty, and plastic surgery; past, present, and future, including the surgeons and treachers who trained me, my current Yale Craniofacial, Plastic, and Maxillofacial teams and colleagues, and the multiple collaborators locally and around the world.

– **Patients** for providing daily unique challenges, and enabling the surgical, technical, and artistic endeavors to change facial form, function, and aesthetics. Your trust, generosity, and shared images will help many generations of patients to come.

– **Julie, Brooke, and Cora**. My wife Julie; and my daughters Brooke and Cora; I love you immensely. Thank you for your excitement, humor, patience, and unwavering support during the hours of performing surgery, drafting, and preparing this book.



Cora Steinbacher: Nasolabial points and measures from: Steinbacher DM. Normal nasolabial anatomy in infants younger than 1 year of age. Plast Reconstr Surg. 2013 Apr;131(4):574e-81e

About the Companion Website

This book is accompanied by a companion website:

www.wiley.com/go/steinbacher/orthognathic

The website includes:

- Case studies
- Videos

VIDEO LEGEND
VIDEO KEY:

Planning video (chapter 4)

1. 3D Planning and VSP

Rhinoplasty Videos (chapter 18)

2. Rhinoplasty: incision, exposure, tip
3. Cephalic trim
4. Dorsal rasping
5. Septoplasty
6. Spreader grafts

Additional rhinoplasty videos

- 3D planning and simulation in rhinoplasty
- Additional Rhinoplasty techniques

Orthognathic Videos (chapter 19)

7. Full orthognathic rhinoplasty video
8. Le Fort I
9. BSSO

Genioplasty video (chapter 20)

10. Genioplasty

Submental liposuction video (chapter 21)

11. Submental liposuction

Fat grafting video (chapter 22)

12. Fat grafting

Anesthesia/Airway Videos (chapter 24)

13. Fiberoptic awake intubation
14. Nasal intubation
15. Nasal to oral tracheal intubation (tube change)

Video credits, Anamika Veeramani and Anusha Singh

1

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.

Aesthetic Orthognathic Surgery and Rhinoplasty, First Edition. Edited by Derek M. Steinbacher.

Companion website: www.wiley.com/go/steinbacher/orthognathic

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].

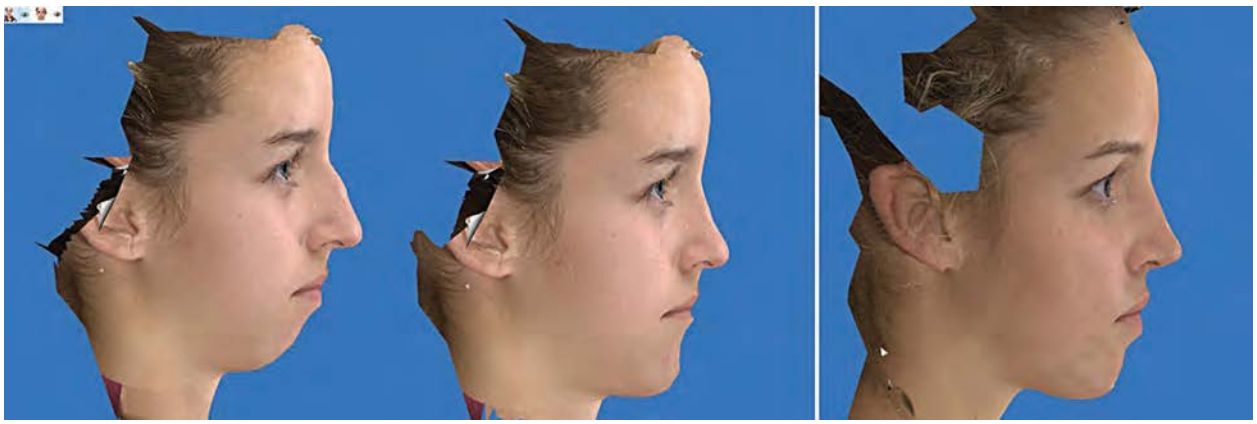


Figure 1.2 3D soft-tissue prediction used as part of patient education.

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.

