ESSENTIALS OF
ORTHOGNATHIC
SURGERY
SECOND EDITION

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The positive reception of the first edition of Essentials of Orthognathic Surgery was gratifying and can probably be ascribed to its concise and to-the-point approach. This second edition pursues the same objectives of the first: to meet the needs of oral and maxillofacial surgery and orthodontic residents in training as well as young clinicians interested in orthognathic surgery. However, even experienced surgeons will find value in the text to improve the management and treatment outcomes of their patients. Because orthognathic surgery is a dynamic field influenced by a continual increase in clinical experience, accumulation of scientific knowledge, and development of esthetic acumen, an update was needed. In this edition, many sections have been added, revised, and expanded, and the quality and clarity of the illustrations have been improved with the use of full-color images and the addition of new figures and case reports.

The principles of the clinical evaluation of patients, analysis of diagnostic records, treatment planning, cephalometric analysis, and orthodontic and surgical visual treatment objectives remain the basic science of orthognathic surgery and have changed very little. However, the approach to and interpretation of the data have evolved. It is important to remember that cephalometric and soft tissue anthropometric analyses represent average values of individuals who are considered to have normal facial features. Some individuals with normal facial proportions may be unattractive while others whose facial measurements fall outside normal ranges are strikingly beautiful. Treatment planning is therefore a challenge that requires an artistic flair, an imagination, and an ability to think originally and creatively. Orthognathic surgical planning should be derived primarily from esthetic considerations based on the surgeon's esthetic sense as guided by the cephalometric data. The other two cornerstones of orthognathic treatment are correcting occlusal and orofacial function and ensuring stability of treatment results.

The section dealing with the rotation of the maxillo-mandibular complex has been expanded. The geometry of its treatment planning is explained in depth, and the expected soft tissue changes for clockwise and counterclockwise rotations at various rotation points have been tabulated for easy reference. Moreover, the addition of several new case studies helps to illustrate the concepts of this unique surgical design.

The discussion of anterior open bite dentofacial deformities has been updated in keeping with new philosophies regarding their diagnosis and correction. Most notably, this section presents the correction of an anterior open bite by means of mandibular surgery and includes indications for this approach as well as reasons why this method of treatment has proven to be stable despite previous assumptions to the contrary.

More than a decade following the introduction of distraction osteogenesis of the bones of the face, this concept of treatment is finally finding its rightful place in facial reconstruction. While not the replacement for orthognathic surgery that some clinicians had predicted, this treatment modality has become an important adjunct to traditional craniofacial and orthognathic surgical procedures. The principles of distraction osteogenesis and its indications for implementation are discussed, and new case studies demonstrate this method of lengthening facial bones and its role in orthognathic surgery.

The procedure of choice for setting the mandible back—especially for large setback procedures—is the intraoral vertical mandibular ramus osteotomy. Thus, a detailed description of this procedure was added to the chapter on surgical technique.

In the words of George Lois, “Creativity can solve almost any problem. The creative act, the defeat of habit by originality, overcomes everything.” I hope this new edition will further empower young orthognathic surgeons and orthodontists to develop their creativity, expand their vision, and apply their imagination in the treatment of their patients. It is essential to remember that we do not treat teeth but rather a person who has teeth and that in changing the faces of our patients we are also certainly changing their lives.

Last, I would like to express my sincere gratitude to Quintessence Publishing, which, after the success of the first edition, had the confidence to publish a second edition. It was a privilege to work again with the true professionals at Quintessence.
Preface to the First Edition

Although many books have been written on the subject of orthognathic surgery, none of them specifically addresses the essentials of treating patients with dentofacial deformities. This book, which presents both the science and art of orthognathic surgery, was written to fill that void. The research component has been omitted, since those aspects have been adequately presented in other textbooks. Instead, it focuses on the surgical and orthodontic principles of orthognathic surgery, allowing the clinician to learn the subtleties of treating patients with dentofacial deformities without first wading through scientific data and treatment philosophies.

The text opens with a concise description of the principles of the clinical evaluation of a patient, analysis of diagnostic records, treatment planning, and surgical procedures with possible complications. Clinical cases are then presented to demonstrate treatment outcomes, which are evaluated in all three dimensions and may be used by clinicians as an atlas for patient education. The text is enhanced and clarified by detailed illustrations that are used liberally throughout the book in the belief that “one illustration is worth a thousand words.”

