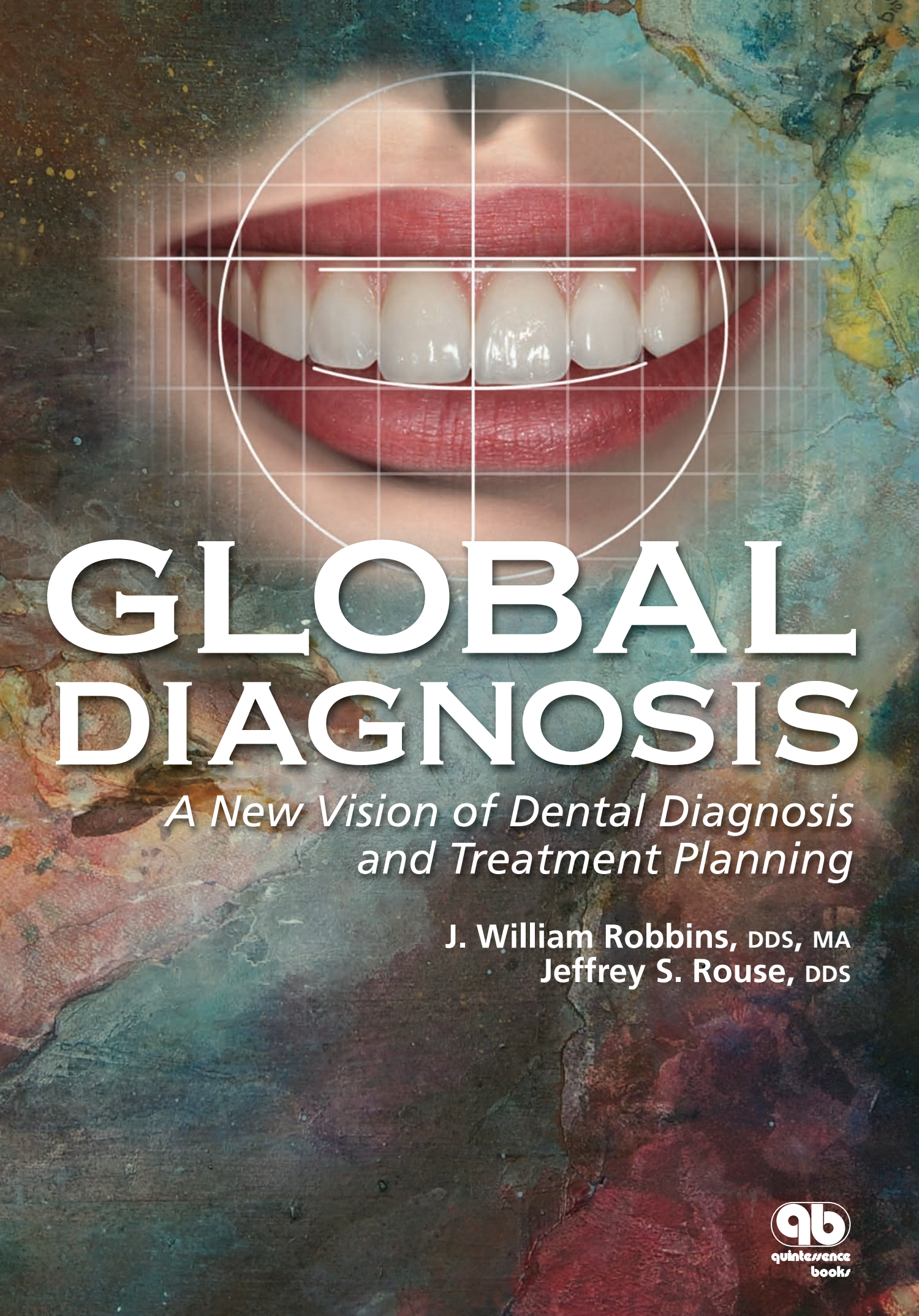

GLOBAL DIAGNOSIS

A New Vision of Dental Diagnosis and Treatment Planning

J. William Robbins, DDS, MA
Jeffrey S. Rouse, DDS

quintessence books

Global Diagnosis

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Contents

Dedication

To my favorite kids—Alyssa, Sarah, Andrew, and Patrick
and
To the love of my life for more than 35 years, my wife and best friend, Brenda

–JWR

To my wife, Lisa, who provides serenity to our family through her wisdom and love,
thank you for relinquishing your dreams for mine and ours.

To my kids—Sydney, Zachary, and Jake. Few children in the world can identify the proper "Global" diagnosis for the gummy smile of waiters by the age of 10. I hope that skill serves you well in life! Love y'all.

And, finally, to Bill Robbins. I hope this book confers a legacy to the greatest teacher
and person I have ever known. No moment impacted my life more
than when you agreed to mentor me and bring me into your world.

–JSR

Preface

Global Diagnosis is a story of mentorship and friendship. We first met when Jeff was a dental student and Bill was a full-time faculty member, so our relationship started as a student/mentor relationship. Jeff completed a 2-year general practice residency and returned to full-time private practice in San Antonio. After a few years in practice, Jeff urged Bill to leave academics and to join Jeff's practice. That is when our friendship began.

We practiced together for several years, and professionally it was a very rich time for both of us. We grew a lot as individuals and as colleagues. We also began teaching and lecturing together. This was the genesis of our teaching partnership, CORE Dentistry, which is still alive and well today. After a few years, we separated our practices as Jeff pursued graduate training in prosthodontics and Bill started his solo private practice. However, we continued to learn and teach together. We shared the goal of providing high-level interdisciplinary dentistry to our patients. To that end, we attended a lot of continuing education. Our dentistry and our teaching were impacted significantly by a group of teachers who were groundbreakers in the areas of esthetic and interdisciplinary dentistry. These included John Kois, Frank Spear, Vince Kokich, Pat Allen, Gerry Chiche, Bob Cronin, Jim Summitt, Burt Melton, and Jim Kessler. We both feel blessed that these iconic teachers have become our friends. Those of you who are familiar with their work will see their fingerprints throughout our book. Once again, what started as a student/mentor relationship has ended in lifelong friendships.

Through our years of treating complex restorative patients, we have come to believe that the parameter that makes these cases interdisciplinary is the patient's aberrant gingival levels. In our early years of treatment planning these patients, the emphasis was on the incisal edge position of the maxillary central incisors. We still put a great deal of emphasis on the incisal edge position, yet the incisal edges can be in a perfect position and the final treatment result a failure due to unacceptable gingival levels. Therefore, the emphasis in our Global Diagnosis system is to determine the etiology of the aberrant gingival positions. Once the etiology is determined, there are only a limited number of treatment options to correct the discrepancy. That is the power of the system: The diagnosis leads to the treatment plan.

Our Global Diagnosis system is based on five CORE questions:

1. What are the facial proportions and skeletal relationships?
2. What are the length and mobility of the upper lip?
3. What is the relationship between the gingival line and the horizon?
4. What is the length of the maxillary central incisor?
5. Is the CEJ palpable in the gingival sulcus?

This book outlines how to use these questions to determine a diagnosis and includes chapters on the treatment options available for various diagnoses, including crown lengthening, tissue grafting, intrusion, forced eruption, orthognathic surgery, facial plastics, and extrusion. Chapter 12 describes our CORE template, which is included on the attached CD, and how to use thirteen photographs to complete the template. This template can be used for presentations for dental study clubs as well as to keep track of pertinent information. In the final chapter, we invite readers to plan the treatment for five case studies based on the CORE questions and other diagnostic information.

The Global Diagnosis system, which we share with you, would not have been possible without those who came before us. To our teachers, to the teachers who taught them, to all of the links in the chain, we raise our glasses.

Acknowledgments

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Jeffrey S. Rouse, DDS, maintains a full-time private practice in San Antonio, Texas, and is a clinical adjunct associate professor in the Department of Prosthodontics at the University of Texas Health Science Center at San Antonio Dental School. He is a member of the American Academy of Restorative Dentistry and the American College of Prosthodontists and past president of the Southwest Academy of Restorative Dentistry. Dr Rouse has written numerous journal articles, including a portion of the "Annual Review of Selected Dental Literature" published each summer in the *Journal of Prosthetic Dentistry*. In addition, he has contributed chapters on porcelain veneers and anterior ceramic crowns to three editions of a dental textbook. Dr Rouse lectures nationally and internationally on a wide variety of topics ranging from dental esthetics to sleep prosthodontics.

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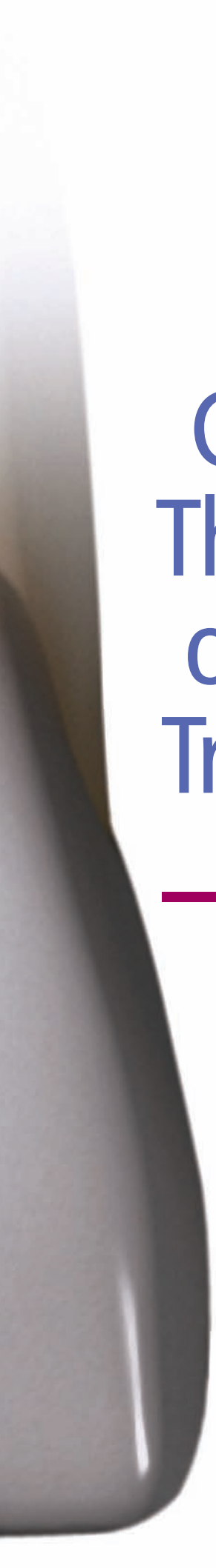

Global Diagnosis: The Art and Science of Interdisciplinary Treatment Planning

1

This chapter compares the traditional and contemporary approaches to diagnosis and treatment planning and offers an alternative, global approach.

Traditional Approach to Diagnosis and Treatment Planning: Occlusal Relationships

With an increased emphasis on interdisciplinary treatment planning in recent years, the deficiencies associated with traditional methods of diagnosis and treatment planning have become more evident and problematic. Historically, sophisticated, comprehensive diagnosis and treatment planning was based on an occlusally driven philosophy. The traditional data-collection process included, but was not limited to, a social history, a medical history, a determination of the patient's chief complaint, a past dental history, charting of missing teeth, charting of existing restorations, charting of defective restorations and caries, periodontal charting, vitality testing, cancer screening examination, occlusal examination, temporomandibular joint and muscle examination, a complete series of radiographs, diagnostic photographs, and study casts mounted on an articulator in a predetermined position.

Once this enormous amount of data was gathered, the dentist would then complete a risk assessment associated with each of the areas of collected data. The dentist then made a diagnosis of each tooth based on the data. This diagnosis may have been related to the pulpal health, the periodontal health, and/or the restorability of the tooth. Additionally, the mounted casts were used to evaluate tooth-to-tooth and arch-to-arch relationships. If required, a diagnostic wax-up was accomplished, based on the occlusal evaluation. The treatment plan was simply based on restorative space, anterior guidance, and resistance and retention form of the final preparations, with no focus on placing the teeth in the correct position in the face.

Once this process was completed, the next step was to create a sequenced treatment plan. However, because of the sheer amount of data, the dentist was often overwhelmed and therefore unable to develop a sequenced treatment plan. The dentist literally did not know where to start. The problem with this traditional approach is that there are many "regional" diagnoses made (ie, pulpal status of the maxillary first premolar) but no "global" diagnosis (ie, where the teeth fit into the patient's mouth and face). The dentist gets lost in all of the details.

In medicine, the approach is different. When a patient presents with a chief complaint, a history is taken to determine the nature and duration of the complaint. Any systemic conditions such as hypertension are also noted in the history. Specific diagnostic tests are ordered and evaluated based on the chief complaint. Based on the collected data, the next step is to make a diagnosis. If the diagnosis is cancer, for example, then the treatment plan is based on the type and stage of the malignancy. The patient will receive either chemotherapy, radiation therapy, surgery, or a combination approach. However, if the diagnosis is a localized condition, the treatment plan will be completely different. The treatment plan is based on the global diagnosis, not the initial symptoms. If the patient has any systemic conditions such as hypertension, they are considered regional diagnoses. They may be important and may impact the final treatment plan, but they do not dictate the plan.

In medicine, therefore, the sequence is *(1)* data collection, *(2)* global diagnosis (perhaps modified by regional diagnoses), *(3)* treatment plan, whereas in dentistry the sequence is *(1)* data collection, *(2)* regional diagnoses, *(3)* treatment plan. In dentistry, a global diagnosis would determine where the teeth and gingiva should be placed in the patient's mouth and face, but it is impossible to make this determination using regional diagnoses alone. The dentist is expected to make a global treatment plan based on a lot of regional diagnoses.

Decades ago, the traditional style of regional treatment planning was effective because treatment options were very limited; the restorative dentist had few treatment modalities in addition to tooth preparation. At that time in history, the primary tools available for treating the complex restorative patient were functional crown lengthening surgery and increasing the vertical dimension of occlusion. Practitioners did not have access to advanced periodontal therapies. Predictable root coverage with grafting procedures had not been discovered. Additionally, esthetic crown lengthening surgery had not been described and was not used routinely to treat altered passive eruption.

Orthodontic treatment was primarily for the adolescent patient and was used infrequently with the adult patient. It was seldom a part of a comprehensive treatment plan in an adult patient because there was no emphasis on orthodontic intrusion and extrusion of teeth to enhance the restorative treatment plan. Oral surgery had nothing to offer the restorative dentist other than tooth extraction. More sophisticated maxillofacial surgical procedures were used primarily to treat the trauma patient. Finally, the use of plastic surgery procedures to enhance a comprehensive dental treatment plan had not even been conceived.

Contemporary Approach to Diagnosis and Treatment Planning: Tooth Position

This all changed in the early 1980s. Two young prosthodontists, John Kois and Frank Spear, challenged the traditional approach to prosthodontic treatment planning. With the advanced treatment modalities offered by orthodontics, periodontics, and oral and maxillofacial surgery, along with an increased emphasis on esthetics, they offered a new treatment-planning paradigm based on the belief that if the teeth were placed in the correct position in the patient's face, effective function would follow. In other words, they began their treatment planning with tooth position rather than condylar position, hence their term *facially generated diagnosis*.

Along with many others in our profession, the authors embraced this new logical vision of treatment planning. Over the years, we developed a set of guidelines to help us determine the new incisal edge position of the maxillary anterior teeth as the starting point in treatment planning the interdisciplinary patient.

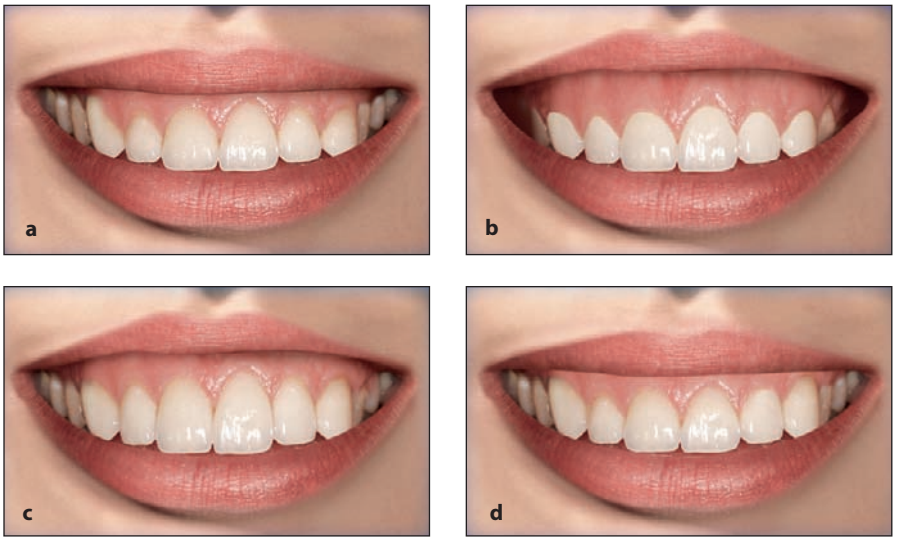

Fig 1-1 Incisal edges in the correct positions but with unesthetic gingival levels. *(a)* Uneven gingival levels (note the right lateral incisor and canine). *(b)* Excessive gingival display. *(c)* Uneven gingival levels (note the central incisors) and excessive gingival display. *(d)* Uneven gingival levels (note the right lateral incisor and left canine).

Establishing incisal edge position

Descriptive guidelines

- The incisal edges of the maxillary anterior teeth should be cradled by the lower lip in full smile.
- There should be a smooth continuation between the incisal edges of the maxillary anterior teeth and the buccal cusp tips of the maxillary posterior teeth with no step-up or step-down from front teeth to back teeth.

Confirmation guidelines

- The average incisal display of the maxillary central incisors in repose is 3 to 4 mm in the young female and 1 to 2 mm in the young male.[1]
- The average length of the maxillary central incisor is 10 to 11 mm.[2]

Using these guidelines, a new incisal edge position can be established by the dentist, although this is just a "best guess" based on the four guidelines. A diagnostic wax-up is then completed on the mounted study casts, and stents are fabricated for provisional restorations. After the teeth are prepared, the provisional restorations are placed according to the new proposed incisal edge position. Over the next several days, the patient can dynamically determine if the new position is acceptable in terms of function, phonetics, and esthetics. The provisional restorations can be adjusted until both the patient and the dentist are satisfied. This information is then transferred to the laboratory, and the definitive restorations are fabricated.

The authors utilized this approach to treatment plan complex patients and continue to use it today. However, with time, we realized that this approach also had shortcomings. The incisal edges of the maxillary anterior teeth could be in a perfect position, and yet the definitive restorative result could be a failure because the gingival tissues and/or smile frame were unesthetic (Fig 1-1).

Global Approach to Diagnosis and Treatment Planning

This was the genesis of the "global diagnosis" concept, a systematic approach to evaluate, diagnose, and treat aberrations in the gingival positions and the smile frame. In dentistry, there are four primary global diagnoses related to *(1)* the facial and skeletal proportions, *(2)* the length and mobility of the maxillary lip, *(3)* the relationship of the gingival line to horizon, and *(4)* the length of the clinical crowns of the relevant teeth. In order to determine the global diagnosis, the clinician must first collect a set of data that is not commonly gathered in a traditional dental examination. Chapter 2 defines each of the parameters required to make the global diagnosis along with their normative values. In addition, a form is provided to aid in the collection of the relevant data. In chapter 3, a set of five questions will allow the clinician to determine the global diagnosis. In chapters 4 through 9, the six tools available to treat the global diagnosis are discussed in detail. In chapter 10, special emphasis is given to the global diagnosis that most commonly impacts the treatment plan in the interdisciplinary patient: dentoalveolar extrusion. Once the global diagnosis has been established, it is time to sequence the treatment plan, which is the topic of chapter 11. Chapter 12 features a global diagnosis treatment-planning template that is used for organizing a diagnosis and treatment plan presentation for a patient or a study club. Finally, case studies using the global diagnosis system are presented in chapter 13.

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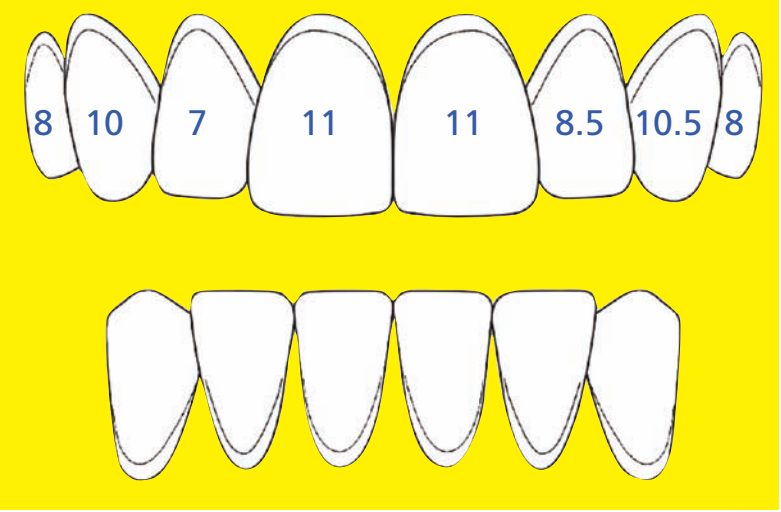
1. Vig RG, Brundo GC. The kinetics of anterior tooth display. J Prosthet Dent 1978;39:502–504.
2. Gillen RJ, Schwartz, RS, Hilton TJ, Evans DB. An analysis of selected normative tooth proportions. Int J Prosthodont 1994;7:410–417.

Length of maxillary anterior teeth—(chart)

Tissue levels—(chart)

Angle of incisal plane—(chart)



Posterior occlusal plane (ok, step-up or step-down, cant) _____

Pathologic tooth wear—Y/N (tooth #s) _____

CEJ located Y/N _____

Tooth color _____

_____

Tooth alignment (spacing, overlap)_____

_____

Doctor notes

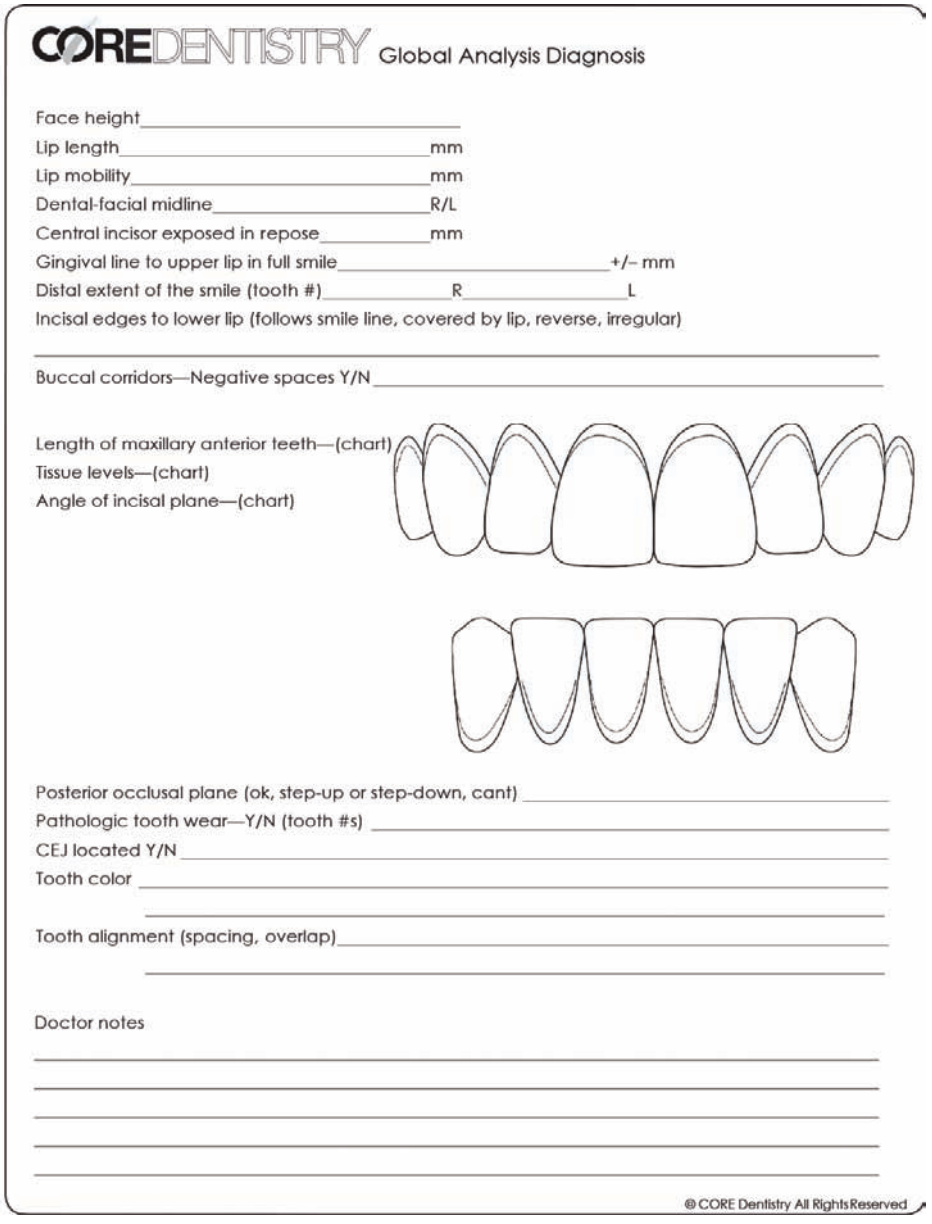
_____

_____

_____

Global Analysis Diagnosis Form

The Global Analysis Diagnosis form is the vehicle that leads the dentist through the Global Diagnosis system. This chapter provides instructions for completing the form as well as a set of normative numbers to be used in evaluating the interdisciplinary patient.



CORE DENTISTRY Global Analysis Diagnosis

Face height_____

Lip length_____mm

Lip mobility_____mm

Dental-facial midline_____R/L

Central incisor exposed in repose_____mm

Gingival line to upper lip in full smile_____+/– mm

Distal extent of the smile (tooth #)_____R_____L

Incisal edges to lower lip (follows smile line, covered by lip, reverse, irregular)

_____

Buccal corridors—Negative spaces Y/N_____

Length of maxillary anterior teeth—(chart)

Tissue levels—(chart)

Angle of incisal plane—(chart)

Posterior occlusal plane (ok, step-up or step-down, cant)_____

Pathologic tooth wear—Y/N (tooth #s)_____

CEJ located Y/N_____

Tooth color_____

_____

Tooth alignment (spacing, overlap)_____

_____

Doctor notes

_____

_____

_____

_____

_____

Fig 2-1 GAD form. CEJ, cementoenamel junction.

As with any dental examination, a reliable, expedient process of recording information is key. The "Global" Analysis Diagnosis (GAD) form (Fig 2-1) allows practitioners to record key esthetic and functional information in a small amount of time. With proper training, any staff member can accomplish the measurements. This allows it to be incorporated into almost any type of new patient experience, hygiene recall, or reevaluation. It generally requires no more than 5 minutes to complete the examination.

This chapter focuses on making proper measurements and demonstrates annotations used to record ideal and abnormal findings. The GAD form is organized from outside in, starting with the face and ending with the teeth, so as to reduce redundancy.

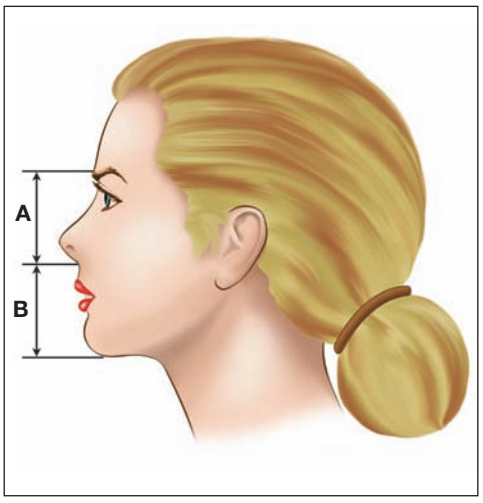


Fig 2-2 Rule of thirds. (A) Midface measurement is from soft tissue glabella, the most prominent point between the eyebrows, to under the nose. (B) The lower third is measured from the base of the nose to the base of the chin.

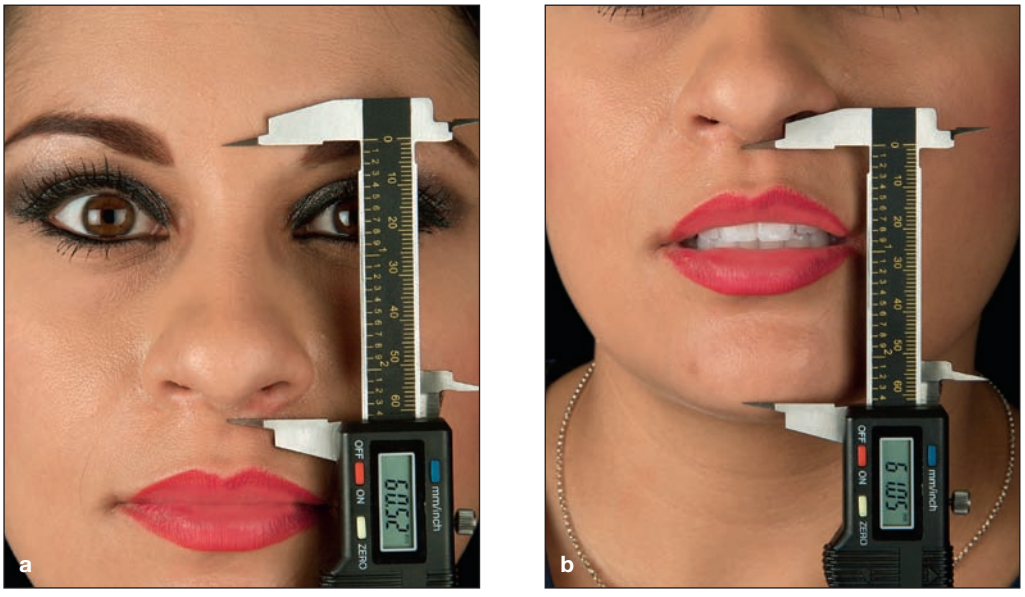


Fig 2-3 *(a)* Middle third measurement from the soft tissue glabella to the base of the nose. *(b)* Lower third measurement from under the nose to under the chin. Note that the measurement is made with the lips and teeth apart in a repose position.

Face Height

Face height is a measurement used to evaluate facial proportions. The "rule of thirds" separates the ideal facial proportions into thirds in the horizontal plane[1] (Fig 2-2). We are only concerned with the middle and lower thirds of the face. The middle third is measured from soft tissue glabella (the most prominent point between the eyebrows) to under the nose (subnasale) (Fig 2-3a). The lower third is measured from under the nose to under the chin (soft tissue menton) (Fig 2-3b). These measurements must be made in a repose position of the lips and jaw. *Repose* is defined as physiologic rest with lips

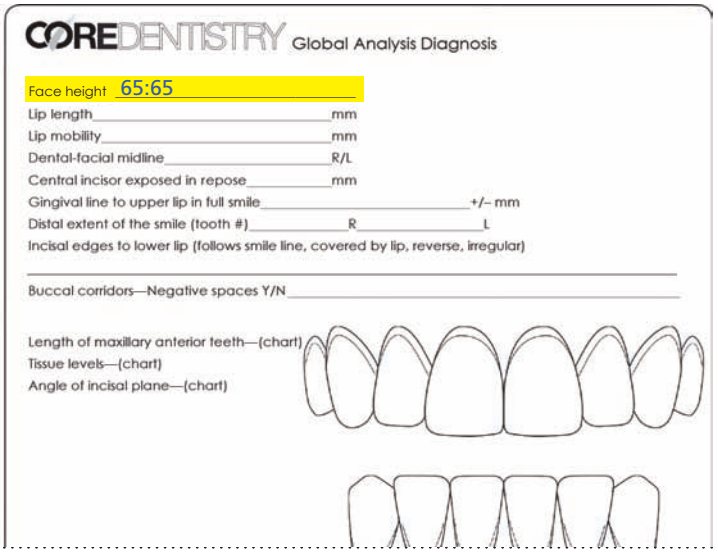


Fig 2-4 The face height measurements are recorded on the GAD form.

and teeth slightly apart. The measurements are written on the GAD form as a ratio of the middle third to the lower third, and the first piece of the diagnostic puzzle is solved (Fig 2-4).

The face height measurement is critical to any esthetic evaluation because one of the four etiologies for a malpositioning of the teeth in the face is a skeletal discrepancy. The skeletal discrepancy that most commonly affects facial esthetics is vertical maxillary excess, an excessive downgrowth of the maxilla. If the lower third of the face is significantly longer than the middle third, an additional measurement may assist in determining if the problem is located in the maxilla or the mandible. The lower third proportion is ideally composed of one-third maxilla and two-thirds mandible. With the lips in repose, the maxilla measurement is from the base of the nose to the mid-commissure line, and the mandible measurement is from the mid-commissure line to the inferior border of the chin. However, the determination as to whether the problem is in the maxilla or mandible should be evaluated in the context of the patient's emotional smile. If the smile does not appear to be gummy, the patient does not have a "problem."

Lip Length

The upper and lower lips frame the smile. They are extremely important in displaying the beauty of the teeth. However, they are commonly ignored in the comprehensive dental examination. The upper lip length is measured from the base of the nose to the inferior border of the lip (Fig 2-5). The average length of an upper lip for a 30-year-old woman is between 20 and 22 mm. Upper lips of men are routinely 1 to 2 mm longer.[2] Mandibular incisor display will increase throughout life as the lips lose tone. Lower lips that are asymmetric, cover the maxillary incisal edges, or display too much negative space will alter the framing of the smile (Fig 2-6). Tooth position as it relates to lip dynamics may need to be modified during the course of treatment.

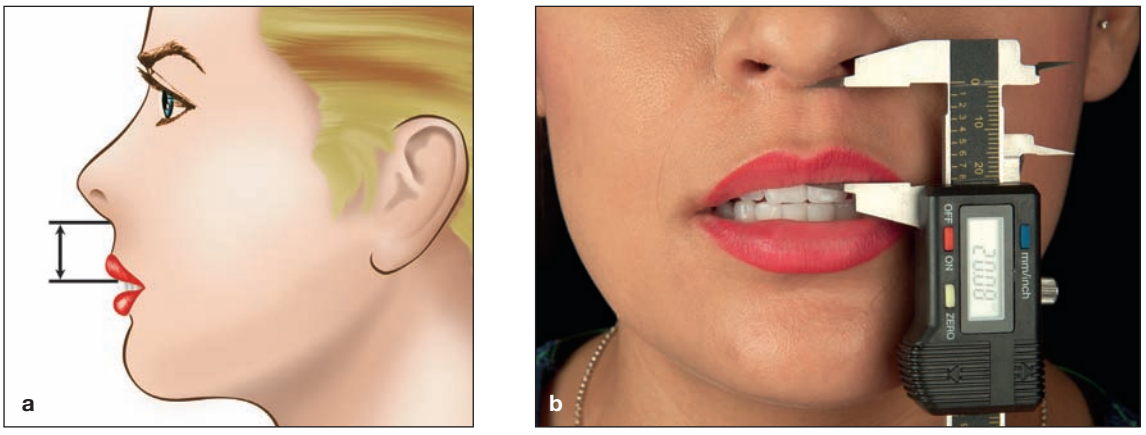


Fig 2-5 *(a)* Upper lip measurement from the base of the nose to the wet-dry border of the lip. *(b)* The upper lip must be measured in repose and at the midline.

Fig 2-6 The asymmetric lower lip in full smile impacts the esthetics.

Lip Mobility

The mobility of the upper lip is determined in one of two ways: direct measurement or mathematically. Measuring mobility begins with determining the amount of the central incisor displayed in repose. The patient relaxes the lip, and the distance from the incisal edge to the inferior border of the lip is determined (Fig 2-7a). The patient is then coached into a dynamic full smile. When the lip is at its highest position, the distance from incisal edge to the inferior border of the upper lip is measured (Fig 2-7b). Multiple locations of movement may be measured given that the lip may change in dynamics across the anterior teeth (Fig 2-8).

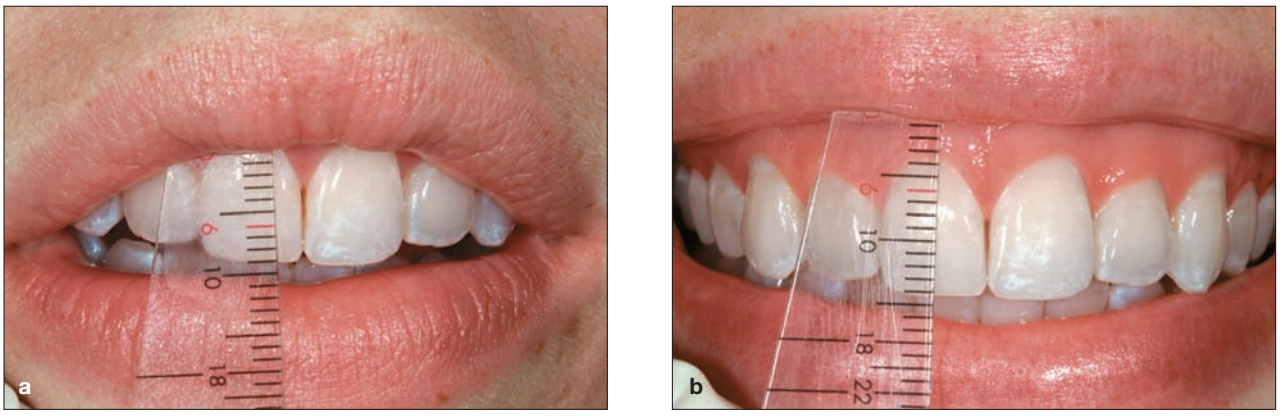


Fig 2-7 *(a)* Lip mobility measurement begins from repose. *(b)* In full smile, measure from the same incisal edge position to the upper lip. The difference between the two measurements is the upper lip mobility. In this case, 9 mm in repose and 14 mm in full smile demonstrates a lip mobility of 5 mm.

Fig 2-8 The arch of the upper lip in an expressive smile routinely demonstrates additional gingival display over the lateral incisors and first premolars.

Fig 2-9 A clenched-teeth grimace is typical of many patients asked to smile.

The mathematic method can be done directly from the GAD form. The amount of central incisor exposed in repose is subtracted from the total length of the central incisor. This equals the amount of tooth structure hidden by the lip in repose. If the lip moves to an ideal position at the free gingival margin (FGM) of the tooth, the amount of lip movement is equal to the amount hidden in repose. Finally, the number of millimeters of gingival display in full smile is added. The gingival display is the amount the upper lip moves past the FGM. Normal lip mobility is 6 to 8 mm.[3]

Interestingly, most patients have difficulty smiling on demand. They will either grimace or not smile to their normal full smile position. Because the position of their teeth in relation to their social smile is key to the authors' global system, we utilize two different approaches to obtain a measurable smile. First, we ask the patient to laugh instead of smile. The command "smile" is many times met with a tooth-together grimace (Fig 2-9) rather than a relaxed smile with teeth apart. When patients are asked to laugh out loud, it demands that the teeth are not together and eliminates the grimace. With some effort, the patient can be coached into a smile that demonstrates a natural look. In patients who cannot be coached into a natural full smile, the "high E" rule is used. The patient is asked to say a long "E" out

Fig 2-10 *(a)* Smile lacks animation and does not demonstrate the full extent of upper lip activity. *(b)* "High E" smile demonstrates the maximum limits of the patient's upper lip movement.

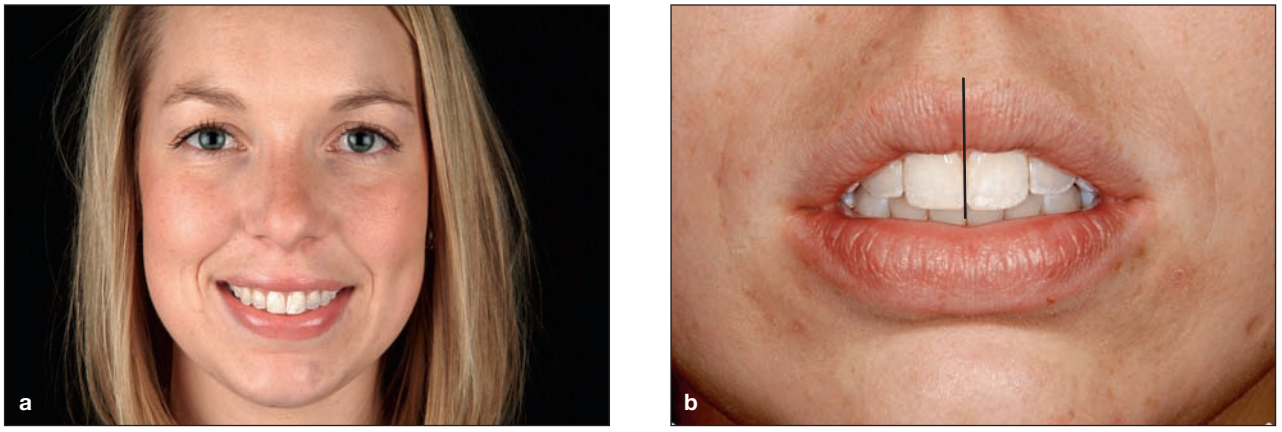


Fig 2-11 *(a and b)* The maxillary central incisor midline is viewed as it relates to the facial midline.

loud. The dentist then lightly touches the area beneath the patient's eyes and asks the patient to flex these muscles and to move the upper lip as high as possible (Fig 2-10). If done correctly, the "high E" rule demonstrates the maximum mobility of the upper lip when evaluating the amount of gingival display.

Dental-Facial Midline

The dental-facial midline measurement is used to determine the position of the maxillary dental midline in relation to the facial midline (Fig 2-11). Ideally, the maxillary dental midline should be perpendicular to the horizon (see Fig 2-11b) and coincident with the facial midline (Fig 2-12). The facial midline can be difficult to determine with the patient in a supine position. Many times the patient must be asked to stand in order for the dentist to evaluate. Three issues make the facial midline difficult to evaluate: *(1)* Most people have asymmetric faces, *(2)* the majority of noses deviate to one side, and *(3)* many

Fig 2-12 *(a)* Facial and dental midlines not coincident in repose. *(b)* Facial and dental midlines not coincident in full smile.

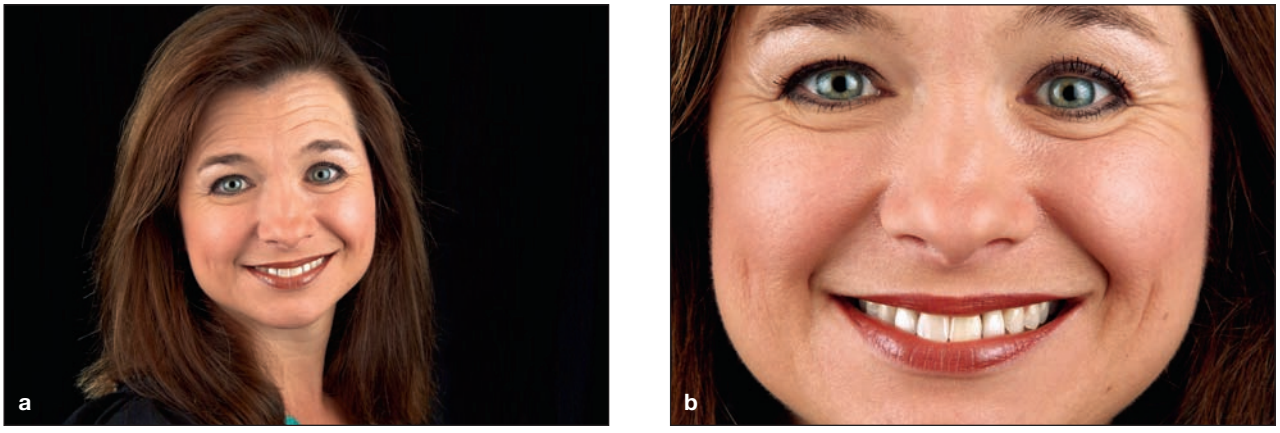


Fig 2-13 *(a)* Patients routinely alter their head position to correct for a dental asymmetry. *(b)* When the patient's head is straightened, the dental midline cant becomes apparent.

people compensate for the asymmetry by canting their head (Fig 2-13). Two methods may assist with this measurement. First, the tip of the "Cupid's bow" of the upper lip is generally coincident with the facial midline (Fig 2-14). Second, the patient can be asked to stand, and the head can be adjusted to be level with the horizon. It is then much easier to evaluate the midline relationships. The threshold for noticing facial tilt for both dentists and laypersons is less than 1%. The GAD charting will indicate whether the dental midline is in alignment with the facial midline or how many millimeters off it is and in which direction (eg, 2 mm right). Finally, the midline should be perpendicular to the horizon (see Fig 2-11b). If it is canted, this note is recorded as well as the direction of the cant. Alternatively, a line can be drawn on the teeth portion of the form indicating position and cant of the midline.

A number of studies have investigated the esthetic importance of the dental-facial midline.[4,5] The results indicate that perfect midline harmony is of little importance. The majority of studies have found that if the maxillary dental midline is within 2 mm of the facial midline, it is deemed acceptable. However, one important study went so far as to suggest that 4 mm may be acceptable to general dentists

Fig 2-14 Contours of the face can make evaluation of the midlines difficult. The tip of the Cupid's bow of the upper lip usually represents the midline of the face.

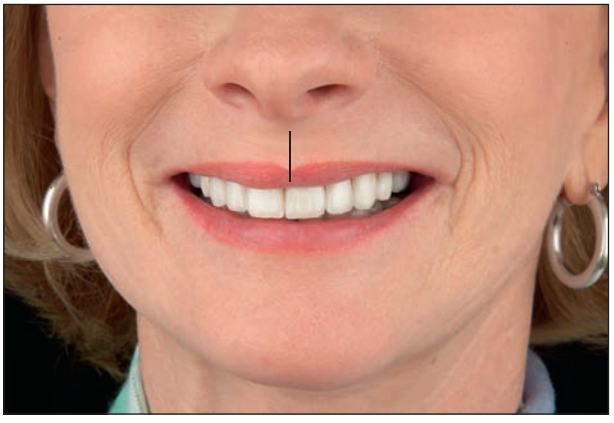


Fig 2-15 A maxillary midline discrepancy of more than 2 mm is distracting.

and the lay public and 3 mm to orthodontists.[6] Methodologic problems prevent acceptance of those results given the preponderance of evidence to suggest otherwise (Fig 2-15). The authors believe that a discrepancy of less than 2 mm is acceptable. If the observer is given a reference of the lips and face, a 3- to 4-mm deviation creates a visual tension that is unacceptable.

Fig 2-16 A midline cant is a significant esthetic detractor.

Fig 2-17 Midline discrepancy and cant must be addressed in the global analysis to achieve an esthetic resolution.

Even more important than midline position is the angulation of the midline. All researchers agree that a cant at the midline of any amount is found visually unappealing to dentists, orthodontists, and the lay public (Figs 2-16 and 2-17). Finally, the relationship between the maxillary and mandibular dental midlines has no esthetic meaning and therefore is not evaluated.

Central Incisor Exposed in Repose

This measurement is made in the repose position with the lips slightly parted and teeth apart. The ruler is held on the incisal edges of the central incisors. The distance to the inferior border of the maxillary lip is recorded (see Fig 2-7a). If the incisal edges are visible, the number is recorded as positive (eg, +2 mm). If, however, there is no display of the incisal edge in repose because of lip coverage, the number will be recorded as a negative exposure (eg, –2 mm). When recording a negative display, the lip must be held in place while a ruler or periodontal probe is inserted behind the lip and moved apically until the incisal edge of the maxillary central incisor is located (Fig 2-18). If the lip is not held in place, the patient will instinctively move the lip to avoid the probe.

The amount of maxillary central incisor exposed in repose is a key measurement in the global system. Multiple diagnoses can be made from this simple measurement. It also helps in positioning the teeth during the placement of restorations and in orthodontic treatment. The average incisal display in the young woman is 3 to 4 mm. A young man displays an average of 1 to 2 mm.[7]

The lip lengthens at two times in life: during craniofacial development and during the last decades of life. As a general rule, the lip will lengthen 1 mm per decade after the age of 40 years.[8,9] This is due to the loss of muscle tone and loss of collagen in the skin. Some patients will be more or less prone to this loss, due to genetic variability. This helps to explain why a 65-year-old woman may complain

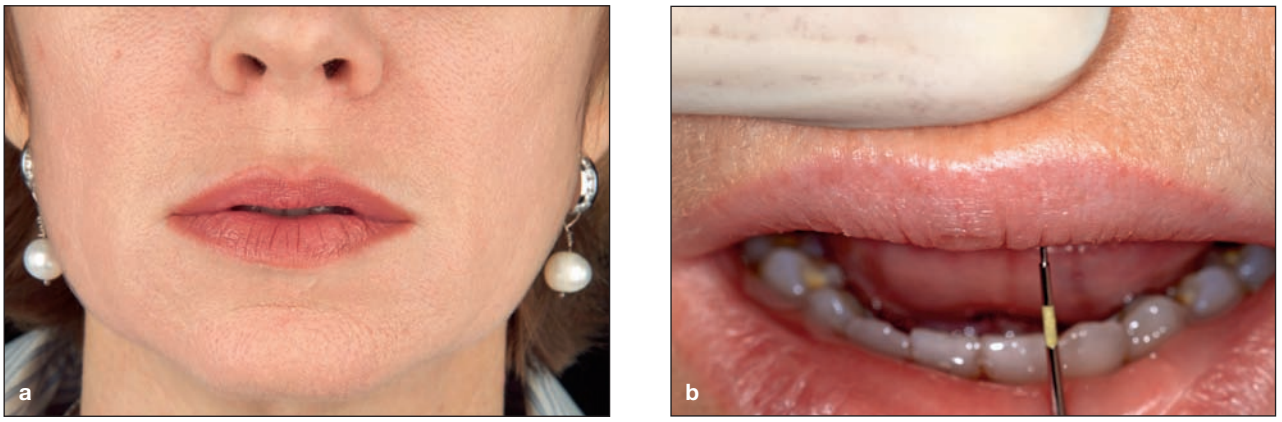


Fig 2-18 *(a and b)* Negative exposure in repose requires that the upper lip be held stable when measuring.

Fig 2-19 Ideal gingival exposure in full smile.

that her smile does not present with the same dynamism as it did when she was 30. The additional 2 to 3 mm of lip length coupled with the possible loss of incisal edge length (due to attrition) results in an aged smile.

Gingival Line to Upper Lip in Full Smile

The gingival line is a line drawn from canine to canine at the tooth-gingiva interface. The gingival line to upper lip in full smile is the amount of gingiva exposed above the gingival line in the patient's full smile. A 0-mm measurement indicates that the upper lip translates right to the FGM (Fig 2-19). If, in full smile, there is 2 mm of gingiva displayed above the central incisors, then +2 mm is recorded. If more or less gingiva is displayed over other teeth in the smile, then these measurements are also recorded (Figs 2-20 and 2-21). If the lip does not reach the FGM, then a probe or ruler is inserted below the lip and pushed apically until the FGM is located. The amount that is hidden by the upper lip is recorded as a negative number (eg, –2 mm). Again, when any instrument is placed beneath the lip, the patient tends to move the lip to assist the dentist. Once the high smile is obtained, the lip should be held in place as the measurement is made, to minimize error.

In an ideal smile, the upper lip translates right to the FGM of the maxillary central incisors and canines (see Fig 2-19). The lateral incisors, because of their coronal gingival margins, may demonstrate

Fig 2-20 Excessive gingival display in full smile.