(a)

(b)

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

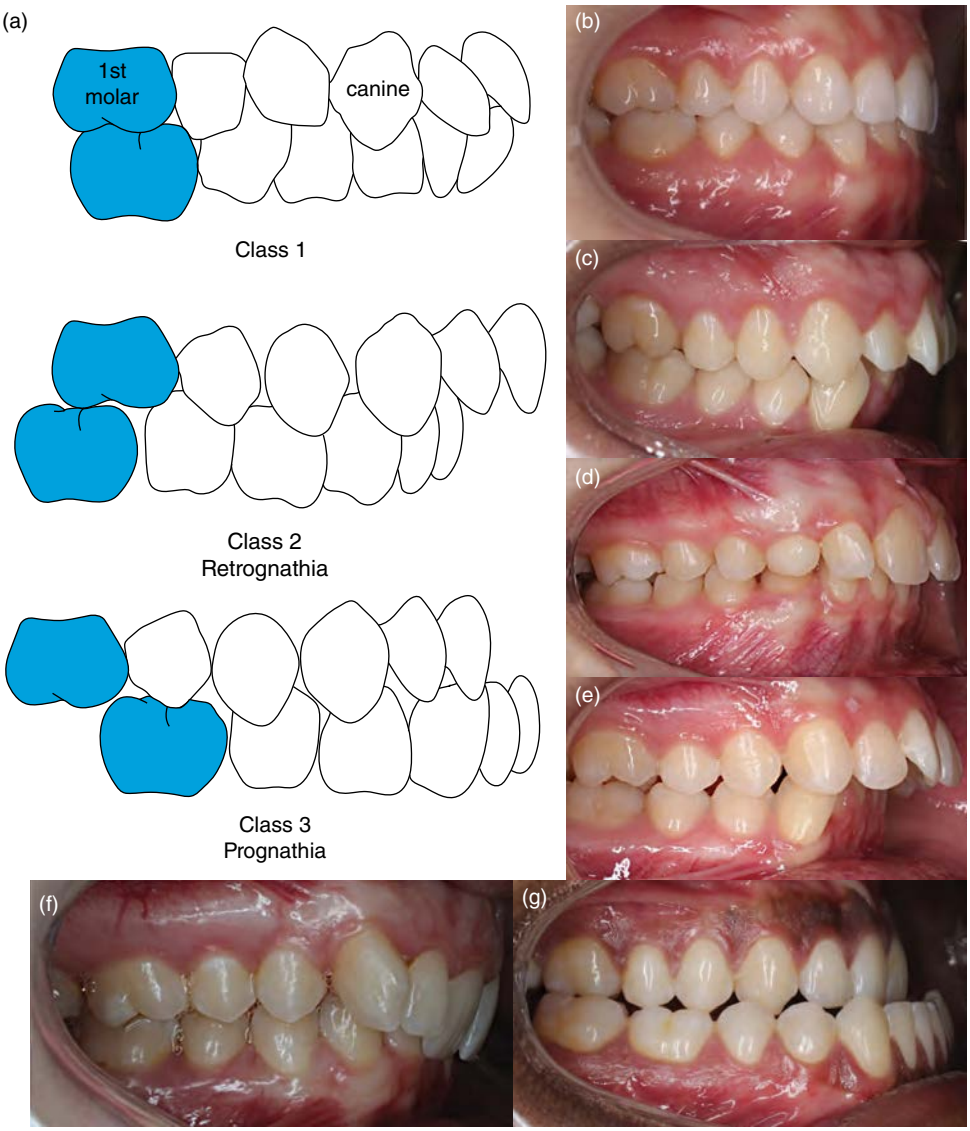


Figure 1.5 Angle classification of occlusion. (a) Overview of Angle classification; (b) class I occlusion; (c) class I malocclusion; (d) class II malocclusion; (e) class II division 1; (f) class II division 2; and (g) class III malocclusion.