This book specifically addresses several issues that are essential to orthognathic surgery. For example, cephalometric analysis is routinely used by orthodontists and oral and maxillofacial surgeons as a diagnostic guide and method of communication between members of a treatment team. However, because of their sheer numbers, relevant cephalometric analyses may become confusing and are often contradictory. To help assuage this difficulty, the relevance of the various analyses, including the new innovation of anteroposterior cephalometric analysis of the chin, is clarified with respect to skeletal, soft tissue, and dental relations in both lateral and anteroposterior cephalometry. An interpretation of each analysis is given to allow the clinician to choose the relevant analysis for the diagnosis of a specific facial deformity.

Another key issue in orthognathic surgery is the visual treatment objective. This tool is possibly the most meaningful, illustrative communication medium between team members as well as for patient information. Substantial space is therefore devoted to discussion of the development of a visual treatment objective for each deformity or combination of deformities in a step-by-step manner.

The modern orthognathic surgeon is exposed to a number of surgical procedures to correct dentofacial deformities. There is little doubt that the three most commonly used techniques are the Le Fort I maxillary osteotomy (including segmental surgery), the bilateral sagittal split ramus osteotomy of the mandible, and the sliding genioplasty. These three techniques are comprehensively described and clearly illustrated in a step-by-step manner. The basic principles necessary for a successful result, including the management of possible postoperative complications, are emphasized.

Although this book is designed to fit the specific needs of residents and young surgeons, experienced clinicians busily engaged in everyday practice also may find many refreshing reminders and hints for improving diagnostic and technical management of patients with dentofacial deformities.

I am deeply indebted to the pioneers of orthognathic surgery, on whose shoulders we, as modern practitioners, stand today, and feel extremely privileged to have been part of the exciting evolution of this fascinating field since the 1970s. Although it seems as if most of the basic scientific and technical parameters of orthognathic surgery have been established, new innovations and developments will improve the treatment we offer patients, and the development of the artistic flair that accompanies the science is unbounded.

This project was conceived about 10 years ago as a manual for a series of courses in orthognathic surgery written with the help of two orthodontic colleagues and friends, Tony McCollum and Bill Evans. I am eternally grateful for their enthusiasm, help and support, and also for making me think like an orthodontist—sometimes!

This book could not have been written without the support and encouragement of Dr Wynand van der Linden, a dear friend and colleague. A great debt is owed to Professor John Lownie for his enthusiasm and allowance of the time necessary to complete this project. The typing—and retyping—of the manuscript was done by Antoinette Markram, who was simultaneously managing my busy private practice. Her expertise and competence are greatly appreciated. Finally, I would like to express my love and gratitude to my extraordinary wife, Ingrid, and children, Johan and Mignon, for their patience, encouragement, and trust.
Systematic Patient Evaluation

The patient with a dentofacial deformity receives the best results from surgical therapy when there is clear and effective communication between the orthodontist and the maxillofacial surgeon from the outset of treatment. Through this close relationship, a full exchange of information and data can be made. Hence, in the following discussion no reference is made to “the orthodontist” or “the surgeon.” Each should be familiar with the standard records required, and the data on the patient should be shared regardless of who actually carries out the investigations. Treatment should commence only after both the orthodontist and the surgeon have consulted with the patient and a treatment plan has been jointly prepared (records can be duplicated). Orthognathic surgeons should have a thorough understanding of orthodontic treatment principles to enable them to communicate sensibly, to plan realistically, and to know what can be expected from the orthodontic treatment. Conversely, orthodontists should understand the surgical possibilities, limitations, and requirements to make the partnership ultimately advantageous to the patient.