Fig 2-21 More than 2 mm of tooth hidden in full smile is defined as a low smile line.

Fig 2-22 The discrepancy in crown size between canines and second premolars can lead to excessive gingival display and an unesthetic smile.

some gingival display. The first premolars routinely have the greatest amount of gingival display in full smile. Dentists need to pay particular attention when premolars are covered by excess gingival tissue or possess excessive buccal bony contours, or when second premolars are substituted for first premolars. All of these conditions may distract from an attractive smile (Fig 2-22). Premolar substitution is a problem because of the 3- to 4-mm gingival height difference between a maxillary canine and a maxillary second premolar. When considering maxillary premolar extraction for orthodontic purposes, attention must be given to the gingival levels when deciding which premolar to extract.

In the global system, a smile is deemed "gummy" if more than 2 mm of gingiva is exposed in full smile (see Fig 2-20). While some educators believe that the ideal smile can display up to 4 mm of gingiva before treatment is warranted, the preponderance of evidence indicates that dentists and the lay public notice a deficiency in the smile with greater than 2 mm of gingival display. While the term *gummy* is not diagnostic, it will serve until a formal diagnosis is made (see chapter 3).

The smile takes on an aged appearance when more than 2 mm of the central incisor is covered by the upper lip in full smile (see Fig 2-21). This implies that the lip has lengthened and is no longer able to uncover the full extent of the teeth in the active smile. The global system will also help to diagnose the aged smile (see chapter 3), which is much more difficult to address and may require significant alteration of the skeletal or dental structures to resolve.

Fig 2-23 The most posterior teeth displayed in a full smile should be recorded. These teeth set the limits for esthetic evaluation. In this case, the right and left first molars would be recorded on the GAD form.

Fig 2-24 An ideal smile has the incisal edges cradled by the lower lip.

Distal Extent of the Smile

The most distal maxillary tooth displayed on each side in a maximum smile should be recorded (Fig 2-23). A patient may also display a significant number of mandibular teeth in full smile. These may be noted as well. This determines the esthetic zone for that particular patient. Teeth that are displayed will need more attention in the final plan than those that can only be seen when the patient purposefully moves the lips. If any discolored teeth, esthetically compromised restorations, or gingival asymmetry can be detected in the maxilla or mandible in a routine smile, then the dentist must address the issue in the treatment plan. However, just because the deficiency does not show in the full smile does not mean that it does not bother the patient, and it should be addressed in the treatment plan. Careful questioning of the patient is still required.

Incisal Edges to Lower Lip in Full Smile

When the patient smiles or laughs, the position of the incisal edges of the maxillary anterior teeth are evaluated in relation to the lower lip contour. In an ideal smile, the maxillary incisal edges are lightly cradled by the lower lip (Fig 2-24). In a laugh, the lips and teeth routinely separate, and a negative space will be created between the incisal edges and the lower lip. The dentist should evaluate whether the

Fig 2-25 Smiles with the incisal edges hidden by the lower lip indicate a vertical discrepancy in the face, teeth, or both.

Fig 2-26 *(a)* Reverse smile line created by epigenetic alteration of craniofacial growth and development, typically a tongue posture problem. *(b)* Reverse smile line caused by flat incisal edges not following the lower lip contour. Greater negative space creates the visual impression of the reverse architecture.

negative space is uniform across the smile. It is important to note any irregularities in this relationship. For example, if the incisal edges are covered by the lower lip in full smile, the vertical relationship of the teeth in the smile may be a problem (Fig 2-25). A reverse smile line can be caused by a true reverse curve of the incisors (Fig 2-26a), or the illusion of a reverse smile line can be created when the incisal edges of the maxillary teeth are flat and the lip drops in the midline, showing greater negative space (Fig 2-26b). Even though the appearance is the same, the solutions are different. Finally, any irregularities with the upper or lower lips should be evaluated and noted in the Doctor notes section of the form. These may include asymmetric hypermobility/hypomobility, irregular shape or contour, injury, or developmental problems.

Buccal Corridors

The buccal corridor is the space between the buccal surfaces of the maxillary posterior teeth and the cheek (see Fig 2-23). There is no rule for measuring an ideal amount of negative space; this is left to the discretion of the dentist and the patient. Buccal corridors will always be present in a natural smile. Orthodontic or restorative overexpansion (Fig 2-27a) of the maxillary arch can eliminate the negative

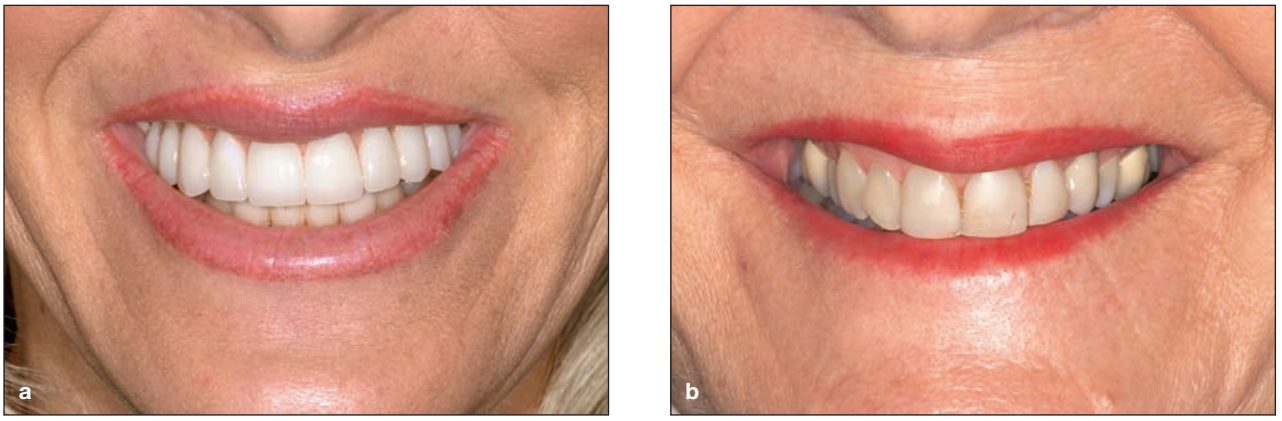


Fig 2-27 *(a)* The lack of buccal corridors does not exist in nature and indicates iatrogenic orthodontic or restorative intervention. *(b)* Excessive buccal corridors create visual tension.

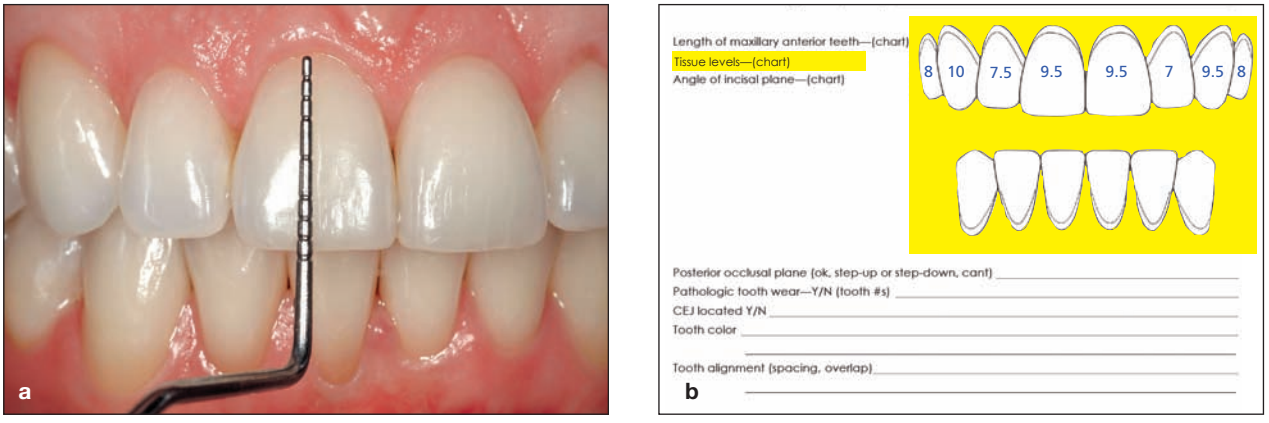


Fig 2-28 *(a and b)* Teeth can be measured with a digital caliper, a millimeter ruler, or a periodontal probe. If the cementoenamel junction is exposed due to recession, the entire length of the tooth should be recorded.

space. This problem is most commonly found in maxillary dentures. The technician simply pushes the maxillary teeth to the buccal to idealize the occlusal relationship against a buccally displaced mandibular ridge. This improves the occlusion to the detriment of the buccal corridors. However, too much negative space is a much more common problem (Fig 2-27b). The excessive darkness is distracting because it minimizes the fullness of the smile. This can be either unilateral or bilateral and should be noted as such.

Length of Maxillary Anterior Teeth

This measurement is made with a digital caliper, millimeter ruler, or periodontal probe. The length of each tooth, from maxillary first premolar to first premolar, is measured and recorded (Fig 2-28). The diagram on the GAD form allows the actual tooth length to be recorded and any root exposure to be noted. Mandibular anterior teeth may also be measured. This is usually limited to cases that present with severely worn mandibular incisors. The width of any tooth that measures shorter than average (Fig 2-29) is recorded in the space below the drawing of the tooth.

Fig 2-29 Lateral incisors that measure short in length require an analysis of tooth width.

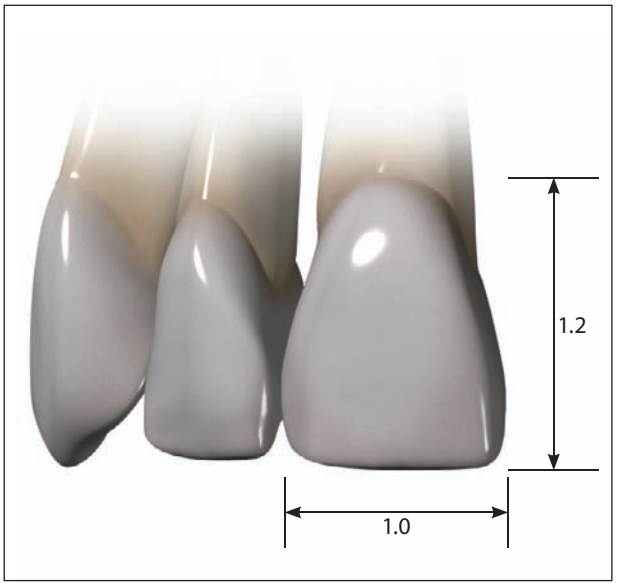


Fig 2-30 Ideal height-to-width ratio of the central incisor in the natural dentition.

The average length of the maxillary central incisor is 10.0 to 10.5 mm long.[10] Men's teeth are slightly longer than women's. Canines mimic the length of the central incisors. The lateral incisors tend to have more variability; the average length has been reported at 8.2 mm. That would make the tooth 1 mm shorter, both incisally and gingivally, than the central incisors. The lateral incisor provides the personality to the smile. A slight asymmetry in the smile line provided by the incisal edge position of the lateral incisor can add a degree of character. However, it is common for the lateral incisor to have more than 2 mm of gingival display in full smile. In many smiles, the arc of the upper lip rises more over the lateral incisors, displaying more tooth and gingiva than in other areas of the smile. If the lateral is 2 mm shorter gingivally than the central incisor, the gingival display may be unattractive. Careful positioning of the gingival margin of the lateral incisor, either orthodontically or surgically, is very important in these patients. In high smiles, when given the choice, the gingival line of the lateral incisors should be coincident with the canines and central incisors (see chapter 4).

The width of teeth is as important as length. While the visual width or "Golden Proportion" has received significant attention, the "actual" height-to-width ratio is more valuable in the laboratory and intraorally. The height-width ratio in the maxillary central incisor is 1.2 to 1.0[10] (Fig 2-30). In other words, the width should be 75% to 80% of the height. A central incisor measuring 10 mm long should be approximately 8 mm wide. In patients with missing teeth or microdontia requiring restoration, the dentist should decide on the ideal tooth length based on the ideal gingival line and most esthetic and functional incisal edge position. Once the length has been determined, the width of the required

Fig 2-31 Diagram of ideal gingival architecture.

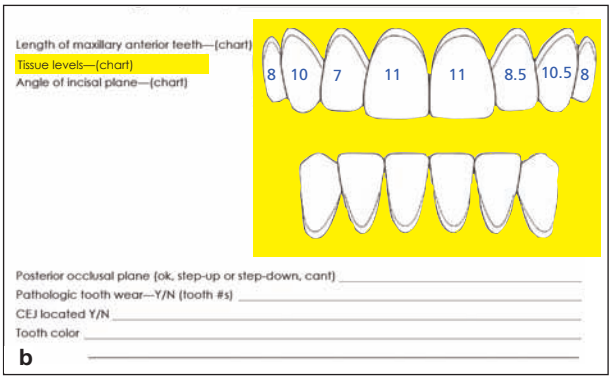


Fig 2-32 *(a and b)* Gingival step-down on lateral incisors clinically and shown on the GAD form.

space is determined mathematically. The orthodontist can then create the ideal space for the restoration or the replacement. In the GAD system, only teeth that measure short in length have their widths recorded as well.

Tissue Levels

Idealizing the gingival architecture is the focus of interdisciplinary dentistry. Therefore, recording the patient's gingival line is a key to the global system. While the focus of this textbook is maxillary anterior esthetics, rules for gingival symmetry are as true for posterior teeth and mandibular teeth as they are for the maxillary anterior teeth. Ideally, a line connecting the FGMs of the maxillary canines and central incisors should form a straight line that is parallel to the horizon (Fig 2-31). The gingival margins of the lateral incisors may be on the line or up to 2 mm below the line. This esthetic plane does not, however, stop at the incisors. It extends posteriorly in the maxillary arch and has a similar symmetry in the mandible. Any deviation from normal should be noted on the diagram of the teeth. A line is drawn on the form above the teeth to indicate a discrepancy from horizon (Fig 2-32). Posterior irregularities that fall beyond the charted teeth can be noted with extension of the diagram to the posterior, and a note should be added to the Doctor notes section.

Fig 2-33 Incisal edges demonstrating normal relationship to horizon.

Fig 2-34 *(a)* The angle of the incisal edges and the posterior occlusal plane are difficult to evaluate within the frame of the smile. *(b)* To provide a reference for examination, the upper lip is engaged by the practitioner's fingers, and the upper lip is straightened to mimic the horizon or esthetic plane. The incisal plane can more easily be evaluated using the upper lip as a reference.

Angle of Incisal Plane

The angle of the incisal plane should be parallel to the horizon (Fig 2-33). Some practitioners have difficulty with this measurement because they take it too literally. The incisal edges will have a curve somewhat parallel to the lower lip. However, if a line is drawn from canine to canine cusp tip, that line should be parallel to horizon. Any deviation from level creates a visual tension and should be recorded on the form.[6] It can be difficult to evaluate cants because of facial and/or smile asymmetries (Fig 2-34a). A practical technique is to use the upper lip as a reference for horizon. First, a source for the horizon is

Fig 2-35 Posterior occlusal planes. *(a)* A posterior occlusal plane level with the horizon is ideal. *(b)* Step-up to the left side. *(c)* Step-down bilaterally. *(d)* Canted.

determined. It may be the patient's eyes, if they are level with horizon, or something in the operatory that can be seen during the examination. The dentist's pointer fingers are placed in the corners of the patient's mouth, and the upper lip is stretched flat. The fingers are moved up and down to level the lip with the horizon. After the lip is level, it is a small distance for the eye to travel from lip to the teeth to determine if the incisal plane is level with the horizon (Fig 2-34b). The angle of the incisal plane is recorded on the form with a line drawn below the incisal edges to demonstrate any cant from parallel.

Posterior Occlusal Plane

While the angle of the incisal plane is being evaluated, the plane of the posterior teeth should also be noted. Using the same lip technique, the maxillary posterior occlusal plane is evaluated. Ideally, there should be a smooth continuation from anterior to posterior with no step-up or step-down, and the occlusal plane should be level with the horizon (Fig 2-35a). If there is a deviation from ideal (Figs 2-35b to 2-35d), it can be described with words or drawn on the form.

Fig 2-36 Pathologic or physiologic wear is determined by whether it is appropriate for the patient's age. This amout of attrition and erosion would not be commensurate with a 21-year-old patient.

Fig 2-37 Ideal osseous positioning 2 mm apical to the CEJ.

Pathologic Tooth Wear

With normal function, teeth should not wear through the enamel in a lifetime. Thus, any dentin exposure would be determined to be pathologic. The authors believe that wear should be evaluated based on the patient's age (Fig 2-36). If the wear appears to be commensurate with the patient's chronologic age, then the wear is deemed normal. If, however, the wear is beyond the expected levels, we note it as pathologic. If the wear is pathologic, notes are also included on the dentist's impression of the possible etiology of the wear. If it is attrition, the pathway of wear is also recorded.

Location of the Cementoenamel Junction

The cementoenamel junction (CEJ) is the transition from enamel to root surface. It has a distinctively rougher feel than enamel with an explorer. In the normal crest attachment, the CEJ should be approximately 2 mm from the osseous crest and mimic the contour of the osseous crest (Fig 2-37). It lies in the sulcus and should be easily detected. An explorer is gently placed under the FGM. The smooth enamel transitions from a convex surface to the roughness of the CEJ. Past the CEJ, the flatness of the root is palpated, and finally the base of the sulcus is determined when the tissue blanches (Fig 2-38). If the CEJ is covered by the attachment due to altered passive eruption (see chapter 4), then it cannot be detected in the sulcus (Figs 2-39 and 2-40). Because the CEJs of teeth with normal anatomical lengths are easily detected, this measurement is only made on short teeth. This includes teeth both with and without attrition.

Fig 2-38 Teeth with normal anatomical crown exposure will allow an explorer to detect the CEJ on probing.

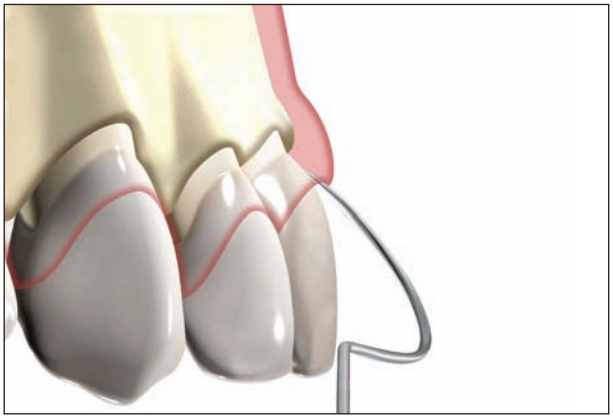


Fig 2-39 Osseous positioning near the CEJ prevents detection of the CEJ with a probe.

Fig 2-40 Surgical exposure of a patient with altered passive eruption, demonstrating bone contiguous with the CEJ.

Tooth Color

Shade guides may be used to register the chroma and value of the patient's teeth. Intrinsic and extrinsic discolorations are also noted (Fig 2-41). The probable causes of the discoloration are registered as well. An interesting term, *calico*, has been used by the authors to describe a mouth with multiple shades including old crowns placed over an extended period (Fig 2-42). Patients understand the implication without offense and appear more open to a discussion of change.

Fig 2-41 Unusual discoloration patterns can be noted in the tooth color section.

Fig 2-42 Multiple colors of teeth from staining and old restorative dentistry, referred to as *calico* by the authors.

Fig 2-43 Diastema width is noted on the GAD form.

Tooth Alignment

In this section, information about malocclusions that could have an impact on the final esthetic or functional result is noted. A diastema may be noted here or visually displayed on the tooth drawing (Fig 2-43). These notes will of course be supplemented with accurate casts and photographs.

Doctor Notes

Any note that is beyond the scope of the form should be included in this section. Lip asymmetries in full smile, the patient's insights, and the doctor's impressions are recorded (Fig 2-44). These will be reviewed during the diagnosis and sequential treatment-planning session to assure that the final plan addresses these additional issues.

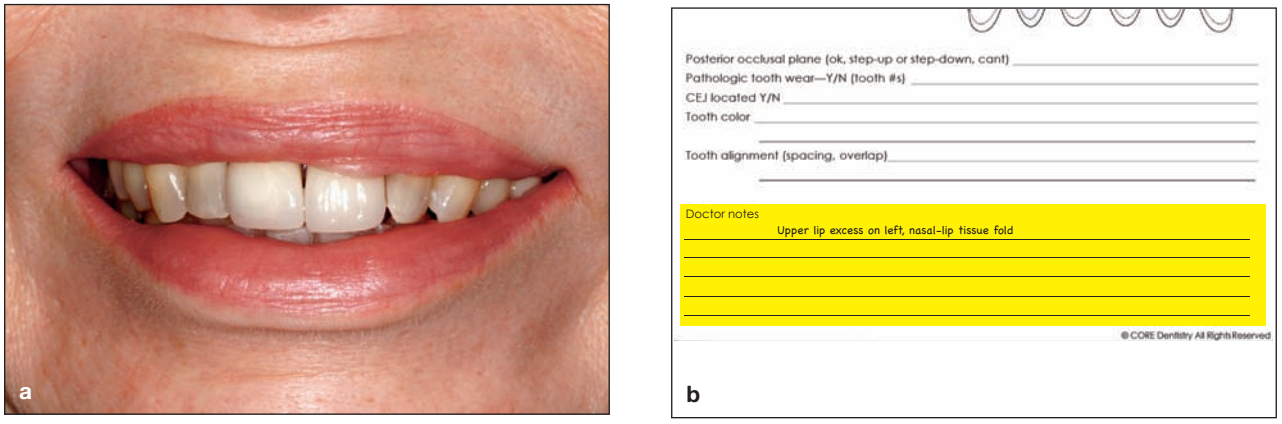


Fig 2-44 *(a and b)* The Doctor notes section allows the practitioner to add notes on esthetic issues beyond what the form records. In this example, the excess tissue on the upper lip and the nasal-lip tissue fold presenting in full smile would be noted.

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The Five CORE Questions

3

In order to make a global diagnosis, the dentist must ask and answer the five CORE questions. The answers to these questions will lead you through the thought process of global diagnosis and treatment planning.

Once the CORE evaluation form is completed, the dentist now has the information required to make the global diagnosis (or diagnoses). By asking and answering the five CORE questions, the global diagnosis process becomes very straightforward. The diagnosis always starts with the patient's facial presentation. If gingival levels or the frame of the smile is incorrect, then the patient will be a complex interdisciplinary treatment-planning patient. The five CORE questions are then used to explain the etiology of the discrepancies.

Question 1: What Are the Facial Proportions and Skeletal Relationships?

In the proportional face, the middle and lower thirds should be 1:1 in measurement[1] (Fig 3-1). If the lower third of the face is long in comparison to the middle third of the face, this defines a "global" diagnosis of vertical maxillary excess (VME). This patient commonly presents with excess gingival display in both the anterior and posterior maxilla (Fig 3-2). This condition is related to growth and development of the maxilla and the mandible. The mandibular ramus is commonly short, resulting in an obtuse mandibular plane angle. The maxilla grows excessively long in order for the maxillary teeth to continue to occlude with the mandibular teeth. If the VME results in a significant functional and/or esthetic problem for the patient, the primary treatment is orthognathic surgery. The maxilla is impacted with a Le Fort I osteotomy and stabilized. In some instances, the mandible will autorotate into a favorable occlusal relationship with the maxilla. If this is not the case, a mandibular bilateral sagittal split osteotomy (BSSO) must also be accomplished. Canted maxillae and those with arch-width discrepancies may be treated with multiple maxillary osteotomies. If the patient chooses not to have orthognathic surgery, Botox (Allergan) can be used to mask the excess gingival display.

If the lower third of the face is shorter than the middle third, this is commonly due to vertical maxillary deficiency. If the deficient maxilla results in a significant functional and/or esthetic problem for the patient, the primary treatment is again orthognathic surgery. This procedure generally requires a downfracture of the maxilla and a mandibular BSSO.

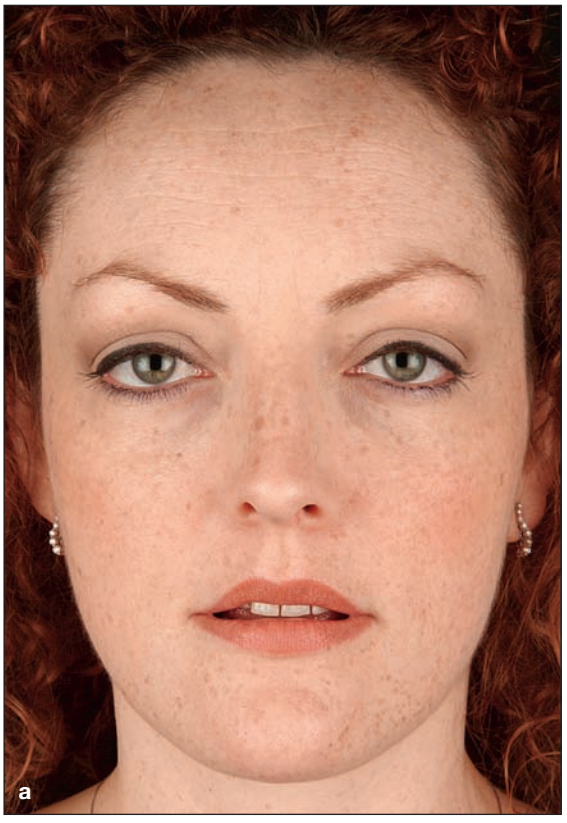

Fig 3-1 *(a to c)* Full face with face measurements of middle and lower thirds.

Fig 3-2 Excess gingival display in a patient with vertical maxillary excess.

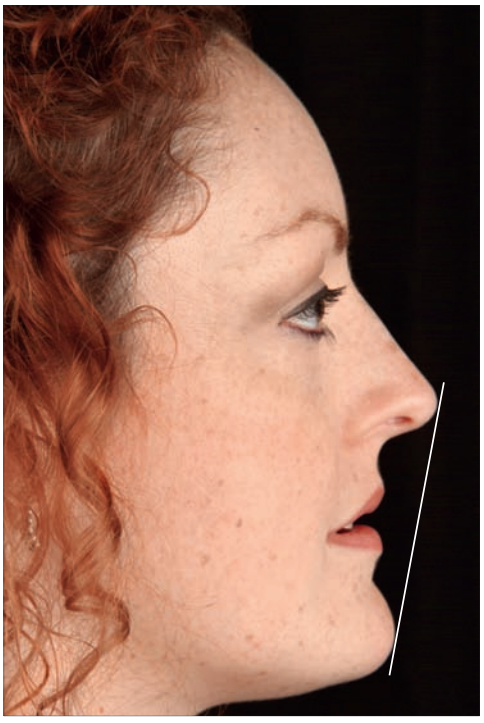

Fig 3-3 Ricketts E-line.

Finally, the anterior-posterior relationship of the maxilla and mandible must be evaluated. The Ricketts E-line is a helpful screening tool to assess this relationship.[2] In the sagittal view, a line is drawn from nose to chin (Fig 3-3). In a 1:1 representation of the youthful face, the upper lip should be 2 to 4 mm behind the line, and the lower lip should be 0 to 2 mm behind the line. The normal face has a straight facial projection. If the lower lip is more than 2 mm behind the line, the facial projection is convex, which is indicative of an Angle Class II malocclusion. If the lower lip is in front of the line, the facial projection is concave, which is indicative of an Angle Class III malocclusion.

Global diagnosis: Vertical maxillary excess
Primary treatment: Maxillary Le Fort I impaction
Secondary treatment: Botox

Global diagnosis: Vertical maxillary deficiency
Primary treatment: Maxillary downfracture, BSSO

Global diagnosis: Angle Class II or Class III malocclusion
Primary treatments: Orthodontic treatment, orthognathic surgery

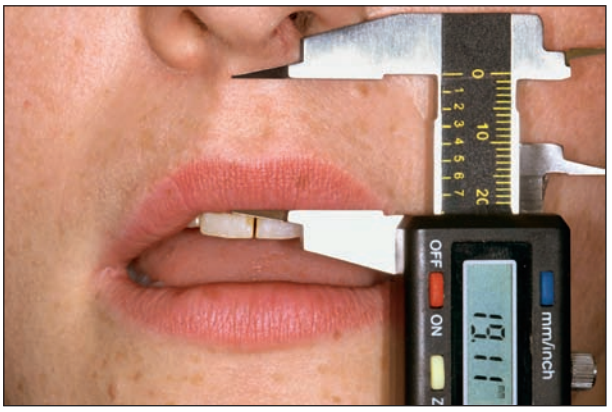

Fig 3-4 Measuring a short upper lip.

Question 2: What Are the Length and Mobility of the Upper Lip?

Upper lip length

The average length of the upper lip in the young woman (25 to 30 years) is 20 to 22 mm and in the young man, 22 to 24 mm[3] (Fig 3-4). Age is important because as the patient ages, the upper lip tends to increase in length.[4] As a rough rule of thumb, the upper lip will lengthen 1 mm per decade starting at age 40 years.[5] If the upper lip is shorter than normal, the result may be excess gingival display during full smile (see Fig 3-2).

There are surgical procedures to lengthen the upper lip, but these procedures are not routinely recommended for reasons that are discussed in chapter 9. Using behavior modification, the patient may reduce the movement of the upper lip.[6] The patient is instructed to look into a mirror and learn to smile with less lip mobility, resulting in decreased gingival display. However, this is simply a biofeedback procedure and is only effective as long as the patient practices in the mirror. In addition, this procedure only works on the learned smile; it is not effective for the emotional smile.

The primary treatment for the short upper lip is Botox.[7] It is injected into the facial muscles responsible for upper lip translation and temporarily paralyzes these muscles. In some circumstances, dermal filler may also be used to treat the short upper lip. The use of Botox and dermal fillers is discussed in chapter 9.

Global diagnosis: Short upper lip
Primary treatments: Botox, lip filler
Secondary treatments: Patient education, behavior modification

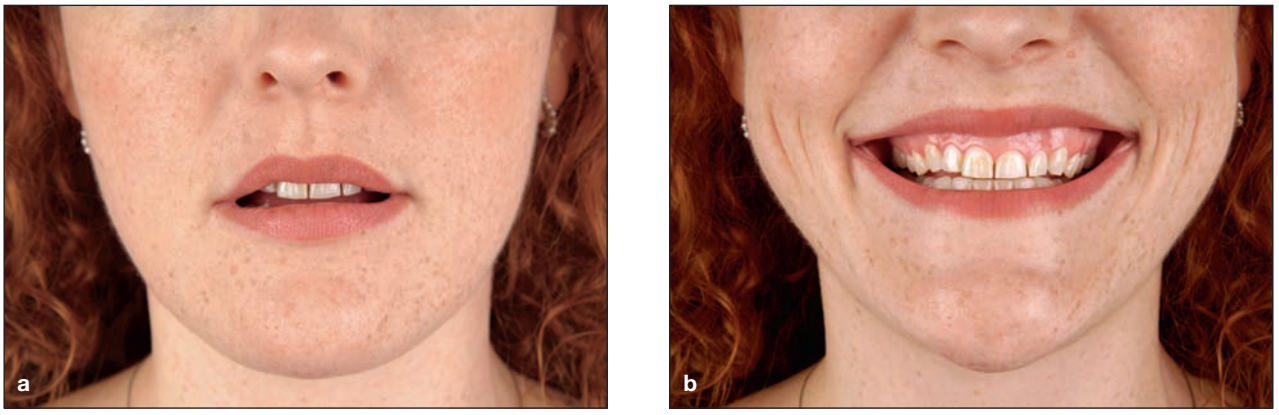

Fig 3-5 *(a and b)* Lip mobility measured from repose to full smile position.

The upper lip may also be anatomically long. The options are more limited when dealing with a long lip. The patient must be made aware that the upper lip is longer than the norm and will continue to lengthen with age due to loss of collagen and muscle tone. A primary but seldom used treatment for the long upper lip is a plastic surgery procedure to shorten the lip.[8] This would only be indicated if the patient had major complaints about the lip. On the other hand, lengthening the incisal edges of the maxillary anterior teeth will make them more visible in both repose and full smile. However, this may result in a significant step-up in the incisal edges from canine to first premolar. In order to address the excessive length of the upper lip, a significant amount of restorative dentistry may be required.

Global diagnosis: Long upper lip
Primary treatments: Patient education, lip surgery
Secondary treatment: Restorative dentistry

Hyperactive upper lip

The normal mobility of the upper lip, measured from repose to full smile, is 6 to 8 mm.[9] The ideal lip mobility moves the upper lip to the gingival line (a line drawn canine to canine at the tooth-gingiva interface) in full smile. The hypermobile upper lip may move well above the gingival line in full smile, resulting in excess gingival display (Fig 3-5). While it is not specifically linked to sex or age, women tend to have greater lip mobility.[9] Increased lip mobility coupled with anatomically shorter lips result in greater amounts of gingival display in women compared with men.[9] The use of Botox and behavior modification is discussed in the previous section. Plastic surgery may also benefit a subset of patients with a hyperactive upper lip.[10] The hypertrophied depressor septi nasi muscles are dissected, resulting in decreased lip mobility at the midline. However, this procedure does not address the other muscles of facial expression, which can still cause significant lip mobility.

Global diagnosis: Hypermobile upper lip
Primary treatment: Botox
Secondary treatments: Plastic surgery, behavior modification

Fig 3-6 Canted maxillary occlusal plane.

Hypomobile upper lip

Decreased lip movement can negatively impact the dynamics of a smile. There are two different types of hypoactive smiles: First, the patient does not desire or know how to smile normally. If the patient has adopted the hypoactive smile in order to cover up an esthetic deficiency, treating this deficiency may free the patient to develop a higher smile dynamic. If the patient just does not know how to create a normal smile, exercises can increase the tonicity of the muscles and promote increased lip mobility.[6] In the second type of hypoactive smile, the patient does not have the ability to smile to a higher level. Many times the elevator muscles are limited by the strong activation of the depressor muscles. The triangularis muscles insert at the corners of the lips and create a frown. If the depressor muscles are paralyzed with Botox, the elevator muscles may increase the movement of the upper lip.

> ***Global diagnosis:*** Hypomobile upper lip
> ***Primary treatments:*** Smile exercises, Botox

Question 3: What Is the Relationship Between the Gingival Line and the Horizon?

When positioned correctly, the maxillary anterior teeth create a symmetry with the gingival line. This is a line drawn from the gingival margin of one canine to the gingival margin of the contralateral canine (Fig 3-6). The central incisors should be on the line, and the lateral incisors may be on the line or up to 1.5 mm below the line. In addition, this line should be parallel to horizon. The posterior teeth should maintain the same horizontal symmetry. When teeth overerupt, they bring bone and gingiva with them, resulting in a concave rather than a straight gingival line. This is termed *dentoalveolar ex-*

trusion (DAE) and may occur with or without incisal attrition. It is most common in the anterior teeth but may occur anywhere in the mouth and on any number of teeth. DAE generally occurs in three circumstances:

1. Teeth supererupt due to inadequate occlusal contact (ie, Class II malocclusion) or missing opposing teeth.
2. Teeth supererupt due to attrition.
3. The occlusal plane is canted due to aberrant growth or attrition (see Fig 3-6). As the teeth supererupt, the dentogingival complex moves with the teeth, resulting in a canted gingival line.

There are three primary treatment strategies for DAE. The first and generally most desirable treatment is orthodontic intrusion of the teeth to their original positions prior to supereruption. If the supereruption occurred due to lack of occlusal contact, the teeth may not require restoration after intrusion. However, attention must be given to long-term retention of the intruded teeth. They must be retained with either a newly created occlusal relationship with the opposing teeth or a fixed or removable retention appliance. However, if the extrusion occurred due to attrition, the teeth will generally require restorations at the completion of orthodontic intrusion.

A more traditional but generally less desirable treatment for DAE in a patient with wear is functional crown lengthening surgery to reestablish the original position of the gingival line prior to restoration. There are several disadvantages to this treatment. First, the surgery will expose root surfaces, resulting in a less desirable surface for bonded restorations. Second, because of the narrowing diameter of the roots, the definitive restorations will be triangular in shape, which is esthetically displeasing. Third, the surgery commonly results in rolled rather than knife-edge gingival margins. The gingival margin was designed to be on enamel, and when moved to root surfaces, it does not heal with the ideal knife-edge gingival margin. Fourth, the functional crown lengthening surgery requires removal of interproximal alveolar bone, commonly resulting in open gingival embrasures. Finally, the ostectomy results in an increased crown-to-root ratio.

The third treatment option is to increase the vertical dimension of occlusion with restorative dentistry or orthodontics. This treatment does not actually treat the DAE; however, it does provide interocclusal space for restorations in the patient with DAE secondary to attrition. DAE is discussed in greater detail in chapter 10.

Global diagnosis: Dentoalveolar extrusion without wear
Primary treatments: Orthodontic intrusion, orthognathic surgery (ie, segmental osteotomy)

Global diagnosis: Dentoalveolar extrusion with wear
Primary treatment: Orthodontic intrusion and restoration
Secondary treatment: Functional crown lengthening surgery and restoration, increasing the vertical dimension of occlusion

Global diagnosis: Dentoalveolar extrusion secondary to aberrant growth or attrition
Primary treatment: Orthodontic intrusion
Secondary treatments: Orthognathic surgery, functional crown lengthening surgery with restoration

Fig 3-7 Short maxillary central incisor.

Question 4: What Is the Length of the Maxillary Central Incisor?

When the maxillary central incisor is shorter than the average (10 to 11 mm) (Fig 3-7), there are three possible etiologies[11]:

1. Microdontia
2. Loss of incisal length due to attrition
3. Altered passive eruption

If the etiology is microdontia, the teeth will be proportionally smaller and the cementoenamel junction (CEJ) can be felt in the sulcus. If the etiology is loss of incisal length due to attrition, the normal incisal edge anatomy will be altered. If the etiology is altered passive eruption, the diagnosis must be confirmed with question #5.

Global diagnosis: Microdontia
Primary treatments: Restorative therapy, if required; orthodontic repositioning to align the gingiva and to create correct proportions

Global diagnosis: Incisal attrition
Primary treatment: Restorative therapy, if required
Secondary treatment: Occlusal appliance to protect teeth

Fig 3-8 Feeling for the CEJ in the sulcus with an explorer.

Question 5: Is the CEJ Palpable in the Gingival Sulcus?

If the tooth is short by measurement and the CEJ is not detected with an explorer in the sulcus, the etiology is altered passive eruption.[12] The gingival tissue has not migrated to its correct position to within approximately 1 to 2 mm of the CEJ, resulting in excessive coverage of enamel (Fig 3-8). The normal passive eruption process is generally complete by age 15 to 16 years.[13] Altered passive eruption is treated with esthetic crown lengthening surgery.[14]

> ***Global diagnosis:*** Altered passive eruption
> ***Primary treatment:*** Esthetic crown lengthening surgery

Once the global diagnoses are made, an interdisciplinary treatment strategy can be developed. The regional diagnoses (ie, pulpal status, periodontal status, joint status, etc) can then be evaluated to develop the definitive sequenced treatment plan. If a patient presents with more than one global diagnosis, then sequencing of the treatment becomes critical.

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Esthetic Crown Lengthening Surgery

4

One of the primary causes of a short tooth is excess gingival tissue covering the tooth. This chapter describes the surgical protocol for the treatment of altered passive eruption.

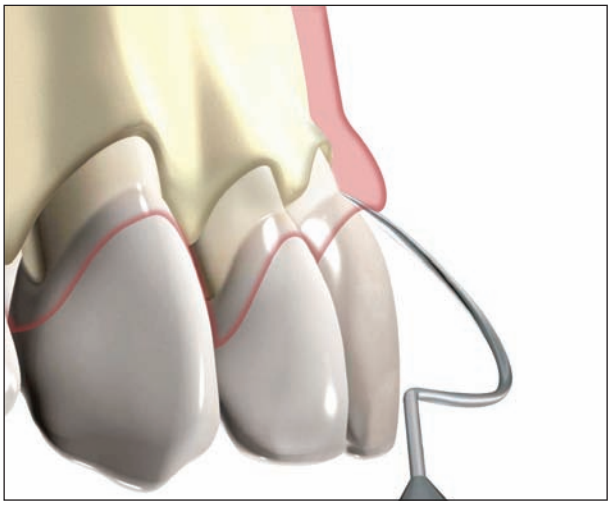

Fig 4-1 Normal attachment apparatus.

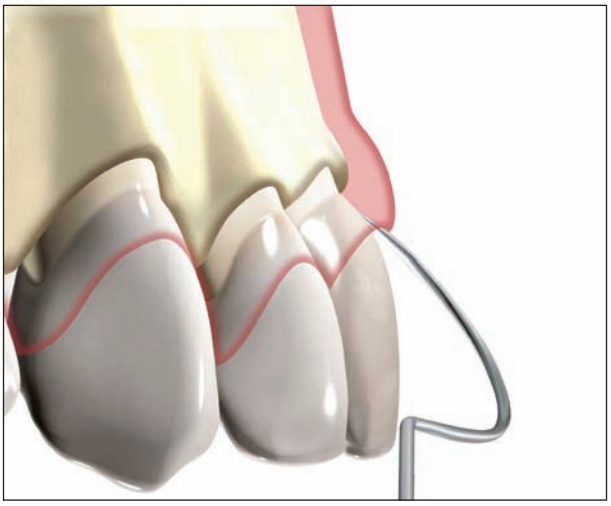

Fig 4-2 Attachment apparatus in altered passive eruption.

One of the six tools used in the Global Diagnosis system is esthetic crown lengthening surgery. This surgical procedure is specifically designed to treat one condition: altered passive eruption. Altered passive eruption is a condition that was described by Coslet et al[1] nearly 40 years ago. They differentiated patients with excess gingival coverage into four categories based on the position of the alveolar bone in relation to the cementoenamel junction (CEJ) and the mucogingival junction. However, the clinical treatment of these patients is the same[2,3]; therefore, the term *altered passive eruption* is used to describe all of the categories of excess gingival coverage of the anatomical crown.

In order to diagnose a patient with altered passive eruption, two criteria must be met. First, the tooth must be short by measurement. The average length of the clinical crown of the normal maxillary central incisor is 10 to 11 mm,[4] so the teeth must be shorter than this. Second, the CEJ cannot be detected in the sulcus with the tip of an explorer. In a patient with a normal attachment apparatus, the CEJ can be detected in the sulcus due to its roughness compared with the smoothness of the adjacent enamel (Fig 4-1). However, in the patient with altered passive eruption, the dentist can only feel smooth enamel all the way to the base of the sulcus. The CEJ cannot be felt because it is covered by the attachment apparatus (Fig 4-2).

The prevalence of short clinical crowns due to gingival coverage was evaluated by Konikoff et al.[5] The study population was a group of 200 teenagers who had recently had orthodontic appliances removed. They evaluated the width-to-height ratios of the central incisors and used 0.8 or less as normal. In this population, they found that 66% had a width-to-height ratio greater than 0.8. This study suggests that a significant percentage of postorthodontic patients have short clinical crowns due to gingival coverage of the anatomical crown. They also did a 5-year follow-up on patients and found that if a patient has short clinical crowns prior to orthodontic treatment, there is a high probability that these teeth will continue to have short clinical crowns 5 years after completion of orthodontics.

One of the most common etiologies of the *gummy smile*, defined as 2 mm or more of gingival display in full smile, is altered passive eruption. Tjan et al[6] reported on the smile dynamics of a population in their second decade of life. He reported 2 mm or more of gingival display in 13% of females and 7% of males. It is fair to say that there are many teenage and adult patients with altered passive eruption who are not being diagnosed and treated.

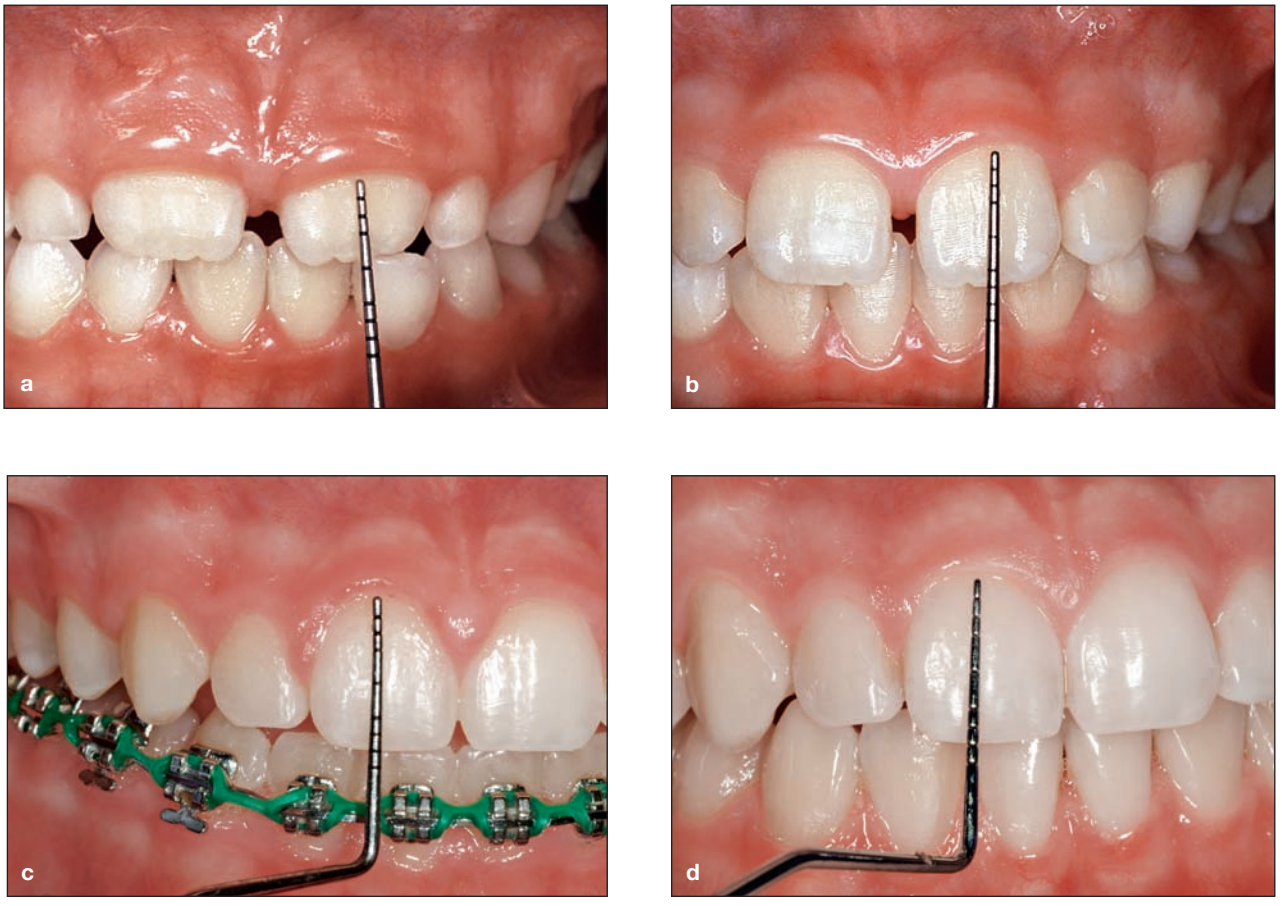

Fig 4-3 Clinical crown length. *(a)* At age 7 years: 4 mm. *(b)* At age 11 years: 8 mm. *(c)* At age 15 years: 9 mm. *(d)* At age 18 years: 9 mm.

In order to understand altered passive eruption, it is important to first understand the normal eruption process, which consists of two stages.[7] The first is termed *active eruption*. As the crown of the tooth (ie, the central incisor) forms, it begins to erupt through the bone and soft tissue and grows down into the mouth. It continues to actively erupt until it occludes with the opposing tooth into a stable occlusal relationship. At this point, for all practical purposes, active eruption is complete. Growth of the maxilla and mandible will continue, but eruption of the tooth out of the alveolar process is complete. However, at the completion of the active eruption process, the clinical crown may only be 5 to 6 mm in length. At this time, the second stage of the eruption process—passive eruption—begins. *Passive eruption* is the normal apical migration of the gingival tissue up the anatomical crown until it gets to within approximately 1 to 2 mm of the CEJ. At this point, the tissue stabilizes, resulting in the normal clinical crown length of 10 to 11 mm.

In altered passive eruption, the tissue does not migrate to its correct position, 1 to 2 mm coronal to the CEJ. This results in excessive gingival coverage of the cervical enamel and a short clinical crown. Research has shown that the normal eruption process of the anterior teeth is essentially complete at approximately 15 to 16 years of age.[8] It is at this age that esthetic crown lengthening surgery is generally recommended. Figure 4-3 illustrates the natural course of the eruption process in a patient from age 7 to age 18 years. Note that there is no change in the length of the clinical crown from age 15 to age 18 years.

Fig 4-4 Internal bevel gingivectomy.

Fig 4-5 Internal bevel gingivectomy when tissue levels are uneven.

Surgical Technique

Esthetic crown lengthening is a surgical procedure specifically designed to treat altered passive eruption. The traditional functional crown lengthening procedure, which is used to treat fractured teeth, deep caries, biologic width impingement, and inadequate clinical crown length for restoration, requires both facial and palatal flaps as well as excision of the interdental tissue. In contrast, in the esthetic crown lengthening procedure, only a facial flap is elevated, leaving the thinned interdental papillary tissue and palatal tissue intact.

The distal extent of the initial incision must be determined by evaluating the dynamic smile prior to anesthesia. The incision generally extends one tooth distal to the distal extent of the smile to include all of the maxillary teeth that are visible in the smile.

Surgical goals

There are three surgical goals with the esthetic crown lengthening procedure:

1. Thin and move the alveolar bone 2 mm apical to the CEJ from facial line angle to facial line angle.
2. Position the gingival crest 3 mm coronal to the new alveolar crest position.
3. Level the tissue at the new position.

Initial incision

There are two different techniques for the initial incision.

Option 1: Internal bevel gingivectomy

The initial incision is an internal bevel gingivectomy, which removes a collar of crestal gingiva (Fig 4-4). The incision is a thinning incision made with the scalpel blade (15c) nearly parallel to the long axis of the tooth. This incision is difficult because the architecture of the scallop must be esthetically correct and symmetric with the adjacent teeth while at the same time thinning the new marginal tissue. The incision continues as a thinning incision across each papilla to the distal extent of the surgical site. The collar of tissue is removed. A full-thickness flap is then elevated, and the appropriate ostectomy is performed. The tissue is then replaced and sutured. This incision may be used in all esthetic crown lengthening procedures; however, it must be used when the presenting gingival levels are uneven (Fig 4-5). The internal bevel gingivectomy incision is used to level the gingiva prior to elevating the flap.