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

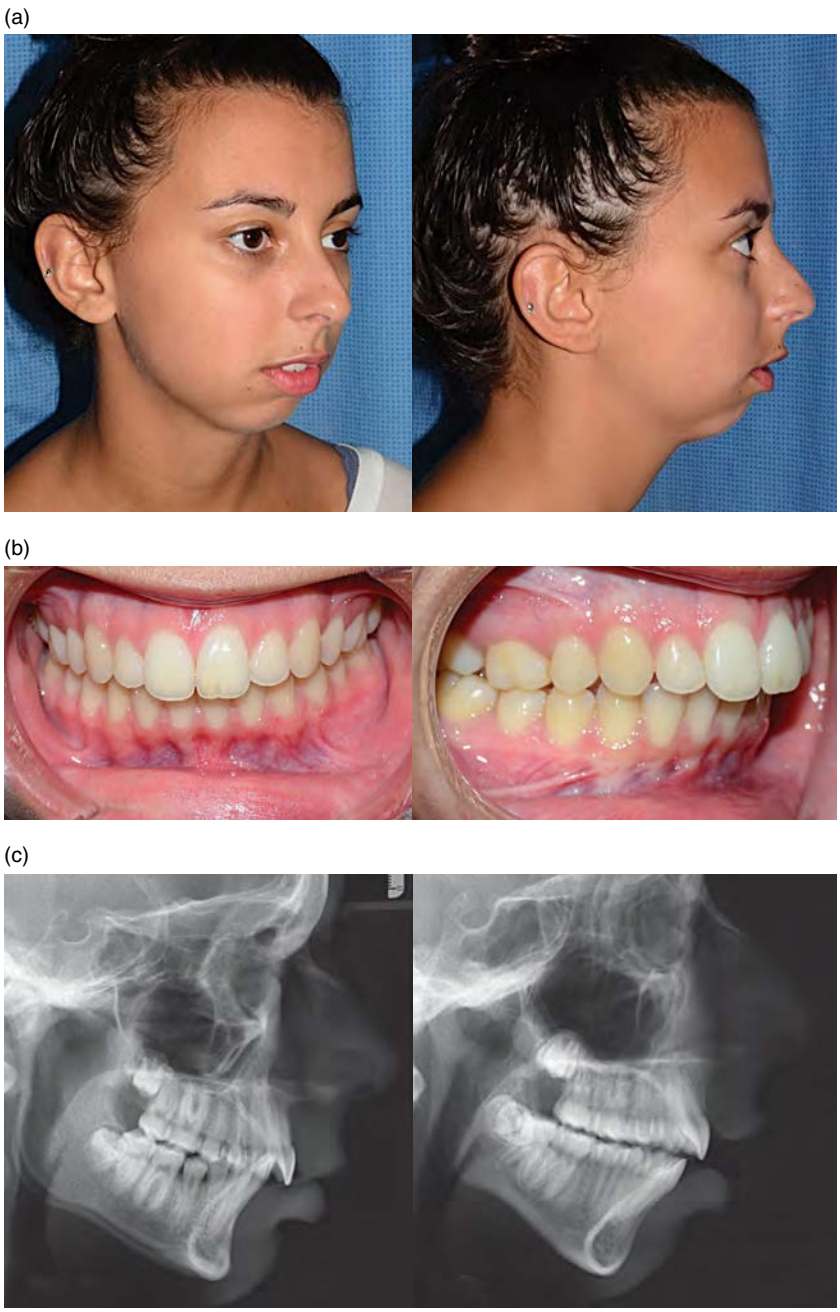


Figure 1.7 Compensated occlusion in the presence of a class II convex facial appearance. (a) Convex facial appearance with mandibular retrognathia and a short cervicomental distance; (b) occlusion is compensated (due to extractions) to a class I; and (c) lateral cephalogram shows before and after extractions, 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

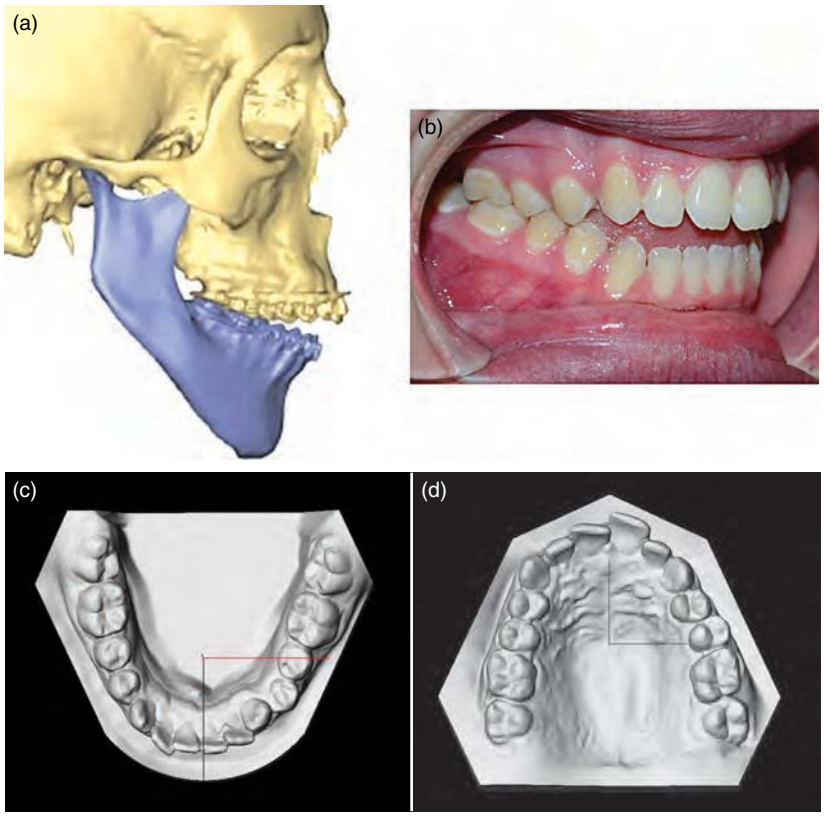


Figure 1.8 Apertognathia with two planes of occlusion. (a) Lateral 3D CT view with discrepant maxillary and mandibular occlusal planes and an open bite; (b) clinically, the presence of an anterior open bite. Digital models, to assess and measure a Bolton discrepancy; (c) lower model; (d) upper model.

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