A systematic examination is necessary to adequately evaluate and plan treatment for patients with dentofacial deformities. In routine cases this evaluation includes the following:

- General patient evaluation
- Sociopsychologic evaluation
- Esthetic facial evaluation
- Radiographic evaluation
- Occlusion and study cast evaluation
- Temporomandibular joint evaluation

General Patient Evaluation

Medical history

The patient’s medical history can be obtained by means of a questionnaire that the patient fills out at the first consultation. The questionnaire’s coverage should be thorough so that no important areas are overlooked. The data are used to focus follow-up questions. Existing medical problems must be further evaluated and discussed with the appropriate physician or specialist. The potential for these medical problems to complicate general anesthesia or reconstructive surgery must be evaluated. Risk management and potential complications related to any medical problem should be discussed with the patient and carefully documented. Other medical specialists treating the patient should be consulted as necessary, and reports on existing conditions and drugs the patient may be taking should be obtained. It is also important to look for and recognize congenital syndromes because these patients may have unusual growth patterns and may respond unpredictably to orthodontic or surgical treatment.

Dental evaluation

History

Previous restorative, orthodontic, periodontal, and facial pain treatment should be reviewed. The dental history is often an important barometer of the patient’s probable commitment to future treatment.
Arch leveling requires arch length. Additional arch length will be necessary with crowding. Further considerations include the angle of the mandibular incisors and the quality and amount of attached gingiva in the incisor region. If the mandibular incisors are angled lingually, improving the angulation by labial movement will create the space needed for arch leveling (Fig 3-8a). If the mandibular incisors are protrusive and crowding is present, extractions will be necessary (Fig 3-8b). The mandibular arch may be leveled surgically. This will not require additional arch length (Fig 3-8c).

Ensuring that the maxillary (unoperated jaw’s) dental midline coincides with the facial midline is another orthodontic consideration. Finally, the maxillary arch should be leveled, and the dental arches should be compatible.

**Single-jaw surgery with maxillary repositioning**

When the maxilla is advanced, the mandible (the unoperated jaw)—especially the mandibular incisors—determines the new anteroposterior position of the maxilla (Fig 3-9). However, the surgeon may also alter the anterior facial height by inferior or superior repositioning of the maxilla. When the maxilla is superiorly repositioned (vertical maxillary excess) or downgrafted (vertical maxillary deficiency), the mandible will autorotate around a point at the condyle. Following any vertical changes, the anteroposterior position of the maxillary incisors will be determined by the anteroposterior position of the mandibular incisors after autorotation.

Correction of vertical maxillary excess by superior repositioning of the maxilla will result in superior and anterior rotation of the lower incisors caused by the autorotation of the mandible. It will make the occlusion more Class III and may require maxillary advancement in addition to superior repositioning (Fig 3-10). If necessary, the orthodontist should compensate the incisors for this “added” advancement of the maxilla. This may entail a slight retraction of the mandibular incisors or may necessitate two-jaw surgery if the anteroposterior discrepancy becomes too large to be treated by maxillary surgery only. Secondary anteroposterior changes following superior repositioning of the maxilla are summarized in Table 3-3.

Increasing the height of the maxilla by downgrafting will lead to clockwise rotation of the mandible (downward and backward). This secondary anteroposterior change will make the occlusion more Class II and may require orthodontic proclination of the lower incisors or even necessitate two-jaw surgery. Maxillary setback in these circumstances is not a good option and will worsen the esthetic outcome. Secondary anteroposterior changes following inferior repositioning (downgrafting) of the maxilla are summarized in Table 3-4.

Transverse discrepancies between the upper and lower dental arches can be surgically corrected. Narrowing or widening of the maxillary arch, vertical occlusal plane discrepancies (open bites), and interdental spaces in the maxillary arch may be corrected by segmental surgery (see chapter 4).
Specific Orthodontic Treatment Required to Facilitate Surgery

Fig 3-9 (a) Anteroposteriorly deficient maxilla with a Class III dental relationship. (b) The maxilla will be advanced to a Class I malocclusal relationship determined by the anteroposterior position of the mandibular incisors.

Fig 3-10 (a) Vertical maxillary excess and an anterior open bite malocclusion. (b) The bite is closed by surgical superior repositioning of the maxilla with autorotation of the mandible. Because of the anterior component of the autorotation, the maxilla needs to be advanced as well.