Fig 4-6 *(a and b)* Initial sulcular incision. *(c)* Completed sulcular incision.

Option 2: Sulcular incision

When the sulcular incision is chosen, there is no removal of a collar of gingival tissue. The incision is made through the sulcus to the crest of alveolar bone (Figs 4-6a and 4-6b). The incision continues as a thinning incision across each papilla to the distal extent of the surgical site (Fig 4-6c). A full-thickness flap is elevated beyond the mucogingival junction, and the appropriate ostectomy is performed. The flap is then apically positioned to its new position and sutured. The sulcular incision may only be employed when the presenting gingival levels are even; it cannot be used as the initial incision with uneven gingival levels. However, once the gingiva is leveled with the internal bevel gingivectomy incisions, the sulcular incision may be used to complete the initial incision. The sulcular incision is an easier initial incision to perform than the internal bevel gingivectomy. Additionally, it has been the author's experience (JWR) that the tissue heals more quickly and more beautifully knife-edged with the sulcular incision.

Fig 4-7 Before the ostectomy.

Fig 4-8 Ostectomy with 12-fluted carbide bur.

Fig 4-9 Ostectomy with a Wedelstaedt chisel.

Fig 4-10 Final thinning of marginal alveolar bone with a bullet-nosed diamond bur.

Alveolar recontouring

The alveolar crest is always too close to the CEJ in some areas and is commonly too thick. The goal is for the alveolar bone to be 2 mm apical to the CEJ from facial line angle to facial line angle. Generally, facial alveolar bone must also be removed to thin the buccal plate between the roots of the teeth (Fig 4-7). The bone must be recontoured, much like a denture is festooned. A large, 12-fluted, round carbide finishing bur in a high-speed handpiece with water irrigation is used for the gross bone removal. This bur will aggressively remove bone and must be used with a light touch (Fig 4-8). It is preferable that the bur not touch the tooth root. Once the initial thinning of the bone has been accomplished, a Wedelstaedt chisel is used to remove the thinned bone over the root surface (Fig 4-9). The new alveolar crest should parallel the CEJ with one modification: A small amount of additional bone must be removed at the line angles. This will ensure a more rounded and pleasing gingival contour after healing. Once the correct bony contours are established with the Wedelstaedt chisel, the marginal alveolar bone will be ledged and too thick. A less aggressive bullet-nosed diamond bur in a high-speed handpiece with water irrigation is used to recontour the marginal alveolar bone to a knife edge (Fig 4-10). After the ostectomy is complete, the surgeon should stand in front of the patient to evaluate the horizontal symmetry of the newly created alveolar crests and to ensure the required 2 mm from CEJ to alveolar crest (Fig 4-11). Commonly, this evaluation will reveal the need for additional alveolar recontouring to create the desired symmetry.

Fig 4-11 Distance of 2 mm from the CEJ to the new alveolar crest.

Fig 4-12 Recontouring the papillae for a smooth blend between the papillae and the flap.

Tissue recontouring

After the alveolar recontouring is complete, the flap is repositioned, and the relationship between the flap and the remaining interdental papillae is evaluated. Commonly, there is excess facial interdental papillary tissue that does not smoothly blend with the flap. A new 15c scalpel blade is used to thin and recontour the papillary tissue until a satisfactory blend with the flap is accomplished (Fig 4-12).

Suturing

The placement of the flap is critical prior to suturing. The new gingival crest must be placed 3 mm coronal to the new alveolar crest. A 5/0 polygalactic acid suture is used. The suture is a simple interrupted suture that goes from flap to papilla. The suture is placed in the facial surface of the papilla and does not need to engage the palatal tissue. Once the suturing is complete, the surgeon should sound the bone of the maxillary central incisor to ensure that the distance from the gingival crest to the alveolar crest is 3 mm. If not, this must be corrected before completion of the surgery. The final step after suturing is to perfect the tissue blend between the flap and the papilla. This can be accomplished with a laser or an electrosurgery unit. Periodontal dressing is seldom needed with this surgical procedure. However, it may be useful when the surgery is performed with orthodontic appliances in place, because it is sometimes difficult to stabilize the flap in the correct position. In this circumstance, the orthodontic appliances can be used to maintain the periodontal dressing, which will stabilize the flap in the correct position.

Postoperative course

The postoperative course is usually uneventful with minimal discomfort. The patient is shown the surgical result with a mirror and then asked not to pull the lip up to look for the next week. It is important that the tissue remains stable in its new position, so the patient is advised to not activate the lip muscles during the first week with activities such as sucking through a straw or kissing. The patient is also advised to refrain from brushing the entire mouth for 3 days. The patient is given an antimicrobial rinse to gently swish two times per day. Gentle brushing of the mandibular arch may be started after 3 days. The patient returns for suture removal after 1 week, and at that time the dentist decides if the tissue is stable enough to allow the patient to start gentle brushing of the maxillary arch. Postoperative pain is almost always managed with over–the-counter nonsteroidal anti-inflammatory drugs. The patient generally only needs pain medication for 1 or 2 days after the surgery.

Fig 4-13 Case 1. *(a to c)* Short teeth and excess gingival display.

Case Presentations

Case 1

A 16-year-old girl presented with a chief complaint of short teeth and a gummy smile (Figs 4-13a to 4-13c). Her medical history was noncontributory. Her maxillary central incisors were 8.5 mm long, and the CEJs could not be detected in the sulcus; therefore, a diagnosis of altered passive eruption was made. The surgical procedure, as previously described, was accomplished with local anesthesia (Figs 4-13d to 4-13f). Six weeks postoperatively, the tissue was well healed in its new position (Figs 4-13g to 4-13i). Although it appears that an open gingival embrasure was created with the surgical procedure, it was actually present preoperatively. It is not obvious in the preoperative photograph because it is filled with dental plaque, but it can be seen in the intraoperative photograph.

Fig 4-13 *(cont) (d)* Relationship of the alveolar bone to the CEJs prior to ostectomy. *(e)* Relationship of the alveolar bone to the CEJs after ostectomy. *(f)* Tissue sutured in the new position. *(g)* Postoperative result at 6 weeks.

Fig 4-13 *(cont) (h and i)* Postoperative result at 6 weeks.

Fig 4-14 Case 2. *(a to c)* Preoperative clinical presentation.

Case 2

A 35-year-old woman presented with a chief complaint of short teeth and a gummy smile (Figs 4-14a to 4-14c). Her medical history was noncontributory. Her maxillary central incisors were 5.5 mm long, and the CEJs could not be detected in the sulcus; therefore, a diagnosis of altered passive eruption was made (Figs 4-14d and 4-14e). The surgical procedure, as previously described, was accomplished with local anesthesia. There was a greater amount of alveolar bone (Fig 4-14f) than in Case 1, so more aggressive ostectomy and thinning of alveolar bone was required (Fig 4-14g). Six weeks postoperatively, the tissue was well healed in its new position (Figs 4-14h and 4-14i).

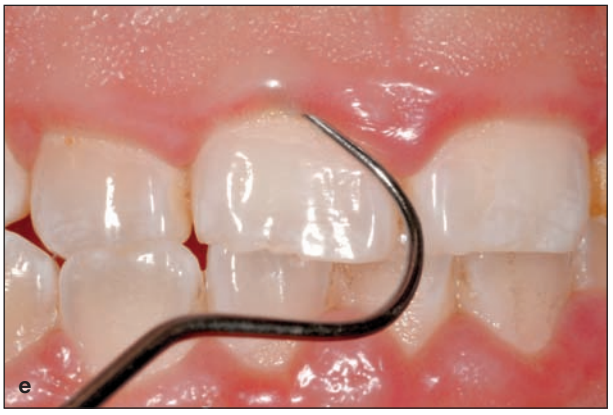

Fig 4-14 *(cont) (d and e)* Preoperative clinical presentation. *(f)* Alveolar bone prior to surgical recontouring. *(g)* Alveolar bone after surgical recontouring.

Fig 4-14 *(cont) (h and i)* Postoperative result at 6 weeks.

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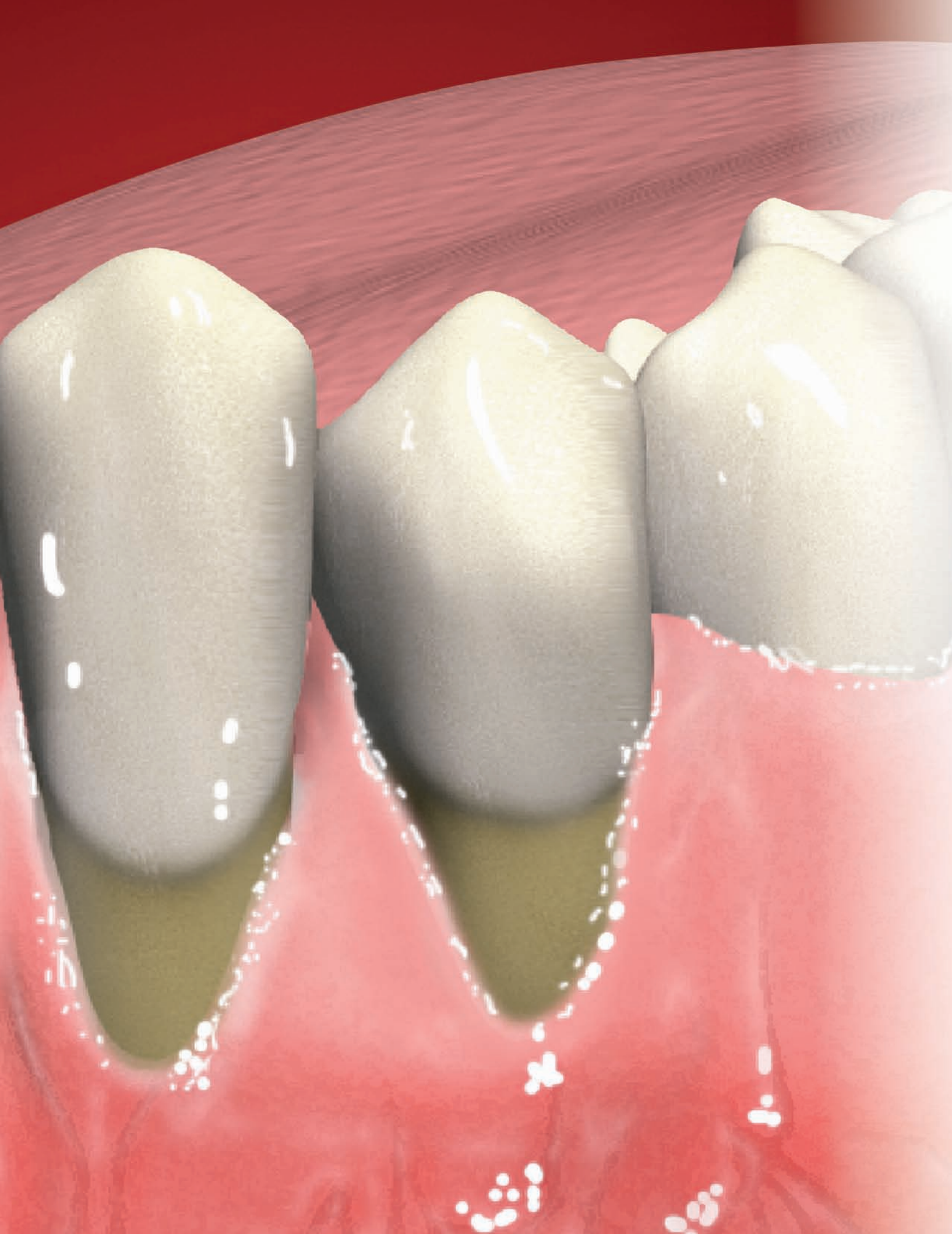

5 Tissue Grafting

Edward P. Allen

One of the global diagnoses is a long clinical crown. An important strategy for correcting a long tooth is root coverage grafting. Gingival recession is a common problem that is complicated by the loss of cervical tooth structure. It is always a difficult decision whether to graft or to restore. This chapter provides a set of guidelines to help direct the decision-making process.

Fig 5-1 Miller recession classification. *(a)* Miller Class I. *(b)* Miller Class II. *(c)* Miller Class III. *(d)* Miller Class IV.

Tooth form is considered one of the most critical factors in esthetic dentistry, and gingival architecture impacts tooth form. Altered passive eruption reduces tooth length, while gingival recession increases tooth length. Placing restorations without first correcting these gingival abnormalities results in teeth that are either too short (in the case of altered passive eruption) or too long (in the presence of gingival recession). Fortunately, both of these gingival problems can be corrected surgically.

Root coverage with gingival grafting has been considered to be a predictable procedure for over 25 years and is routinely performed. When a patient is evaluated for restorative dentistry and recession is noted, a surgeon should be consulted prior to any restorative treatment to determine the need for gingival grafting and the degree of root coverage that can be expected. Complete root coverage is dependent upon the nature of the interdental bone and soft tissue. Miller described a classification system to serve as a guide for determining the outcome of root coverage grafting[1]:

- *Miller Class I:* Recession does not extend to the mucogingival junction (MGJ), and there is no loss of interdental bone or soft tissue. Complete root coverage is expected (Fig 5-1a).
- *Miller Class II:* Recession extends to the MGJ, and there is no loss of interdental bone or soft tissue. Complete root coverage is expected (Fig 5-1b).
- *Miller Class III:* Recession extends to the MGJ, and there is some loss of interdental bone or soft tissue. Partial root coverage can be achieved (Fig 5-1c).
- *Miller Class IV:* Recession extends to the MGJ, and there is such severe loss of interdental bone and soft tissue that no root coverage can be achieved (Fig 5-1d).

Determining the proper treatment for cervical lesions presents a perplexing problem for both periodontists and restorative dentists because the tooth defect is usually accompanied by gingival re-

cession. Cervical lesions are commonly seen in adult patients. These lesions may be asymptomatic, or they may present patient-related concerns including sensitivity, food retention, or esthetics. Restorations placed in or on root surfaces often lead to undesirable outcomes, especially in the absence of adequate marginal gingiva.

There are three types of cervical lesions: *(1)* noncarious cervical lesions, *(2)* restored cervical lesions, and *(3)* carious cervical lesions. Proper treatment of each of these types of cervical lesions may require placement of restorations, soft tissue grafting, or both surgical and restorative treatment.

Noncarious cervical lesions have multiple possible etiologies, including erosion or chemical agents, abrasion or physical agents (ie, aggressive tooth brushing), and abfraction or occlusal forces causing tooth flexure. Whatever the causes may be, they must be managed effectively if treatment is to be successful. Once the causative factors are determined and managed, five questions can be used to simplify the treatment-planning process for all three types of cervical lesions. All five questions must be answered before the final treatment decision is made.

The Five Questions

Question 1: Where is the cervical lesion located?

There are only three possibilities for location of the lesion: *(1)* on the crown only, *(2)* on the root only, or *(3)* on the crown and the root. The location of the lesion will obviously impact the treatment decision. If the lesion is on the root only or on the crown and the root, further assessment is needed before deciding whether to graft, restore, or both. If the lesion involves only the crown, the solution is a restoration. However, gingival grafting may also be indicated if the marginal gingiva is inadequate.

Question 2: What are the dimensions of the gingiva apical to the cervical lesion?

The marginal gingiva is an important, yet often overlooked feature when treating cervical lesions. All teeth require an adequate zone of marginal gingiva for function and comfort. While it is generally accepted that a minimum of 2 mm of gingiva (1 mm of attached gingiva and 1 mm of free gingiva) is necessary for health, more is desirable adjacent to restoration margins. Thus, assessment of four dimensions of gingiva must be made:

1. Total vertical dimension of gingiva
2. Vertical dimension of attached gingiva
3. Vertical dimension of free gingiva
4. Thickness of gingiva

The total vertical dimension of gingiva is determined by measuring the distance from the MGJ to the gingival crest. When the MGJ is not readily apparent, it can be found by gently displacing the mucosa coronally with a periodontal probe until it meets the attached gingiva. The mucosa will roll slightly at the MGJ and thus reveal this demarcation between the mucosa and the attached gingiva. Next, the sulcus is probed to determine how much of the gingiva is free gingiva. The vertical dimension of free gingiva, the distance from the gingival crest to the base of the sulcus, is equal to the probing depth. The amount of attached gingiva is the total vertical dimension of gingiva minus the probing depth. The probing depth on the facial aspect ideally should be 1 to 2 mm, and there should be no bleeding on probing. Probing depth greater than 2 mm and/or bleeding on probing indicate a periodontal problem that requires additional periodontal evaluation and treatment. The gingival thickness is subjectively judged as thin, adequate, or thick. Ideally, the gingiva should be approximately 1 mm thick. Thin marginal gingiva is at risk for progressive recession, especially in the presence of existing recession or a cervical restoration.

If the dimensions of gingiva are found to be inadequate, gingival grafting is indicated whether a restoration is placed or not.

Fig 5-2 *(a and b)* Shallow cervical notching and recession involving a maxillary canine and premolar. *(c)* Root planing has reduced the sharp borders of the root notch in preparation for grafting. *(d)* Complete root coverage and thickened attached gingiva 6 months after surgery.

Question 3: What are the dimensions of the cervical lesion?

The dimensions of the cervical lesion will clearly impact the treatment decision. Both the horizontal depth toward the pulp and the vertical height of the lesion should be measured.

Grafting can successfully treat shallow cervical lesions (1 mm or less) involving the root only (Fig 5-2). If an existing shallow restoration or shallow carious lesion is present, grafting can be performed following removal of the restoration or the carious portion of the root (Fig 5-3). The root is simply reshaped to remove any sharp margins and to create a uniform surface for graft adaptation.

For moderately deep cervical lesions (less than 2 mm), the cervical enamel may be beveled and polished to reduce any potential undercut or minor enamel defect, and the root can be covered by a graft after root reshaping. The same is true for a moderately deep restoration or carious lesion.

A significantly deep lesion (at least 2 mm horizontally) would require excessive root reshaping in order to create a proper root form for coverage with a graft, especially where the vertical dimension of the cervical lesion is minimal. As the vertical dimension of the lesion increases, the possibility for grafting also increases because the amount of root reshaping diminishes. Thus, it is the geometric relationship of the horizontal and vertical dimensions of the lesion that directs the treatment decision toward a restoration, a graft, or both. In some sites, there may be a deep, V-shaped, horizontal cervical lesion with minimal vertical extent associated with significant root exposure apical to the true cervical lesion. In such a site, the cervical lesion should be restored and the remaining root exposure treated by grafting. The restoration should be limited to the true cervical lesion and not extend over the portion of the root that can be covered by the grafting procedure.

Fig 5-3 *(a and b)* Composite restorations placed to treat root sensitivity on maxillary teeth, resulting in long teeth and an unesthetic appearance. *(c and d)* Complete root coverage has restored the original gingival position and natural tooth form, resulting in a pleasing appearance.

As the horizontal depth of the cervical lesion increases, the potential for crown involvement increases, and thus the potential need for a restoration also increases. Class V restorations may be required if the lesion is very deep or there is significant loss of anatomical crown form.

Question 4: How much root exposure is there?

The greater the amount of root exposure, the more likely it is that grafting will provide a significant benefit, especially in the esthetic zone. Shallow recession (less than 2 mm root exposure) in the presence of adequate dimensions of gingiva rarely requires root coverage grafting except where esthetics or root sensitivity is a factor. However, it is desirable to cover roots where the recession is at least 3 mm.

Question 5: What is the classification of the recession?

Determination of the classification of recession is necessary to ascertain where gingival grafting will result in complete root coverage.[1] Complete root coverage can routinely be achieved in sites with Miller Class I or Class II recession. For sites with Miller Class III or Class IV recession, complete root coverage is not possible. Partial root coverage can be achieved in Miller Class III sites, but no root coverage is expected in Miller Class IV sites.

Table 5-1 | Treatment guidelines

Variable	Graft	Restore
Location of the lesion	Root	Crown
Dimensions of the marginal gingiva	Inadequate	Adequate
Depth of the cervical lesion	≤ 2 mm	> 2 mm
Amount of root exposure	Significant	Minimal
Classification of the recession	Miller Class I or Class II	Miller Class III or Class IV

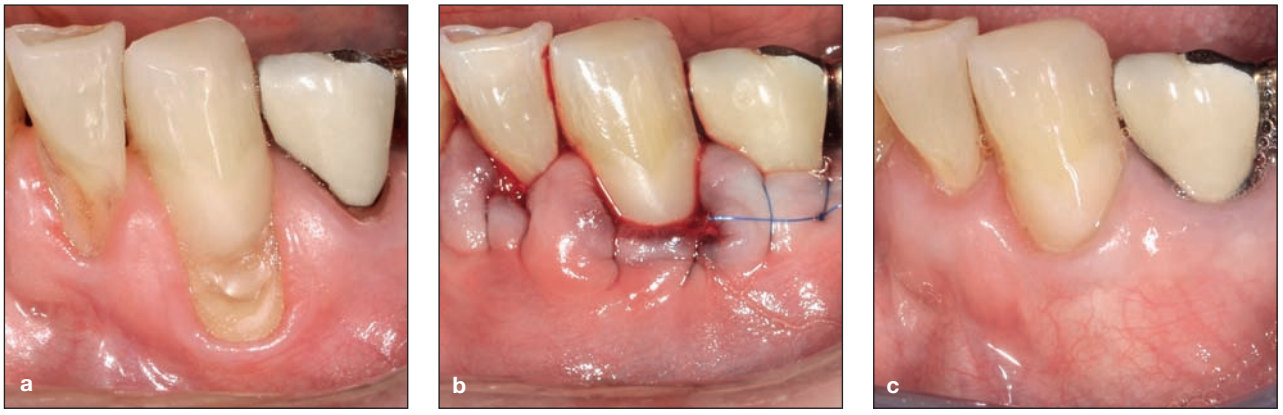

Fig 5-4 *(a)* Severe recession and cervical lesion involving both crown and root surfaces. The coronal portion of the defect was restored, leaving the root exposed prior to grafting. During root planing, the small amount of composite material was removed from the root surface prior to grafting. *(b)* An AlloDerm (LifeCell) graft was used with the tunnel technique to treat the root exposure as well as the lack of attached gingiva. *(c)* Complete root coverage and thickened marginal tissue 5 years after surgery. The gain of dense attached tissue extends beneath the overlying mucosa well apical to the MGJ.

It is necessary to assess the amount of root coverage that can be expected when deciding whether to graft or restore a cervical lesion on a root surface with Miller Class III recession. Generally, grafting procedures can cover a root to within 3 mm of the tip of the gingival papillae. A restoration should not be placed over the portion of the root that can be covered by a graft unless dictated by the depth of the cervical lesion. Restoration of cervical lesions should be secondary to placing the gingival level back to its ideal position.

Guidelines

Guidelines for treating cervical lesions based on these five questions are shown in Table 5-1. When all variables are in the Graft column, grafting is indicated, and when all variables are in the Restore column, placement of a restoration is indicated. However, often some variables will fall in each column *(circled in red)*, leading to a decision to perform both grafting and restorative procedures. In this example (Fig 5-4a), review of the five variables reveals that:

- The cervical lesion is on the root, indicating a *preference* for a graft.
- The dimensions of marginal gingiva are inadequate, indicating the *need* for a graft.
- The depth of the cervical lesion is greater than 2 mm, *suggesting* that the cervical lesion should be restored.
- There is significant root exposure *indicating* root coverage grafting.
- The recession is Miller Class III or IV, meaning that complete root coverage is not possible.

These findings indicate the need for a graft due to the inadequate dimensions of marginal gingiva. There is also significant root exposure, but the recession is Miller Class III or IV, so complete root coverage is not possible. Because the cervical lesion is deep, a restoration should be considered. Figures 5-4b and 5-4c show the treatment and results.

When it is necessary to both graft and restore a cervical lesion, it is preferable to graft first because the outcome can be more precise when the restoration is placed after the root coverage surgery. In a non-esthetic area, the restoration may be placed first while leaving the root exposed for coverage with the grafting procedure. A graft can predictably cover a root to within 3 mm of the adjacent papilla tips. If there is a difference between the mesial and distal papilla heights, the shorter of the two papillae will determine the level of root coverage. Thus, ideally a restoration should not extend more than 3 mm apically from the papilla tip, leaving the rest of the root exposed for root coverage grafting.[2]

Soft Tissue Grafting Technique

Surgical techniques for predictable root coverage grafting were first described more than 25 years ago. Earlier grafting procedures, such as the free gingival graft, were used primarily for augmenting sites with insufficient marginal gingiva, but coverage of exposed roots was not predictable prior to the introduction of the subepithelial connective tissue graft (CTG) technique.[3] Not only did the CTG provide a predictable method for root coverage, but it also introduced a more comfortable internal harvesting method for obtaining palatal donor tissue.

Currently, root coverage grafting can be accomplished with a minimally invasive tunnel technique using an allograft or palatal donor tissue.[4,5] An allograft results in predictable root coverage and an increase in marginal gingival thickness equivalent to the CTG, and multiple teeth can be treated in one visit without concern for the amount of palatal tissue available.[6–9] The tunnel technique has been demonstrated to be more comfortable for the patient than flap procedures.[10]

The recipient site is prepared with an intrasulcular approach without surface incisions, followed by placement of an allograft within a pouch and coronal advancement of the graft and pouch (Fig 5-5). The site preparation begins with an intrasulcular incision made with an End-Cutting Intrasulcular Knife (Hu-Friedy), followed by a subperiosteal blunt reflection with an Allen Microsurgical Elevator (Hu-Friedy). The papilla is elevated from the interdental crest with a Younger-Good 7/8 curette.

After mobilization of the marginal tissue, root preparation is performed with curettes and/or an ultrasonic instrument with a safe-sided diamond tip (Varios 750, Brasseler USA) to remove shallow restorations, to eliminate any angular portions of the lesion, and to create a uniform root surface without damaging the soft tissue. Ethylenediaminetetraacetic acid (EDTA) is applied to the root surface to remove the smear layer. If there is an enamel overhang coronal to the cervical lesion, it may be beveled and polished.

The next step is apical extension and mobilization of the pouch by sharp dissection using a Modified Orban Knife (Hu-Friedy). This instrument will allow dissection that is immediately supraperiosteal to ensure passive advancement of the pouch to the cementoenamel junction and to create space for the graft while maintaining an immobile recipient bed.

The reconstituted allograft is trimmed to the proper dimensions and soaked in a platelet-rich plasma preparation for enrichment with growth factors. Alternatively, a CTG may be harvested from the palate. The graft is inserted into the pouch and aligned level with the gingival margins of the pouch. The graft and pouch are then coronally advanced simultaneously with a single subpapillary 6-0 polypropylene continuous sling suture.[5]

Typically, gain of keratinized tissue is minimal with a submerged grafting technique whether an allograft or a CTG is used.[9,11] Realistically, gain of keratinized tissue is a rather meaningless parameter for submerged grafts. While gain of keratinized tissue is useful for assessing graft success for surface grafts such as free gingival grafts, the amount of keratinized tissue on the surface is not reflective of the gain of functional, dense, collagenous connective tissue with submerged grafts. The small gain of keratinized tissue following a submerged grafting technique is reflective of initial graft exposure and secondary retraction of the overlying tissue exposing a small portion of the graft, and it is not an indicator of graft success.

Fig 5-5 *(a)* Gingival recession facial to the maxillary right canine through the second molar with minimal to no attached gingiva. *(b)* Following root preparation, the recipient tunnel is prepared by intrasulcular dissection. *(c and d)* The graft is inserted through the sulcus and aligned facial to the teeth within the tunnel. *(e)* The graft and overlying tissue are advanced and secured level with the cementoenamel junction with a single continuous sling 6-0 polypropylene suture. *(f)* Complete root coverage (except at the molar with Miller Class III recession), gain of attached gingiva, and extension of vestibular depth 6 months after surgery.

The advantages of this minimally invasive grafting technique include the following:

- No surface incisions, and thus no scarring
- Use of an allograft eliminating the need for a palatal donor site
- Reduced patient discomfort
- Greater acceptance of treatment
- Ideal esthetics

Palatal grafts are also very effective for predictable root coverage; however, they are subject to enlargement, thereby negatively impacting the esthetic outcome. Graft enlargement may be desirable in some alveolar ridge or papilla augmentation procedures, and thus palatal connective tissue may be a better choice for these applications. In sites where the graft cannot be completely covered, palatal tissue will perform better than an allograft.

Summary

Soft tissue grafting is an integral part of treatment of cervical lesions due to the root exposure and lack of adequate attached gingiva often associated with these lesions. Complete root coverage is a predictable outcome for Miller Class I and Class II recession defects, and partial root coverage can be achieved in Miller Class III defects. In the esthetic zone, it is desirable to cover as much of the root as possible, and all sites require an adequate zone of attached gingiva, especially adjacent to a restoration.

Restorations are required for cervical lesions with excessive depth and significant involvement of the enamel, but they should be avoided where the lesion is shallow and the enamel involvement is minimal. Of course, some sites will require both soft tissue grafting and placement of a restoration.

An interdisciplinary approach to treating cervical lesions will create the most biologically appropriate, stable, and esthetic outcome. Establishing the appropriate tooth form will determine the gingival level and extent of surgical procedures necessary to achieve the desired outcome.

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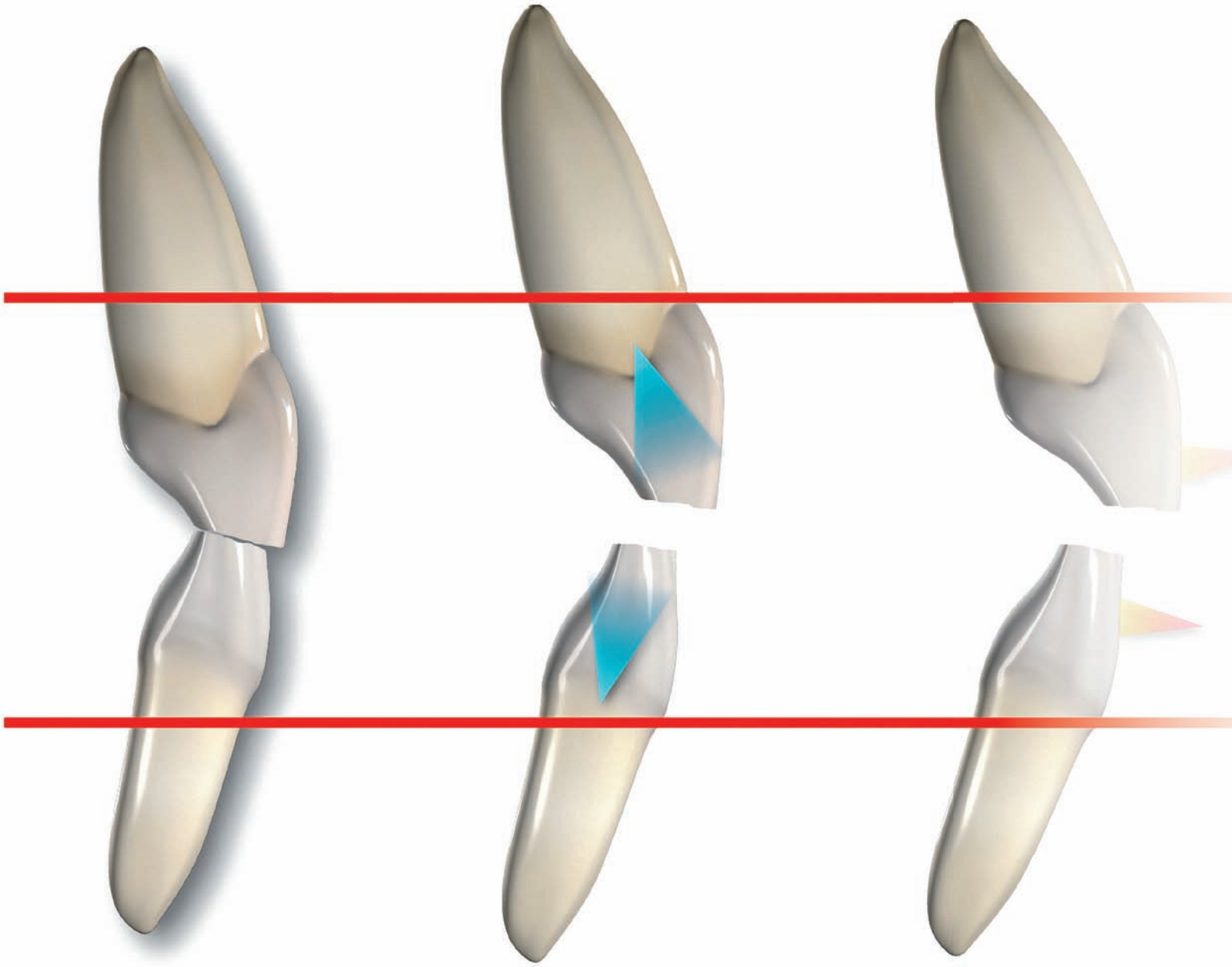


Dentoalveolar Intrusion of the Adult Dentition

6

Jay Gibson | Jeffrey S. Rouse

The most difficult global diagnosis for the restorative dentist is dentoalveolar extrusion (DAE). The authors recommend orthodontic intrusion as a primary treatment for DAE. This chapter discusses this treatment option in detail.

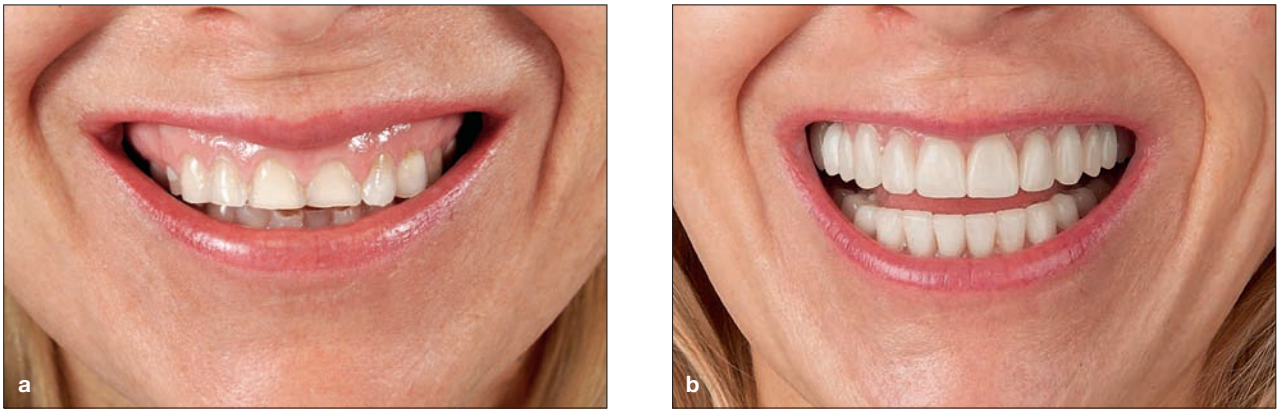


Fig 6-1 *(a)* Traditionally, the most difficult restorative cases are patients with significant attrition and/or erosion. A systematic approach to interdisciplinary care can improve the coordination of care in these difficult cases. *(b)* Postoperative smile.

Vertical management of the extruded dentition has long been recognized as a restorative and esthetic challenge. Orthodontic intrusion of teeth is a primary treatment strategy for supererupted, worn, and traumatized teeth.[1,2] Intrusion has been included in traditional orthodontic care for decades,[3] but its use in pre-restorative treatment planning is relatively new. Complex orthodontic tooth movement for restorative purposes requires careful interdisciplinary coordination to ensure ideal esthetics and function in the definitive restorations. The Global Analysis Diagnosis (GAD) system allows for the creation of results that have been difficult to consistently achieve in interdisciplinary treatment in the past (Fig 6-1).

Rationale for Orthodontic Intrusion

There are three primary strategies for treating DAE:

1. Restoring at an increased vertical dimension of occlusion
2. Functional crown lengthening surgery
3. Orthodontic intrusion

However, restoring at an increased vertical dimension does not treat the DAE itself; rather, it is just a strategy to create space for restoring the worn dentition. Additionally, functional crown lengthening requires osseous recontouring and apical positioning of the soft tissue onto root surfaces, which has several disadvantages (see chapter 4). Apical repositioning of tissue does not improve the restorative position of the tooth in the arch. It only addresses the visual irregularity of the gingival architecture and provides adequate tooth structure for retention and resistance form. When teeth are worn and extrude into a tight occlusal or interincisal relationship, additional restorative space is required. Functional crown lengthening only resolves the gingival problem. Restoratively, the vertical dimension of occlusion must commonly be altered, or the teeth must be over-reduced to create the required restorative space. There is always a significant biologic price to be paid when DAE is treated with functional crown lengthening, but these negative sequelae do not occur when DAE is treated orthodontically.

Dental shifting and extrusion frequently occur secondary to latent growth, aging parafunction, malocclusion, and attrition. Intrusion offers the opportunity to reposition the tooth and dentoalveolar complex to its original or ideal restorative position (Fig 6-2).

Fig 6-2 *(a)* Preoperative deep bite resulting from excessive erosion and attrition. *(b)* Extensive wear and erosion demonstrated on occlusal view. *(c)* Preparation of the palatal aspect of the teeth would biomechanically compromise their structure. *(d)* Sagittal view. *(e)* The maxillary left first molar is worn deeply into the mandibular crown. Because of the depth of the wear, all of the teeth in the arch must be intruded to provide restorative space and minimize tooth preparation. *(f)* All of the teeth in the arch are intruded sectionally to create material space.

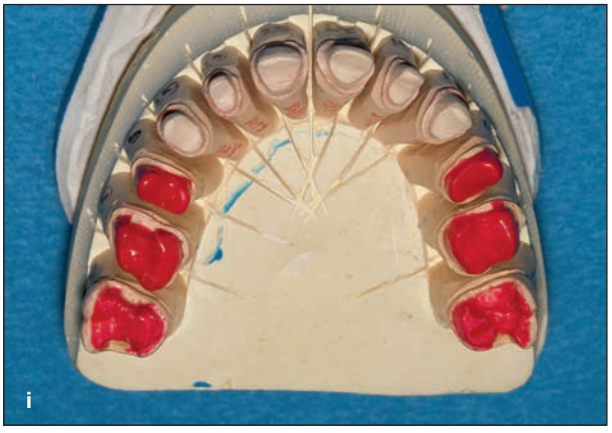


Fig 6-2 *(cont) (g)* Intrusion not only provides space for restoration but also corrects the disocclusive angulation. *(h)* Interarch space is established. *(i)* The conservative preparation design maintains vital tooth structure. *(j)* The definitive restorations with an ideal occlusal relationship established through orthodontic intrusion. *(k)* View of the definitive anterior restorations and healthy gingival tissue.

Fig 6-3 *(a to d)* Preoperative views. *(e)* Intrusion appliances in place on both arches. *(f)* Space created for restorations after removal of the orthodontic appliances.

The primary purpose of orthodontic intrusion in the adult patient with tooth wear is to decrease the restorative compromise. This is facilitated in two ways. First, intrusion requires minimal tooth structure to be removed during tooth preparation. Commonly, that structure which was already lost due to attrition becomes the incisal reduction for restorations, with no additional tooth removal required. The patient in Fig 6-3 had attrition on the palatal surfaces of the maxillary anterior teeth and incisal-facial attrition of the mandibular anterior teeth. However, there was no attrition of the posterior teeth. After

Fig 6-3 *(cont) (g and h)* Twelve-year postoperative views of the porcelain veneers placed on the maxillary and mandibular incisors.

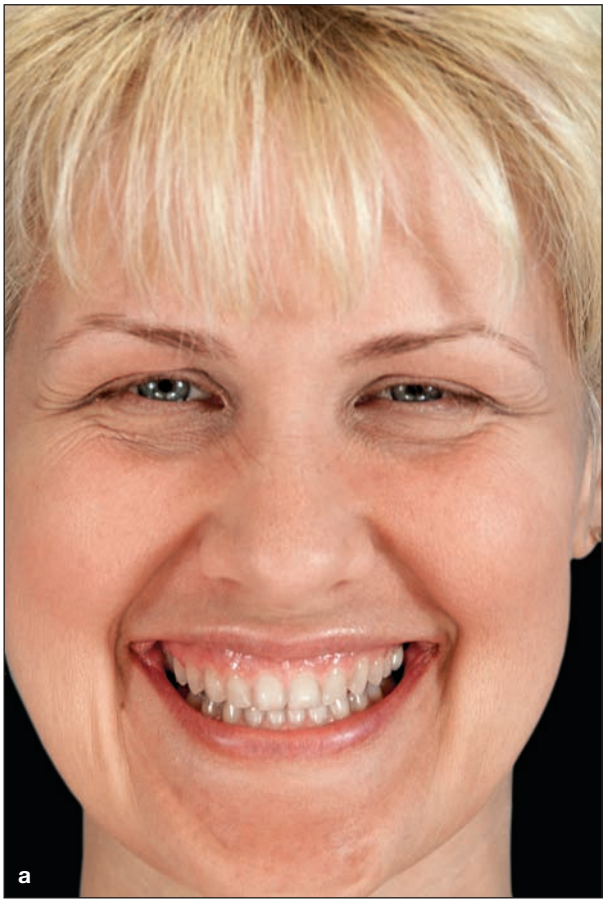


Fig 6-4 *(a)* Postorthodontic smile demonstrating worn anterior teeth, excessive gingival display, and a gingival cant. *(b)* The smile shows short, worn teeth. Adding structure to the incisal edges would further compromise the smile. *(c)* Note the cant of the occlusal plane. Traditionally, smiles with cants were treated with functional crown lengthening to correct the gingival architecture. Afterward, the entire mouth would need to be restored to correct the occlusal cant and create a level functional plane.

orthodontic intrusion of the incisors in both arches, enamel-bonded restorations were placed on the four maxillary and four mandibular incisors with minimal additional tooth reduction. Second, intrusion can minimize the number of teeth requiring restoration by limiting restoration to only the damaged teeth at the existing vertical dimension (Fig 6-4).

Fig 6-4 *(cont) (d)* Intrusion allows the wear to be addressed and the cant to be corrected with minimal restorations. *(e)* Mock-up to assist in determining if the intrusion is complete. *(f)* After the orthodontic appliances are removed, the teeth are ready for restoration. *(g)* The interincisal angle has been corrected with orthodontics. *(h)* Spacing for the mandibular porcelain veneers, created with orthodontic intrusion, minimizes the preparation for enamel-bonded porcelain veneers. *(i)* Postoperative smile after restoration with only four maxillary and four mandibular anterior porcelain veneers.

Fig 6-4 *(cont) (j)* Sagittal postoperative view. *(k)* Animated smile. Intrusion can assist in creating a beautiful smile and minimize the restorative dentistry required to achieve that goal.

Cementoenamel Junction Alignment

The planning and treatment strategies in this chapter focus primarily on the maxillary anterior teeth. The anterior maxilla is the most common area treated and is the easiest to visualize. However, DAE can occur in both arches as well as in the posterior teeth. The planning concepts are the same no matter where the DAE is identified; the anchorage mechanics are simply adapted to the unique nature of the particular case.

Before the orthodontic movement begins, the interdisciplinary team must have a vision of the final tooth position in all three planes of space. The GAD system is extremely helpful because it focuses on the desired location of the cementoenamel junction (CEJ) rather than the existing incisal edges. This CEJ-driven planning is especially valuable in cases involving the worn dentition. The simplest technique is for the team to designate the CEJ on a single tooth as ideal and then position the other teeth in relation to the ideal reference tooth. Using a single CEJ as a guide minimizes the guesswork between the orthodontist and the restorative dentist. For the restorative dentist, it is similar to setting denture teeth, where one tooth is in an ideal position and all of the other teeth are set in relation to it. A line drawn horizontally and at a tangent to the target tooth/CEJ provides this visual reference for positioning the other teeth (Fig 6-5). If a simple tooth or gingival guide does not exist, the final position of the CEJs is determined by the patient's smile (Fig 6-6). This criterion is more difficult, and diagnostic photographs of the repose and full smile positions, from both frontal and oblique perspectives, are essential. In these patients, the CEJ locations must be reevaluated during orthodontic treatment to ensure that the intrusion is meeting the treatment goals.

Fig 6-5 *(a)* The patient presents with DAE in the anterior and posterior. The maxillary left canine provides an ideal marker for the orthodontist to use to intrude and extrude teeth and level the gingival architecture. *(b)* Preoperative smile. *(c)* The retracted view highlights the DAE with wear on the anterior teeth and the supereruption of the maxillary posterior teeth on the right side. *(d)* DAE without wear of both maxillary molars as a result of missing mandibular teeth. *(e)* Maxillary anterior teeth have been intruded to mimic the gingival line of the maxillary left canine. Ligatures on the right side attach to a temporary anchorage device (TAD) in the premolar area.

Fig 6-5 *(cont) (f)* The incisal edges can be repaired without further reduction. *(g)* The molars are intruded above the ideal occlusal plane so that the mandibular implants can be restored and then the maxillary teeth extruded back into ideal occlusion. It is very difficult to determine the perfect level at which to stop the intrusion. *(h)* Completed bonding on the maxillary anterior teeth to restore worn incisal edges. The smile demonstrates the use of the maxillary left canine as a guide. The gingival level of that tooth remains the same as the preoperative position. (Bonding performed by Dr Lisa Rouse). *(i)* Postoperative smile. *(j)* The gingival contours and tissue health are maintained by avoiding the traditional DAE approach of functional crown lengthening surgery.

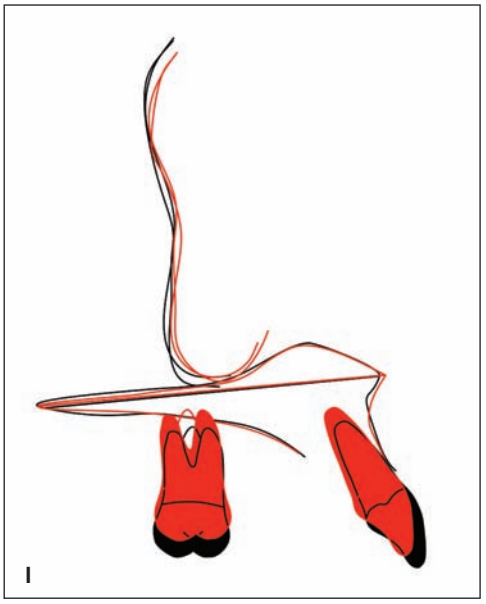
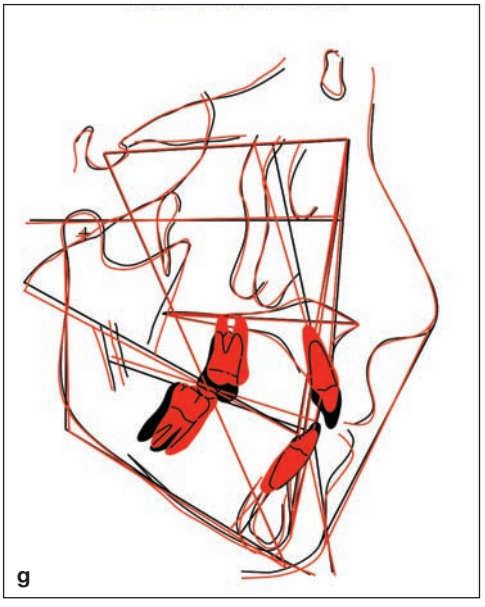


Fig 6-5 *(cont) (k)* Extrusion of the maxillary molars into occlusion. *(l)* Preoperative and postoperative cephalometric tracing overlay demonstrating anterior and posterior absolute intrusion.

Fig 6-6 *(a)* DAE has left the smile without a marker for the orthodontist to use as a guide for intrusion. In this case, the maxillary smile line must be the guide for intrusion. *(b)* Intrusion of the entire maxillary arch utilizing TADs. The canines and second molars are not included in early intrusion. Instead they maintain the existing vertical dimension. *(c)* The gingival line has improved. Provisional bonding assists in orthodontic completion. *(d)* Intrusion is nearly complete. The smile and gingival line continue to improve.



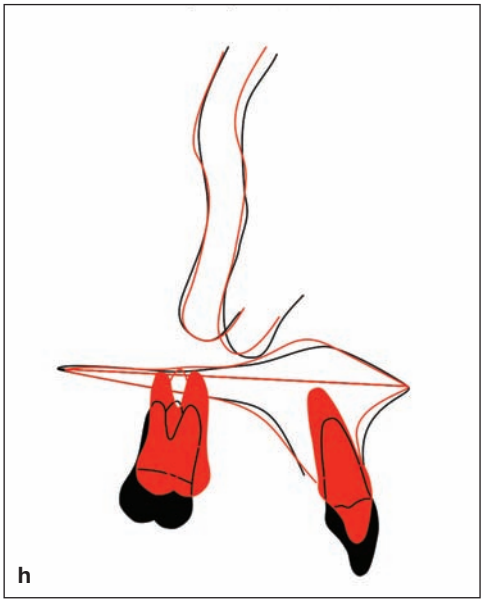


Fig 6-6 *(cont) (e)* The brackets are removed, and the teeth are ready for restoration. The smile line and gingival line are ideal. *(f)* Completed ceramic restorations. *(g)* Cephalometric tracing overlay of preoperative and postoperative tooth position. *(h)* Cephalometric overlay demonstrating the extent of incisal and molar intrusion.

Absolute Versus Relative Intrusion

It is important for the restorative dentist to understand the concepts of absolute and relative intrusion (Fig 6-7). *Absolute intrusion* is the bodily intrusion of a targeted tooth without torquing. The result is a vertical vector of force through the long axis of the tooth, which allows for true intrusion (Fig 6-8). This movement is ideal when the eruption and wear of a tooth have not altered its anterior-posterior

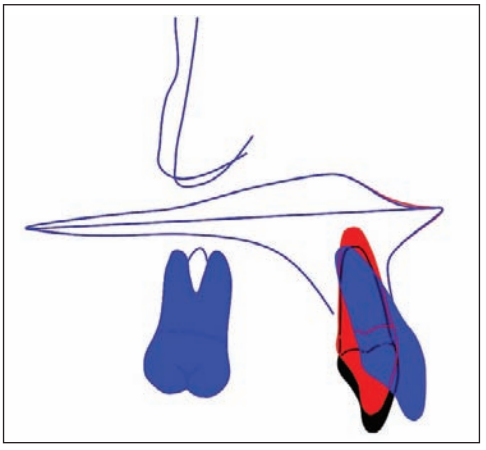


Fig 6-7 Absolute intrusion through the long axis of the incisor is shown in *red*. Relative intrusion due to tipping of the incisor is shown in *blue*.

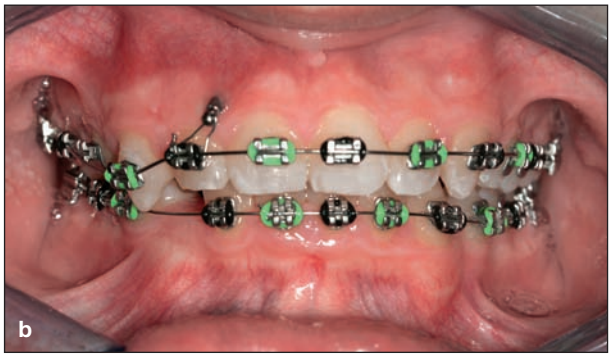


Fig 6-8 *(a)* DAE without wear of the maxillary right canine and first premolar. Given the ideal position of the maxillary left anterior teeth in the smile, absolute intrusion of the extruded teeth would correct the right-side gingival architecture while maintaining the left-side gingival architecture. *(b)* TADs assist with indirect anchorage. Note the coronal angulation of the screw head for improved stability during treatment. *(c)* Absolute intrusion demonstrated by the vertical movement of the maxillary right teeth in relation to the target line without altering the position of the gingival margins of the maxillary left teeth in the smile. Note the remodeling of the gingival tissue and mucogingival junction associated with the intrusion and correction of the anterior cant. No periodontal treatment was performed.

relationship in the arch (Fig 6-9). Absolute intrusion has many preprosthetic implications. The gingival levels of microdont or peg-shaped teeth can be aligned before restoration to improve the height-to-width ratio of the teeth. In this circumstance, the teeth are aligned apicocoronally based on the position of the CEJs, not the incisal edges that will ultimately be restored. Additionally, when teeth are placed in positions in the arch that are aberrant, the gingival architecture becomes an esthetic distraction. For example, canine substitution and first premolar extraction result in teeth with unes-

Fig 6-9 *(a)* The patient's chief complaint is her unattractive smile. *(b)* The target CEJs were the maxillary canines, and all of the maxillary incisors were scheduled for intrusion to that reference line. *(c)* Segmented intrusion wires and differential mechanics with single-point contacts were utilized to intrude the most inferiorly positioned maxillary teeth sequentially between 2.0 and 5.5 mm. *(d)* Treatment completed in a continuous wire and anterior TADs for finalization of the vertical movements.

thetic gingival levels (Fig 6-10). In these situations, the ideal method to correct gingival esthetics is with orthodontic intrusion or extrusion. This is a much better method to level the gingiva than functional crown lengthening surgery, because there is no root exposure with orthodontic movement and a conservative enamel-bonded restoration can be placed (Fig 6-11).

Relative intrusion is a more difficult tooth movement to visualize. There are two circumstances in which relative intrusion occurs. The first is flaring of the target teeth rather than apical movement.

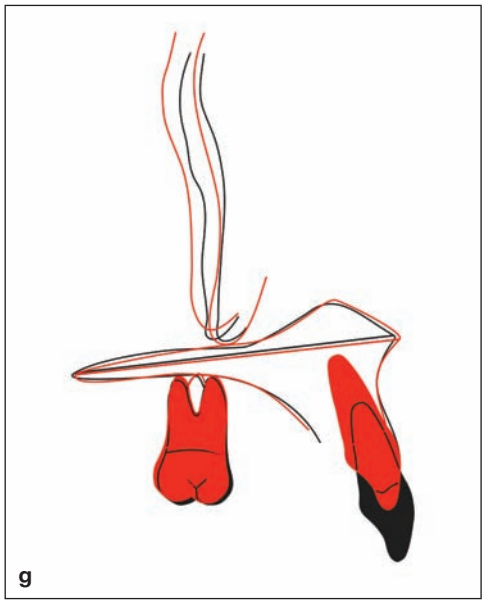


Fig 6-9 *(cont) (e)* Interim bonding was performed on the maxillary right central incisor as part of orthodontic treatment due to severe wear. No change in vertical facial height was noted. *(f)* No gingival or periodontal treatment was needed during or after orthodontic treatment, and there was minimal evidence of external apical root resorption clinically. Long-term retention includes a maxillary splint and mandibular lingual bonded retainer from canine to canine. *(g)* Preoperative and postoperative cephalometric tracing overlay demonstrating significant anterior absolute intrusion.

This flaring is the result of torque, which causes rotation around the center of resistance, thereby allowing for vertical change.[4] If a force is placed that pushes apically on the facial of an incisor, the tooth will rotate around the center of resistance due to the moment of force. The crown will be torqued facially while the incisal edge moves facially and apically. Relative intrusion alters the arch form as a component of the movement. The second type of relative intrusion is extrusion of the anchor teeth. It appears that the target teeth have been intruded, but in reality the anchorage teeth have been extruded.

Both absolute and relative intrusion can be utilized to facilitate vertical change, and they can also be used together. Worn, retroclined, extruded anterior teeth are the best indication for absolute intrusion, which provides apical movement while proclining the crowns with relative intrusion. This results in rapid and significant vertical change in incisal edge position.

A distinction must be made between the orthodontic movement and the effect of the movement. Relative intrusion can be a description of a mechanical movement or it can describe the effect on a

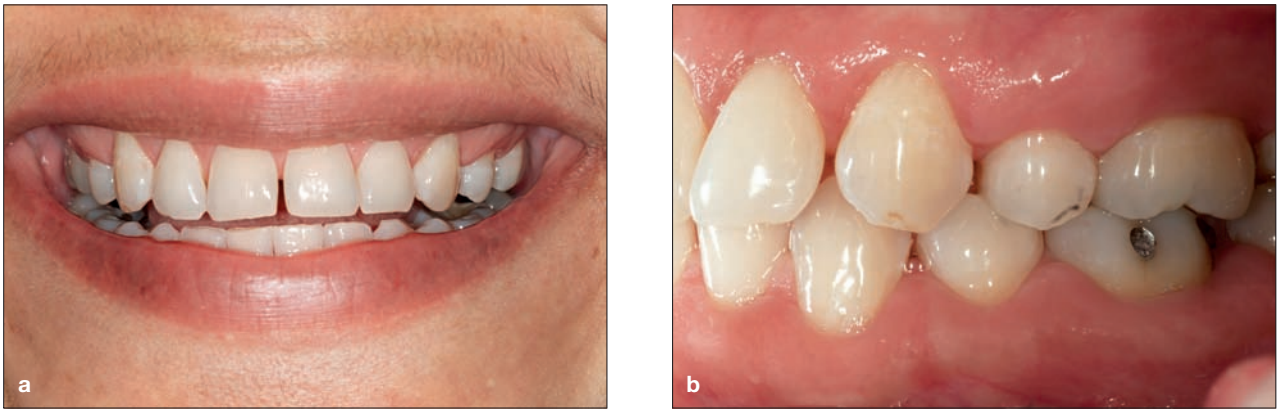


Fig 6-10 *(a)* Extraction of the maxillary first premolars may result in a significant gingival step. This can create excessive gingival display in the smile. *(b)* Excessive gingival step.

Fig 6-11 *(a)* A patient who has previously undergone maxillary canine substitution for congenitally missing lateral incisors. *(b)* Bulky lateral incisors result from the substitution. Additionally, the gingival position of the "canines" is below the gingival level required to mimic the form of that tooth. *(c)* Retracted view.

Fig 6-11 *(cont) (d)* The teeth in the canine positions were provisionalized. Preparation thinned the interproximal width and flattened the facial surfaces of both teeth. Absolute intrusion of the premolars improved the gingival architecture. The gingival line is ideal. *(e)* The teeth are ready for restoration. The orthodontist must focus on the gingival alignment and ignore the incisal display. *(f and g)* The first and second premolars are intruded. *(h)* Definitive restoration creates an illusion of reality. *(i)* The improved gingival line creates a beautiful smile.

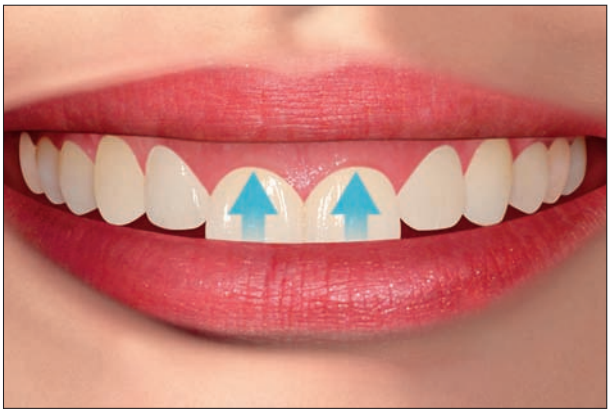


Fig 6-12 Absolute intrusion of the central incisors.

Fig 6-13 Relative intrusion.

smile of a combination of intrusion and extrusion. For example, if two maxillary central incisors are worn and supererupted 2 mm, the orthodontist can align the CEJs by intruding both incisors with absolute intrusion (Fig 6-12). However, with relative intrusion, it can appear that the incisors were intruded when, in reality, the anchorage teeth were extruded (Fig 6-13). Relative intrusion is indicated when dental arches are leveled and aligned, especially in children with malocclusions. Rarely is it indicated in adult prerestorative patients.

A problem may occur when the orthodontist and restorative dentist have different visions of the type of intrusion required. For example, in a given patient, the goal of intrusion is to move a target tooth apically 2 mm to place the free gingival margin (FGM) ideally in the smile and create space to conservatively restore the tooth. If the target tooth is intruded only 1 mm and the adjacent anchorage teeth are extruded 1 mm, it will give the illusion incisally of a full 2 mm of intrusion. However, it will leave the FGM in a poor position relative to the smile and not provide the desired restorative space.

Parameters and Biology of Intrusive Tooth Movement

The biomechanical parameters governing intrusion are still being debated. Bone in children and adults, regardless of facial morphology, tends to respond in a similar fashion to intrusive forces.[1] The optimal force level for intrusion is one that will produce the desired intrusion in the least amount of time while minimizing negative side effects. Although a broad range of forces can be used to intrude teeth, it has been shown that force levels of 25 g per maxillary incisor, 15 g per mandibular incisor, 50 g per canine or premolar, and 100 to 200 g per molar are effective for the majority of patients, with minimal side effects.[4,5] Force levels in these ranges are used commonly for other types of orthodontic movements in all three planes of space. The extent that teeth may be intruded varies. In adults, median intrusion of 1.5 mm for maxillary incisors and 2.0 mm for mandibular incisors is routinely attainable.[6] Significantly greater amounts of intrusion have been reported for incisors (6.5 mm) and molars (8 mm).[7] The rate of intrusion with traditional mechanics described in the literature also differs among patients. Intrusion rates between 0.5 and 1.0 mm per month are possible, with most patients demonstrating 0.5 mm per month.[8]

Bone, nerves, blood and lymph vessels, periodontal ligaments, cementum, and gingival tissues restructure biologically to accommodate to the intrusive pressure applied to the teeth. Alveolar bone will remodel, allowing it to migrate evenly with the CEJ. Minimal or no bone loss will occur outside of the normal rates associated with aging and routine orthodontic tooth movement. When wires are activated for intrusive movements, pulpal blood flow briefly decreases, neuropeptide molecules are released into pulp tissue, pulp vitality is altered, and very minor external apical root resorption (EARR) occurs.[2] These responses are normally transient and reversible from a clinical standpoint. During this period, the periodontal ligament and associated gingival tissues reorganize. The gingival margin and mucogingival junction normally move in the direction of intrusion by 67% to 72% of the total intrusive movement.[9] In some patients, 1:1 gingival tracking will occur. However, because of the lag in movement of these tissues or excessive buccal bone thickness, gingival and osseous recontouring may be required after intrusion. Patients should be made aware of this possibility at the beginning of treatment.

External Apical Root Resorption

EARR has long been a concern with orthodontic treatment. It is a poorly understood, complex biologic phenomenon that may occur with intrusion.[2,10–12] However, in recent years, a better understanding of this process has developed, particularly as it relates to intrusion. Typically, EARR during intrusion is clinically insignificant, with less than 5% of patients experiencing significant root loss. It is not clear whether intrusion predisposes patients to greater EARR than other types of orthodontic movements. There are a variety of predisposing factors that have been suggested as triggers for this response, including narrow root tips, long roots, a genetic history of EARR, amount of apical displacement, asthma, and sensitivity to seasonal allergens. Adults may also be at greater risk than children. Mandibular incisors in adults have been shown to resorb more frequently than in children.[13] There appears to be a strong genetic component to EARR that is associated with those homozygous for the IL-1B allele. These patients have a 5.6-fold greater risk for EARR of more than 2 mm. In patients who are not genetically predisposed, there does not seem to be a correlation between EARR and length of treatment, normal force levels, or the amount of intrusion. For susceptible patients, significant changes in root length may occur in the first 4 to 6 months of treatment. It is difficult to predict which patients undergoing orthodontic intrusion will experience clinically severe EARR; therefore, the authors recommend that progress radiographs be taken by the 6th month of treatment for adult patients undergoing intrusion.

When the orthodontic stimulus is removed, the damaged cementum normally repairs or partially remodels.[13,14] It has been suggested that when EAAR does occur, the orthodontic appliances should be removed for at least 6 months. After the orthodontic holiday, orthodontic treatment may be reinstituted with minimal risk of further resorption.

Intrusion Mechanics and Skeletal Anchorage

The orthodontic biomechanics of intrusion require targeted movements paired with well-constructed anchorage units to minimize unwanted changes. A variety of orthodontic techniques can be used to accomplish the intrusion of teeth, including continuous archwire, segmented archwire, and lingual techniques.[6] Continuous archwires, whether buccal or lingual, may be utilized for limited intrusion by stepping the wire apically between the teeth or placing a curve or sweep in the archwire.[15] Bends between teeth can cause one tooth to intrude and the adjacent teeth to extrude (Fig 6-14). Archwire sweeps tend to cause extrusion of the midbuccal segment and mild intrusion and labial tipping of the anterior teeth. Segmented wire systems use lever arms for intrusion. A segment of teeth may be secured and stabilized by one wire, while an active wire with a lever arm is used for targeted intrusive movement (Fig 6-15).

Fig 6-14 Bends or steps in the orthodontic wire intrude the teeth.

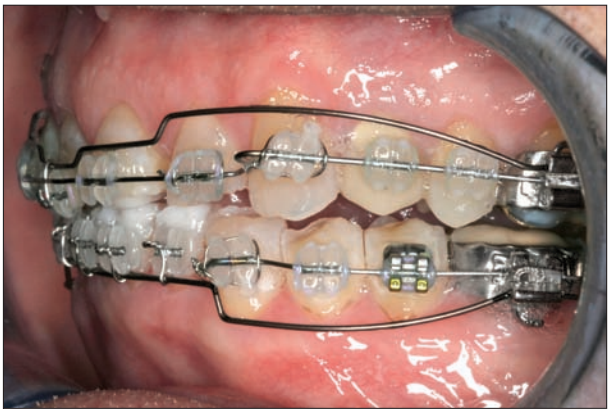


Fig 6-15 Segmental orthodontic intrusion.

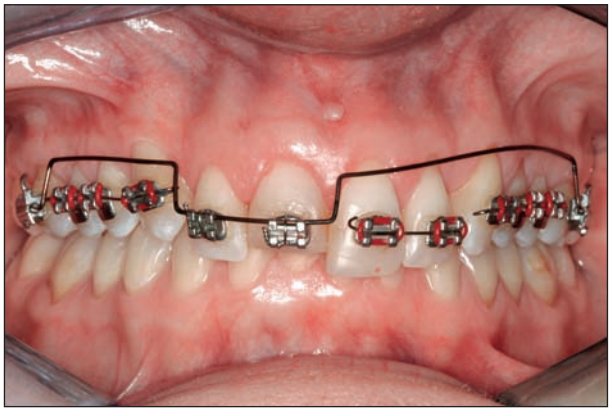


Fig 6-16 Intrusion of the central incisor with single-point contact.

Differential mechanics (lever systems) and single-point contacts have been demonstrated to be remarkably effective for intrusive movements.[4,16–18] Single-point contacts engage the wire to the bracket with one point of contact, as opposed to a wire engaged in a bracket slot, which allows intrusion to occur along the path of least resistance (Fig 6-16). Extrusion, tipping, rotation, and torque changes of anchor teeth are possible side effects of intrusion using traditional mechanics.[7] Anchor teeth also tend to loosen, sometimes significantly in the adult, and typically retighten during the retention phase following orthodontic treatment. These side effects can be minimized with carefully constructed anchorage design.

Anchorage control for intrusion is very important and can be divided into two general categories: *(1)* traditional orthodontic biomechanics and *(2)* orthodontic biomechanics facilitated with skeletal anchorage. Designing anchorage units with the greatest amount of root structure linked in a rigid way facilitates stability of the anchor unit. This may be accomplished with the inclusion of second molars and premolars. Transpalatal and lingual arches link the root structure transversely across the arch. Segmentalizing mechanics allows for more precise activation for intrusion, lower force levels, and less taxation of the anchor unit of teeth.

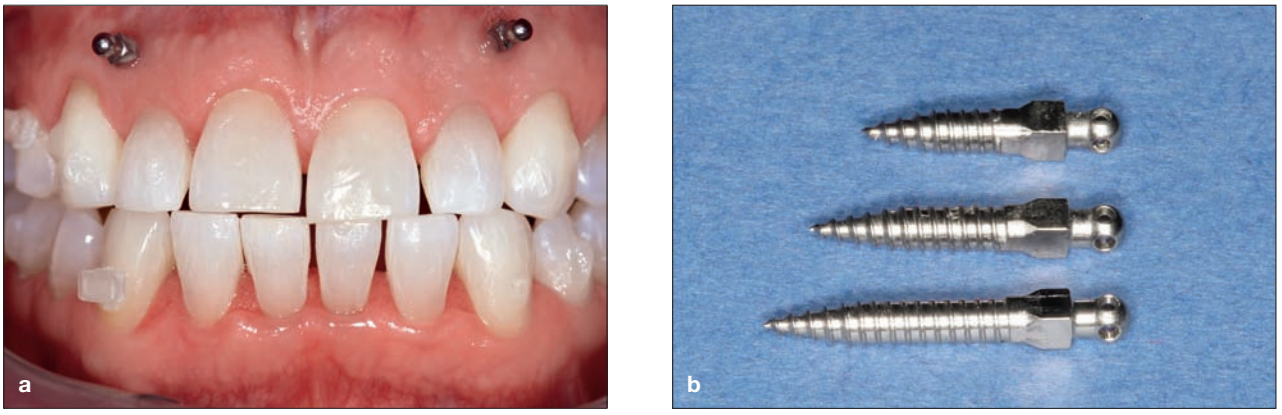


Fig 6-17 *(a)* Microscrews placed anteriorly to assist in indirect anchorage for intrusion. *(b)* Microscrews come in multiple lengths to improve stability. They are easily removed after orthodontic movement is completed.

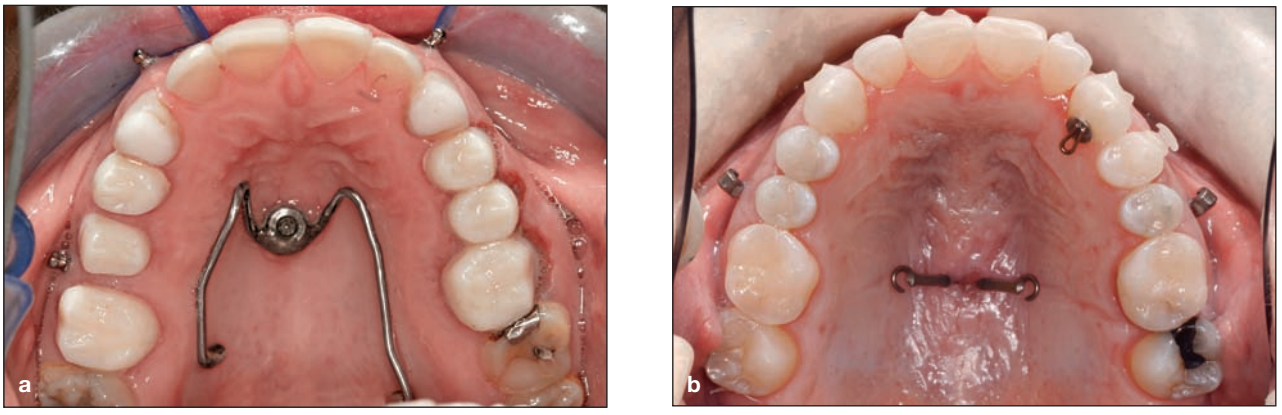


Fig 6-18 *(a)* Orthodontic palatal implant. *(b)* Orthodontic palatal plate.

Temporary Anchorage Devices

Although previously conceptualized, the initiation of a profound orthodontic paradigm shift occurred in 1983 when Thomas Creekmore demonstrated that incisor intrusion was possible utilizing a surgical bone screw for anchorage superior to the maxillary incisors.[19] A plethora of skeletal anchorage systems have been developed and used since that time for intrusion of posterior and anterior teeth.[7,20–22] There are three general categories: *(1)* temporary anchorage devices (TADs), or miniature bone screws modified for orthodontic use (Fig 6-17); *(2)* palatal implant systems (Fig 6-18); and *(3)* skeletal bone plates, which are commonly attached to the zygoma or ramus (Fig 6-19). Restorative implants and ankylosed teeth can also be used to provide equivalent nonmoving anchorage. Traditional anchor units are subject to unwanted movements secondary to intrusion, extrusion being the most common. By connecting skeletal anchorage rigidly to the traditional anchor unit, unwanted side effects can be minimized or eliminated.[23–25]

Skeletal anchorage can be used indirectly (most common) to control anchor units or directly to intrude targeted teeth. In some scenarios, direct connection is the most effective technique for intrusion with the fewest side effects. When attaching force modules directly for intrusion, it is important to balance forces buccally and lingually to prevent unwanted torque during vertical movement. The

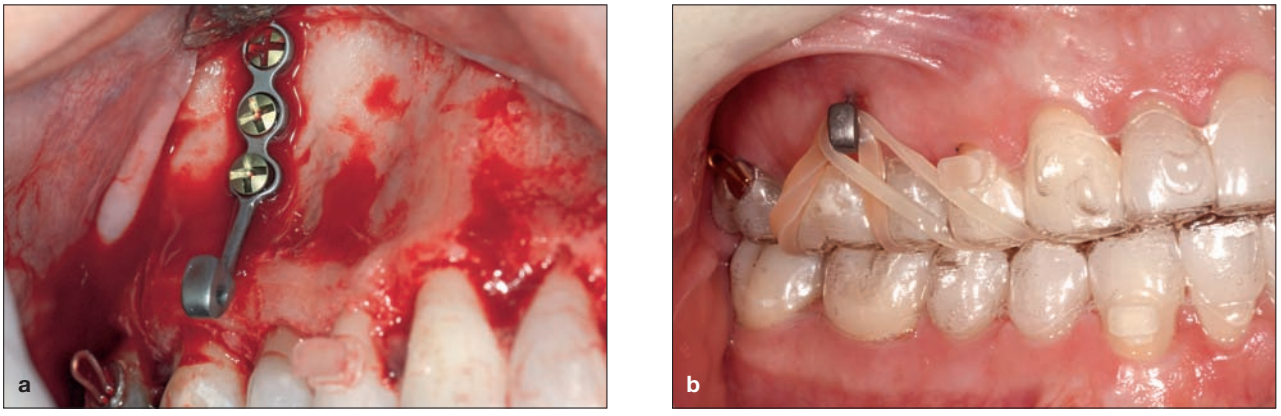


Fig 6-19 *(a)* Skeletal bone plate placed below the zygoma and fixated with bone screws. *(b)* Skeletal bone plates provide the orthodontist with significant anchorage points for intrusion.

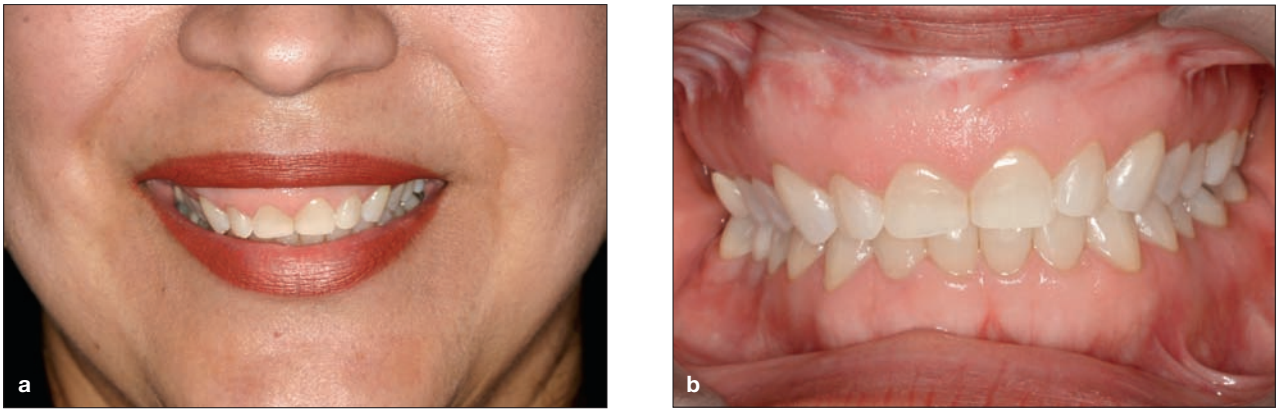
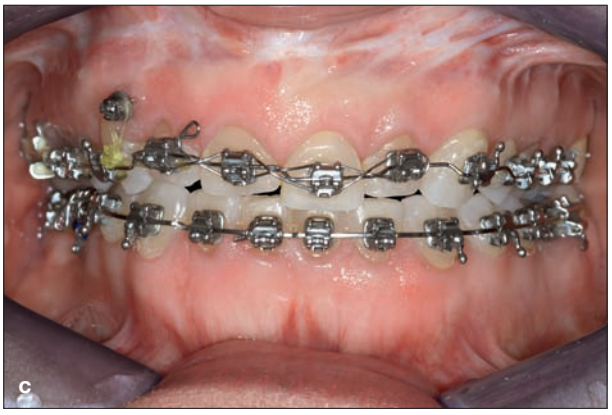
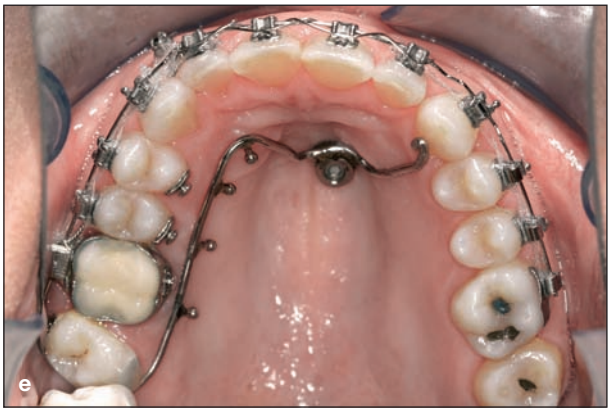


Fig 6-20 *(a)* The patient presented 2 years after orthognathic surgery. She was unhappy with the appearance of her smile and wanted correction without redoing the orthognathic surgery. *(b)* Postorthognathic retracted view demonstrating a cant, tooth wear, and altered passive eruption. This case requires creative use of TADs to correct the cant and to create restorative space for anterior veneers. →

creative incorporation of varied types of skeletal anchorage into traditional orthodontic mechanics allows for unparalleled control of anchor units and an improved ability to efficiently achieve intrusive treatment goals with minimal side effects (Fig 6-20). Vertical correction of a single tooth, groups of teeth, canted occlusal planes, anterior open bites, and entire arches can be accomplished effectively and predictably with skeletal anchorage[26] (Fig 6-21). When orthodontic treatment is completed, these anchors are routinely removed under local anesthetic by unscrewing them with a surgical driver, hemostat, or needle holder.





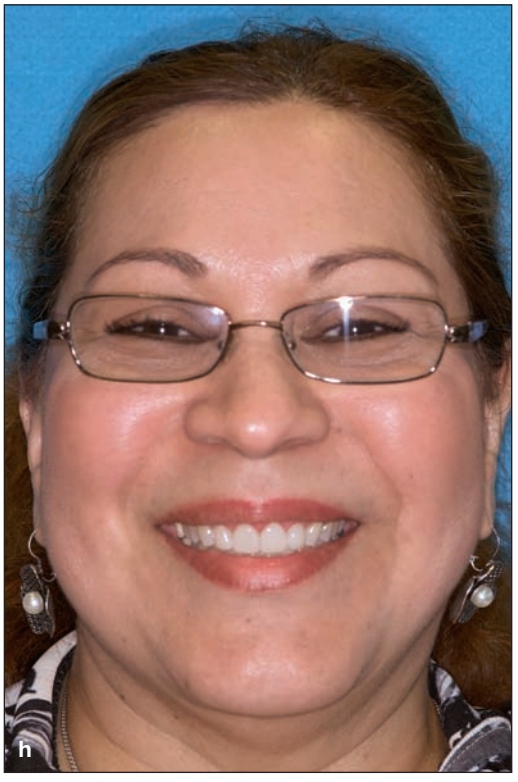


Fig 6-20 *(cont) (c)* A buccal miniscrew aids in absolute intrusion. *(d)* Close-up view of buccal miniscrew. *(e)* Palatal implant system. *(f)* A space created between the mandibular first molar implant restoration and the new occlusal plane demonstrates the extent of absolute intrusion in this case. *(g)* Immediate postoperative veneers on the four maxillary anterior teeth. *(h)* The cant has been corrected, and the teeth have been restored through creative utilization of TAD technology.

Fig 6-21 *(a)* Patient with severe anterior open bite. *(b)* Seated condylar position demonstrating the extent of the open bite. *(c)* Molar intrusion with TADs and autorotation of the mandible allows closure without restorative dentistry. *(d)* Retracted view.

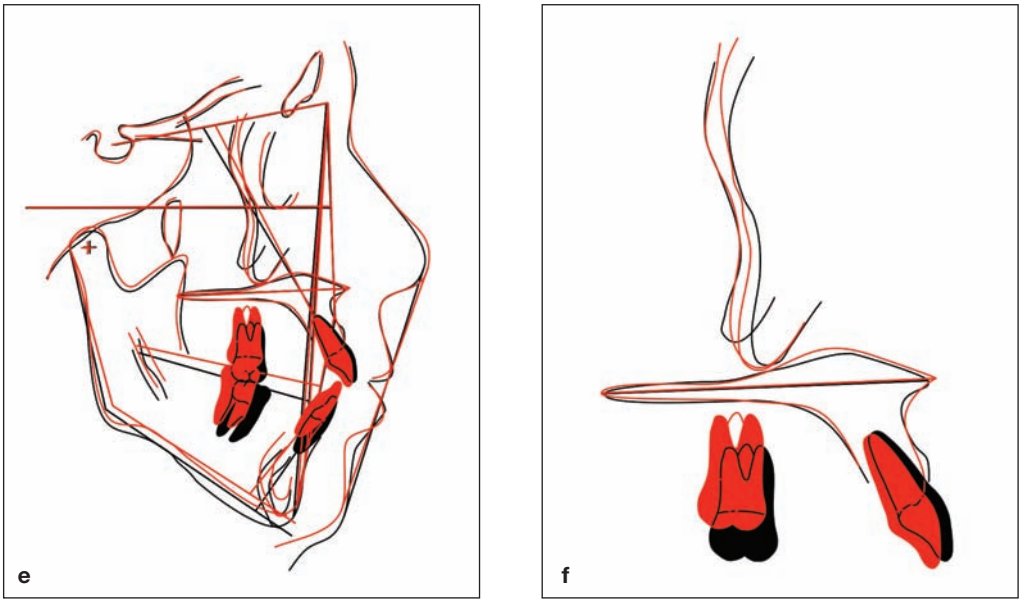


Fig 6-21 *(cont) (e)* Preoperative and postoperative cephalometric tracing overlay. *(f)* Significant molar intrusion with minimal anterior extrusion creates stability.

Surgically Facilitated Orthodontic Treatment

Surgically facilitated orthodontic treatment (SFOT) is a type of tissue engineering in which corticotomies or micro-osteoperforations are made between the roots of teeth targeted for accelerated movement[27–29] (Fig 6-22). This surgical procedure initiates a regional acceleratory phenomenon (RAP) that can increase the speed of tooth movement by 66% to 75% for up to 4 months[30] (Fig 6-23). It is very likely that this acceleration peaks within 2 months of surgery and declines each month thereafter, with a normal rate of tooth movement resuming 4 to 6 months postsurgery. The RAP effect is a regional osteopenia resulting from the activation of the receptor activator of nuclear factor κB ligand pathway/cascade, which creates a significant increase in the number of molecular wound healing mediators such as chemokines. These chemokines recruit osteoclastic precursor cells and influence their development into mature osteoclasts. The mediators accelerate the degradation of hyaline in the periodontal membrane, so the osteoclasts are able to eliminate bone at an earlier stage, thus accelerating movement. The localized transient decrease in bone density is believed to facilitate accelerated tooth movement. Greater surgical insults produce less dense bone without any decrease in bone volume. Secondary procedures have been shown to continue the acceleratory process. Corticotomy or micro-osteoperforation repeated on a 4- to 6-month cycle may be a way to keep this process going without significantly affecting the rate of tooth movement (Fig 6-24).

The SFOT technique for bone stimulation can be used to intrude teeth more rapidly than with conventional treatment. Decreased EARR and improved posttreatment stability have been suggested as additional benefits associated with this procedure. The combination of SFOT with skeletal anchorage systems offers new opportunities in orthodontic treatment for exceptionally stable anchorage control accompanied by accelerated movements.[31,32]

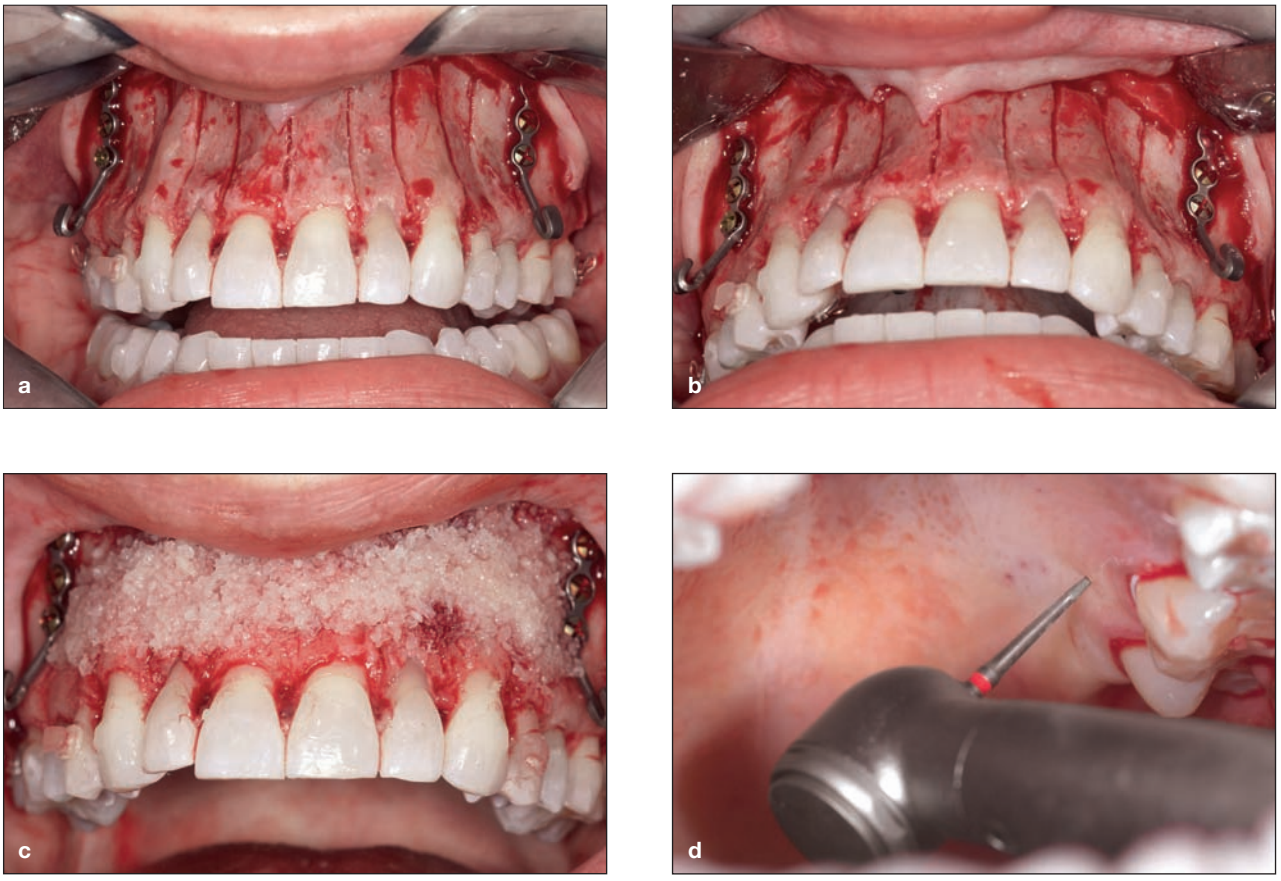


Fig 6-22 *(a and b)* Corticotomies and microperforations. (Surgery by Dr Michael Curry). *(c)* Addition of osseous inductive foundation. *(d)* Microperforations on the palate.

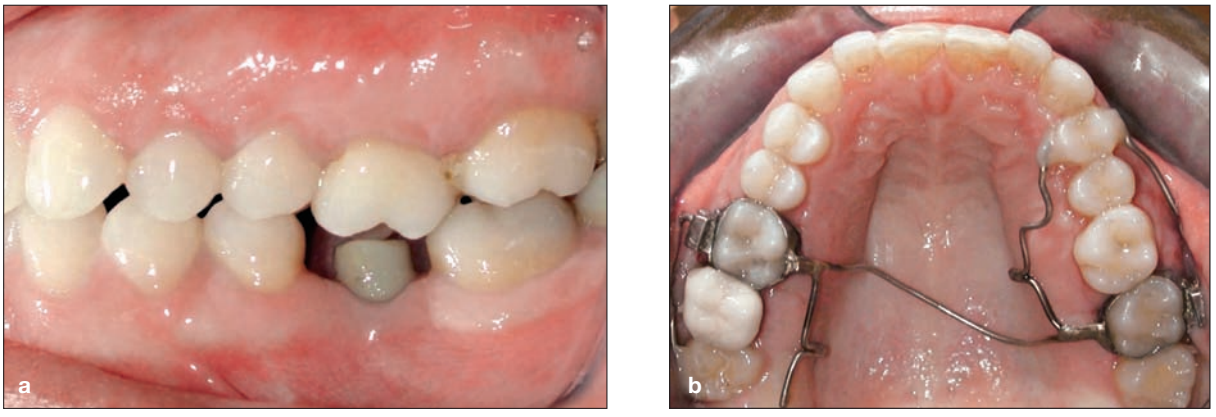


Fig 6-23 *(a)* Maxillary molar in contact with an implant abutment. The implant is not restorable, and the molar would be seriously compromised if treated restoratively. *(b)* Framework for anchorage.

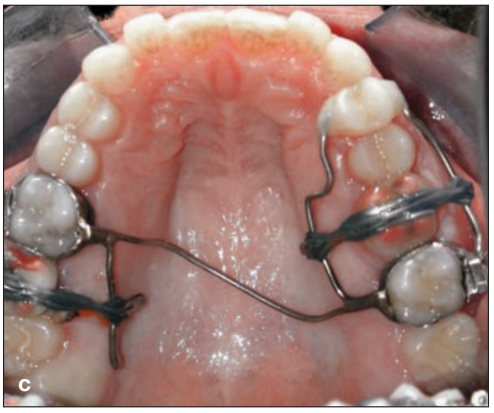


Fig 6-23 *(cont) (c)* Immediately postoperative, intrusion elastics are added to the framework. *(d)* Intrusion elastics. *(e)* Definitive restoration of the implant did not require alteration of the maxillary molar.

Fig 6-24 *(a)* Preoperative maxillary arch constriction. SFOT allows for expansion without jeopardizing the teeth by pushing them out of the osseous housing. *(b)* A gingival flap is reflected, demonstrating limited buccal bone, especially posteriorly.

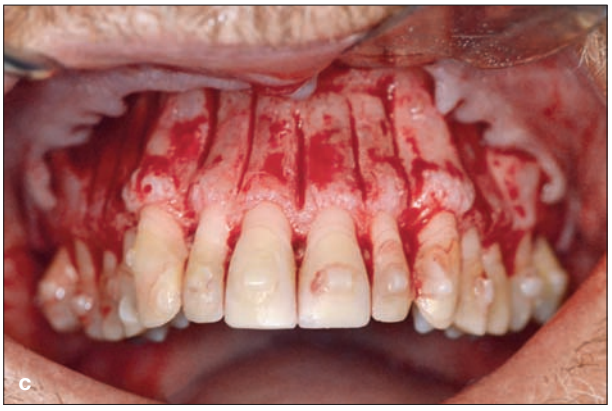


Fig 6-24 *(cont) (c)* Corticotomy cuts. (Surgery by Dr Michael Curry). *(d)* Bone matrix is added. *(e)* Four months postoperative. Expansion has been gained but mostly via tipping. Further movement would be assisted by additional SFOT. (Orthodontics by Dr Richard Roblee). *(f)* Second surgical intervention. Hard and bleeding bone noted on reentry. *(g)* Additional bone matrix added. *(h)* After an additional 4 months of orthodontics. More expansion has been gained, and interproximal space has been created for provisional restorations.

Fig 6-24 *(cont) (i)* The provisional restorations create a guide for orthodontic completion.

Fig 6-25 Retention is key with intrusion cases. It must be diligently maintained throughout the entire restorative process and full-time for at least 6 months postorthodontically.

Postorthodontic, Prerestorative Retention

There is limited research on adult retention protocols after intrusion. Retention of orthodontic movements is very important because of the potential for relapse and changes that occur with aging. Intrusive movements for worn or supererupted teeth or canted arches seem to be relatively stable, but limited relapse should be expected.[15,33] Patients with normal and low-angle mandibular planes have a higher potential for relapse after intrusion than those with high mandibular plane angles.[34] Retention planning is a key component of the overall treatment plan and should be managed immediately after debonding, during provisionalization, and after completion of restorative treatment (Fig 6-25). After intrusion, posterior teeth may be retained by the opposing occlusion or restorations (interim or definitive). Ideally, these posterior vertical stops should be in place prior to the removal of appliances. Alternatively, the intruded teeth may be held with a bonded wire on the buccal or lingual. Anterior teeth can also be held in place with buccal or lingual bonded wires. Full-coverage vacuum-formed retainers may assist with vertical retention but do not provide absolute or long-term control due to the nature of the material. They should be worn full-time immediately after removal of appliances. In some cases, passive bonded composite bite planes may be used on the lingual of anterior teeth, providing positive stops to assist in retention of the intruded teeth. During the restorative phase, retention must be kept in place as well. Any changes made to the dentition that cause the existing retainers to fit improperly necessitate the fabrication of new retainers immediately. Linking provisional restorations together interproximally until the individual definitive restorations are cemented/bonded also helps with vertical retention but should never be relied upon as the sole form of retention. A fractured or lost provisional restoration will allow unwanted tooth movement. Once the definitive restorations are completed, retention must continue. Permanently bonded wires are the most ideal form of retention, when possible. Full-coverage orthotic splints may also be utilized. Wear of any removable retainers can gradually decrease to night-only wear after the definitive restorations are completed.

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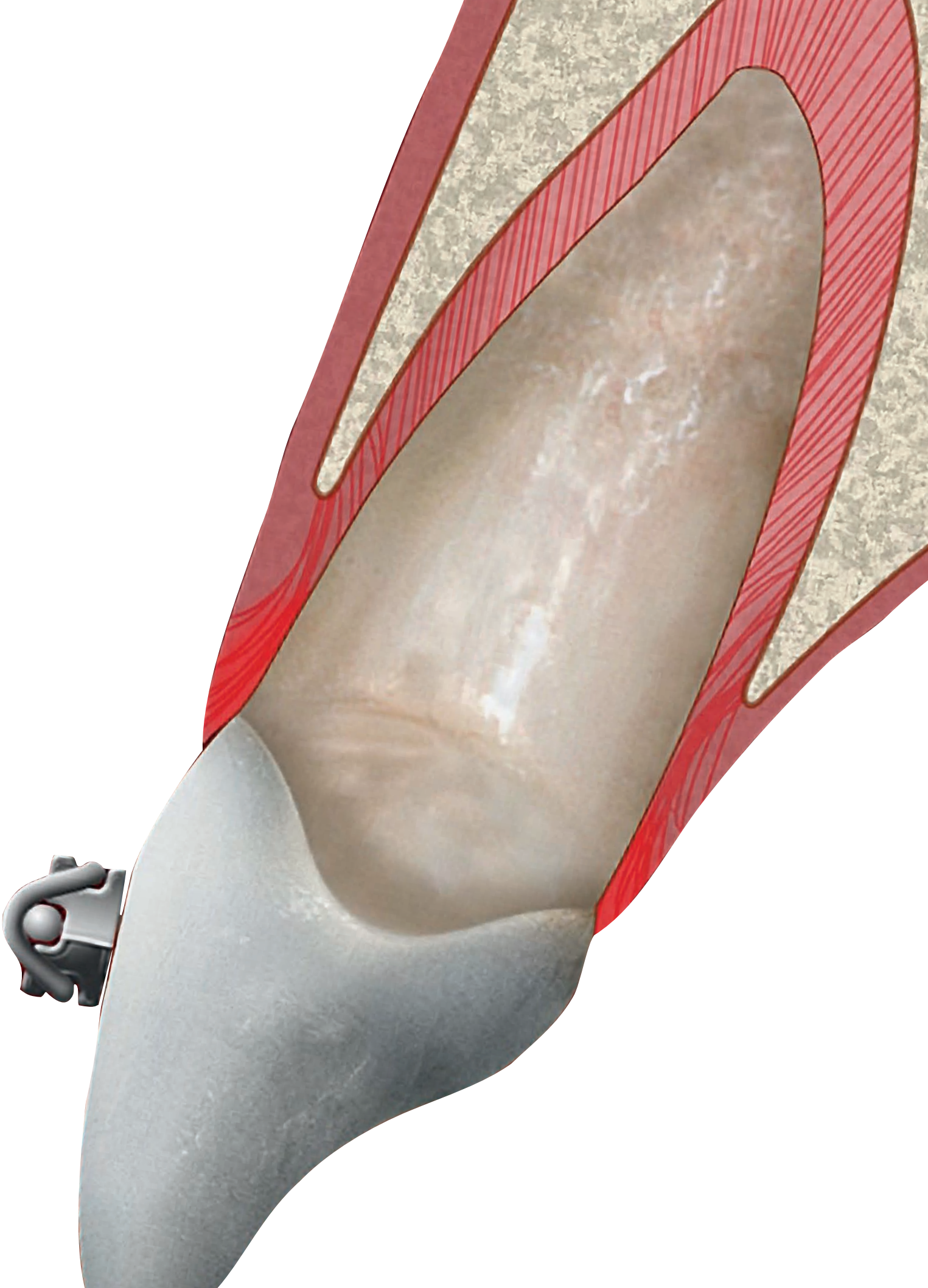


7

Forced Eruption

Jeffrey S. Rouse | Marco A. Brindis

Many restorative dentists choose not to provide orthodontic treatment due to a lack of expertise. However, forced eruption is a prerestorative treatment that should be offered by restorative dentists. This chapter presents a simple forced eruption protocol for non-orthodontists.

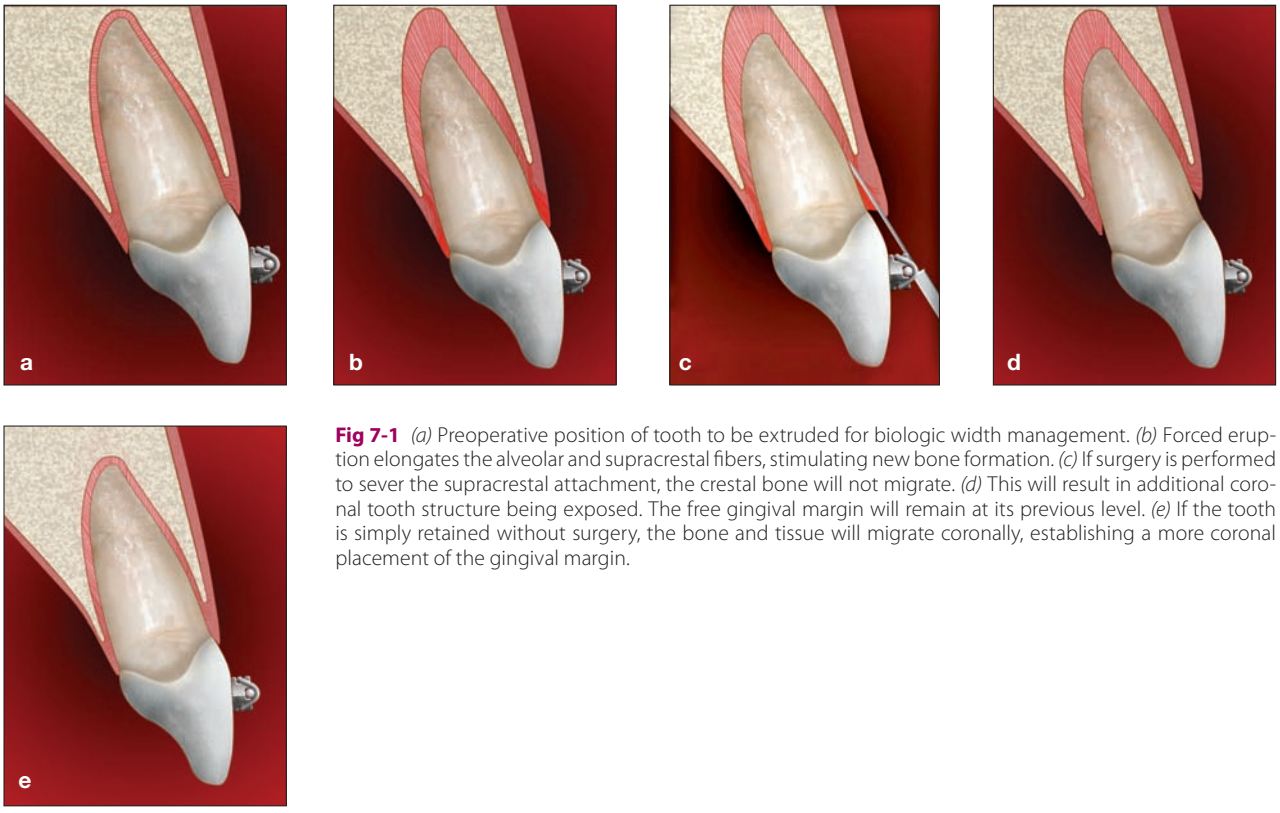


Fig 7-1 *(a)* Preoperative position of tooth to be extruded for biologic width management. *(b)* Forced eruption elongates the alveolar and supracrestal fibers, stimulating new bone formation. *(c)* If surgery is performed to sever the supracrestal attachment, the crestal bone will not migrate. *(d)* This will result in additional coronal tooth structure being exposed. The free gingival margin will remain at its previous level. *(e)* If the tooth is simply retained without surgery, the bone and tissue will migrate coronally, establishing a more coronal placement of the gingival margin.