Table 3-3 | Secondary anteroposterior changes following superior repositioning of the maxilla

<table>
<thead>
<tr>
<th>Following superior repositioning of the maxilla</th>
<th>Surgical correction of secondary skeletal anteroposterior problems</th>
<th>Orthodontic correction of secondary dental anteroposterior problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class I will rotate to Class III</td>
<td>Mandibular setback/maxillary advancement/genioplasty</td>
<td>Procline maxillary incisors/retract mandibular incisors</td>
</tr>
<tr>
<td>Class II will rotate to Class I</td>
<td>Genioplasty</td>
<td>Coordinate incisor positions</td>
</tr>
<tr>
<td>Super Class II will rotate to Class II</td>
<td>Mandibular advancement/genioplasty</td>
<td>Procline mandibular incisors/retract maxillary incisors</td>
</tr>
<tr>
<td>Class III will rotate to super Class III</td>
<td>Maxillary advancement/mandibular setback/genioplasty</td>
<td>Retract mandibular incisors/procline maxillary incisors</td>
</tr>
</tbody>
</table>

Table 3-4 | Secondary anteroposterior changes following inferior repositioning (downgraft) of the maxilla

<table>
<thead>
<tr>
<th>Following maxillary inferior repositioning (downgraft)</th>
<th>Surgical correction of secondary skeletal anteroposterior problems</th>
<th>Orthodontic correction of secondary dental anteroposterior problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class I will rotate to Class II</td>
<td>Advance mandible/genioplasty (maxillary setback not recommended)</td>
<td>Procline mandibular incisors/retract maxillary incisors</td>
</tr>
<tr>
<td>Class II will rotate to Super Class II</td>
<td>Advance mandible/genioplasty</td>
<td>Procline mandibular incisors/retract maxillary incisors</td>
</tr>
<tr>
<td>Class III will rotate to Class I</td>
<td>Genioplasty</td>
<td>Coordinate incisor positions</td>
</tr>
</tbody>
</table>
posterior mandible. Failure to compensate for the variation in mandibular body width may result in loosening of the screws, bending of the device, development of a torque force on the condyles, and failure of distraction.

**TMJ considerations**

Once the distractor is activated, reciprocal forces are placed on the glenoid fossa by the condyle. Flattening of the condyle, thinning and even perforation of the cartilaginous disc, subcondylar bone formation, and loss of the superior and inferior joint space have been reported. Some clinicians think that it is fundamental to unload the joints before distraction. It is recommended that during the presurgical orthodontic phase, the joints should be unloaded by Class II elastics, 6 oz per side. The unloading forces are continued during the distraction and consolidation phases and later discontinued by the orthodontist.

An open bite may develop during the distraction phase as a result of lack of parallelism or poor vector control of the devices. Open bite may be overcome by releasing the anteroposterior arm of the device following full activation. The bite is then closed by placement of strong maxillomandibular elastics that are maintained during the consolidation phase.

**Postsurgical orthodontics**

Once the distraction devices are removed, the patient is again referred to the orthodontist to finalize the occlusion. Some clinicians recommend the use of Class II elastics during the distraction and consolidation phases. The long-term effects of this action on the TMJs have not yet been established.

There are two main indications for distraction of the mandible: (1) in young children with severe mandibular deficiency where conventional orthognathic surgery cannot be performed (Fig 4-69); and (2) in adult patients with abnormally shaped mandibles requiring large advancements (Fig 4-70).

A patient was referred at the age of 5 years with Pierre Robin syndrome and had severe difficulty with chewing, speech, and nocturnal breathing. Bilateral distraction devices were placed with the distraction drivers exiting extraorally in the postauricular area. Following a latency period of 4 days, the distractor was turned twice daily (0.5 mm of distraction per turn), and the mandible was lengthened by 15 mm on each side during a 15-day period. The distraction devices were removed following a consolidation period of 4 months. The protrusion of the maxillary incisors was controlled by a removable orthodontic appliance (see Fig 4-69).

A patient was referred by his orthodontist for the correction of a severe Class II malocclusion by surgical advancement of the mandible. The patient required superior repositioning of the maxilla and a large advancement of his mandible to establish a normal occlusion. However, the shape of the patient’s mandible was not favorable to sagittal split osteotomy (see Fig 4-70a). His maxilla was superiorly repositioned by means of a Le Fort I osteotomy and the occlusal plane manipulated, reducing the occlusal plane angle. Bilateral intraoral mandibular distractors were placed at the same time maxillary surgery was performed. His mandible was lengthened by 17 mm by means of bilateral intraoral distractors, with the drivers exiting intraorally. A ge-
Mandibuloplasty was performed at the time of distractor removal, 5 months after completion of the distraction (see Fig 4-70).