Restorative forced eruption is the orthodontic movement of a limited number of teeth intended to correct structural or cosmetic deficiencies. While the biology of the movement is the same as in orthodontics, the goal in restorative forced eruption is alteration of the supporting structures, not changes in the spatial relationship of the teeth to the arch. This chapter discusses the utilization of forced eruption in multiple clinical situations and provides clinical guidelines.

Biology of Forced Eruption

When extrusive forces are introduced to the teeth, both the hard and soft tissue of the periodontium undergo a dynamic biologic transformation. In the early periodontal literature, tooth extrusion was described as a nonsurgical technique to correct osseous defects.[1,2] The periodontal membrane is tethered by fibers to newly formed bone; therefore, when tension is placed on the tooth, the alveolar and supracrestal periodontal fibers are lengthened. This generates an osteoblastic reaction to form new bone. The tooth can be used to "drag" new bone to fill a vertical defect or augment a narrow arch[3–5] (Fig 7-1). The ideal rate of tooth extrusion has not been well defined in the current literature. The range varies widely from rapid extrusion (1 mm per week) to slow extrusion (1 mm per month).

Because extrusion is not dependent on bone resorption, rapid extrusion of 0.5 to 1.0 mm of tooth movement per week can be achieved without damage to the periodontal ligament space. Initially, the free gingival margin moves with the erupting tooth through the eversion of the lining of the sulcus. This intrasulcular tissue is nonkeratinized and only a few cells thick. It will appear redder than normal marginal tissue. It has been referred to as a *red patch*[6] (Fig 7-2). This "red patch" will be more apparent when the tooth being extruded begins with a periodontal pocket. The tissue will remain red for 28 to 42 days until keratinization occurs.[6] The position of the mucogingival junction remains unaltered.[7]

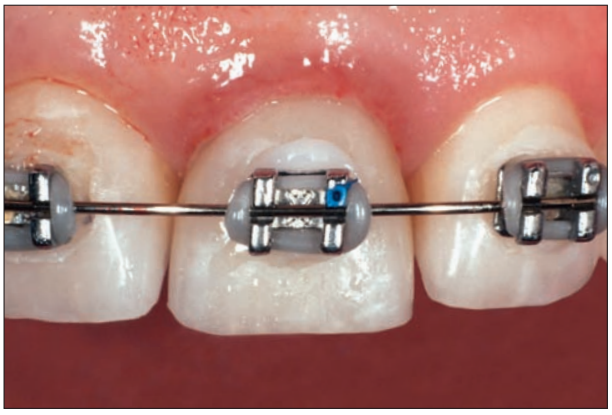


Fig 7-2 A "red patch" occurs when the sulcus everts during extrusion. Normal oral abrasion from food and tooth brushing will keratinize the tissue.

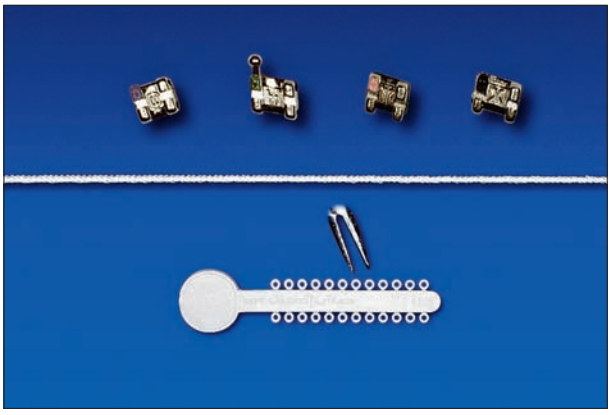


Fig 7-3 Anterior orthodontic brackets, light- or dual-cured composite, a leveling orthodontic wire, and ligating elastics comprise the forced eruption kit.

Therefore, the width of keratinized tissue can be increased through eruption of the tooth. The bone development requires 3 to 6 months after the completion of the movement to stabilize. The greater the movement, the longer the delay in bone remodeling. If the tooth is adequately retained, the bone migration typically reestablishes the normal, pretreatment dentogingival complex dimensions.

Proponents of slow extrusion suggest that excessive force and an accelerated rate of movement risk tissue damage and ankylosis.[8] Slow extrusive movement results in as little as 1 mm of coronal tooth movement per month.[9] By limiting the speed of the tooth movement, the osseous and tissue migration is more predictable, following the progression of the tooth. The improved periodontal response and root stability are highlighted as advantages of slow extrusion. However, the slower the extrusion, the greater the skill required in managing the orthodontic movements. The brackets and wires act not only on the tooth being extruded but also on the anchorage teeth. Unwanted tip, torque, and alignment changes are a possibility. The most damaging morbidity occurs when the root is torqued through the buccal plate, resulting in a bony dehiscence. These negative outcomes are less frequent with rapid forced eruption.

Orthodontic Technique

Management of the supracrestal fibers is the central focus of the extrusion technique. A decision must be made regarding the final position of the osseous crest. If the supracrestal fiber tension is surgically eliminated, the osseous crest will not migrate (see Figs 7-1c and 7-1d). This will leave the tissue and bone in its original position while the clinical crown length increases. Examples include crowning fractured teeth or restoring subgingivally carious teeth without impinging on the biologic width. If the goal is to move the free gingival margin more coronal, the connective tissue fibers should not be excised. The fibers should be left intact when aligning an apically positioned gingival margin or augmenting a site before extraction.

The technique is relatively simple, but errors can be difficult to overcome. Forced eruption for restorative purposes should be limited to anterior teeth and possibly first premolars. Because of the complexity of anchorage, posterior tooth extrusion should be referred to a specialist for treatment. Anchorage in the anterior teeth is rarely an issue given that the movement is rapid and requires no osseous remodeling to accomplish. Practitioners need a selection of anterior orthodontic brackets (Fig 7-3). The brackets will be called upon to hold a round wire, not to direct the tooth movement. A bracket without built-in tip and torque may assist in avoiding some unintended tooth movement,

but otherwise the style and mechanics of the bracket are unimportant. Anterior brackets are recommended due to their smaller size. Ceramic or composite brackets improve the esthetics. However, most tooth-colored brackets require specific instruments for removal and have been reported to have deleterious consequences when removed improperly.

An orthodontic wire used for initial leveling and aligning works well. The authors recommend a 0.014 for a single lateral or central incisor, 0.016 for two incisors, and 0.018 for canines. However, any small-diameter nickel-titanium or twisted stainless steel round leveling wire may be used. A light-cured, dual-cured, or chemically cured composite can secure the brackets to the teeth. Orthodontic elastic bands are required to secure the wire in the bracket. The elastic band keeps the wire from falling out of the bracket but should not prevent the wire from sliding in the brackets as the tooth moves. A hemostat designed for inserting elastic bands increases the speed of delivery, but a traditional hemostat may be utilized.

One tooth on either side of the tooth being extruded will provide adequate anchorage in most rapid extrusion cases. Exceptions include anchorage teeth that are periodontally involved or have poor root dimensions. Slow extrusion requires more control. In this case, the authors recommend placing brackets from canine to canine with the use of a tube on the first molars to avoid any undesired movement.

Extrusion Technique

The teeth are etched with a 37% phosphoric acid for 30 seconds on the enamel. With a pencil, a midfacial reference line is made on the anchorage and extrusion teeth (Figs 7-4a to 7-4c). This pencil mark on the enamel serves to direct bracket placement and acts as a guide in removing the composite after eruption without damaging the enamel. Bonding adhesive is applied and cured. A small increment of composite is added to a bracket for the anchorage tooth. It is placed so that the center of the bracket is directly over the line on the tooth. The second anchorage bracket is placed in a similar manner. Ideally, a wire should lie passively between the two brackets to prevent unwanted movement of the anchorage teeth. If the teeth are not in the same anterior-posterior plane, the wire will be active, deflecting to mimic the arch form. This may cause the anchorage teeth to move in a buccolingual direction during the course of treatment. For example, when the maxillary canine is being extruded, generally a wire will not lie passively between the brackets on the first premolar and lateral incisor due to the arc of the arch. While the wire could easily be bent and ligated into the brackets, the force on the wire would not only extrude the canine but also move the anchorage teeth buccally. This would lead to an undesirable occlusal and/or esthetic change. An easy solution is to bond the brackets far enough away from the tooth surface to eliminate the arc in the wire.

Once the anchorage brackets are in place, the extrusion bracket is bonded above the midfacial line (Fig 7-4d). The distance above the reference line is determined by the amount of extrusion desired. A damaged tooth requiring the exposure of 2 mm additional coronal tooth structure would have the extrusion bracket placed 2 mm apical to the midfacial line. When the tooth erupts and the wire becomes straight, the movement has been completed. Typically, teeth being extracted at the completion of treatment are bonded at the apical extent of the tooth to ensure 3 to 4 mm of tooth movement. If further extrusion is required, the extrusion bracket may be re-placed more apically during treatment. The wire is placed in the brackets and ligated with elastics (Fig 7-4e). The excess wire is removed with wire cutters or a diamond bur. The patient must be checked weekly during the extrusion. The tooth must be adjusted out of occlusion because it will no longer erupt when it is back in occlusion.

The variables that provide the clinician with insight on how the tooth will move include the amount of tooth attachment to bone, the root length, patient age, and the periodontal health of the tooth being extruded. The occlusion is relieved once a week to provide space for eruption (Fig 7-4f). A tooth without opposing occlusal contact is still relieved in an effort to lessen the functional trauma incurred when it moves beyond the incisal plane and to minimize esthetic concerns. Because of the need to reduce the incisal edge during the extrusion process, root canal therapy may be necessary before or during tooth extrusion. It is important to plan for incisal and lingual reduction to prevent tipping secondary to inappropriate tooth contact as the tooth erupts. It is important to follow the forced eruption

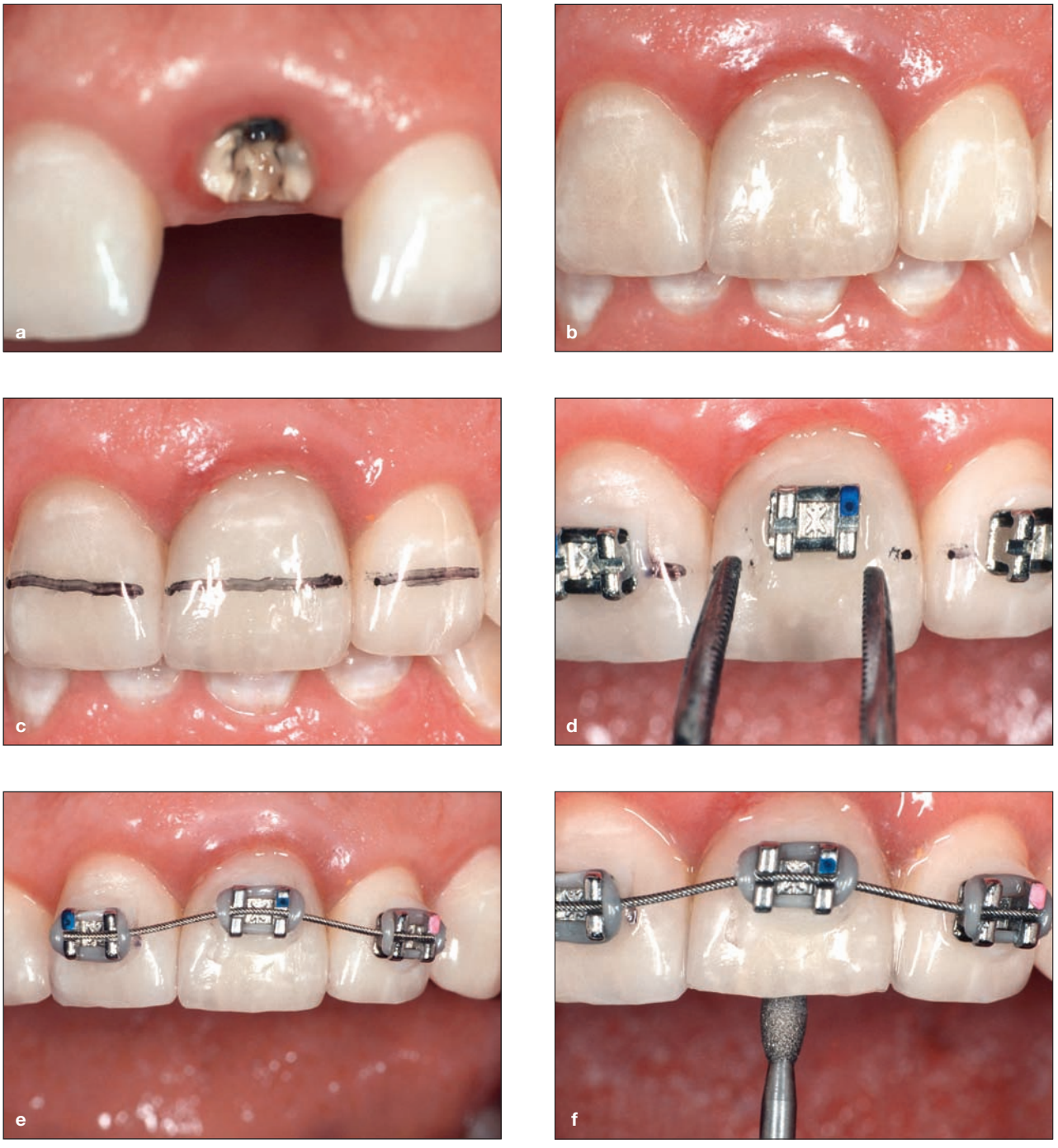


Fig 7-4 *(a)* Trauma fractured the left central incisor at the free gingival margin. Treatment options of an implant and ovate pontic were reviewed. The patient chose to retain the tooth if possible. *(b)* Eruption of a tooth requires a surface to attach the bracket. In this case, the crown was re-cemented successfully. *(c)* The facial surfaces were prepared for bonding, and a midfacial reference line was drawn. *(d)* The bracket slots for the anchorage teeth are placed on the line, and the bracket on the tooth being erupted is placed apically based on the amount of eruption required. The amount required in this case is 2 mm, or the biologic dimension required for a successful preparation. *(e)* A 0.0175 twisted wire is ligated to the teeth, and the additional wire is cut at both ends. Because of the bracket placement, when the wire becomes straight, the movement will be done. *(f)* The occlusion must be relieved every week.

closely. If the tooth planned for eruption is ankylosed, the anchorage teeth will start to intrude. When caught early, removal of the orthodontic brackets will allow the anchorage teeth to move back to their original positions. If, however, the patient has been in active treatment for weeks before the problem is detected, the teeth may not regain their original position, and further orthodontic treatment may be required. As the bend comes out of the wire weekly, the excess wire will extrude beyond the anchorage brackets and will need to be removed to prevent buccal tissue trauma.

Decision-Making

As a tooth is extruded, the supracrestal fibers are elongated. If the tooth is retained in a new position, the fibers will promote osseous deposition around the tooth. This can work to the advantage of the restorative dentist if the goal of therapy is to alter the free gingival margin and supporting bone in a coronal direction. Examples include pre-extraction site management or prerestorative gingival alignment. However, if the initial gingival architecture is acceptable, coronal tooth movement may cause a gingival irregularity that is unacceptable.

Biologic width management

Restoration of fractured or carious teeth may be unpredictable due to a lack of remaining coronal tooth structure. If the restorative margin is placed too deep into the sulcus in an attempt to increase the clinical crown length, a biologic width impingement occurs, creating a chronic inflammatory process that may be both uncomfortable and unesthetic. Because this chronic inflammatory reaction is mechanically rather than bacteriologically induced, the reddened gingival margin will remain long term. Traditionally, functional crown lengthening surgery has been used in these cases to gain more tooth structure and prevent biologic width impingements. The removal of bone along with the apical positioning of the flap will increase the amount of exposed tooth structure. Disadvantages include altering the facial gingival position on the surgical tooth and two to four adjacent teeth and weakening the periodontal status of all of the teeth. If the preoperative gingival position is ideal but more restorative tooth structure is required or an existing biologic width impingement must be resolved, forced eruption with surgical supracrestal fiber elimination is the treatment of choice.[10] Severing the supracrestal fibers will prevent coronal bone migration and the associated tissue repositioning. Two surgical treatment options are available: closed fiberotomy or open flap.

For restorative dentists not comfortable with a surgical approach, a transseptal fiberotomy is an option[11] (Fig 7-5). The supracrestal fibers are cut circumferentially with a surgical blade to the osseous crest (see Fig 7-5a). The residual fibers embedded in the root are scaled aggressively to prevent reattachment (see Fig 7-5b). The lack of fiber attachment will prevent coronal migration. The trauma from the incision and scaling will create a healing response from the marginal tissue, and it will reestablish at the pretreatment contours. The transseptal fiberotomy procedure has been recommended to accompany the occlusal adjustment during each week of extrusion. However, osseous migration and maturation are not fast enough to demand multiple procedures. The authors suggest that the transseptal fiberotomy be done only once when the tissue begins to migrate with the tooth at week 2 or week 3.

The open flap surgical option has the advantage of visualizing the bony contours and correcting any defects (Fig 7-6). An internally beveled gingivectomy on the extruded tooth repositions the free gingival margin to an ideal architecture. This is followed by a sulcular incision from anchor tooth to anchor tooth. The tissue is reflected, and any osseous recontouring is achieved according to the guidelines in chapter 4. The flap is replaced with simple interrupted sutures. The open flap procedure is accomplished at the completion of the forced eruption, which is generally at week 4. In both techniques, 3 to 6 months of retention is important for tooth and tissue stability before definitive restoration.

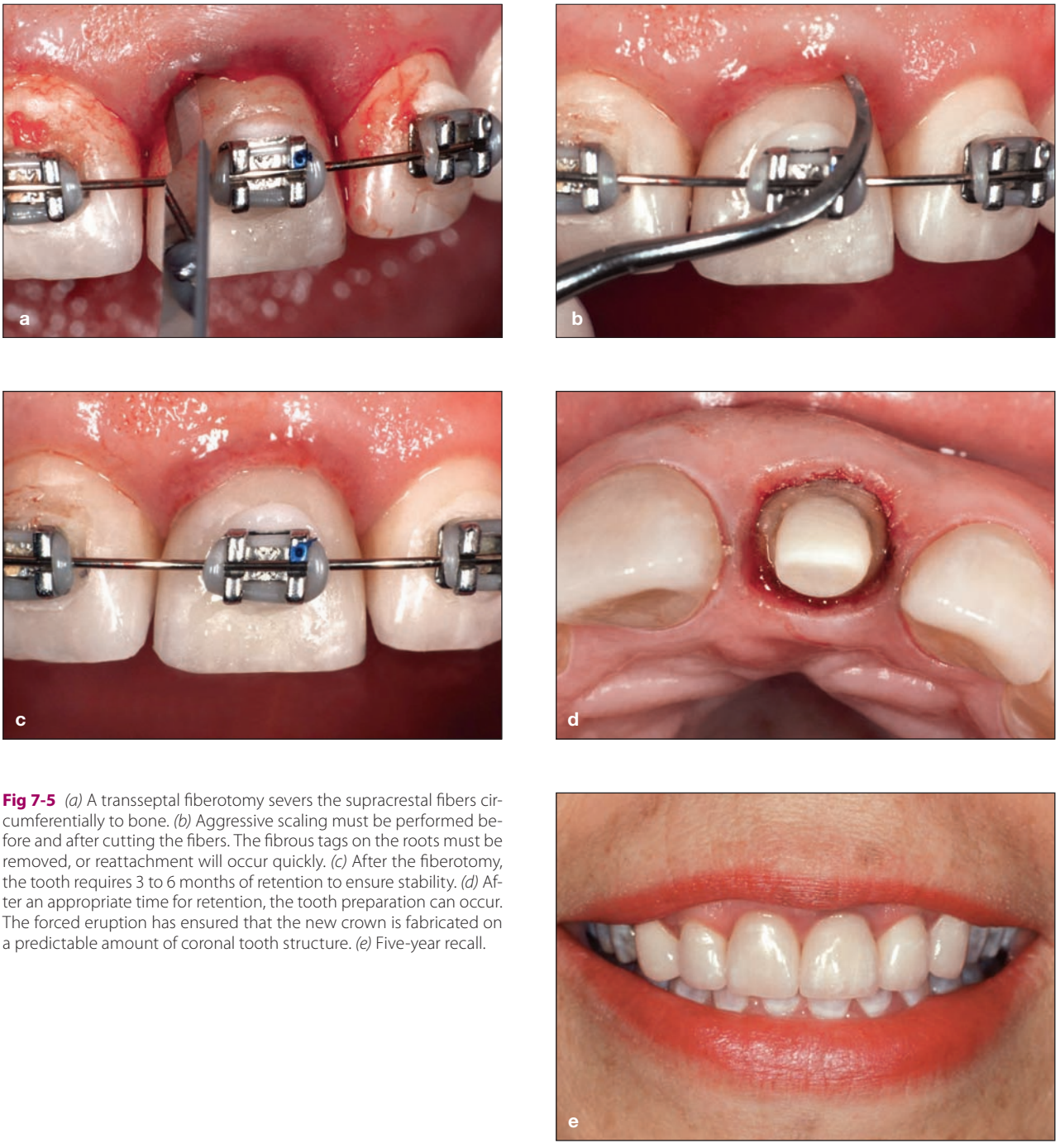


Fig 7-5 *(a)* A transseptal fiberotomy severs the supracrestal fibers circumferentially to bone. *(b)* Aggressive scaling must be performed before and after cutting the fibers. The fibrous tags on the roots must be removed, or reattachment will occur quickly. *(c)* After the fiberotomy, the tooth requires 3 to 6 months of retention to ensure stability. *(d)* After an appropriate time for retention, the tooth preparation can occur. The forced eruption has ensured that the new crown is fabricated on a predictable amount of coronal tooth structure. *(e)* Five-year recall.

Fig 7-6 *(a)* A 17-year-old boy suffered trauma to his anterior teeth. The maxillary left central incisor is fractured subgingivally. Because of the risk of latent growth, an implant restoration was not chosen at this time. Endodontic therapy and forced eruption to manage the biologic dimension were begun. *(b)* Bracket placement was based on moving the fracture margin out of the biologic width. *(c)* As the wire levels, the movement is complete. *(d)* In this case, the supracrestal fibers must be severed in order to prevent osseous migration. Open flap debridement was chosen. *(e)* Six months healing and retention before preparation. *(f)* After healing, the tissue levels remain at the preoperative ideal, yet the fracture has been relocated coronally.

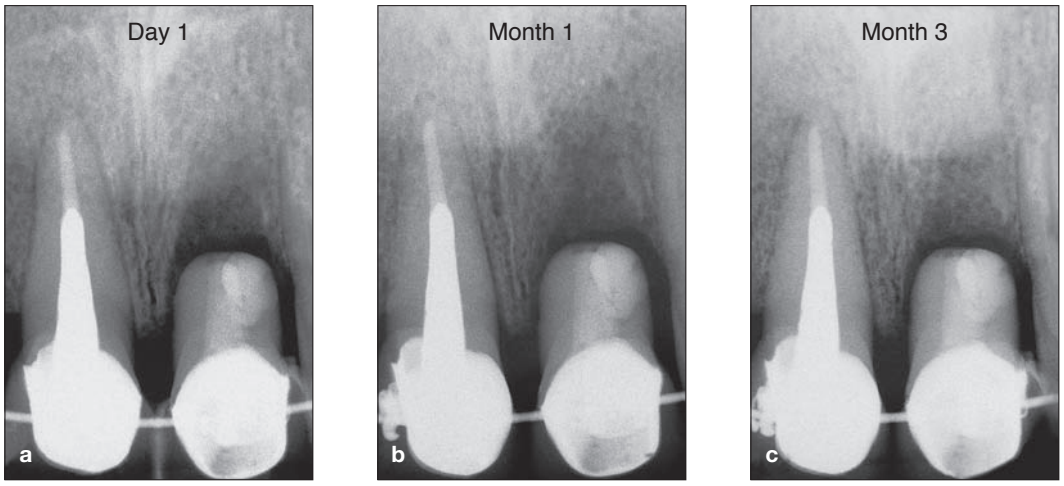
Fig 7-6 *(cont) (g)* Tooth preparations. *(h)* Definitive restorations. (Case by JWR.)

Fig 7-7 *(a)* Highly scalloped tissue, which is more susceptible to recession. *(b)* Flatter and thicker gingival scallop, which is less susceptible to recession.

Extraction site management

Bone scallop requires the tooth root for support. Extraction of a tooth creates an irreparable alteration of the bone and tissue contour. This healing of the socket will predictably create a facial gingival recession of approximately 2 mm. The loss in papilla height will depend on the preoperative distance from the tip of the papilla to the crest of interdental bone as well as the tissue phenotype. Highly scalloped and/or thin gingival tissues are more prone to recession (Fig 7-7a) than thick, flat tissue (Fig 7-7b). Furthermore, the loss of support is in both the vertical and buccolingual dimensions. Research has shown that 91% of anterior ridges heal with a defect after extraction.[12] The largest percentage of these deficiencies occurs in both the vertical and buccolingual dimensions. These combination defects can cause patients to have difficulties with food impaction, phonetics, and esthetics. Forced eruption of a hopeless tooth may proactively alter the ridge position, improving the facial bone relationship. Additionally, the use of properly shaped ovate pontics and implant provisional restorations may assist in maintaining excellent tissue architecture.

After tooth extraction, facial gingival tissue commonly retracts a minimum of 2 mm. Therefore, a hopeless tooth may be extruded a minimum of 2 to 3 mm and retained at least 3 months to allow the osseous crest to migrate coronally. This will proactively create additional bone and soft tissue support. When the tooth is removed, the socket retraction will be working from an advantageous position fa-



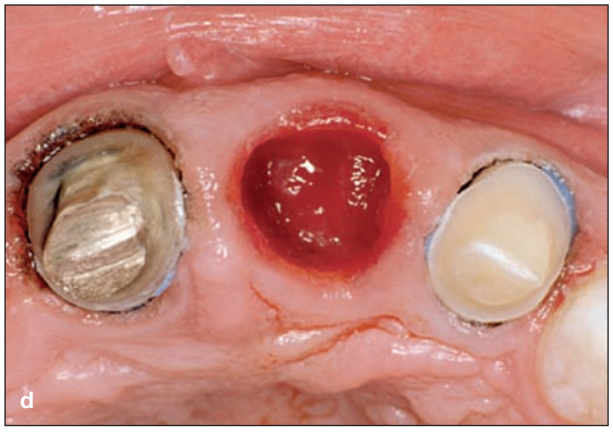


Fig 7-8 An ovate pontic directs healing after extraction. *(a)* The extracted tooth was modified, replaced in the socket, and ligated to the orthodontic wire. *(b)* At 1 month, the radiograph demonstrates the osseous migration. *(c)* At 3 months, the radiograph displays a zone of attachment around the pontic. *(d)* The modified tooth directed healing and created support for a pontic or implant.

cially. Extrusion does not help maintain the papillae, only the facial margin. The adjacent teeth dictate the interproximal bone position and papilla support after tooth extraction. The orthodontic bracket is bonded as high apically as possible, and the supracrestal fibers are not surgically severed. The supracrestal fibers will promote and direct bone growth in a coronal direction (Fig 7-8). Most teeth will be extruded 3 to 5 mm. Subcrestally fractured or periodontally compromised teeth may be extruded more to augment the three-dimensional contours of a pontic or implant recipient site. The greater the coronal movement, the more control that is required of the anchorage teeth. In these cases, referral to an orthodontist may be prudent. At the completion of eruption, teeth should be retained for 4 to 6 months. The longer the retention, the more bone maturation that will occur at the new position. Extraction should be done atraumatically with no interproximal or facial elevation of the tooth, because the force may damage the bone, causing a greater loss of support than anticipated.

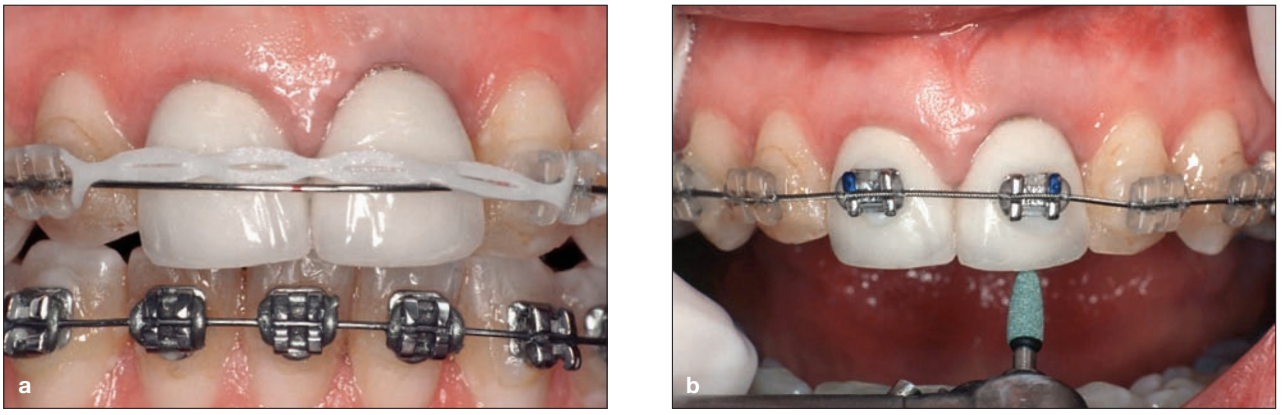


Fig 7-9 *(a)* On examination from an orthodontic office, the central incisors exhibited biologic width impingements and 5-mm roots. They were both deemed hopeless. Treatment options were outlined, and the patient chose a fixed partial denture and ovate pontics. *(b)* Extrusion brackets were placed and the occlusion relieved. Given that the teeth were treatment planned for extraction, the brackets should have been placed as far apically as the crowns allowed.

Ovate pontics

The ideal pontic form must be functional, cleansable, and provide an "illusion of reality." Ridge lap and modified ridge lap pontics routinely cause inflammation under the pontic. When the ovate pontic lies within the tissue, it creates a 0.5- to 1.0-mm gingival cuff. Debris will not accumulate under the pontic as readily, resulting in a healthier site. The pontic cannot encroach on the biologic dimension any more than an intrasulcular restoration. If the tip of the pontic lies closer than 2 mm to the crestal bone, it will stimulate an inflammatory response from the connective tissue. The neurovascular irritation may cause the patient discomfort on cleaning and/or a "toothache" when pressure is applied. Therefore, for gingival health, an ovate pontic must lay 0.5 to 1.0 mm into the tissue and be no closer than 2 mm from the crestal bone.

When utilized to manage extraction site healing, the ovate pontic is placed 3 mm into the extraction socket. Three millimeters will allow for the loss of 2 mm of facial height, with 1 mm of the pontic remaining subgingivally to support the tissue contours. To minimize the loss of ridge contour apically, an osteoconductive material is inserted into the socket. The provisional ovate pontic will prevent the osteoconductive material from being lost. The ovate pontic guides regeneration, resulting in more rapid healing and thicker epithelium. Minimum healing time is 3 months after the extraction. However, a longer healing period of 6 months will allow for more complete bone consolidation. The extraction site should not be disturbed during the healing process. This means no flossing, because the connective tissue fibers may attach to the pontic during healing. The patient should be evaluated every 2 to 4 weeks to monitor the site and to ensure that the pontic does not lose support during the healing. Figure 7-9 shows an example of ovate pontics used to direct healing and maintain tissue contours and papilla form.

Fig 7-9 *(cont) (c)* Extrusion continues. The wire can be placed above the brackets to speed up the movement or extend the duration of the bracket placement. *(d)* The expected apical migration of the free gingival margin after extraction is at least 2 mm. The extrusion must extend beyond that 2 mm to ensure proper gingival architecture after healing. *(e)* Atraumatic extraction. *(f)* The provisional restoration is fabricated to extend into the extraction sites and mimic the root contours of the teeth. *(g)* The tissue is allowed to heal for a minimum of 3 months before definitive restorations are fabricated. *(h)* The ovate sites maintained the facial tissue contour and papilla form.

Fig 7-9 *(cont) (i)* Support of the facial plate assists in preserving the thickness of the existing ridge. *(j)* Definitive restoration. *(k)* Thick, anatomically accurate tissue provides an illusion of reality. *(l)* Eight-year recall exhibiting stability.

Implant Site Development

The concept of forced eruption prior to implant placement is similar to that described for the ovate pontic (Fig 7-10). The typical 2-mm loss of vertical facial dimension and buccolingual contraction will occur when the hopeless tooth is removed. If the implant is placed immediately, the anticipated loss of facial height is only 1 mm on average. The variability is dependent on facial bone thickness and tissue phenotype. Thinner bone can be expected to lose more height.[13] Forced eruption can positively modify an implant site before extraction to reduce or eliminate the need for augmentation.[14,15] Periodontal defects may not be completely eliminated with extrusion, but any positive change will assist the surgeon (Fig 7-11). After the forced eruption is completed, 4 to 6 months is required for bone migration and maturation. At that point, normal extraction, implant placement, and provisionalization procedures can be performed.

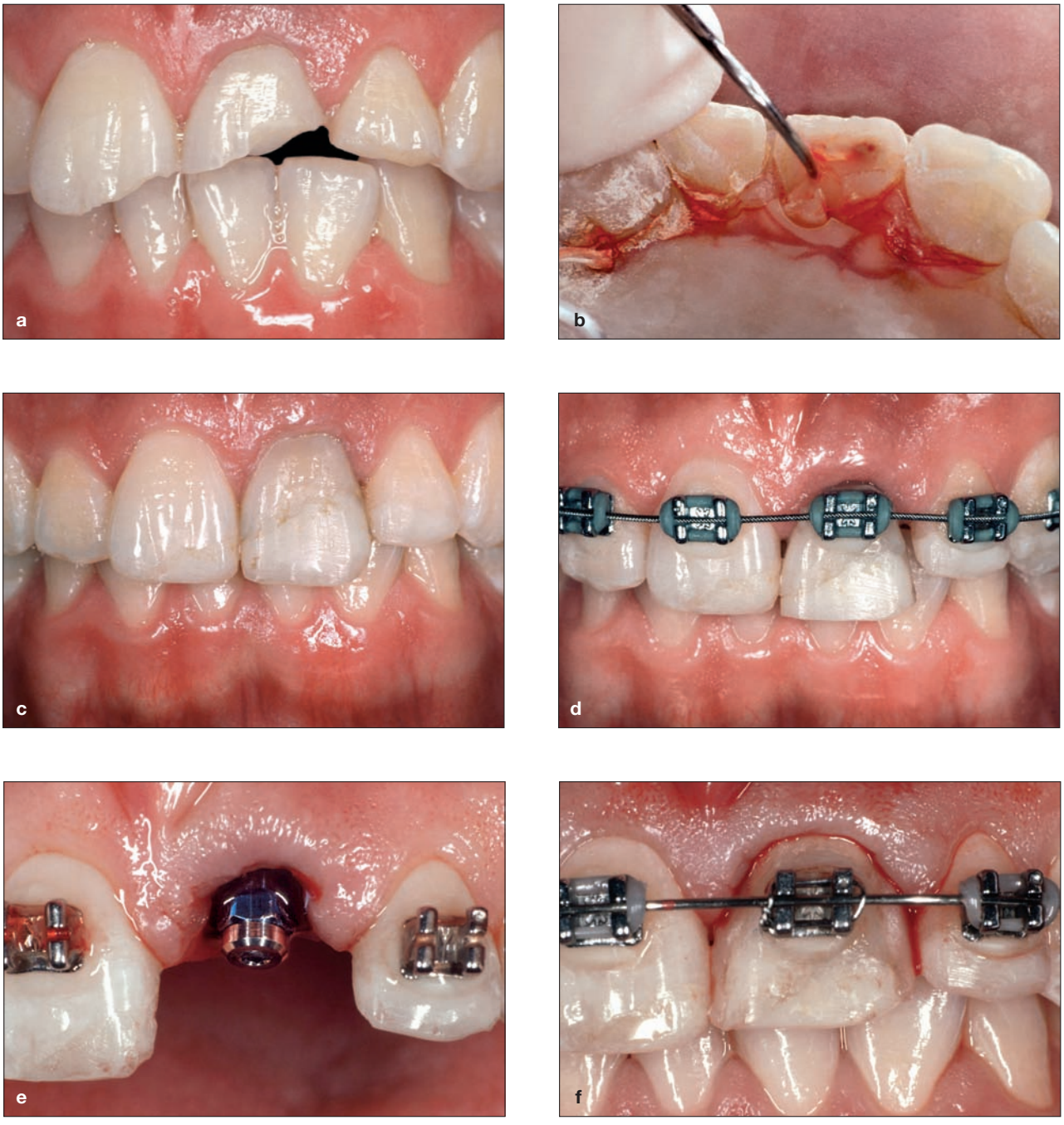


Fig 7-10 *(a)* Three anterior teeth fractured due to trauma. *(b)* Vertical fracture of the maxillary left central incisor makes it hopeless. *(c)* Fractured tooth fragments were bonded together to allow bracket placement. *(d)* An extrusive bracket was placed at the gingival margin, and the tooth was shortened significantly. Endodontic treatment was initiated, and interim medication was placed. *(e)* The central incisor was extracted in three pieces, and an immediate implant was placed. *(f)* The coronal portion of the tooth was reshaped and ligated to the orthodontic wire as an ovate pontic. The root must not place pressure on the implant during healing.

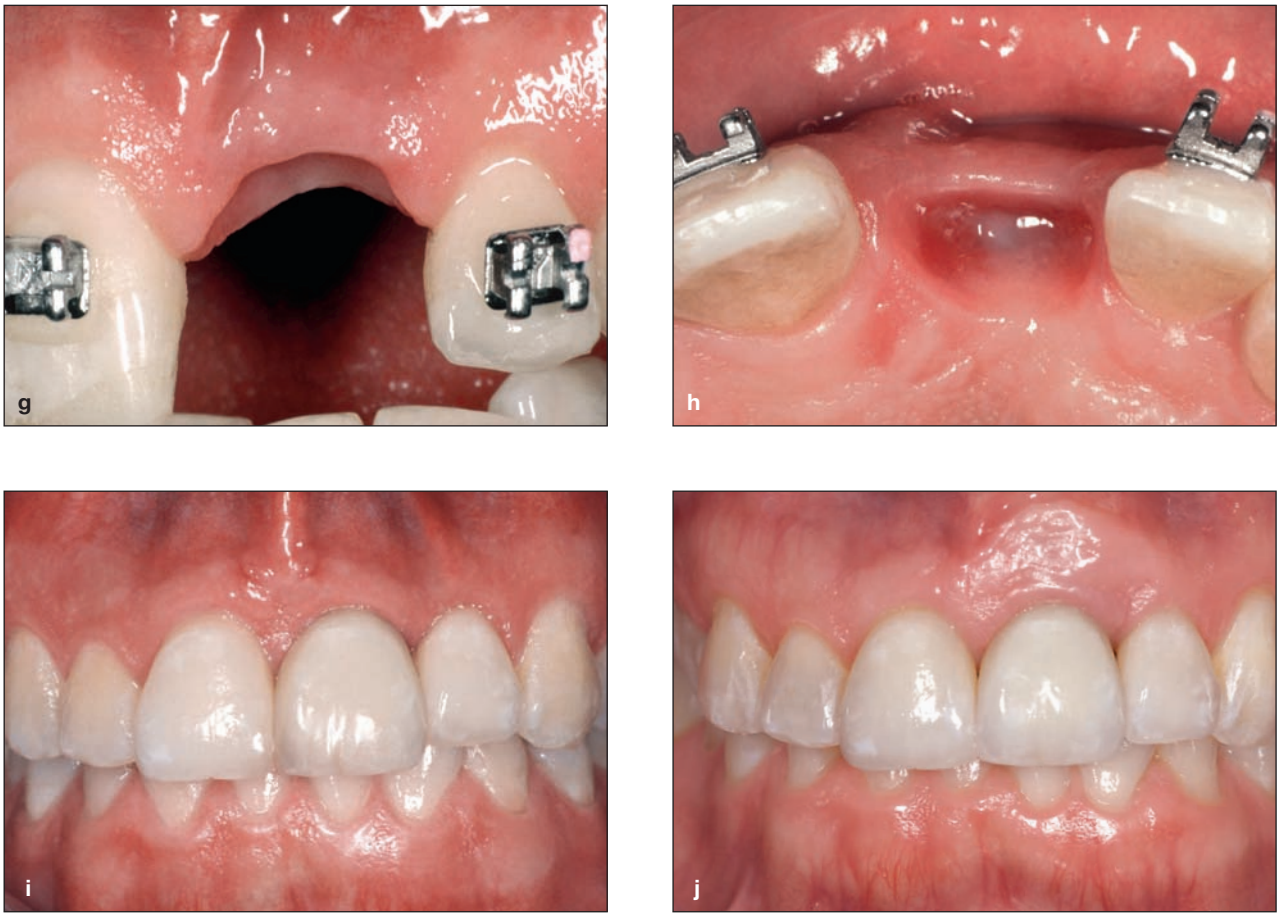


Fig 7-10 *(cont) (g)* The facial and interproximal contours have been retained. *(h)* The facial width has been preserved. *(i)* Definitive restoration. *(j)* Fourteen-year follow-up.

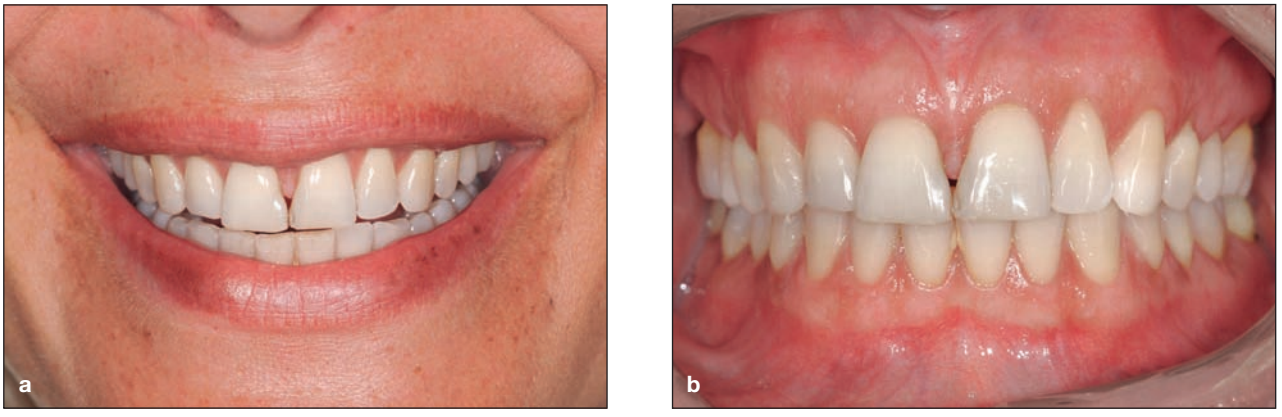


Fig 7-11 *(a)* Preoperative smile. *(b)* The retracted view demonstrates the diastema between the maxillary central incisors and the excessively long interproximal papilla.

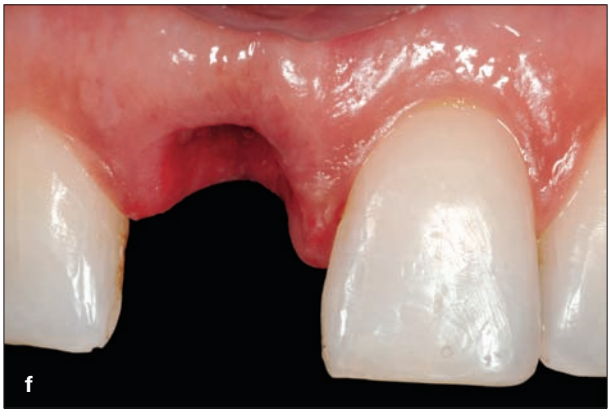
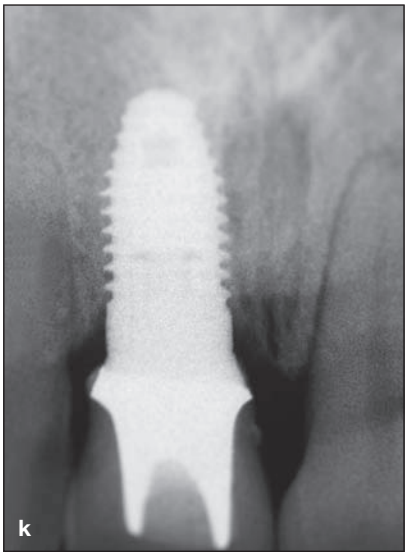
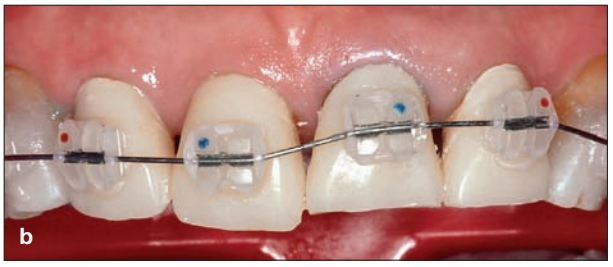


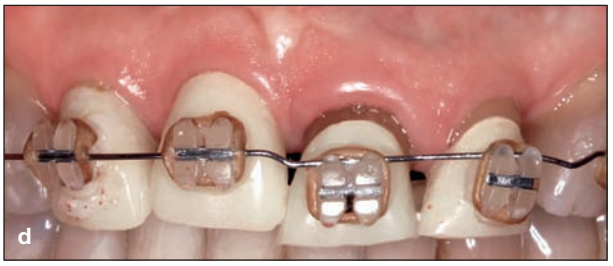
Fig 7-11 *(cont) (c)* Periodontal defects associated with the maxillary right central incisor. *(d)* Slow forced eruption of the right central incisor with molar anchorage and a heavy, rectangular wire to control torque. *(e)* Forced eruption is completed and retained for 6 months. *(f)* Atraumatic extraction and immediate implant placement. *(g)* Removable provisional prosthesis with ovate pontic. *(h)* Stable tissue contours 4 months after surgery.

Fig 7-11 *(cont) (i)* Custom anodized implant abutment. *(j)* Definitive restorations. *(k)* Nine-year postoperative radiograph demonstrating stable osseous levels.



When more than one tooth is scheduled for extraction, sequencing of extractions and implant placement becomes important. After the successful healing of one implant, the interproximal osseous stability is improved (Fig 7-12). Additionally, the extracted tooth may be modified to mimic an ovate pontic and retained with the existing orthodontic brackets and wire during healing. Because of the ability to proactively create additional bone and soft tissue, all anterior teeth scheduled for extraction and implant placement should be evaluated for extrusion, even when significant damage of the remaining tooth and/or bone exist.[16]





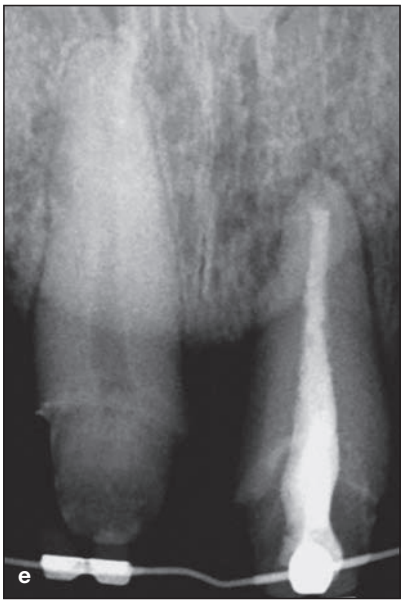


Fig 7-12 *(a)* The maxillary left central and lateral incisors are hopeless, and two implants are treatment planned. *(b)* Four anterior teeth are provisionalized to improve the incisal edge position and allow access for ideal orthodontic bracket placement. Slow forced eruption requires the additional anchorage of molars bilaterally. *(c)* Progression of slow forced eruption. *(d)* A step in the wire is added to maximize the eruption. *(e)* Radiographic comparison of the apices of the central incisors demonstrates the amount of eruption. *(f)* Finish lines demonstrate the amount of extrusion. After 4 months of retention, implants were placed one at a time and provisionalized with ovate-style pontics during healing. Four months elapsed between implant surgeries. *(g)* Custom zirconia abutments ready for restorations. *(h)* Definitive restorations. Tissue health and contour mimic that found in the natural dentition.

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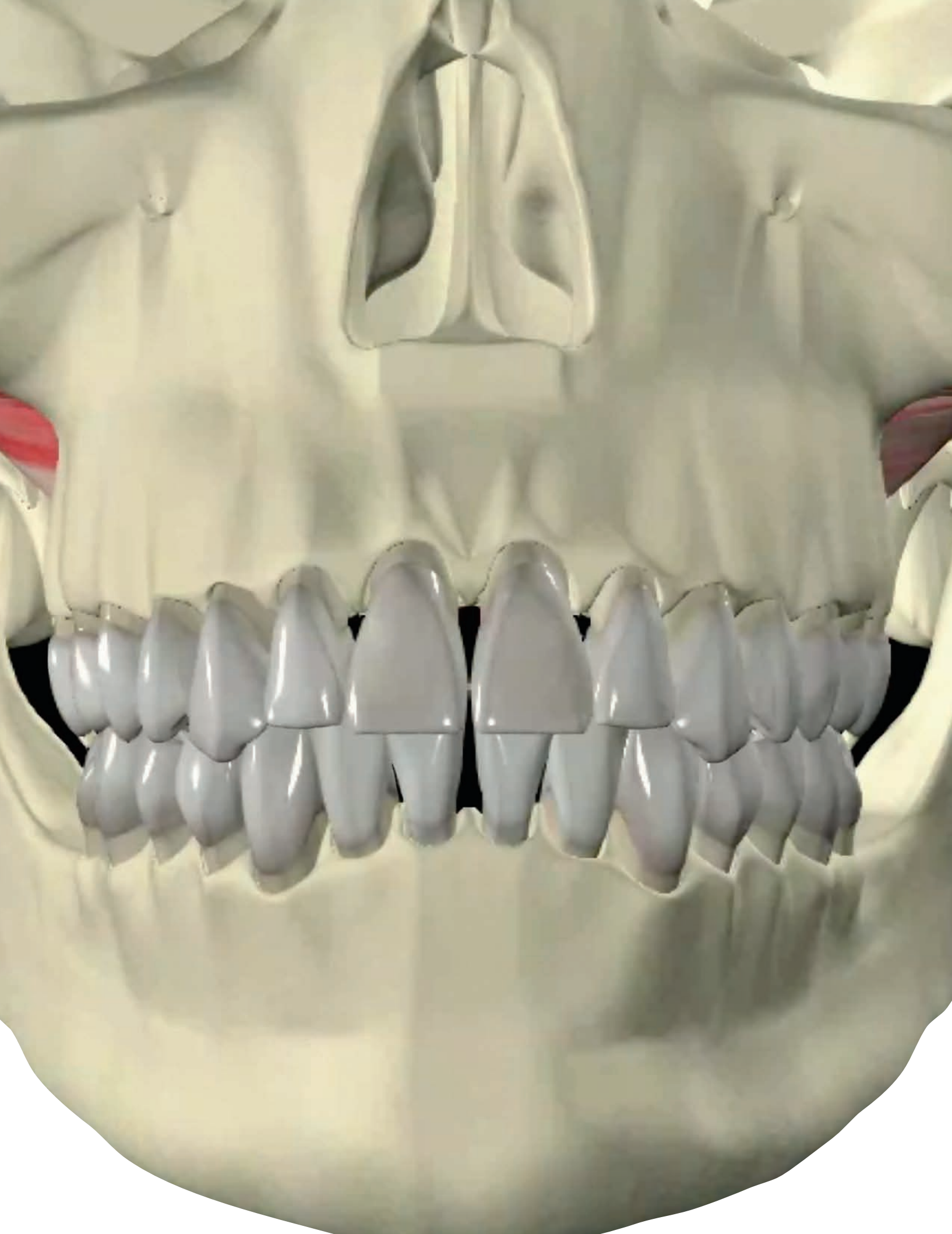

Orthognathic Surgery

8

Joseph E. Van Sickels

Although many of our patients could benefit from orthognathic surgery, this treatment option is commonly overlooked by the restorative dentist. This chapter provides an overview of the surgical options offered to the interdisciplinary patient by the oral and maxillofacial surgeon.

Over the last 50 years, orthognathic surgery has evolved from treatment based on the available surgical procedures to a patient-oriented approach. In the past, handheld casts were often used by the orthodontist and the oral and maxillofacial surgeon to determine the ultimate occlusal and skeletal position for a patient. While the goal of achieving an improved occlusion for the patient has not changed, the assessment and treatment planning has. The impact of the combined orthodontic and surgical treatment plan must account for the effects on the patient's hard and soft tissue. Aligning the skeletal bases to correct the occlusion while ignoring possible negative effects on the overlying soft tissue is no longer acceptable. Additionally, it is essential to create a treatment plan that will serve the patient, both functionally and esthetically, for many years. Up until the 1970s, many of the surgical procedures were designed to set back parts or all of the maxilla and/or mandible. While there are still indications to do some of these procedures, in general it is preferable to give more strength to a patient's face rather than to take it away. For example, in many Angle Class III patients, moving the maxilla forward rather than retracting the mandible gives a more youthful appearance to the face by giving more support to the overlying soft tissues, whereas setting the mandible back may prematurely age the patient's appearance. Similarly, increased incisal display of the maxillary anterior teeth results in a more youthful appearance.[1]

As early as 1969, Ackerman and Proffit recognized that describing a patient based on Angle's classification of Class I, II, or III did not address the patient's skeletal issues in all three planes in space.[2] In 2007, Ackerman et al further defined dentofacial deformities in three dimensions using the terms *pitch*, *roll*, and *yaw*.[3] Using this concept, not only the anterior-posterior and vertical-superior dimensions are assessed in a patient, but rotations within the complex are also noted. Recognition of the three-dimensional nature of the facial skeleton stresses the importance of clinical assessment, which is discussed in more depth in the following section. With the progression of cone beam radiographic images and software that accompanies this technology, the facial skeleton and its overlying envelope can be rotated in all planes of space.[4]

Assessment of the Patient

The assessment of each patient is done with a clinical examination that includes photographic documentation, radiographic examination, and a dental examination. By far the most important part of the assessment is the physical clinical examination of the patient. It is helpful to have family members present during the examination in order to evaluate a tendency for familial trends.

There are many textbooks that describe facial measurements and facial balance.[5,6] In general, the face is balanced with the upper, middle, and lower thirds about equal in both the frontal and profile views. While most individuals have some degree of facial asymmetry when viewed from the front, facial esthetics are not negatively impacted unless the asymmetry is significant.

Most patients are keenly aware of their facial appearance. As a result of either positive or negative reinforcement, they will try to mask elements of their face that they find unattractive. For example, if the patient has a dental midline off to one side, he or she will often pose for photographs with the head turned to the opposite side. If a woman has facial asymmetry, she may allow her hair to grow long and pull it to one side of her face to mask the asymmetry. Patients with open bites will often purse their lips to achieve lip competency, resulting in the artificial appearance of a long chin and decreased incisal display in repose. The mandibular-deficient patient will posture his or her mandible forward to mask the underlying deficiency. Even well-trained orthodontists and oral and maxillofacial surgeons have been fooled by the patient with a mandibular deficiency who postures the mandible forward. Failure to recognize masking attempts or posturing of the jaw can lead to inadequate diagnosis and treatment. Figure 8-1a shows the habitual occlusion of a patient as captured in her initial lateral ceph-

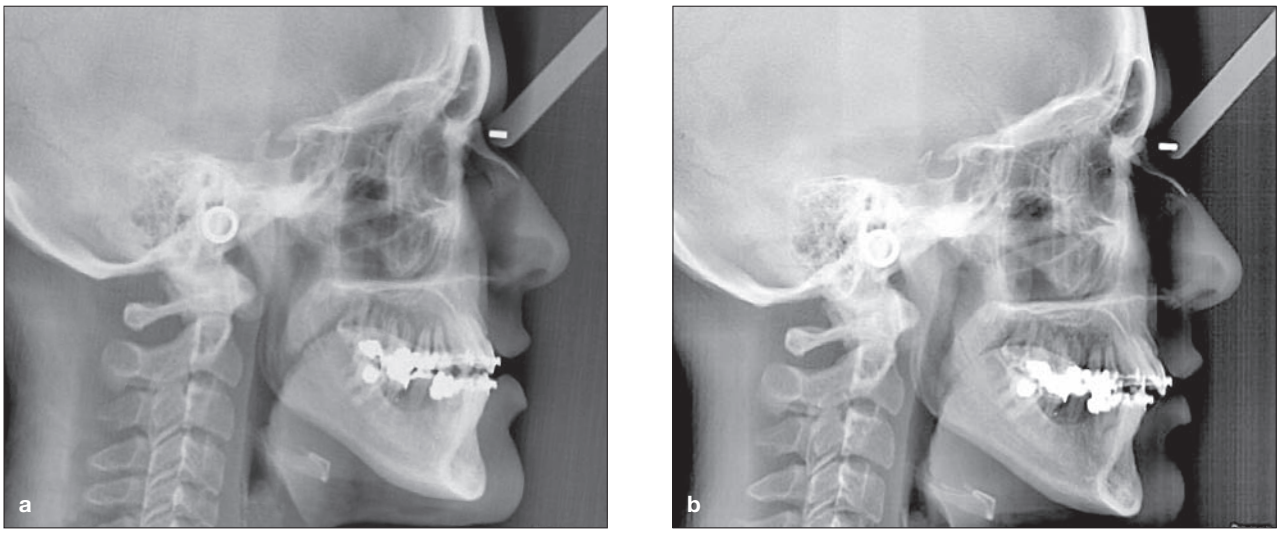

Fig 8-1 *(a)* Preoperative lateral cephalometric radiograph with the patient posturing the mandible forward in her habitual occlusion. *(b)* Lateral cephalometric radiograph with the patient in true seated condylar position.

alometric radiograph, while Fig 8-1b shows the patient in seated condylar position. There is a 6-mm difference in the position of the mandible between the two images. If only the first cephalometric radiograph were used for diagnosis, she would be a straightforward orthodontic case, but the true seated condylar position radiograph reveals that she is a surgical case.

The initial clinical examination should always be done with the patient in a standing position with the lips relaxed and the mandible in a nonpostured position. It may require practice for the patient to maintain this position during the examination. The patient should be assessed from the frontal, profile, and submental views. Special attention should be paid to the frontal view because this is how the patient sees himself or herself. The analysis of a patient by a clinician who is sitting on one side of the chair can lead to a significant underestimation of the degree of facial and dental asymmetry. The patient is directed to stand with the head in a natural head position, and the cranial base and upper face are evaluated for symmetry and cant. If the interpupillary line is not parallel to horizon, assessing the maxillary occlusal plane is more difficult. Next, the symmetry of the ears is evaluated. While asymmetric ear levels may not influence the assessment of facial symmetry, it is an indication that the cranial base may not be normal. Asymmetric ear levels make an accurate facebow registration much more difficult. Next, the nose is evaluated in the frontal plane. It is common for a patient to have an asymmetric nose due to previous trauma. It is important for the clinician to evaluate the nose to ensure that the asymmetry is not missed. If a deviated septum is present, the asymmetry of the nose will be more apparent when the patient smiles. If the nasal tip is not congruent with the midsagittal plane, assessing the dental midline is more difficult. The use of dental floss, as discussed below, will help to determine whether the nasal tip is asymmetric or the dental midline is off to one side. Next, the zygomas are evaluated. In general, the point of prominence of the zygoma is approximately 10 to 15 mm lateral and 15 to 20 mm inferior to the lateral canthus of the eyes.[6] Evaluating the patient from a submental view will help to determine if there is zygomatic asymmetry.

Once the symmetry of the upper face has been evaluated, dental floss can be used to determine the midsagittal plane of the face. The floss is placed equidistant between the eyes and the midcoronal portion of the skull to determine if the maxillary midline is congruent with the midsagittal plane. Ideally, the maxillary dental midline is in the middle of the philtrum; however, it can be off by as much as 2 mm before it is clinically obvious.[7] A canted dental midline is esthetically objectionable and is considered more important than a minor dental midline discrepancy.

The relationship of the maxillary and mandibular dental midlines is now evaluated. It is not esthetically important that both midlines be coincident; however, it must be determined if the asymmetry has a skeletal etiology. A submental view can reveal whether the mandibular dental midline is congruent with the chin and can reveal marked asymmetries of the face and chin. The axial inclination of the maxillary central incisors must also be evaluated.

The relationship of the maxillary occlusal plane to horizon is a key element in the facial evaluation. An apparent maxillary cant may be related to an asymmetric upper lip; however, this is not usually the problem. There are four primary etiologies for a canted maxillary occlusal plane: *(1)* a developmental cant, *(2)* a cant secondary to tooth wear, *(3)* a cant related to supererruption of unopposed teeth, and *(4)* a cant related to temporomandibular joint pathosis. Regardless of the etiology, the cant is accentuated when the patient smiles; there is more gingival display on the lower side of the cant. The degree of occlusal cant that can be detected by the lay public is 4 degrees or more.[8] A significant cant is generally present in both the maxilla and the mandible. If present in both jaws, a decision must be made as to whether the patient needs a two-jaw surgery. The patient may elect to have only one jaw surgically corrected and accept the existing cant. When a cant is present only in the mandible, there is usually an asymmetry in one ramus. Aligning the mandible with the maxilla may correct the occlusal cant but leave an asymmetry in the mandibular angle region. This can be secondarily addressed by an augmentation of the angle.

Incisal display of the maxillary anterior teeth in repose is another important parameter to be evaluated. In general, 3 to 4 mm in the young female (25 to 30 years) and 1 to 2 mm in the young male is considered normal incisal display in repose. Within limits, greater incisal display in repose and full smile results in a more youthful smile. Next, the lip support must be evaluated in the frontal and sagittal planes.

The buccal corridors are evaluated in the full smile position. In an attractive smile, there is minimal space between the buccal surfaces of the maxillary posterior teeth and the cheeks, which frames the lateral border of the smile. The posterior extent of the smile is generally the second premolars or the first molars. Excessive space in the buccal corridors is generally related to a constricted maxillary arch.

Finally, the chin-throat angle must be evaluated in profile. The chin/neck area normally has an obtuse angle of 110 degrees.[6] Further assessment of the patient's nasolabial angle (90 to 110 degrees) will help determine if a maxillary advancement is indicated.[5,6] An obtuse nasolabial angle suggests that the maxilla is hypoplastic. The hypoplastic appearance is exacerbated when the patient smiles because the lip will retract against the retruded maxilla and maxillary dentition.

Functional Issues

Orthognathic surgery is a functional surgery that has significant esthetic implications. However, many patients who have a skeletal discrepancy have learned to compensate and may be unaware of the degree to which they compensate for their skeletal discrepancy. When interviewing a patient, the

manner in which questions are asked becomes important. Asking the patient a very specific question can give more information than just asking if he or she has a functional issue, for example, asking a patient, "How do you eat?" rather than "Do you have any trouble eating?" The first question can often elicit more information than the second.

A patient with a skeletal deformity may have several functional problems. These include but are not limited to airway, eating, speech, jaw muscle spasm, traumatic occlusion, and gingival inflammation due to lip incompetency. Patients with anterior open bites compensate for lack of incisal function by breaking up food and putting it on their back teeth. After orthognathic surgery, they must learn to incise food with their anterior teeth. Patients with large mandibular deficiencies must posture their jaws forward to function normally and are therefore more susceptible to muscle dysfunction and pain. Patients with anterior open bites are obligate mouth breathers. This can exacerbate gingival inflammation, especially with nighttime mouth breathing. Large open bite and Angle Class III patients will commonly have difficulties with elements of speech. Deep bite patients will often have gingival inflammation due to trauma on the lingual aspects of the maxillary incisors and/or on the labial surfaces of the mandibular incisors. Less severe Class III patients may have traumatic occlusion on their maxillary incisors due to an end-to-end occlusion. All of these dental issues are manifestations of an underlying skeletal problem.

Airway issues that manifest as upper airway resistance syndrome or obstructive sleep apnea may also be seen in patients with underlying skeletal deformities.[9,10] When symptoms of sleep-disordered breathing are present at the time of consultation, the orthodontic/surgery treatment plan will be impacted. In the past, it was not uncommon for a patient to complete orthodontic treatment with beautiful occlusal results and to have subsequently been diagnosed with obstructive sleep apnea. In current orthodontic/surgical practices, there is an increasing emphasis on the airway evaluation in patients presenting for surgical-orthodontic treatment.

Photographs

Photographs are used to document the patient before intervention and are helpful when making the final treatment plan before surgery. Dynamic video of the patient in conversation is also a helpful diagnostic adjunct.

Cephalometric Radiographs

Cephalometric radiographs are used multiple times during the assessment, treatment planning, and follow-up of orthognathic surgery patients. In the assessment phase, these radiographs are helpful to confirm a diagnosis; however, they should never be used as the sole determinant of care. It is the clinical examination, with an emphasis on facial esthetics and symmetry, that is the primary determinant of the surgical treatment plan. For example, in the illustrated case, the cephalometric evaluation suggested that the mandible should be set back (Figs 8-2a to 8-2c); however, the patient received a maxillary advancement. While her chin appeared strong, it was consistent with her family heritage. As noted in the lateral smiling photograph, she was actually maxillary hypoplastic. After the maxilla was advanced, her mandible did not appear to be as strong (Figs 8-2d to 8-2f).

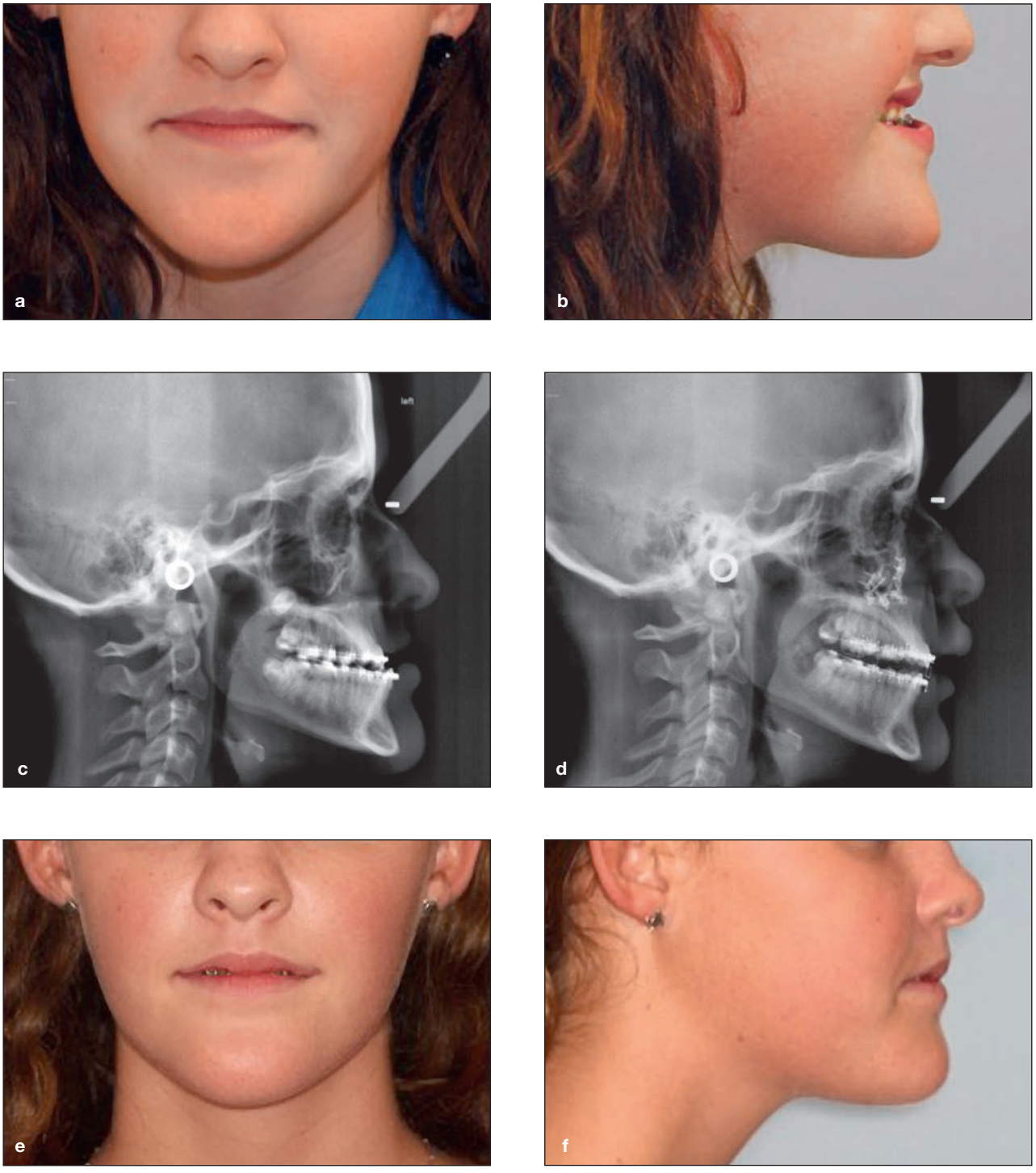

Fig 8-2 *(a to c)* Using a standard analysis, the patient appears to have a prognathic mandible. *(d to f)* However, the patient was treated with maxillary advancement. Note that the chin does not appear as strong after the surgery.

Fig 8-3 A tooth size discrepancy noted upon initial examination of a patient with an open bite.

Fig 8-4 Intermediate splint fabricated after the mandible is moved first.

Casts

Initial evaluation

Accurate casts are an essential element when treatment planning patients with dentofacial deformities. In contrast to the past, today they are used as an adjunctive tool rather than the final determinant in preparation for surgery. As a part of the clinical examination, tooth sizes must be assessed. If there is a Bolton discrepancy, a decision must be made as to how to manage the space before the start of orthodontics. Figure 8-3 shows an obvious example of a tooth size discrepancy. However, many times, tooth size discrepancies are not noted until the casts are studied. In the esthetic zone, the most frequent cause of a Bolton discrepancy is that the maxillary lateral incisors are too narrow. It is always a treatment-planning dilemma to manage either excess or inadequate space. The clinicians involved with the patient's care should preoperatively determine if the space will be managed surgically, orthodontically, restoratively, or with a combination treatment plan.

Presurgical casts

Intermediate splints must be fabricated utilizing the presurgical study casts (Fig 8-4). When there is a surgical correction of both the maxilla and the mandible, well-constructed splints made from correctly mounted study casts are essential. Either the maxilla may be surgically corrected first and then used as the stable base to correct the mandible, or it can be done in the reverse order, starting with the mandible.

Stability

Assessment of the patient is the key factor in developing a treatment plan. However, the postoperative stability of the proposed orthognathic surgery is of paramount importance. Simply stated, the further the jaw is moved, the less stable is the move.[11,12] More specifically, the most stable orthognathic procedure is superior repositioning of the maxilla, closely followed by mandibular advancement, when the mandible is moved in a clockwise direction.[13,14] When counterclockwise movement of the mandible is required, it is less stable.

When moving the mandible and maxilla, the stability of the overall case is related to the stability of each of the individual jaws. Forward movement of the maxilla is reasonably stable, but large movements are not. A large mandibular setback is not stable, and downward movement of the maxilla that creates downward rotation of the mandible is also unstable. The least stable orthognathic procedure is transverse expansion of the maxilla. Chamberland and Proffit have shown a mean relapse of over 2 mm in the transverse dimension following surgical-assisted rapid palatal expansion.[15] They found comparable results when the maxilla was expanded nonsurgically or by a segmented Le Fort I osteotomy.

Techniques

The various surgical techniques are merely tools to accomplish a desired goal. Techniques that are used to move both the maxilla and the mandible, either individually or in combination, are discussed in the following sections.

Mandible: Bilateral sagittal split osteotomy for advancement and/or asymmetry

This is an extremely versatile and popular procedure because it can be used to advance or set back the mandible and to treat a variety of asymmetries. The bilateral sagittal split osteotomy (BSSO) is the most commonly used procedure to move the mandible for several reasons. First, it is a versatile procedure that has many applications. Second, all incisions are intraoral, resulting in limited or no facial scars. Finally, with rigid fixation, the segments may be fixed at the time of surgery, and the patient can have reasonable oral function very soon after surgery.

Postoperative concerns

The importance of maintaining a soft diet for 6 weeks or more is discussed preoperatively and reemphasized after surgery. Maintenance of good oral hygiene is very important both before and after surgery. Postoperatively, oral hygiene is difficult because of the presence of orthodontic appliances, postoperative discomfort, and limited opening. If oral hygiene is a significant problem, the patient is given a limited dental prophylaxis as early as 6 weeks after surgery. Generally, the first prophylaxis is given 12 weeks postoperatively, unless mouth opening is still too limited. The patient is given a postoperative jaw exercise protocol soon after surgery. Usually the patient returns to normal opening by 6 months. Orthodontic appointments resume between 2 and 6 weeks after surgery.

Morbidity

It is common for the patient to have postoperative numbness in the distribution of the inferior alveolar/mental nerve, which can be permanent.[16] There is a possibility of postoperative temporomandibular dysfunction, which must be discussed with the patient. While statistically, muscular symptoms are greatly improved with orthognathic surgery, this cannot be promised.[17,18] Patients with diurnal and/or nocturnal bruxism may continue to brux after surgery. The improvement in temporomandibular/muscular symptoms for most patients is probably related to the fact that they do not have to eccentrically posture their jaws to accomplish normal function.

Maxilla: Le Fort I osteotomy

The Le Fort I osteotomy is the most common procedure used to move the maxilla. The maxilla can be advanced, impacted, set back, and moved downward. The maxilla may also be divided into pieces to correct cants and segmental issues. As discussed earlier, accurate presurgical records are critical to the placement of the maxilla at the time of surgery. The laboratory work-up determines where the maxilla will be placed in anterior-posterior position as well as a lateral position (pitch and yaw). However, the vertical position is determined intraoperatively by an external reference point. Commonly, this is a pin that is placed at the radix of the nose. Measurements are then obtained to determine if the patient is at the correct vertical position once the maxilla has been moved.[13,14] Stability of the maxilla depends on the direction and the amount of movement. When large moves are contemplated in the maxilla and/or the mandible, more rigid plates and screws are frequently utilized.

Vertical maxillary excess

Vertical maxillary excess (VME) is the skeletal discrepancy that most commonly impacts gingival display and facial esthetics. The treatment for VME is a maxillary Le Fort I impaction. A piece of the maxilla is removed, and the maxillary teeth and supporting maxilla are impacted and retained with rigid fixation. On occasion, after the maxillary impaction, the mandible will autorotate into an acceptable occlusal relationship. However, this is generally not the case, and the mandible will also have to be surgically corrected (Fig 8-5).

Transverse discrepancy

The Le Fort I osteotomy is frequently used to treat transverse discrepancies of the maxilla. Once the maxilla is mobilized, it can be cut into segments to correct transverse or vertical discrepancies. When correcting transverse discrepancies, stability is a problem, and the segments must be maintained for as long as 6 months. When the surgical splint is removed, the orthodontist places a continuous archwire. Generally, the maxilla is overexpanded to allow for postoperative relapse.

Fig 8-5 *(a)* Before maxillary impaction and mandibular advancement. *(b)* After two-jaw surgery.

Summary

While the primary goal of orthognathic surgery is to improve masticatory and respiratory function, it is also a powerful tool to improve facial esthetics. Working together, an interdisciplinary team can develop treatment plans that will dramatically improve the quality of life for our patients.

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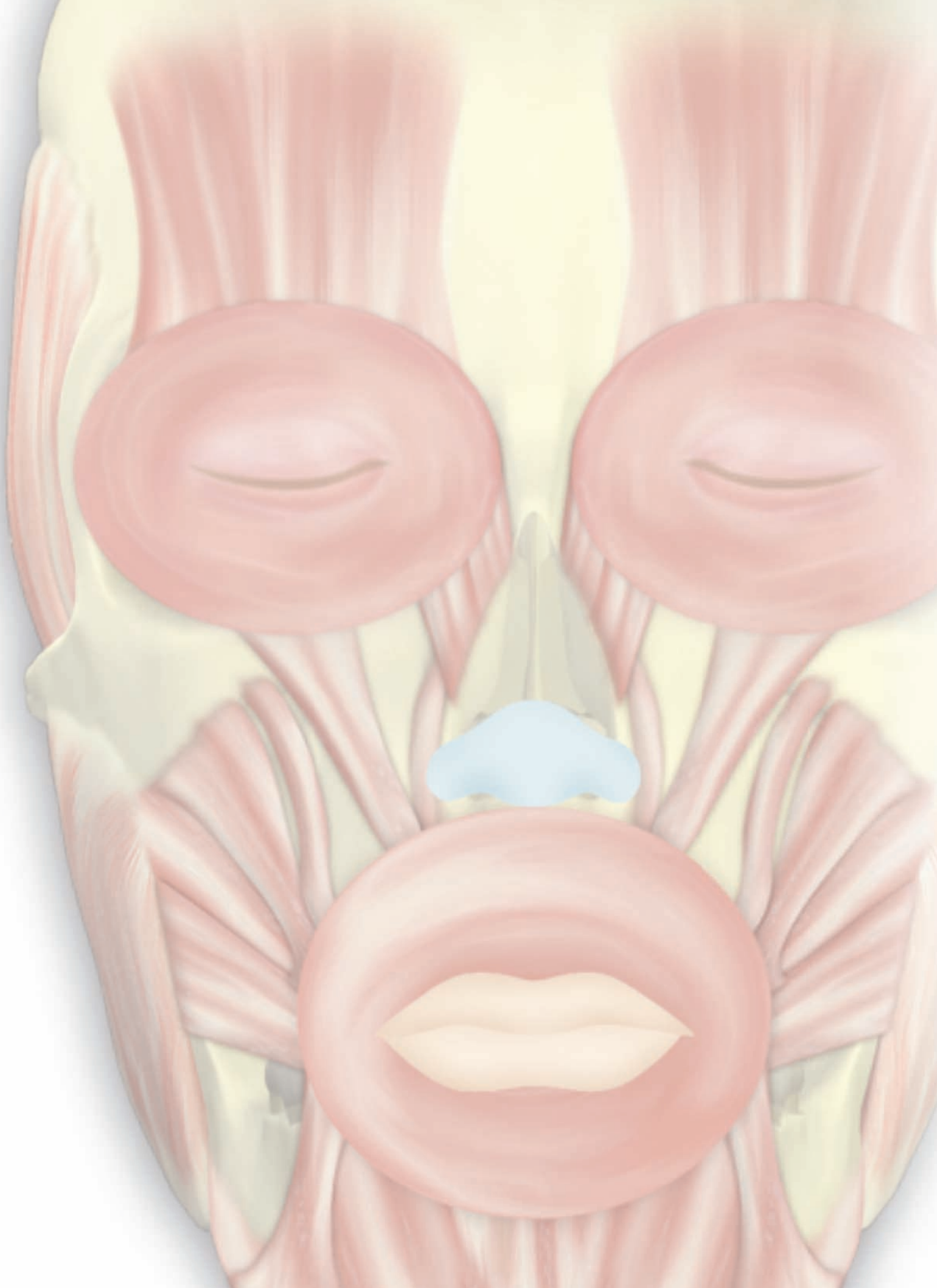

Dental Facial Plastics

9

Jeffrey S. Rouse | Lisa D. Rouse

Dental facial plastics is an exciting new area for the restorative dentist. This chapter describes the use of Botox and dermal fillers as treatments to be offered by the dental team.

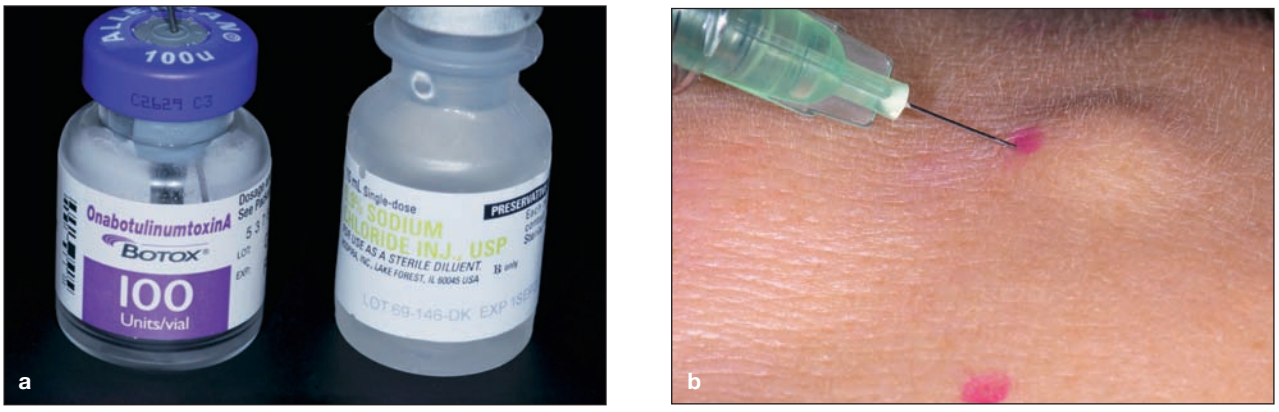

Fig 9-1 *(a)* Botulinum toxin A powder is not visible in the vial. The contents are reconstituted using either sterile or nonpreserved 0.9% sodium chloride injection USP. The dissolution determines the volume of each unit delivered. A limitation in private practice is that the material will lose its effectiveness after reconstituting and cannot be stored for long-term use. *(b)* Injections of Botox are given with a 32-gauge half-inch needle to the level of the targeted muscle groups.

Dental facial plastics focuses on therapies that may be utilized in a typical dental practice. Surgical options further expand the dentist's ability to work with an interdisciplinary team. Because of the ever-changing presentation of the perioral tissues, reversible treatment options are advantageous when smile esthetics are a primary concern. Therefore, in general, the dental treatment options presented in this chapter are reversible. For example, upper lips with insufficient length and/or hypermobility commonly result in a "gummy" smile. Botulinum toxin A (Botox, Allergan) and dermal fillers can be used to treat this excess gingival display. The long or hypomobile upper lip may create an esthetic dilemma as well. Treatment alternatives for these cases are also discussed.

Dental Facial Plastic Materials

Botox

Clinical use of botulinum toxin has been in the peer-reviewed literature since the late 1970s, focusing on excessive muscle contractility or pain relief.[1] While there are multiple serotypes (A–G) of botulinum toxin produced from *Clostridium botulinum* bacterium, Type A is the most effective and universally accepted. Botox is the trade name of purified onabotulinumtoxinA (Fig 9-1). AbobotulinumtoxinA (Dysport, Medicis) and incobotulinumtoxinA (Xeomin, Merz) are also botulinum toxin A varieties. They differ from Botox in the purification methodology and lack complexing proteins.[1] For patients who are resistant or nonresponsive to Type A, Type B (Myobloc, Solstice Neurosciences) may be indicated. The binding site and target molecules in the presynaptic terminal are different for the two types. The onset is quicker with Type B, but the duration of action is usually shorter.[2]

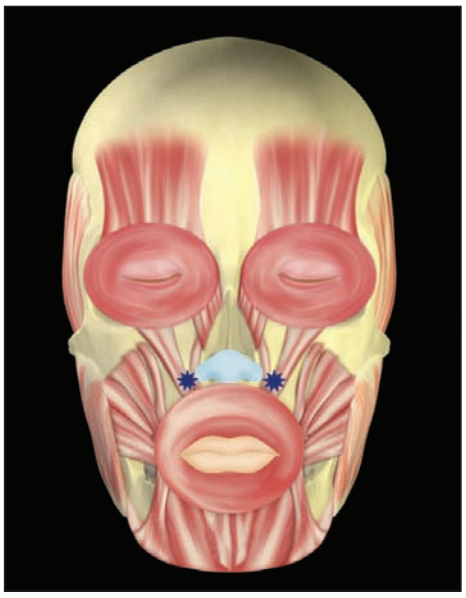

Fig 9-2 Anatomy of the injection sites for the smile elevator muscles *(starbursts)*.

Botox weakens skeletal muscles by blocking the release of acetylcholine from the muscle motor neuron and enables repolarization of the postsynaptic terminal. This produces a partial chemical denervation of the muscle, resulting in a flaccid paralysis of the target muscles. Dosage must be individualized for the muscle mass to be treated and the amount of paralysis desired. The acetylcholine production is not affected and will cause the muscle activity to return to normal function in 3 to 6 months postinjection.

To alter the movement of the upper lip, a patient-specific dosage is injected intramuscularly into both the left and right levator labii superioris, levator labii superioris alaeque nasi, and zygomaticus minor muscles. These muscles converge at the ala of the nose (Fig 9-2). For patients new to Botox, the results may not be detected for 7 to 10 days. During repeat injections, the results will be demonstrated more rapidly. The esthetic trend is to reduce the dosage in order to prevent a frozen appearance and an underexposed smile and to minimize complications (Fig 9-3). Patients should be made aware of this philosophy to prevent disappointment if further refinement of the dosage is required for optimal results.

Dermal fillers

The introduction of bovine collagen in the 1980s increased the longevity and predictability of dermal filler, which led to a dramatic increase in usage. This transformation removed the need for skin testing before use. Today, the most common esthetic procedures conducted worldwide are botulinum toxin and dermal filler injections. The dermal fillers can be permanent or temporary and are grouped into collagens, biosynthetic polymers, and hyaluronic acids (HA).

Fig 9-3 *(a)* Global diagnosis focuses on idealizing the gingival architecture in the animated smile. This patient will require systematic, interdisciplinary care to resolve esthetic issues. *(b)* The five questions detected a combination of gingival recession and a hyperactive upper lip. *(c)* Retracted view of the maxillary arch. *(d)* Gingival grafting and porcelain veneers have improved the smile, but excessive gingival display is still present.

Fig 9-3 *(cont) (e)* Upper lip in repose with 3 mm of central incisor exposure. *(f)* Excessive gingival display in full smile due to upper lip mobility of 12 mm. *(g)* An excessive amount of Botox was originally administered, resulting in a smile with a frozen appearance. Botox should be titrated starting with a small dose. *(h)* After the effect of the initial Botox injection disappeared, a second smaller dose was delivered. The mobility was reduced by half. *(i)* The third titration of Botox was an ideal dose and location. These details were noted in the patient's chart and replicated at future appointments. *(j)* The patient still maintains an animated smile and face without the excessive gingival display.

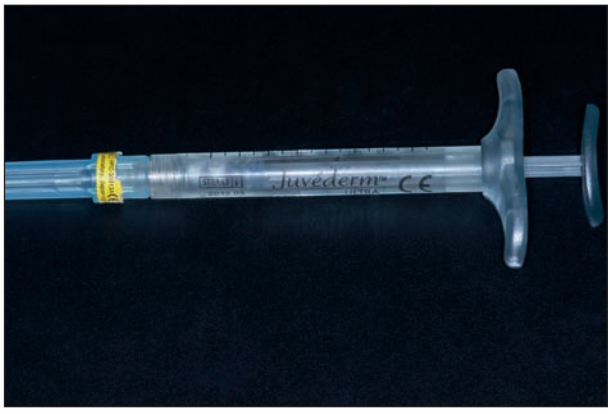

Fig 9-4 Dermal fillers are delivered via syringe. Many are compounded with local anesthetics. The filler can be refrigerated for a single patient to use over time.

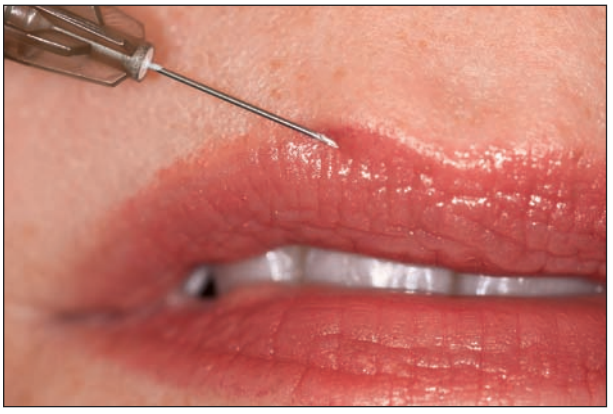

Fig 9-5 The needle is introduced to the full length of the site to create a void for the material. The filler is deposited as the needle is removed. The location of the needle in relation to the vermilion border has an impact on the lip volume and esthetic contours.

The major structural component of human skin is collagen. Injectable forms of collagen are derived from bovine, human bioengineered, and porcine sources. Because of the cost, risk of allergic reaction, and need for preinjection testing, the use of collagen filler has waned.[3] Biosynthetic polymers are synthetic facial fillers that are permanent. The risk of irreversible poor contours and the uncertainty of the long-term effect on the tissue give this class of filler limited usage.

HA is the main polysaccharide in the extracellular matrix of the human connective tissue.[4] It acts as a stabilizer for intercellular structures and provides a framework for collagen and elastin to bind. It potentially creates a binding site for water. The loss of HA during aging decreases the cell's hydration, elasticity, and movement. When it is injected, HA creates volume and smoothes and hydrates the skin. The first HA filler cleared by the US Food and Drug Administration was Restylane (Medicis).[4] Both Restylane and Juvederm (Euromedical Systems) have a current formulation with the addition of lidocaine to decrease the discomfort of injections (Fig 9-4). Regardless of the material, the principles are generally the same. The smaller–particle size filler allows a more superficial injection site to smooth fine lines. The larger-particle fillers are designed for deeper injections to treat volume loss or deep creases. In general, a small-particle product lasts approximately 6 months, while larger-particle products last 6 to 12 months. This chapter is limited to a discussion of dermal fillers for lip volume augmentation. Small-particle HA fillers are well suited for this purpose.

The lower face is the most common area indicated for the use of dermal fillers. The loss of volume associated with aging and gravity lead to thinning of the upper lip, downturn of the commissures, and development of marionette lines that are accentuated by the action of the depressor anguli oris muscles.[5] Descent of the malar fat pads and a deepening of the nasolabial folds exacerbate the aging of the face. A common off-label use of dermal fillers is for lip augmentation. The obicularis oris action causes the perioral rhytids and age-related atrophy. Additionally, the loss of volume, flattening of Cupid's bow, flattening of the philtrum, loss of vermilion contour, and convexity of the pout on profile view accentuate the aging of the face. To some degree, these features can be restored.[4,5] The treatment will result in a lengthening of the upper lip that can serve as an advantage when the normal length is short. It may also act to the detriment of the patient's smile if the added length decreases the maxillary incisor display, which gives the smile an aged look. The injection of filler is painful and requires local anesthesia for comfort.[3] The needle of the filler is introduced at the commissure and can artistically be placed at the vermilion border (Fig 9-5). Filler is injected in an effort to sculpt the Cupid's bow and create an upturn in the commissure. Additional volume can be added by injecting filler at the wet-dry border.[4,5]

Fig 9-6 *(a)* Upper lip in repose of a 42-year-old woman demonstrating a perceived thinning of the contour. *(b)* Broad laugh demonstrating a pleasing smile display; the upper lip translates to the free gingival margin of the central incisors. *(c)* After the addition of dermal filler to improve the upper lip contours. *(d)* While the upper lip appeared more ideal in repose, the additional volume and length inhibited the lip from displaying the full length of the teeth in full smile. The loss of a dynamic smile ages the patient's smile dramatically. Therefore, global evaluation is important prior to selection of any plastic procedures.

Complications of dermal fillers

Because the focus of this chapter is the lower face, the complications of dermal fillers presented here are limited to that area. The immediate complications are the pain of the injection or pain at the injection site. This is usually managed with adequate introduction of anesthesia followed by cold compresses. Swelling and erythema are also managed with cold compresses and pressure. Rarely is pharmacologic intervention with steroids required. The most common complication is asymmetric overcorrection or undercorrection of the deficit.[4,5] Lip contour can be altered during the first week by massage and addition of more filler to the desired sites. Overcorrection simply requires time for the product to disappear. As with Botox, undercorrection is always more ideal, and a discussion with the patient prior to the procedure regarding expectations is critical (Fig 9-6).

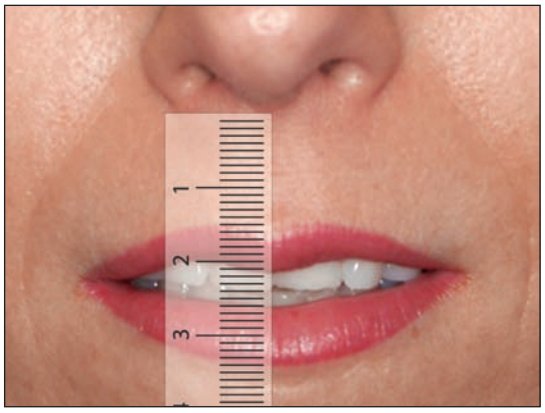

Fig 9-7 Ideal upper lip length measured from the base of the nose to the wet-dry border.

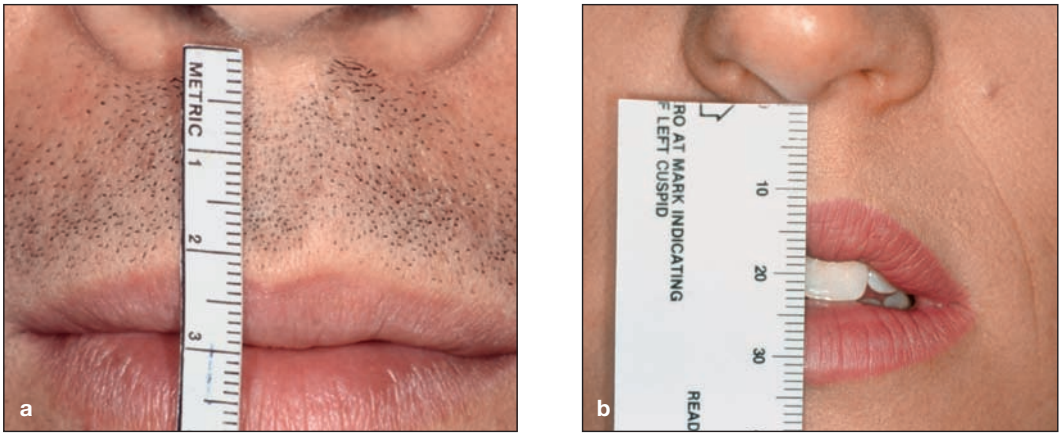

Fig 9-8 *(a)* Men commonly present with longer upper lips than women. *(b)* A short upper lip typically impacts women more than men.

Applications

Upper lip length and dynamics

As outlined in chapter 2, the average upper lip length and mobility for the general population falls within a tight range (Fig 9-7). The philtrum of the upper lip is short initially and increases at a greater rate than the commissure during adolescence up to the age of 14 years. Lip length has a high degree of sexual dimorphism: Men have longer lips than women[6–8] (Fig 9-8). Facial soft tissue changes in the nose, lips, and chin of men occur as much between 18 and 25 years old as they do after 25 years old. Hard and soft tissue changes in women, however, occur most after 25 years of age.[8,9] On average, the

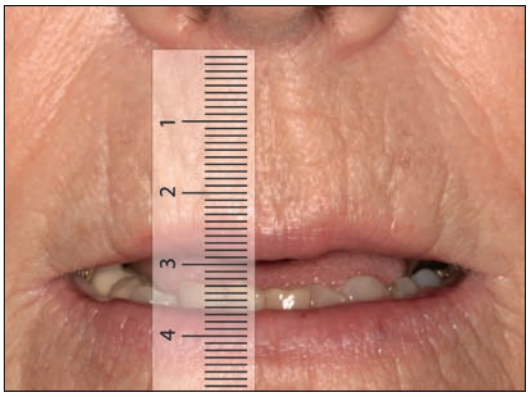

Fig 9-9 Lengthening of the upper lip and thinning of the vermilion border due to age.

upper lip length of a 30-year-old ranges from 20 to 24 mm, depending on sex. The upper lip will then lengthen 1 mm per decade on average, starting at age 40 years. While the notion of the lengthening lip is widely accepted, the nature of the change is poorly understood. It has been postulated that the lengthening is due to a loss of volume. This has led to rejuvenation techniques focused on introducing more volume with dermal fillers. Other explanations focus on the lengthening of the lip itself rather than volume loss. A unique study utilizing magnetic resonance imaging (MRI) and photomorphometric measurements was conducted on 182 white individuals (112 female and 70 male) with an age range of 5 to 83 years.[10] Analysis of the photographs indicated that there was a statistically significant increase in the upper lip length with age when compared with the total face length, lower face length, and width of the mouth. The MRI-based study confirmed the significant increase in upper lip length. The prolabium length increased and the total vermilion height decreased in comparison with the total facial change. The decrease in the visible vermilion can be attributed to this lengthening and subsequent thinning, causing an inversion of this portion of the lip (Fig 9-9). Unlike previous descriptions, this study demonstrated that there is no absolute volume loss but a reorientation from thickness to length. Thus, the lengthening is simply a loss of elasticity with resulting ptosis and redistribution of volume to length. Although men had an increase in total upper lip length, this increase was more pronounced in women, confirming the impression that many female patients have "upper lip problems." When the patients are grouped into age decades, it creates an almost linear pattern throughout life.[10,11]

Long upper lip

Upper lips that measure outside the norm in a youthful patient are relatively rare and, when detected, are usually minimally distracting to the smile. However, with age comes a lengthening that may impact the youthful appearance of the smile. Dentistry has very few options to assist in improving the aging lip. Because of the additional lip length, the teeth will become hidden in repose and less displayed in animation (Fig 9-10). Additional length may be added to the teeth to create greater exposure in repose and full smile (Fig 9-11). However, this additional length cannot be added to just the anterior teeth because this will create a dramatic and unesthetic step-up from the anterior incisal plane to the posterior occlusal plane (Fig 9-12). If restorative dentistry is to play a role in providing a more youthful

Fig 9-10 Elongation of the upper lip and loss of lip volume in an older patient results in reduced tooth display in full smile.

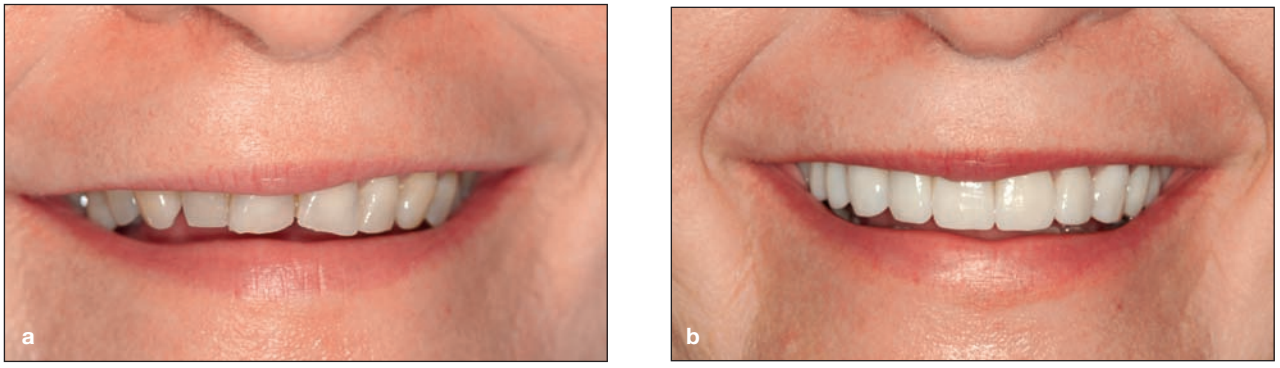

Fig 9-11 *(a and b)* Restoration of all maxillary teeth allows for improvement in smile display while maintaining an ideal occlusal plane at an increased vertical dimension.

Fig 9-12 Maxillary anterior teeth can be lengthened restoratively, but the resulting step-up in the posterior occlusal plane is esthetically displeasing.

smile, all of the maxillary teeth and possibly the mandibular teeth must be restored. Generally this rehabilitation must be accomplished at an increased occlusal vertical dimension. Another option is to orthodontically reposition all of the teeth by extrusion.