**Maxillary advancement by distraction osteogenesis**

Midface deficiencies are traditionally treated by surgical advancement of the maxilla in the Le Fort I, II, or III level. Severe hypoplasia of the maxilla often occurs in syndromic patients and/or patients with cleft lip and palate. The maxillary skeletal hypoplasia in patients with cleft lip and palate is usually a manifestation of impaired growth as a result of multiple previous surgeries and related scar tissue formation. These patients often require large advancements of the maxilla with bone grafting and extensive rigid fixation, but postoperative stability proves to be questionable.

Anterior distraction of the maxilla should be considered as the preferred method of treatment in patients with obstructive sleep apnea. The distraction technique has the added advantage of monitoring the improvement of the posterior pharyngeal airflow and allowing titration of the advancement during the distraction phase.

Intraoral devices can be used for distraction of the maxilla on the modified Le Fort I and modified Le Fort III levels;
Step 16: Anteroposterior reduction of the chin

Position the chin using extraoral digital pressure, check the position of the bone using a caliper, and use a prefabricated chin fixation plate or bend the appropriate plate to fit accurately and passively (Fig 5-4n). Use a prefabricated chin fixation plate, an X- or H-shaped bone plate, or two straight plates. When the chin is set back, the posterolingual area often has a palpable step defect at the inferior border of the mandible, which may concern the patient. To contour this area, the osteotomized segment is pulled downward and forward, and the posterolingual aspect of the chin segment is contoured (Fig 5-4o). Protect the soft tissue at all times during this step.

Anteroposterior reduction of the chin may result in flattening of the labiomental fold. The sharp anterior edge on the superior aspect may be contoured to counter this effect and enhance the depth of the labiomental fold and chin shape (Fig 5-4p).

Step 17: Vertical increase of the chin

Using a 701 fissure bur, drill reference holes recording the vertical dimensions of the chin. To maintain the symmetry of the chin, the reference marks should be made in the midline as well as approximately 15 mm lateral to the midline and the distances between them recorded. Place a bone plate...
while the assistant uses the positioning wire and an instrument wedged between the segments to maintain the required space between the bony segments (Fig 5-4q). At least two screws should be placed superiorly and inferiorly to the osteotomy using an H- or X-shaped plate or two straight plates to secure the segment and maintain the vertical height. It is recommended that a bone graft be placed in the defect however, do not force the bone graft into the defect because doing so might displace or mobilize the chin segment.

**Step 18: Vertical reduction of the chin**

Drill reference marks recording the vertical dimensions of the chin. To maintain symmetry of the chin, place the marks in the midline and approximately 15 mm lateral to the midline, and record the distances between them. Perform the first osteotomy low enough to facilitate performing the second osteotomy from the superior aspect (Fig 5-4r). Complete the lower osteotomy, and mobilize the chin. Mark the amount and shape of bone to be removed, and then complete the superior osteotomy. The shape of the osteotomized bone will influence the final anteroposterior position of the tip of the chin; that is, if the ostectomy is wider anteriorly, the chin will rotate anteriorly, whereas an ostectomy that is wider posteriorly will rotate the chin posteriorly. Maintain as much soft tissue attachment to the chin as possible to ensure good blood supply to the repositioned bone and to reduce dead space. This will also yield a more predictable esthetic result.

**Step 19: Correction of asymmetry of the chin**

Drill reference holes recording the dimensions of the chin. For lateral movement of the chin, the dental midline is marked on the superior aspect of the osteotomy line whereas the midline of the chin is marked on the inferior aspect (Fig 5-4s). When correction of asymmetry requires vertical change as well, marks are placed lateral to the midline to record vertical dimensions on both the left and right sides. Large cants in the chin contour (e.g., in unilateral condylar hyperplasia or hypoplasia) may have to be corrected by a propeller osteotomy. The first osteotomy is performed superior and parallel to the occlusal plane or interpupillary plane. A second osteotomy is performed parallel to the lower border of the chin (Fig 5-4t). The small, triangular