Facial plastic surgery options are available to reduce the lengthened lip by direct surgical excision of the nasal base[12–14] and/or vermilion border advancement.[14] However, both techniques leave a visible scar and are not well tolerated by cosmetically conscious patients. A new technique utilizing an intranasal incision has therefore been introduced.[15] The scars are more hidden, and the procedure shortens the upper lip and improves the contour. In one study, 92 patients were treated with this new technique. Postoperative evaluation demonstrated that 85% had a shortened lip height, 79% had greater sagittal projection, 74% had increased maxillary incisor display, and 25% had increased vermilion display. None of the patients demonstrated worsening in any category. The majority of patients (88%) improved in two or three areas. There were minimal postoperative complications, none of which were long term.[15]

Short upper lip

Several surgical procedures have been proposed for the short upper lip. Many of the techniques are designed to address cleft lips or craniofacial deficits and are not highly esthetic.[16,17] An esthetic option for lengthening the upper lip is blunt dissection and amputation of the levator labii superioris muscle through an incision in the inner aspect of the nostril.[18] Surgical correction of the nasolabial fold with a rhinoplasty can increase the nasolabial angle, producing a greater lip length postoperatively.[19]

The authors have two concerns regarding upper lip–lengthening surgical procedures. First, the amount of lip length gained is arbitrary. Surgeons have limited control over the exact amount of length gained in the procedure. Surgical resection of the depressor septi nasi muscle during functional or esthetic rhinoplasty can cause a change in length of the upper lip in repose. In one study, some patients developed a decrease in lip length postoperatively, and there were no predictable factors that could assist surgeons in differentiating the patients.[20] The difference between 2 mm and 3 mm of lengthening can have a significant impact on facial esthetics. If the lengthening is a byproduct of the correction of an unesthetic nose, then the surgery makes perfect sense. But as a singular option for lip lengthening, it has significant limitations. Second, as the patient ages, the upper lip will lengthen. If the lip is short at 30 years of age, it could conceivably be ideal when the patient is 60 years old. The short-term gain at age 30 years will be offset by the much more deleterious effect of the long lip at age 60 years. The upper lip may drape over the maxillary anterior teeth, creating an aged smile.

A reversible approach to treat the short upper lip is to use dermal fillers and/or Botox. Adding length to the lip with a dermal filler or minimizing the mobility of the upper lip with Botox will improve the esthetics without compromising the long-term outcome (Fig 9-13). The advantage of these techniques is that the effect may be titrated. The dosage and the time between administration can be adjusted (or eliminated entirely) as the aging process begins to correct the upper lip issue.

Hypermobile lip

In addition to length, the amount of mobility of the upper lip and symmetry of movement can affect the framework surrounding the smile. The average upper lip mobility required in order to frame the smile ideally is 6 to 8 mm. If the lip moves too much, there will be excess (> 2 mm) gingival display in an animated smile. This "gummy smile" can be an esthetic distraction and embarrassing to the patient. In these patients, the lip elevator muscles have greater-than-normal contraction potential or are hyperfunctional. The upper lip has three pairs of key elevator muscles and some additional contouring muscles. The main groups impacting the hyperactivity are the levator labii superioris alaeque nasi, levator labii superioris, and zygomaticus minor. Additional muscles involved in the smile include the levator anguli oris, zygomaticus major, and the depressor septi nasi. The depressor septi nasi is a singular muscle at the base of the nose. Hypertrophy can cause hyperactivity of the upper lip in the midline, creating a crease in the upper lip under the nose and a drooping of the nasal tip in full smile. While this muscle can be addressed with Botox, it is not part of the normal protocol.

Fig 9-13 *(a)* Preoperative repose. The lower third of the face is longer than the middle third of the face, consistent with vertical maxillary excess (VME). Also, the excessive central incisor display in repose highlights a vertical and/or lip issue. *(b)* Preoperative full smile demonstrating excess gingival display. The excessive display, including the posterior teeth, is indicative of VME. *(c)* Anatomically short upper lip (18 mm). *(d)* One week after treatment with Botox, the patient's natural smile shows ideal positioning of the lip.

Fig 9-13 *(cont) (e)* The patient's face does not have a frozen appearance, and she is still able to show emotion and animation.

Plastic surgical procedures have been reported in the literature to eliminate a hyperactive upper lip. The most familiar to dentistry is a technique that resembles a reverse vestibuloplasty.[21–23] An incision is made at the mucogingival junction from second premolar to second premolar. Starting at the end of the first incision on one side, a second incision is made up into the mucosa and extends to the other end of the first incision. The band of lip mucosal tissue is undermined and removed. The upper border of the incision is then sutured to the attached gingiva at the inferior border of the incision. This procedure is done with or without muscle detachment from the bony structures above the surgical site. Newer techniques attempt to resect one or both of the bellies of the levator labii superioris muscle. In one clinical study, follow-up at 6 months showed that the effect was esthetically acceptable.[24] Other surgical options include subperiosteal dissection of the upper lip elevator muscles and/or Le Fort I osteotomy. A global strategy is the key to providing the proper diagnosis and treatment of upper lip length and mobility. The literature is replete with examples of improper treatment or overtreatment due to a misunderstanding of these esthetic principles.[25]

Surgical approaches are difficult to control dimensionally and may have dramatic disadvantages. A noninvasive alternative to manage excessive upper lip movement is Botox. There are several advantages: The procedure is reversible, titratable, and may improve lip dynamics without impacting the expressiveness of the face in full smile[26] (Fig 9-14). In a clinical study utilizing Botox, Polo was able to decrease lip mobility by an average of 5.2 mm.[27] Gingival exposure gradually increased from 2 weeks postinjection to 24 weeks with no patient returning to baseline at that time. In the study protocol,

Fig 9-14 *(a)* Excess gingival display secondary to hyperactive upper lip and vertical maxillary excess. *(b)* Two weeks after treatment with Botox, the gingival display is ideal. *(c)* After Botox, the patient's high E smile still displays gingiva in an animated laugh. If the patient does not like that appearance, additional Botox may be added or the dosage and injection sites altered during subsequent sessions.

rather than customizing the dosage, all patients were given the identical dosage of Botox at the same injection sites. At the 2-week evaluation, 31% had a negative gingival exposure, meaning the upper lip could not translate to expose the full length of the maxillary central incisors. This can be very discouraging for the patient, as it ages the smile dramatically. It may take several weeks before the upper lip mobility has returned to ideal.

In clinical practice, the amount and sites should be modified to create the desired results rather than simply giving a predetermined amount. When titrating Botox, the goal is to never give too much. Always inject the smallest dose that could create the desired effect, re-evaluate after 2 weeks, and then deliver more Botox if required. This titration technique minimizes the possibility of aging the patient's smile prematurely. It has been reported that Botox may cause some atrophy of the muscles with continued use. While reported as a disadvantage, less mobility is in fact an advantage. Some clinicians also claim that the reversible nature of Botox is a disadvantage. For dental purposes of managing a smile, it is the authors' opinion that reversibility is an advantage. As the patient ages, the muscles will lose tone and the collagen in the face and lips will diminish. Both of these factors will decrease the excess gingival display as the patient ages. Plastic surgical procedures provide an immediate esthetic effect, while Botox can enhance the esthetics for a lifetime. In younger patients, a higher dose may be required. As the patient ages, the dosage will be decreased until the natural alteration of the lip and face no longer require the Botox.

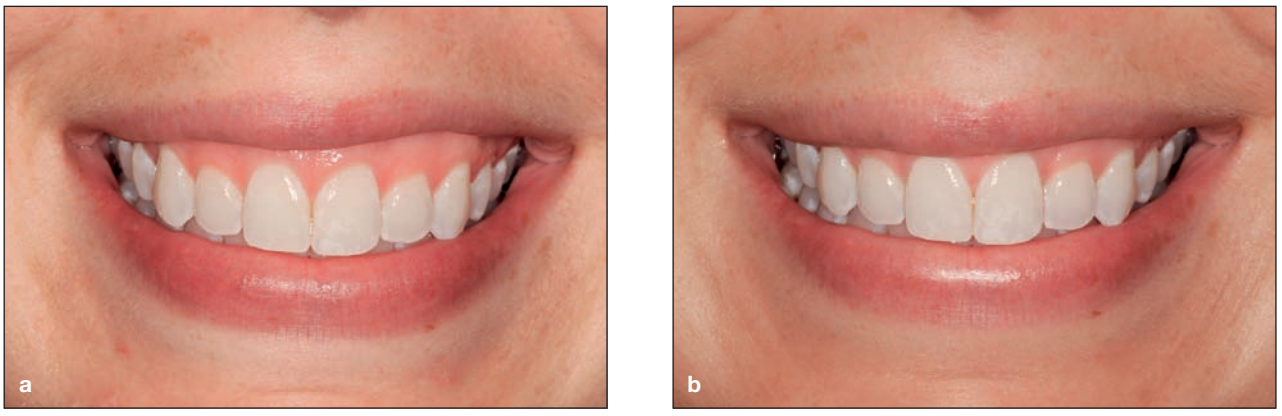

Fig 9-15 *(a)* Upper lip asymmetry with more movement on the left side. *(b)* Botox administered to the ala on the left side only levels the smile.

Asymmetric smiles

Three groups of lip asymmetries have been described. First, the lip can move asymmetrically due to disease (ie, Bell's palsy) or stroke. Second, iatrogenic accidents may create an asymmetry. Surgical damage to a facial nerve or misplaced Botox injections can alter the smile presentation. A third possibility is a familial smile. In this case, one side of the face has stronger or weaker muscles than its complementary muscles. This asymmetry of muscle activity is commonly found in eyebrows and smiles. This is a familial trait that will be passed from one generation to the next. These family smiles can be treated with Botox to create a more balanced smile presentation[28] (Fig 9-15).

Asymmetries may also be seen in the lower lip. Some smiles produce a droop to one side of the lower lip. This is routinely caused by hyperactivity of the depressor labii inferioris muscle. A predictable surgical intervention has not been demonstrated in the literature; however, Botox may provide a solution. The clinician must determine which side of the lower lip is ideal. If the side with less mobility positions the lip in an acceptable location, the problem is caused by hyperactivity of the muscles of expression on the contralateral side. Botox injected into the depressor labii inferioris muscle will relax the lip. A titration protocol is important with lower lip mobility as well. If the less mobile side is not in an ideal position, the problem is hypomobility on the ipsilateral side. This cannot be addressed with Botox. Physical therapy protocols may assist in improving the asymmetry.

Vertical maxillary excess

Chapter 8 discussed the diagnosis of vertical maxillary excess (VME) and the orthognathic surgical treatment of this global problem. However, many times the patient will meet the criteria for VME based on the Global Diagnosis system, but the amount of gingival display in full smile does not warrant orthognathic surgery. There are also those patients who have true indications for orthognathic surgery but who have declined the invasive treatment. Botox is a wonderful masking procedure for VME patients who reject orthognathic surgery. Botox is used to decrease the mobility of the upper lip and the excess gingival display enough to provide a more pleasing appearance without the orthognathic surgery[29] (see Fig 9-13).

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Dentoalveolar Extrusion: The Most Difficult Global Diagnosis

10

Dentoalveolar extrusion is the most difficult global diagnosis for the restorative dentist. This chapter describes nine options to aid the restorative dentist in the treatment of this challenging clinical situation.

Fig 10-1 Significant tooth wear alters the interincisal relationship of teeth, making restoration difficult.

Many of the most complex restorative patients present with tooth wear. The global diagnosis associated with these patients is dentoalveolar extrusion (DAE). The DAE patient with tooth wear is difficult to treat because the worn teeth have commonly migrated into positions that make restorative therapy challenging and in some cases impossible to perform (Fig 10-1).

There are three primary treatment strategies to prepare the DAE patient with tooth wear for restorative therapy: *(1)* orthodontic alignment and intrusion, *(2)* functional crown lengthening surgery, and *(3)* restoration at an increased vertical dimension of occlusion. There are six additional secondary strategies that can be utilized in these patients in very specific situations.

Primary DAE Treatment Options

Orthodontic intrusion

In most circumstances, orthodontic intrusion of the teeth in a patient with DAE and tooth wear is the best treatment strategy. The worn teeth are orthodontically intruded to their original positions. This movement creates both space for restoration of the teeth and better gingival symmetry (Fig 10-2).

With traditional orthodontic techniques and mechanics, it was virtually impossible to intrude posterior teeth. Therefore, orthodontic intrusion was only utilized on anterior teeth, generally maxillary and mandibular incisors. However, with the addition of two currently available treatment options, it is now possible to intrude all teeth. The first adjunctive treatment is the temporary anchorage device (TAD).

Fig 10-2 *(a to c)* Preoperative presentation of a patient with DAE secondary to tooth attrition, inadequate occlusal coupling, and asymmetric mandibular development. *(d)* Using the maxillary left canine as the ideal tooth reference, orthodontic intrusion was utilized to place the other teeth in their ideal positions. The addition of composite to the worn anterior incisal edges assists the orthodontist in proper positioning. *(e)* Temporary anchorage devices are used as indirect anchorage.

Fig 10-2 *(cont) (f)* The ideal gingival architecture and occlusal plane are reestablished. *(g)* Postorthodontic view. *(h to j)* Postoperative view after placement of restorations. Note that the DAE has been resolved with orthodontic intrusion, but the mandibular asymmetry has not been addressed.

Fig 10-2 *(cont) (k to m)* Eight-year postoperative views. Note that 7 years after treatment, subepithelial connective tissue grafts were placed over the canines. The gingival margins were coronally advanced.

TADs are small screws or plates that act as anchorage devices (Fig 10-3). The screws are threaded through the mucosa into the alveolus and provide immediate absolute anchorage. TADs are not implants that osseointegrate but rather mechanically retained screws that are placed and activated immediately. With the introduction of TADs, the orthodontist can intrude one tooth up to an entire arch of teeth.

The second adjunctive treatment that has expanded the ability to intrude teeth is surgically facilitated orthodontics. It was known for many years that the orthodontic movement of teeth occurred more rapidly after osteotomy cuts were performed during orthognathic surgery. Utilizing this concept, surgical perforations or cuts are placed in the alveolar bone adjacent to the teeth that require orthodontic movement (Fig 10-4). This results in a significant decrease in orthodontic treatment time as well as a greater scope of orthodontic movement of teeth.

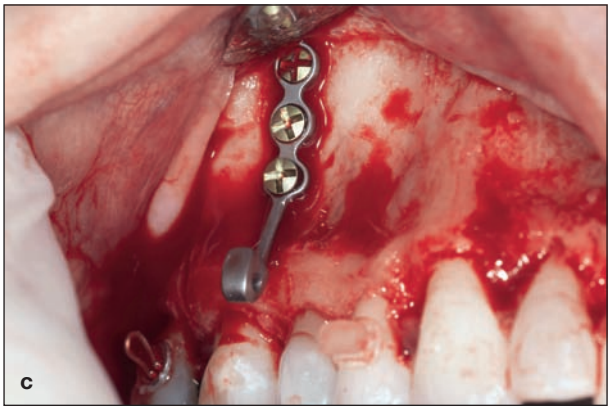


Fig 10-3 *(a)* TADs may be used as direct or indirect anchorage. *(b)* Miniscrews are the most popular TADs because of their ease of placement and retrieval and relatively low cost. *(c)* Bone plates typically are more stable and may offer a greater source of anchorage. Plates require a surgical intervention to place and retrieve, which significantly increases the cost.

Fig 10-4 *(a)* Maxillary preoperative view. *(b)* Full-thickness flap reflection of the buccal tissue in the maxillary arch.

Fig 10-4 *(cont) (c)* Corticotomy cuts begin and end 3 mm from the interproximal osseous crest. They scribe the entire length of the root. *(d)* Bone graft material is placed over the osteotomy cuts. *(e)* The gingival tissue is sutured. *(f)* Mandibular preoperative view. *(g)* Mandibular flap reflection. Note the osseous dehiscences present after previous orthodontic therapy. *(h)* Corticotomy cuts in the mandibular arch. Thicker cuts are made in selected areas to assist in root tipping. *(i)* Bone graft material is placed over the osteotomy cuts. *(j)* Postoperative view.

Functional crown lengthening surgery

Prior to the routine use of orthodontic intrusion, functional crown lengthening surgery was the most commonly used modality for the treatment of a short worn tooth. In this procedure, a correct gingival line is created by performing significant ostectomy and apically positioning the gingival tissue. The surgical technique and goals are much different than those associated with esthetic crown lengthening surgery (see chapter 4). In the functional crown lengthening procedure, facial and palatal full-thickness flaps are reflected, including the interdental tissue. Ostectomy is performed facially, interproximally, and commonly on the palatal surfaces, and the gingival tissue is apically repositioned onto the root surfaces.

There are two primary circumstances in which functional crown lengthening surgery is used to treat DAE. The first indication is when there is not enough clinical crown height (due to trauma, attrition, and/or erosion) for retention and resistance form for the prescribed restorations. The surgical procedure is performed primarily for mechanical reasons, and the esthetic benefits are of less importance (Fig 10-5). However, the surgery creates several negative sequelae:

- When the gingival crest is moved apically, the resultant exposed root surface is a poor substrate for bonding of restorations (see Fig 10-5d).
- The root is narrower mesiodistally than the crown. This results in triangular-shaped definitive restorations, which are unesthetic (see Fig 10-5e).
- The gingival tissue should lie adjacent to enamel with a knife-edge configuration (see Fig 10-5a), but when the marginal gingival tissue is apically positioned onto root surfaces, it commonly heals with a rolled gingival margin (see Fig 10-5d). This problem is accentuated when the gingival tissue is challenged with a restorative margin, resulting in chronic inflammation (see Fig 10-5e).
- The surgery requires removal of papillary tissue and interproximal alveolar bone, which commonly results in open gingival embrasures. If an attempt is made to close the embrasures with the definitive restorations, the long interproximal contacts will accentuate the unesthetic triangular shape of the restorations (see Fig 10-5e).
- The surgery increases the crown-root ratio.

Fig 10-5 *(a and b)* Preoperative views of a patient with DAE secondary to attrition and erosion. *(c)* Surgical view after ostectomy on the canine and lateral incisor. *(d)* Postoperative view. *(e)* Postoperative view after placement of restorations. Note the gingival inflammation adjacent to the crown margins.

Fig 10-6 *(a)* Preoperative view of a patient with DAE limited to the maxillary left quadrant. *(b)* Gingivectomy corrects the gingival asymmetry. Functional crown lengthening surgery followed. *(c)* Definitive restorations demonstrating the red, rolled margins associated with functional crown lengthening. *(d)* Seven-year postoperative view still shows marginal inflammation.

The second and more common indication for functional crown lengthening in the DAE patient is to improve the gingival esthetics prior to restoration of the teeth. Because bonding to root surfaces is not predictable in the long term, functional crown lengthening is generally performed in patients who will receive full-coverage restorations that will not require bonding procedures (Fig 10-6).

Increasing the vertical dimension of occlusion either restoratively or orthodontically

Although this strategy does not actually treat the DAE, it creates space for the restoration of teeth with attrition and/or erosion (Fig 10-7).

Fig 10-7 *(a to e)* Preoperative views of a patient with DAE secondary to attrition and erosion. Because the gingival margins were not visible in his E smile and the remaining coronal tooth structure was sufficient for restoration, the decision was made to restore all of his teeth at an increased vertical dimension.

Fig 10-7 *(cont) (f)* View demonstrating the amount of vertical change with the maxillary provisional restorations. *(g to i)* Postoperative views after placement of the restorations.

Secondary DAE Treatment Strategies

Segmental osteotomy

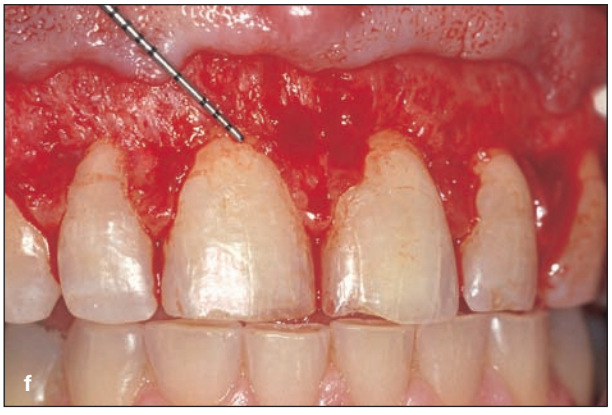
When DAE with tooth wear affects one segment of the arch, a segmental orthognathic surgical procedure can be employed. The extruded segment is surgically impacted to create the desired space and gingival symmetry (Fig 10-8). However, this treatment strategy is used infrequently today. With the advent of TADs and surgically facilitated orthodontics to aid in the intrusion of teeth, segmental osteotomies are rarely indicated.

Fig 10-8 *(a and b)* Preoperative views of a patient with DAE in the maxillary anterior area. *(c)* Postoperative view after segmental osteotomy. *(d)* Postoperative view after esthetic crown lengthening surgery for altered passive eruption. *(e and f)* Postoperative views after restorative dentistry is complete.

Fig 10-9 *(a and b)* Preoperative views of a patient with a severe Class II malocclusion, DAE of the mandibular anterior teeth, and altered passive eruption of the maxillary teeth. *(c)* Orthodontic alignment of teeth prior to orthognathic surgery.

Occlusal equilibration to create restorative space

Occlusal equilibration of a DAE patient with a significant anterior-posterior discrepancy between centric relation and maximal intercuspation may result in additional space for restorations (Fig 10-9). Again, this strategy does not actually treat the DAE. It is a treatment strategy to create restorative space in the patient with DAE secondary to attrition and/or erosion of the anterior teeth.



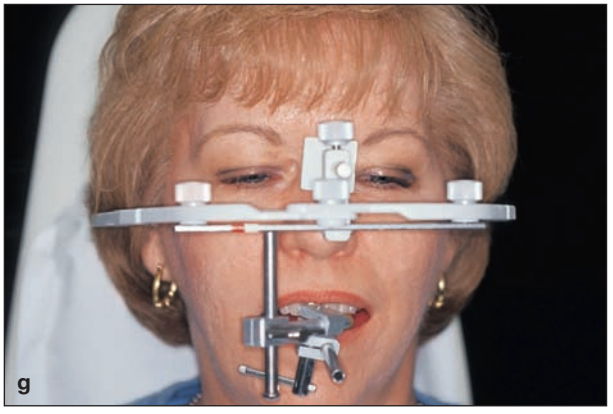


Fig 10-9 *(cont) (d and e)* Postoperative views after mandibular advancement orthognathic surgery. Note the end-to-end occlusal relationship of the maxillary and mandibular anterior teeth with no room to create vertical overlap with restorations. *(f)* Esthetic crown lengthening surgery prior to ostectomy to treat the altered passive eruption. *(g)* Facebow registration for diagnostic mounting. *(h and i)* Casts articulated in centric relation on the articulator. Note the initial occlusal contact on the right second molars.

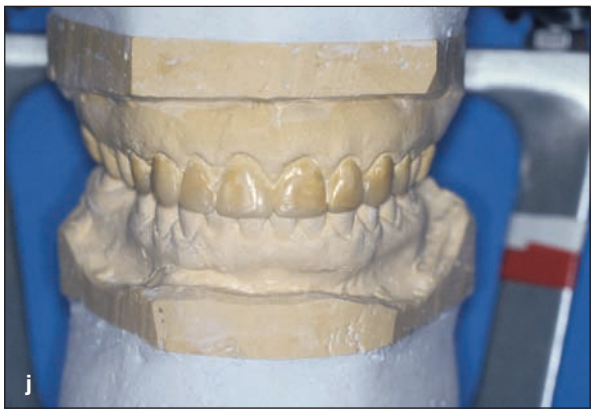


Fig 10-9 *(cont) (j)* After the casts were equilibrated, room was created for vertical overlap of the maxillary anterior teeth in the diagnostic wax-up. The equilibration was then completed on the patient prior to preparing the maxillary teeth for restorations. *(k)* Maxillary anterior teeth prepared for porcelain veneers. When this patient was treated, the authors were not breaking interproximal contacts in porcelain veneer preparations. *(l and m)* Postoperative views after the completion of restorative dentistry. *(n)* Seventeen-year postoperative view. Note the interproximal staining consistent with porcelain veneer preparations that did not extend through the interproximal contacts.

Fig 10-10 *(a)* Preoperative view of extruded mandibular incisors. *(b)* After extraction of the mandibular incisors. *(c)* Placement of implants in the lateral incisor positions. *(d)* Four-unit implant-retained fixed partial denture replacing the mandibular incisors.

Extraction of teeth

Extraction of extruded teeth is primarily indicated in two circumstances: *(1)* when teeth (particularly unopposed teeth) have extruded to such a degree that they are no longer useful in the restorative treatment plan (Fig 10-10), and *(2)* when the extruded teeth have severe attrition, resulting in a poor long-term restorative prognosis. This most commonly occurs with worn mandibular incisors. In these teeth, when a significant amount of the anatomical crown is lost due to attrition, the placement of enamel-bonded porcelain veneers becomes impossible because all of the enamel must be removed in the porcelain veneer preparations. Because of the diminutive size of the mandibular incisors, full-coverage restorations are not the restoration of choice. Therefore, teeth with extensive wear may be extracted and replaced with implants or a fixed partial denture. This treatment may also be employed when the patient with moderate incisal attrition refuses orthodontic intrusion. Worn mandibular incisors are the teeth most commonly considered for extraction because of the difficulty in restoring them with acceptable esthetics and long-term function (Fig 10-11).

Fig 10-11 *(a)* Preoperative view of a patient with severe attrition of the mandibular incisors who rejects orthodontic intrusion. *(b)* After extraction of the mandibular incisors. *(c)* Postoperative view after completion of full-mouth rehabilitation at an increased vertical dimension. *(d)* Four-unit implant-supported restoration replacing the mandibular incisors. Two implants were placed in the lateral incisor positions.

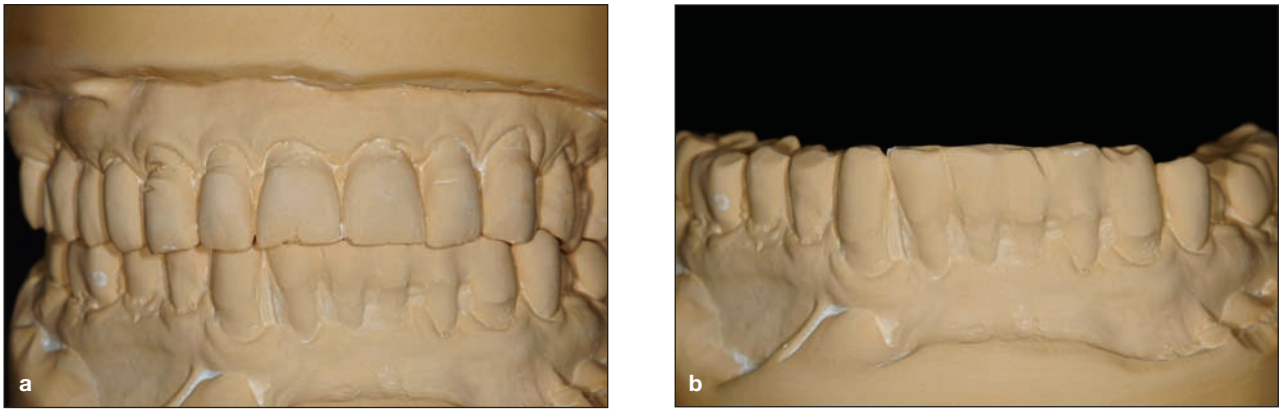


Fig 10-12 *(a and b)* Preoperative casts demonstrating incisal attrition and supererupted mandibular incisors.

Enameloplasty of extruded teeth

Teeth that have supererupted may be reduced incisally to provide a better occlusal relationship and to create the required space for opposing restorations (Fig 10-12).

Fig 10-12 *(cont) (c and d)* Preoperative views showing lingual attrition of the maxillary anterior teeth. *(e)* Diagnostic wax-up of the maxillary anterior teeth. *(f)* Stent made over the diagnostic wax-up. *(g)* Metal matrix separators are placed between each maxillary anterior tooth. *(h)* Try-in stent to ensure complete seating over the matrices and teeth.

Fig 10-12 *(cont) (i and j)* Composite bonding is complete. *(k)* The posterior teeth are not in occlusion because of the addition of anterior composite. *(l and m)* The contacts are marked on the mandibular anterior teeth. *(n)* Mandibular teeth after equilibration.

Fig 10-12 *(cont) (o)* Posterior teeth in occlusion after equilibration. *(p and q)* One-year postoperative views.

No treatment

No treatment is always an option, and it is a strategy that has been used for many years to manage the mandibular incisors as part of a full-mouth rehabilitation. Prior to the routine use of orthodontic intrusion of worn teeth, mandibular incisors were always the most difficult teeth to treatment plan in the context of a full-mouth rehabilitation. Restoring all of the teeth except the mandibular incisors commonly resulted in a better long-term prognosis for the incisors (Fig 10-13). This is still a legitimate treatment option for the patient who requires extensive restorative dentistry but refuses orthodontic treatment prior to restoration of the teeth.

Fig 10-13 *(a and b)* Patient with severe attrition and erosion (circa 1980). *(c)* Metal framework try-in. Note the unprepared mandibular incisors. *(d)* View 25 years after treatment. Note little change in the mandibular incisors.

Prevention of DAE

DAE has two primary foundational etiologies: abnormal craniofacial development and pathologic tooth attrition/erosion. A unique approach to DAE is to focus on *why* it occurred rather than *how* it can be corrected. While genetics plays a significant role in craniofacial development, epigenetics or the environment can alter the natural growth. If a child is unable to breathe through his or her nose at night and/or during the day, an open-mouth posture will create a more vertical-growing, retrognathic patient.[1,2] The alteration in "ideal" growth may lead to many of the factors that have been identified in the DAE adult. Additionally, recent literature confirms that alterations in airflow can induce a bruxism reaction in an effort to protect the airway.[3,4] Contraction of the muscles responsible for bruxism can improve the airway when the patient is asleep. Bruxism has been postulated as a way to improve airway patency after apneic events as well as a mechanism to prevent the respiratory effort events from building into a significant apnea episode. Research also shows that there is a significant relationship between sleep-disordered breathing and laryngopharyngeal reflux, which may result in tooth erosion.[5]

Early intervention in resolving airway issues may prevent DAE through *(1)* removal of tonsils and adenoids and/or *(2)* orthodontic expansion and protraction of one or both arches. Studies show that the earlier the problem is addressed, the more effective the treatment.[6,7] Strategies should focus on the 4-year-old child as an ideal time to intervene. However, this textbook is devoted to the adult patient in whom the craniofacial component is already determined. Although the Global Diagnosis system is primarily used to develop a treatment strategy for the DAE patient, it also includes a health paradigm in the analysis. Nocturnal and diurnal tooth attrition and erosion should be addressed by prevention rather than maintenance. Traditional treatment options included occlusal adjustment and nightguards. However, the modification of tooth contours has never been shown to produce a reduction in sleep bruxism, and nightguards are limited in their utility. Current treatment protocols include screening the DAE patient for sleep-disordered breathing and treatment strategies for this condition. These treatment options are beyond the scope of this chapter. However, it is incumbent upon dentists who treat patients with attrition and/or erosion to become familiar with the diagnosis of sleep-disordered breathing.

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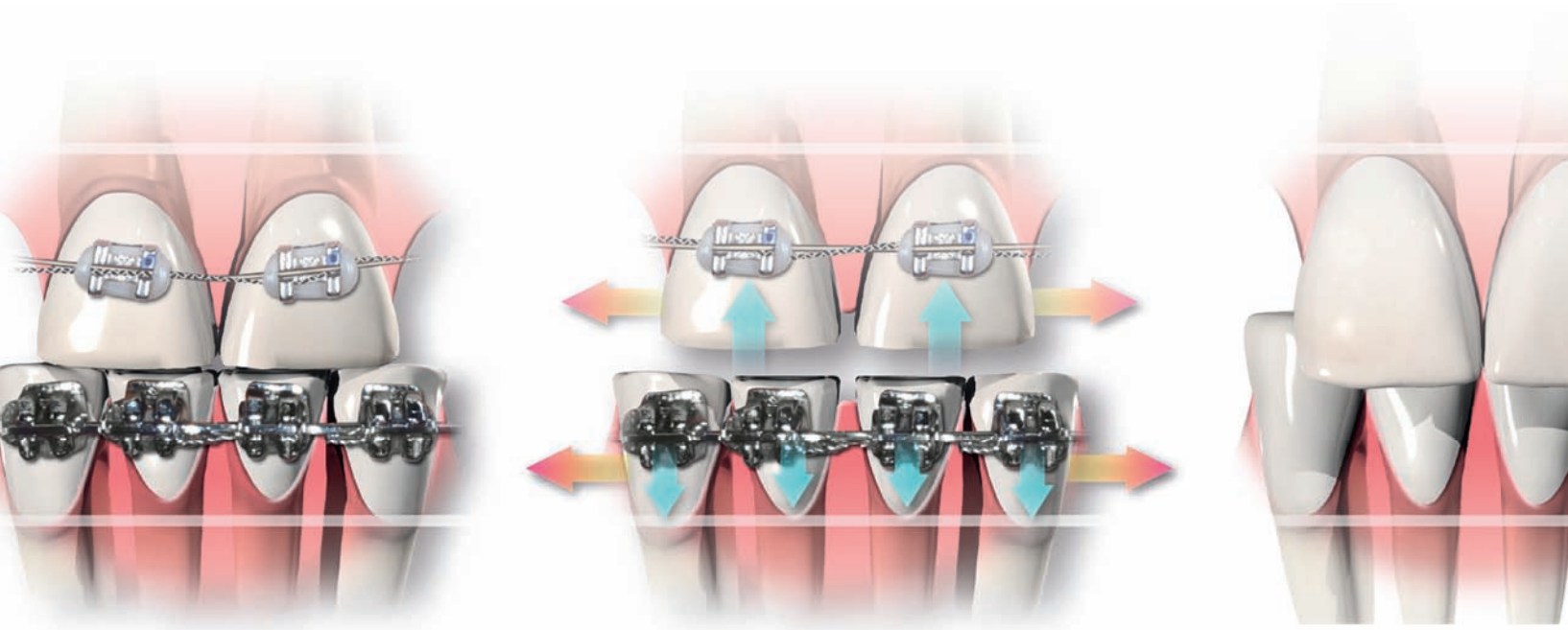

Sequencing the Treatment Plan

11

After the global diagnoses and regional diagnoses are made, the next step is to sequence the definitive treatment plan. This chapter emphasizes the sequencing of periodontal treatment, orthodontic treatment, oral and maxillofacial surgery treatment, and restorative treatment.

Once the global diagnoses are made, an interdisciplinary treatment strategy can be developed. The regional diagnoses (ie, pulpal status, periodontal status, occlusal relationships, etc) can then be evaluated to develop the definitive sequenced treatment plan. If a patient presents with more than one global diagnosis, the sequencing of the treatment becomes critical. Many times, an interdisciplinary treatment plan requires the help of an orthodontist, a periodontist, and an oral and maxillofacial surgeon prior to the definitive restorative therapy. This chapter discusses the sequencing of treatment that has been developed with the global diagnosis concept.

Altered Passive Eruption and Orthodontic Sequencing

It is common for the patient with dentoalveolar extrusion and tooth wear to also require periodontal therapy. This may include esthetic crown lengthening surgery for altered passive eruption (APE) and/or connective tissue grafting for root coverage. APE is a condition in which the gingival tissue does not migrate to its correct position, approximately 1 to 2 mm coronal to the cementoenamel junction (CEJ).[1,2] This normal apical movement of the gingival tissue is termed *passive eruption* and is generally complete at age 15 to 16 years.[3] In order to diagnose APE, two criteria must be met. First, the tooth must be short by measurement. Second, the CEJ must not be detected in the gingival sulcus with an explorer tip. Gingival coverage of the necks of the teeth results in a disproportionally short and square appearance of the teeth and may result in excess gingival display in full smile. The treatment for APE is esthetic crown lengthening surgery[1,2] (see chapter 4). In this procedure, a facial full-thickness flap is reflected, leaving the interproximal papillary tissue in place. The alveolar bone is moved approximately 2 mm apical to the CEJ from facial line angle to facial line angle. The gingival crest is then positioned 3 mm coronal to the new alveolar crest and sutured in place.

When a patient presents with a need for orthodontic therapy and also has APE, sequencing of treatment may become critical. The question arises as to whether the esthetic crown lengthening procedure should be performed before, during, or after orthodontic treatment. The answer is that timing of the esthetic crown lengthening surgery is variable. If the gingival tissue is so excessive that it hinders the placement of orthodontic appliances, the crown lengthening surgery should be done prior to placement of orthodontic appliances. However, this is usually not the case, and timing is generally based on the restorative treatment plan for the patient.

If the patient is diagnosed with APE either before or during orthodontic treatment but has no need for anterior restorative dentistry after completion of orthodontics, esthetic crown lengthening is accomplished after removal of the appliances (Fig 11-1). In this case, final tooth positions are dictated to the orthodontist by the correct incisal edge positions of the maxillary anterior teeth, not gingival levels. It is significantly more difficult to do the esthetic crown lengthening surgery with the orthodontic appliances in place. Additionally, the tissue does not heal as beautifully when surgery is performed during orthodontic treatment. Therefore, when a patient requires no restorative dentistry at the completion of orthodontic therapy, the surgery is accomplished after removal of the appliances.

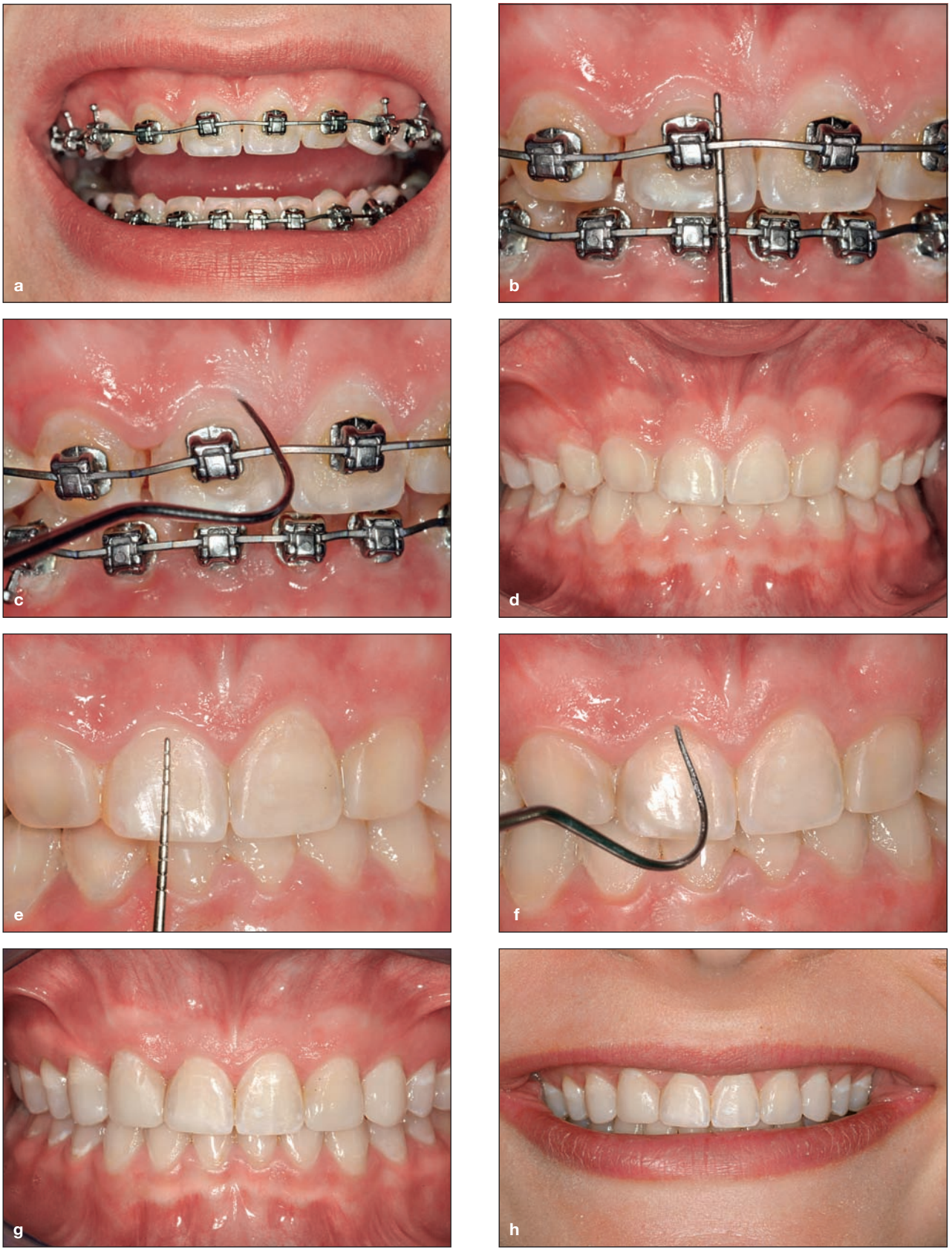

Fig 11-1 *(a to c)* Patient with APE in orthodontic appliances. *(d to f)* The patient still has APE after removal of the orthodontic appliances. *(g and h)* Postoperative views after esthetic crown lengthening surgery.

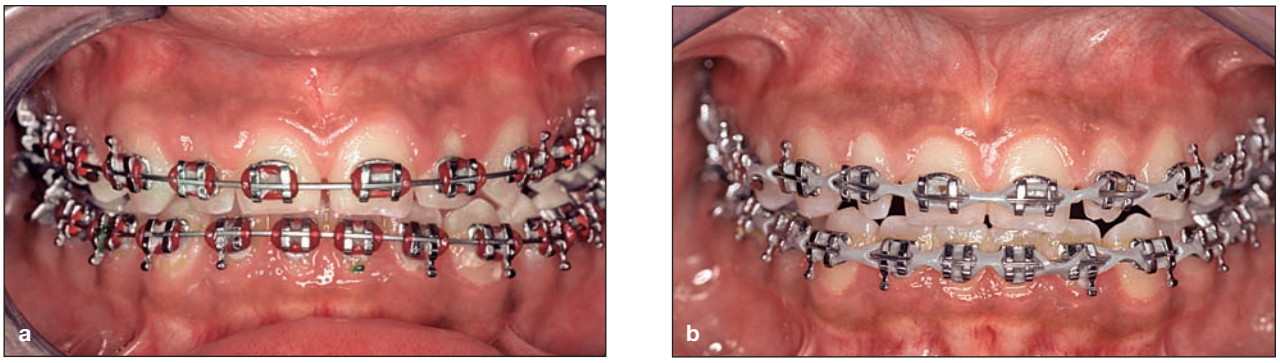

Fig 11-2 *(a)* Preoperative view of a patient with APE in orthodontic appliances. *(b)* Postoperative view after esthetic crown lengthening surgery. Note that the tooth positions were orthodontically changed both apicocoronally and mesiodistally after the surgical procedure.

If the patient will receive restorative therapy at the completion of orthodontics, it is essential that the esthetic crown lengthening surgery be accomplished either before or during orthodontic treatment for two reasons. First, it is impossible to determine the positions of the CEJs in a patient with APE; therefore, it will be impossible for the orthodontist to level the CEJs in an apicocoronal direction. The problem of determining the levels of the CEJs is compounded if there is incisal wear, resulting in supereruption and coronal movement of the CEJs. Once the correct gingival levels in relation to the CEJs are created surgically, the orthodontist can then move the teeth into their desired apicocoronal positions in order to level the gingiva. Second, if there is a tooth-arch discrepancy resulting in excessive interdental space, it is very difficult for the orthodontist to determine the correct spacing of the teeth in a patient with APE. Once the crown lengthening surgery is completed, the correct height-to-width ratios of the teeth can be determined. This allows the orthodontist to move the teeth into their correct mesiodistal positions, which will allow the restorative dentist to create proportional definitive restorations.

When the esthetic crown lengthening surgery is accomplished prior to orthodontic therapy, the gingival tissue will commonly require additional surgical refinement at the completion of orthodontic therapy, due to the inflammation associated with orthodontic appliances. Additionally, gingival surgery cannot be successfully performed on teeth that are crowded or rotated. The teeth must first be correctly aligned orthodontically before the gingival surgery can be accomplished. Therefore, it is the author's opinion that the ideal time for the esthetic crown lengthening surgery is approximately 6 months prior to the removal of the orthodontic appliances. This allows time for the orthodontist to make the final tooth movements prior to debanding. It also allows 6 months of healing time for the tissue, so that the restorative dentistry may be accomplished soon after the patient is debanded.

The 17-year-old patient in Fig 11-2 presented with a maxillary tooth-arch discrepancy resulting in excess interdental spacing (Fig 11-2a). She also presented with APE on her maxillary anterior teeth. Orthodontic treatment was begun to align the teeth, with special emphasis given to the canine tooth positions. Approximately 6 months prior to debanding, the esthetic crown lengthening surgery was performed from maxillary first premolar to first premolar (Fig 11-2b). After debanding, the teeth were in the correct positions for restorative therapy (Figs 11-2c to 11-2e). Porcelain veneer restorations were placed on the maxillary incisors (Figs 11-2f to 11-2h).

Fig 11-2 *(cont) (c to e)* After removal of the orthodontic appliances. *(f to h)* After placement of porcelain veneer restorations.

Surgically facilitated orthodontics

Surgically facilitated orthodontic treatment (SFOT) is a concept that has gained acceptance in recent years.[4–11] It has been known for many years that orthodontic movement occurs more rapidly in the 2 to 4 months following osteotomy cuts associated with orthognathic surgery. The proposed reason for the accelerated movement is termed the *regional acceleratory phenomenon* (RAP). The RAP effect is a regional osteopenia resulting from the activation of the receptor activator of nuclear factor κB ligand (RANKL) pathway/cascade, which creates a significant increase in the number of molecular wound healing mediators, such as chemokines. These chemokines recruit osteoclastic precursor cells and influence their development into mature osteoclasts. The localized transient decrease in bone density is believed to facilitate accelerated tooth movement. Using this concept, the smaller regional osteotomy cuts are made in the areas requiring orthodontic movement. The osteotomies can range from small perforations through the buccal plate to larger osteotomies through the entire buccal plate.

There are several advantages to SFOT. First, the length of orthodontic treatment can be decreased by two-thirds. Second, larger orthodontic movements may be accomplished that would not be possible with traditional orthodontics. Third, with the addition of a bone graft material, along with the osteotomy cuts, teeth may be expanded and protracted into areas that would be impossible with traditional orthodontics. This is especially helpful in patients with a thin biotype and crowding. Fourth, orthodontic movement of teeth is very difficult in patients with a thick bone biotype. The use of SFOT in addition to thinning of the bone facilitates the orthodontic movement.

The sequencing is very important in SFOT. The orthodontic appliances are placed before the surgery. Immediately after the surgery, the appliances are activated. There is a window of opportunity of approximately 2 to 4 months after the surgery during which the teeth will move more rapidly. To maximize the use of this window, the orthodontist sees the patient every 1 to 2 weeks to adjust the appliances. If the orthodontic treatment is not pursued aggressively, the benefit of the surgical procedure is lost in a short period of time.

Root Coverage and Orthodontic Sequencing

With the advent of the connective tissue graft (CTG) procedure, the ability to cover exposed root surfaces has become very predictable. Miller[12] described gingival recession in four categories (Fig 11-3). In Class I recession, there is no loss of interproximal bone or papillary tissue adjacent to the area of recession and an adequate band of attached gingiva. In Class II recession, there is no loss of interproximal bone or papillary tissue, but the band of attached gingiva is inadequate. In Class III recession, there is early loss of interproximal bone and papillary tissue. In Class IV recession, there is significant loss of interproximal bone and soft tissue. As long as the root to be grafted is not too prominent in the arch and the interproximal papillae have normal mesiodistal widths, the probability of 100% root coverage is very high in patients with Class I and Class II recession. With the loss of adjacent interproximal tissue, the probability of 100% root coverage drops dramatically.

There are several circumstances in which the sequencing of the CTG and the orthodontic treatment must be considered. For the adolescent orthodontic patient with minimal and/or thin keratinized tissue, there continues to be a debate regarding the timing of the CTG procedure. Traditionally, the grafting procedure has been done prior to the orthodontic treatment to reinforce the thickness of the gingival tissue. This treatment sequence was developed many years ago, when the less predictable free gingival graft was used for root coverage. However, because of the predictability of the CTG, some periodontal surgeons prefer to wait until there is a definitive need for the grafting procedure. This decision requires clinical judgment based on the prescribed orthodontic movement, the gingival condition, and the age of the patient.

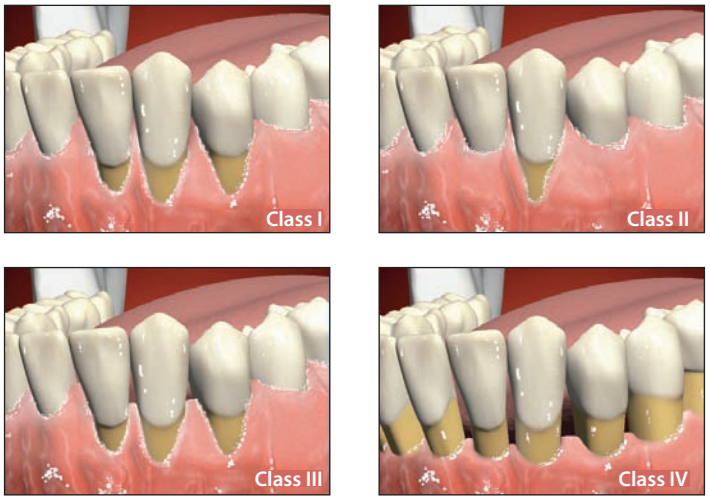

Fig 11-3 Miller classification of gingival recession.

The situation is different in the adult orthodontic patient with a need for root coverage on a tooth that will require a restoration at the completion of orthodontic treatment. If the defect is Miller Class I or II, the graft may be placed before, during, or after the orthodontic therapy. However, if the defect does not lend itself to 100% root coverage (ie, Miller Class III or IV), the CTG should be placed either before orthodontic treatment or prior to removal of orthodontic appliances. Once the CTG is completed and healed, the tooth can be moved apicocoronally to level the gingival crests, prior to removal of the orthodontic appliances and placement of the definitive restoration.

Root Coverage and Restorative Sequencing

When the patient with APE is scheduled to receive restorative therapy, the treatment sequence is obvious. The esthetic crown lengthening surgery is completed prior to the restorative therapy. Ideally, the tissue should be allowed to heal for 6 months prior to tooth preparation to ensure maturity and stability of the tissue.[13]

However, when the restorative patient has gingival recession that will require a CTG, there is no consensus on the preferred treatment sequencing. Some dentists believe the restoration should be completed first, with the crown/veneer margin placed at the correct position to the adjacent gingival margins. The CTG is then placed after the restoration is completed. This sequence ensures that the gingival retraction and impression will not result in recession of the grafted tissue. However, the restorative dentist and the surgeon must have a high level of confidence that the grafted gingival tissue will successfully cover the crown margin. Therefore, the placement of a crown or veneer prior to the CTG would only be attempted in a patient with Miller Class I or II recession.

There is always the possibility that the CTG may not completely cover the root, resulting in an exposed crown/veneer margin (Fig 11-4). For this reason, many dentists believe the preferred sequence is to place the CTG prior to the placement of the definitive restoration (Fig 11-5). Although minimal, the risk of this treatment sequence is that manipulation of the gingival tissue during preparation and impression taking may result in gingival recession.

Fig 11-4 *(a to c)* Preoperative views of a maxillary left canine with Miller Class III wide gingival recession, a prominent buccal position of the root, and a narrow mesial papilla. *(d and e)* Views of the canine after preparation for a porcelain veneer. *(f)* Postrestorative view of the canine after the porcelain veneer has been placed but prior to placement of the CTG. *(g and h)* Postoperative views of the canine after placement of the CTG. Note the incomplete root coverage resulting in a dark shadow at the gingival margin of the porcelain veneer.

Fig 11-5 *(a and b)* Preoperative views of porcelain veneers with marginal staining, gingival recession, and early facial caries. *(c)* Postoperative view after connective tissue grafting of the maxillary anterior teeth but prior to replacement of the porcelain veneers. *(d and e)* Postoperative view after placement of the porcelain veneers.

Fig 11-6 *(a to c)* Preoperative views showing porcelain restorations placed over roots exposed due to gingival recession on the maxillary right and left canines. *(d)* Debonded porcelain veneer on the right canine due to the depth of preparation into dentin. *(e)* Porcelain veneer being removed from the left canine. *(f)* Crown preparation on the left canine with a new crown margin placed more coronally at the corrected position.

If the CTG is going to cover a previously restored root surface, the dentist has two options. First, the entire restoration may be removed, and the new veneer or crown margin may be prepared in the new, more coronal position, followed by placement of a provisional restoration (Fig 11-6). Alternatively, the gingival margin of the existing porcelain restoration may be removed, leaving the desired amount of root exposed for root coverage with the CTG (Fig 11-7). The CTG may then be completed and allowed to heal for 3 to 6 months. Once the gingival margin is deemed stable, the marginal position may be refined to the desired position, and the final impression may be made.

Fig 11-6 *(cont) (g)* Provisional restoration on the left canine. *(h to j)* Three-month postoperative views after CTGs have been placed on the maxillary canines. *(k to m)* Postoperative views with the definitive porcelain restorations in place.

Fig 11-7 *(a and b)* Preoperative views showing excess gingival display on the left side due to dentoalveolar extrusion of the maxillary left posterior teeth. Note that the clinical crown on the maxillary left canine is long (13 mm). *(c)* The gingival margins of the porcelain crowns are removed on the maxillary left lateral incisor and canine to prepare the sites for CTGs. *(d)* CTGs in place. *(e and f)* Postoperative views after placement of the CTGs on the maxillary left lateral incisor and canine and after functional crown lengthening surgery on the maxillary left posterior teeth to treat the dentoalveolar extrusion.

Periodontal–Oral and Maxillofacial Surgery Sequencing

The sequencing of treatment is critical in the patient with both vertical maxillary excess (VME) and APE. The patient with VME presents with a long lower third of the face[14] (Figs 11-8a to 11-8c). This is because of the excessive length of the maxilla, which generally results in excess gingival display in full smile. It is common for the VME patient to also have APE, which adds to the gummy smile (Fig 11-8d). The treatment for VME is orthognathic surgery, a maxillary Le Fort I impaction. As previously discussed, the treatment for APE is esthetic crown lengthening.

When treatment planning the orthognathic surgery, a critical decision that must be made is the amount that the maxilla will be impacted. This decision will affect not only the functional result but also the esthetic outcome of the surgery. In conjunction with the orthodontist and the restorative dentist, the oral and maxillofacial surgeon uses several criteria to determine the amount that the maxilla will be impacted:

- The relationship of the maxillary anterior teeth to the upper lip in repose. The average incisal display in the 30-year-old woman is 3 to 4 mm, and the average incisal display in the 30-year-old man is 1 to 2 mm.[15] The incisal display decreases with age due to lengthening of the upper lip and incisal attrition of the teeth.[16]
- The relationship of the incisal edges of the maxillary anterior teeth to the lower lip in full smile. Ideally, the incisal edges should be cradled by the lower lip in full smile. A few millimeters of space between the maxillary incisal edges and the lower lip can also be esthetically pleasing, as long as the space is uniform.
- The position of the upper lip in relation to the gingival line in full smile. The gingival line is a line drawn from maxillary canine to canine at the tooth-gingiva interface. Both central incisors should be on this line. The lateral incisors can either be on the line or up to 1.5 mm below the line. When the upper lip translates 2 mm or more above the gingival line in full smile, this becomes a significant esthetic detractor.

When treatment planning the VME patient, the primary determinant is the incisal display of the maxillary anterior teeth in repose. If the incisal edges are going to be restored in the future, this must be taken into account. The secondary determinant is the amount of gingival display in full smile. If the patient also has APE (Fig 11-8e), the gingival tissue is not in the correct position on the maxillary anterior teeth; therefore, the gingival line cannot be accurately evaluated. For this reason, the esthetic crown lengthening surgery must always be done prior to the orthognathic surgery so that the real gingival line may be used to aid in the diagnosis of the amount of the maxillary impaction required (Figs 11-8f and 11-8g). In addition, the esthetic crown lengthening surgery has much less morbidity compared with the orthognathic surgery. Upon completion of the gingival surgery (Figs 11-8h and 11-8i), the patient may decide to proceed with the orthognathic surgery (Fig 11-8j) or may be satisfied with the esthetic result and decide not to pursue the orthognathic surgery.

Fig 11-8 *(a)* Patient with VME and APE. *(b)* Middle third measurement. *(c)* Lower third measurement.

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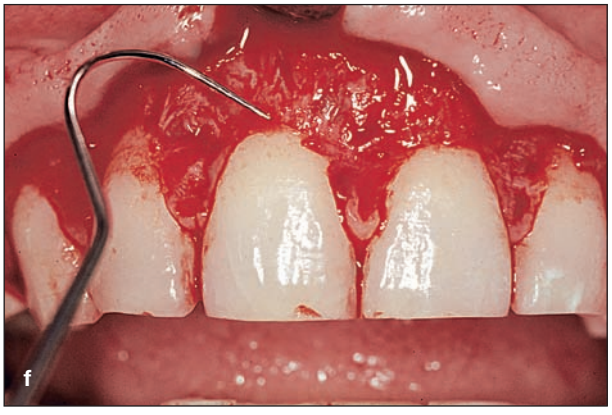

Fig 11-8 *(cont) (d)* Excess gingival display and short teeth. *(e)* Short central incisor (7.5 mm) due to APE and attrition. *(f)* Elevation of a full-thickness flap. The alveolar bone is contiguous with the CEJ. *(g)* The ostectomy has been completed on the right side but not on the left side (for comparison).

Fig 11-8 *(cont) (h and i)* Postoperative views after esthetic crown lengthening. Because of the VME, there was minimal esthetic benefit from the gingival surgery. *(j)* Postoperative view after orthognathic surgery.

Summary

When a patient presents with more than one global diagnosis, sequencing of the treatment plan becomes critical. Interdisciplinary treatment planning commonly includes the orthodontist, the periodontist, and the oral and maxillofacial surgeon, as well as the restorative dentist. It has been the purpose of this chapter to discuss the critical importance of sequencing when treating the interdisciplinary dental patient.

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CORE Questions

	CORE Values	Case Values	Abnormal
Facial Height?	1:1	67:73	☑
Lip Length?	20-22 mm Female 22-24 mm Male	19	☑
Lip Mobility?	6-8 mm	9	☑
Gingival Line?	Straight	Irregular	☑
Tooth Length?	10 mm	8, 7.5	☑
CEJ?	Yes	No	☑
Notes: Buccal Exostosis, Intrinsic Discoloration			

The CORE Template

Bloyce H. Britton III

The accompanying CD provides a treatment-planning template that can be useful to the reader in several circumstances. The template is based on the Global Diagnosis concept and was designed for preparing case presentations for dental study clubs as well as for residents in graduate programs and dental students. It can also be useful in consultations and case presentations for dental patients.

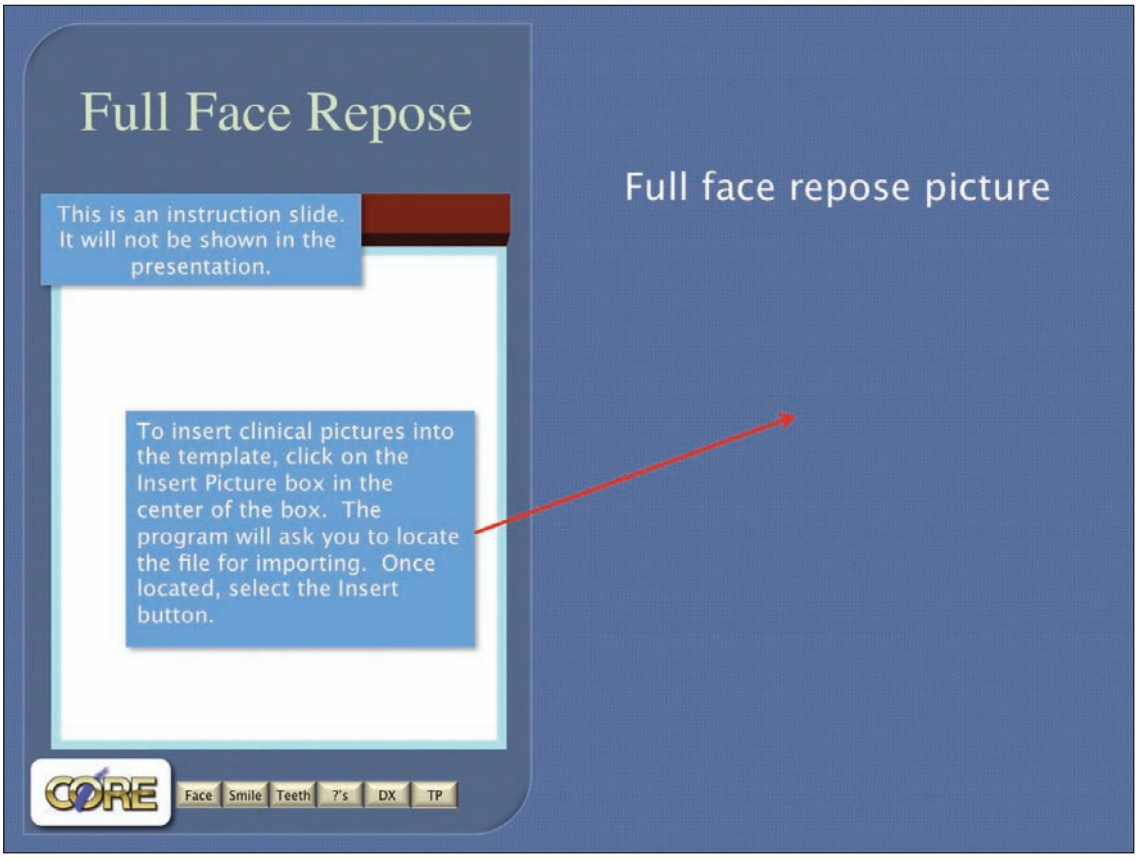
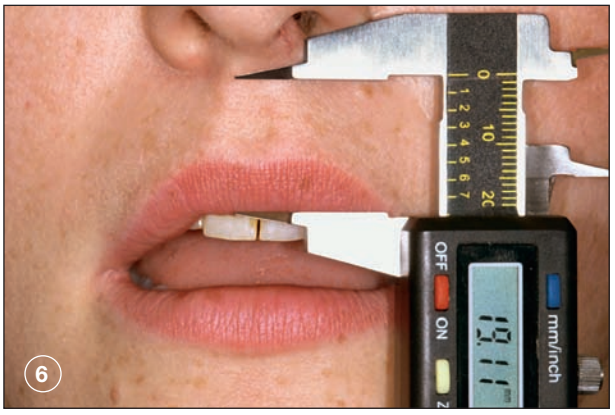


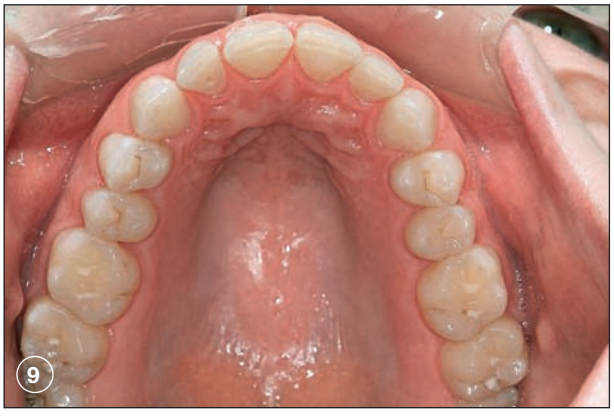
Fig 12-1 CORE template.

The CD contains the blank template along with a template that has been completed to demonstrate to the reader the completed presentation. It is compatible with both Keynote and PowerPoint presentation programs. When using the template, we recommend that a copy of the original template be used to create the presentation so that the master original template can be copied in the future. The CD also contains a blank CORE form that may be downloaded and used in the clinical setting.

The template is very user-friendly and has embedded prompts to help the presenter create the presentation (Fig 12-1). Normal measurements are on the master slides to remind the presenter of the normal numbers during the presentation. Text may be typed into the text boxes, and photographs may be brought into the template. Thirteen photographs are required to complete the template with the appropriate vertical versus horizontal formats (Fig 12-2). At the end of the template is a section for supplemental photographs. This area can be used to add the completed treatment, with intermediate steps and final results.

Fig 12-2 Thirteen CORE Global Diagnosis clinical photographs: *(1)* Full face repose; *(2)* Full face smile; *(3)* Full face profile; *(4)* Middle third of face with caliper; *(5)* Lower third of face with caliper.





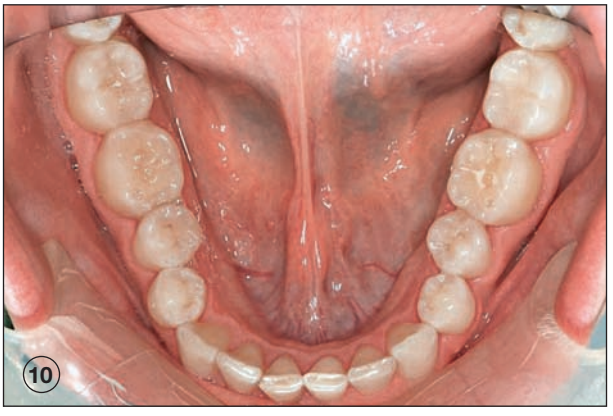
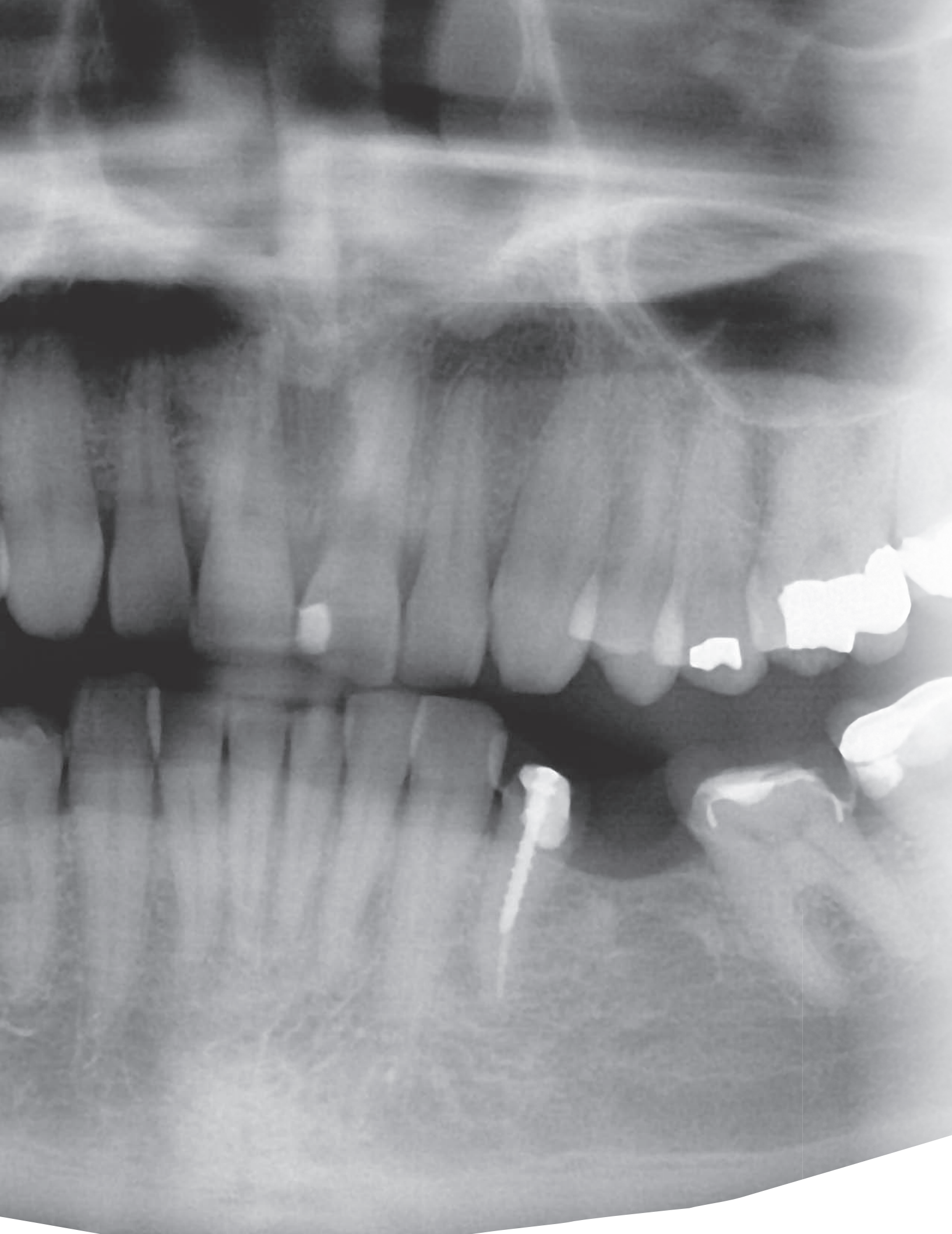


Fig 12-2 *(cont) (6)* Close-up of upper lip with caliper; *(7)* Close-up incisor display in repose; *(8)* Close-up smile; *(9)* Intraoral retracted maxillary arch; *(10)* Intraoral retracted mandibular arch.

Fig 12-2 *(cont) (11)* Intraoral retracted – teeth together; *(12)* Intraoral retracted – teeth apart; *(13)* Incisal plane to horizon.



Case Studies 13

This is the laboratory where we will turn theory into reality. Each case study includes the five questions, global diagnoses, regional diagnoses, risk assessment, and treatment plan. The reader is invited to treament plan each case based on the diagnostic information provided.

Patient #1

Fig 13-1 *(a and b)* Preoperative facial views.

The patient is a 39-year-old entrepreneur who is married with three children. His medical history is noncontributory. He is taking no medications and has no known drug allergies. He has received sporadic dental care in Mexico and has had two dental restorations. He is aware of his nocturnal bruxism but has never worn an oral appliance. His chief complaints: "My front teeth are getting shorter, and I am concerned about continuing wear. Also, I don't like my smile as my teeth are getting shorter."

Five Questions

1. **Face height:** Midface, 65 mm / Lower face, 71 mm
2. **Lip length/mobility:** Length, 22 mm / Mobility, 6 mm
3. **Gingival line:** Concave
4. **Tooth length:** 7 mm
5. **Cementoenamel junction (CEJ) detected:** No

Global Diagnoses

1. Long lower third of the face
2. Dentoalveolar extrusion
3. Altered passive eruption

Fig 13-1 *(cont) (c to e)* Preoperative views. *(f)* Preoperative view showing horizontal attrition of the anterior teeth and mandibular crowding. *(g and h)* Preoperative views showing attrition and erosion of the mandibular molars.

Fig 13-1 *(cont) (i)* Preoperative view of the 7-mm-long central incisor. *(j)* The CEJ cannot be felt in the sulcus.

Regional Diagnoses

1. Attrition on the maxillary and mandibular anterior teeth and mandibular molars
2. Erosion on the maxillary first premolars (minor) and the mandibular molars
3. Inadequate clinical crown height on the mandibular molars
4. Defective restoration on the mandibular left first molar
5. Early interproximal caries
6. Class I occlusion with crowding of the mandibular anterior teeth
7. Hyperkeratosis and pigmentation of the lower lip

Risk Assessment

1. Biomechanical: High
2. Functional: High
3. Periodontal: Low
4. Dentofacial (esthetics): Moderate

Specialty Finding

1. Polysomnogram revealed a severity score of 19.4 on the apnea-hypopnea index.

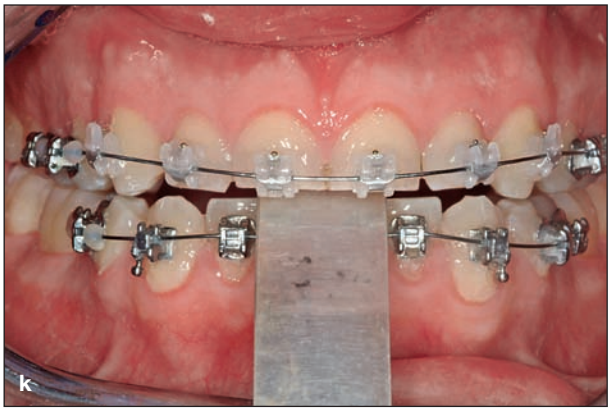
USE THE DIAGNOSTIC INFORMATION PROVIDED TO PLAN THE TREATMENT.

Discussion

The 5 CORE questions revealed that the lower third of the face was longer than the middle third of the face, which would indicate vertical maxillary excess (VME). However, his clinical presentation is not consistent with VME. He does not appear to have a long face, and he does not have excess gingival display in full smile. The reason that his lower face is longer than his midface is due to a large mandible. The 5 CORE questions also indicate that he has altered passive eruption of his maxillary anterior teeth. However, he does not show the maxillary gingival line in full smile; therefore, there is no need for esthetic crown lengthening surgery.

Treatment Plan

1. Implement a caries-control program.
2. Complete functional crown lengthening surgery on the mandibular molars.
3. Place orthodontic appliances to flare and intrude the maxillary anterior teeth and to align the mandibular anterior teeth.
4. Increase the vertical dimension of occlusion by adding composite to the occlusal surfaces of the mandibular molars.
5. Place porcelain veneers on the six maxillary anterior teeth and crowns on the mandibular molars.
6. Use a continuous positive airway pressure (CPAP) mask or mandibular advancement device.



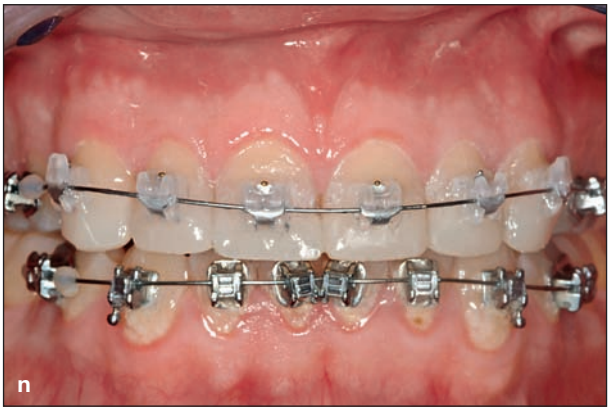


Fig 13-1 *(cont) (k)* Use of a leaf gauge to increase the vertical dimension by a predetermined amount. *(l)* Composite is added to the mandibular molars to increase the vertical dimension with the aid of the leaf gauge. *(m)* New vertical dimension after the addition of composite to the mandibular molars. *(n)* Intermediate composite bonding on the maxillary anterior teeth to facilitate final orthodontic tooth positioning.

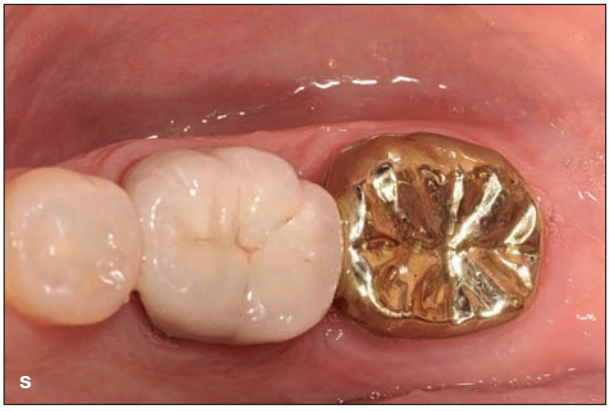


Fig 13-1 *(cont) (o)* Intermediate composite bonding in place after removal of the orthodontic appliances. *(p)* The composite bonding is removed after the orthodontic appliances are removed. *(q and r)* Postoperative views after the placement of porcelain veneers on the six maxillary anterior teeth. *(s)* Restorations on the mandibular molars.

Patient #2

Fig 13-2 *(a)* Preoperative facial view.

The patient is a 57-year-old woman employed as a personal assistant to a company owner. Her medical history includes hypothyroid disease. She is taking levothyroxine 50 mg qd and reports a codeine allergy. She has received sporadic dental care and many dental restorations and is missing some teeth. She is aware of her nocturnal bruxism but has never worn an oral appliance. Her chief complaints: "I am embarrassed by my teeth; they are broken and unattractive."

Five Questions

1. **Face height:** Midface, 62 mm / Lower face, 62 mm
2. **Lip length/mobility:** Length, 23 mm / Mobility, 5 mm
3. **Gingival line:** Canted down on the left
4. **Tooth length:** 11 mm
5. **CEJ detected:** Yes

Global Diagnosis

1. Dentoalveolar extrusion (DAE) with wear and a cant

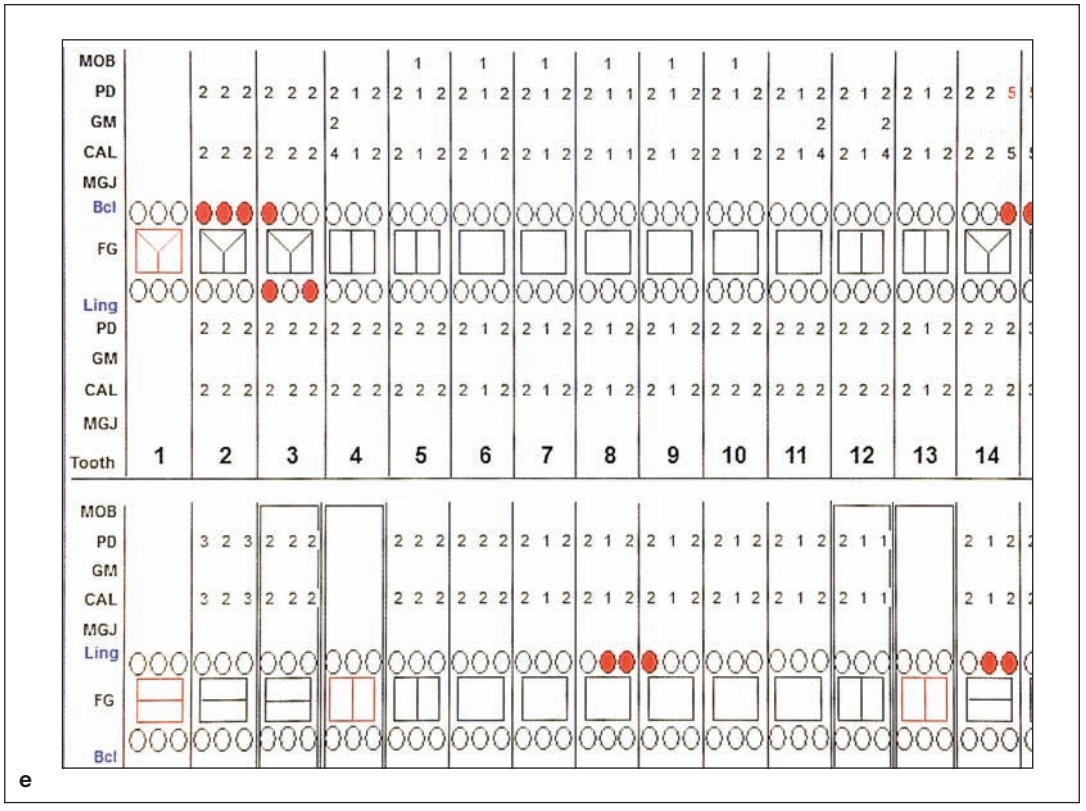


Fig 13-2 *(cont) (b to d)* Preoperative views. *(e)* Periodontal chart.

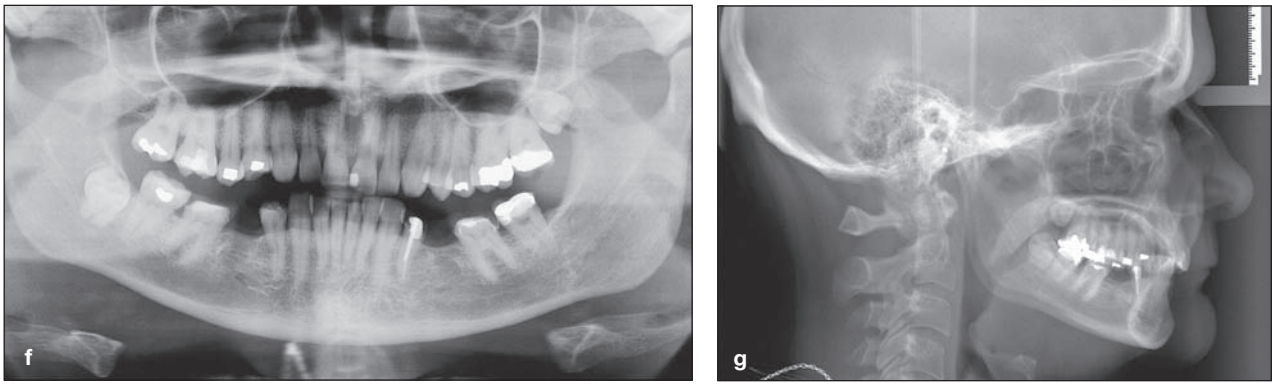


Fig 13-2 *(cont) (f)* Preoperative panoramic radiograph. *(g)* Preoperative cephalometric radiograph.

Regional Diagnoses

1. Attrition on the maxillary and mandibular anterior teeth
2. Missing the mandibular second premolars with bony deficits
3. Caries
4. Impacted maxillary left and mandibular right third molars
5. Two-step occlusion with deep overbite
6. Early periodontal disease

Risk Assessment

1. Biomechanical: High
2. Functional: High
3. Periodontal: High
4. Dentofacial (esthetics): High

USE THE DIAGNOSTIC INFORMATION PROVIDED TO PLAN THE TREATMENT.

Treatment Plan

1. Implement a caries-control program.
2. Perform scaling and root planing in areas of periodontal disease.
3. Increase the vertical dimension of occlusion by adding composite to the occlusal surfaces of the molars.
4. Place orthodontic appliances to intrude and level the maxillary and mandibular teeth.
5. Perform osseous grafting to prepare sites for implants.
6. Place implants in the positions of the mandibular second premolars and mandibular right first molar.
7. Place porcelain veneers on the maxillary anterior teeth.
8. Place crowns on all maxillary teeth and mandibular posterior teeth.

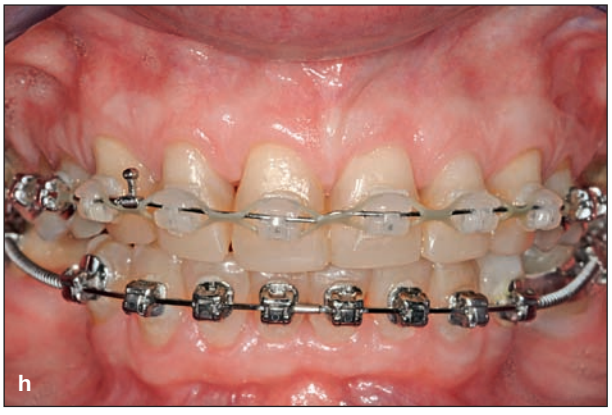


Fig 13-2 *(cont) (h)* View after orthodontic alignment and intrusion. *(i)* View after removal of the orthodontic appliances.

Discussion

Near the end of orthodontic treatment, the patient requested that the orthodontic appliances be removed before the final correction of the canted maxillary occlusal plane. Therefore, there was a minor cant at the conclusion of treatment.

Fig 13-2 *(cont) (j to l)* Postoperative views after placement of all restorations.

Patient #3

Fig 13-3 *(a and b)* Preoperative facial views.

The patient is a 39-year-old family law attorney. Her medical history is noncontributory. She has had infrequent dental care since leaving law school. She is now missing crowns and has fractured restorations. She thinks that she clenches at night but is more aware of her grinding habit during the day. Her chief complaint: "My teeth are getting very short, and I'm worried that I'm not going to have anything left." A review of a photographic history of her tooth attrition provides evidence that a significant amount of the tooth damage has occurred in the past 3 years and the majority of the attrition in the past 10 years.

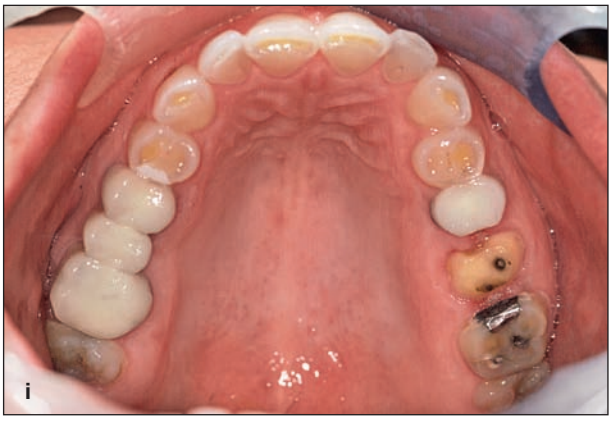
Five Questions

1. **Face height:** Midface, 67 mm / Lower face, 67 mm
2. **Lip length/mobility:** Length, 19 mm / Mobility, 10 mm
3. **Gingival line:** Irregular
4. **Tooth length:** 7.5 mm
5. **CEJ detected:** Yes

Global Diagnoses

1. Short upper lip
2. Hyperactive upper lip
3. Dentoalveolar extrusion with wear

Fig 13-3 *(cont) (c to h)* Preoperative views from 2008, 1 year before treatment began.



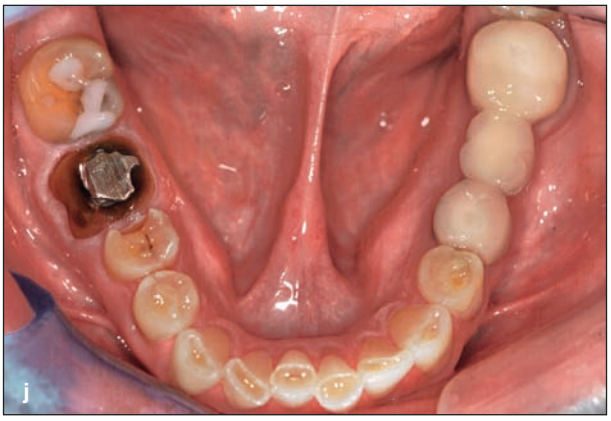


Fig 13-3 *(cont) (i and j)* Preoperative views from 2008, 1 year before treatment began.

Regional Diagnoses

1. Pathologic attrition of all maxillary and mandibular teeth
2. Missing the maxillary left first molar and the mandibular right first molar with a bony deficit
3. Root caries on the maxillary left lateral incisor and canine
4. Generalized erosion on buccal and occlusal surfaces
5. Restoration of buccal erosion and caries on the maxillary right first premolar to left central incisor, the maxillary left first premolar, and the mandibular right canine and first premolar
6. Missing crowns on the maxillary right and mandibular left first molar, and missing a restoration on the distal of the mandibular left second premolar
7. No overjet or overbite (0 mm) in the anterior and a crossbite in the right posterior quadrant
8. Inadequate clinical crown height on the mandibular left first and second molars
9. Soft tissue impaction of the mandibular left third molar

Risk Assessment

1. Biomechanical: High
2. Functional: High
3. Periodontal: Low
4. Dentofacial (esthetics): High

Specialty Finding

1. Sleep airway evaluation shows upper airway resistance syndrome.

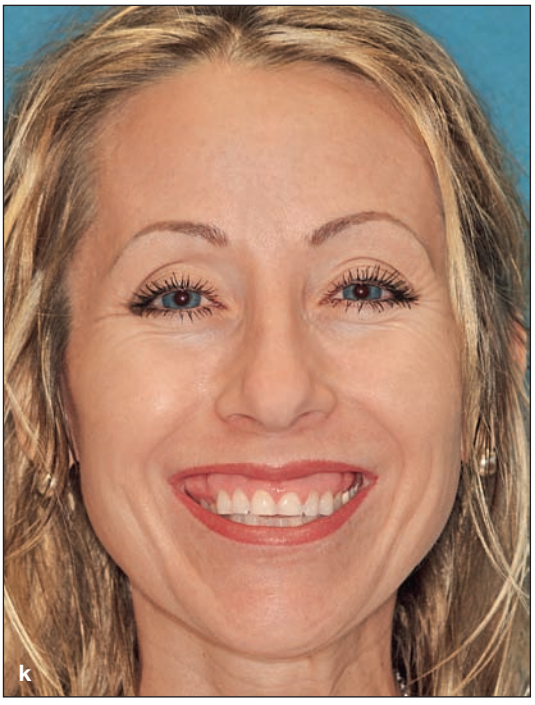
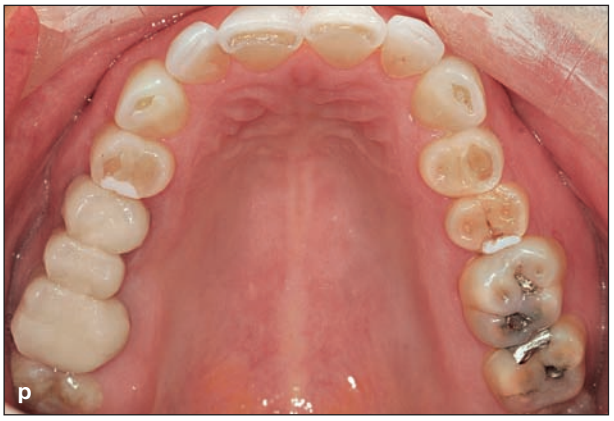


Fig 13-3 *(cont) (k to o)* Preoperative views from 2005. Note the rate of wear in just 3 years.



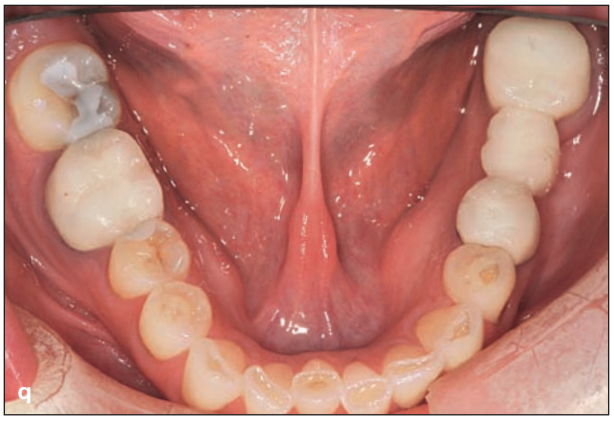


Fig 13-3 *(cont) (p and q)* Preoperative views from 2005. Note the rate of wear in just 3 years. *(r to u)* Historical evaluation of wear: No apparent wear in 1985 *(r)*, wear insignificant in 1996 *(s)*, incisal wear is observable in 2000 *(t)*, and anterior tooth wear and dentoalveolar extrusion are obvious in 2004, making the smile unesthetic *(u)*.

USE THE DIAGNOSTIC INFORMATION PROVIDED TO PLAN THE TREATMENT.

Treatment Plan

1. Implement a caries-control program.
2. Provisionalize the maxillary right and mandibular left first molars.
3. Resolve the maxillary dentoalveolar extrusion with absolute orthodontic intrusion of the maxillary arch using palatal and buccal temporary anchorage devices (TADs). The maxillary canines and maxillary second molars will be intruded secondarily to maintain the current vertical dimension of occlusion.
4. Perform maxillary anterior crown lengthening from first premolar to first premolar before the completion of intrusion to assist in aligning the CEJs.
5. Perform functional crown lengthening on the mandibular left first and second molars, and extract the mandibular left third molar.
6. Place an implant in the position of the mandibular right first molar, and close the edentulous space at the site of the maxillary left first molar orthodontically.
7. Resolve the mandibular dentoalveolar extrusion by increasing the vertical dimension of occlusion.
8. Place porcelain veneers on the maxillary anterior teeth (canine to canine) and porcelain crowns on the maxillary posterior teeth.
9. Place porcelain veneers on the mandibular anterior teeth (canine to canine) and porcelain crowns on the mandibular posterior teeth (excepting the mandibular right first molar, which will receive an implant).

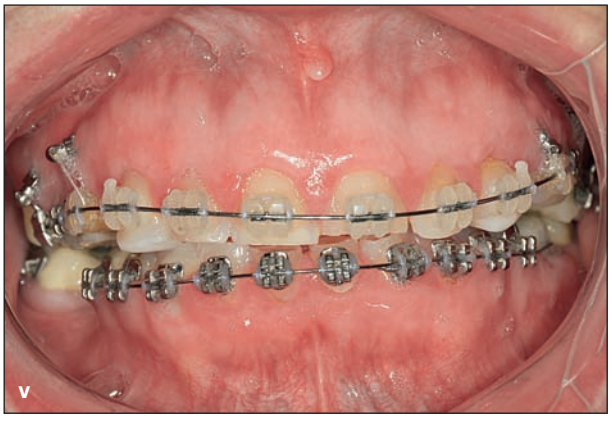
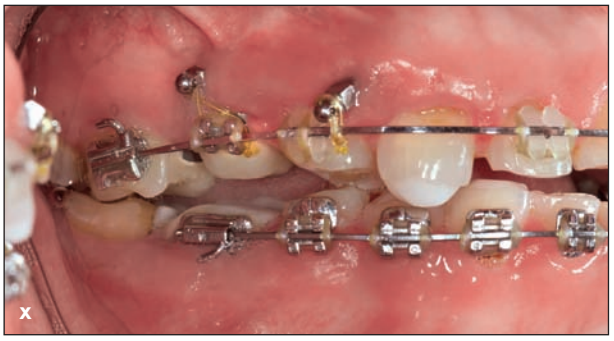
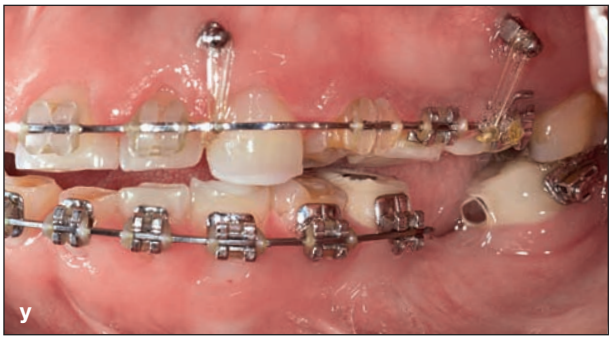
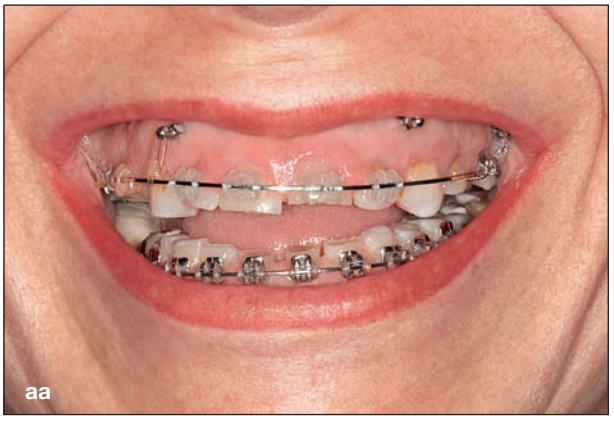


Fig 13-3 *(cont) (v)* Four miniscrew TADs are engaged as indirect anchorage. *(w)* Palatal TAD.







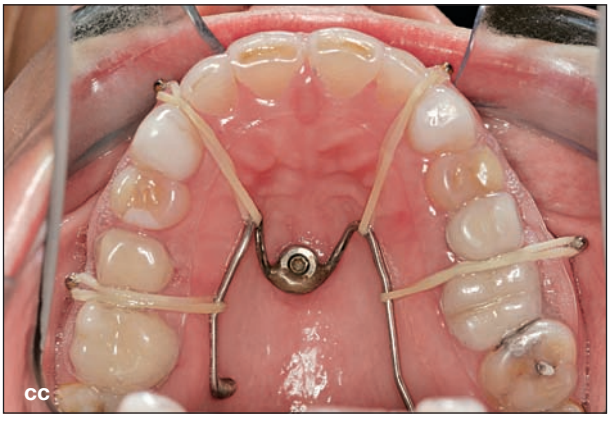
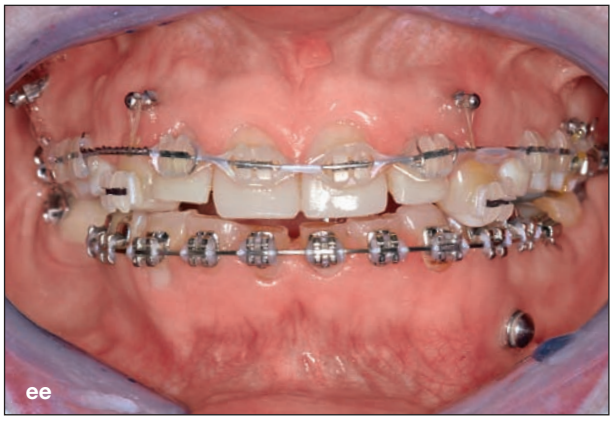
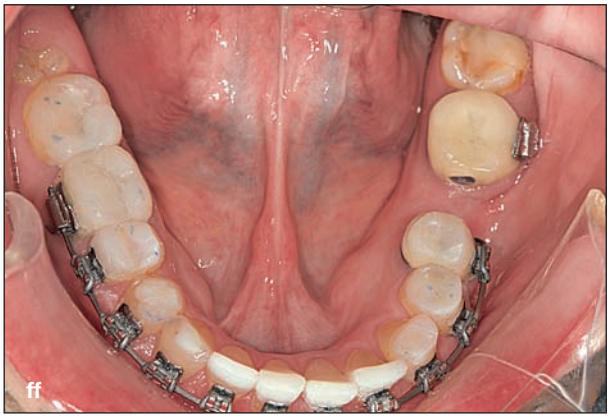


Fig 13-3 *(cont) (x to z)* After the arches were leveled, the maxillary canines and second molar brackets were removed to maintain the patient's existing vertical dimension of occlusion. *(aa)* Intrusion successfully alters the dentoalveolar complex. Bonding of composite to the teeth to accomplish natural tooth length and width will assist in the finalizing of orthodontics. *(bb and cc)* Immediately after the brackets are removed for bonding, an Essix retainer is fabricated. TADs assist in retention of the appliance and teeth.





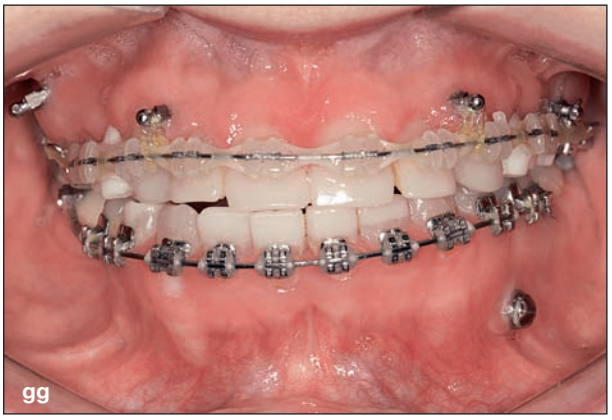


Fig 13-3 *(cont) (dd)* Gingival recontouring and provisional bonding. *(ee)* Brackets are placed on the new bonding. *(ff to hh)* Provisional bonding of mandibular teeth.

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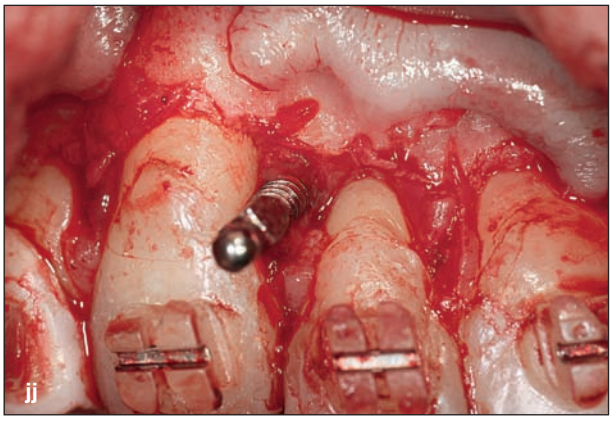


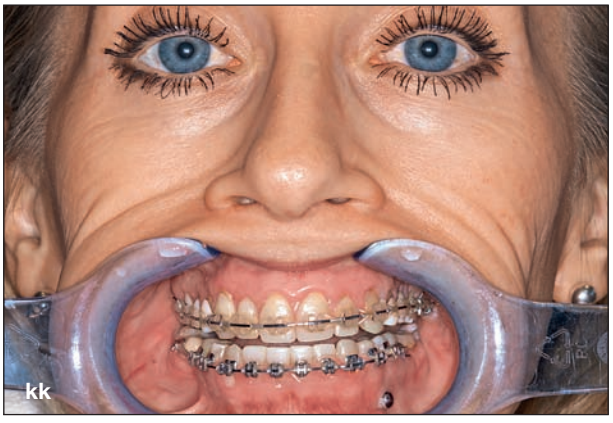
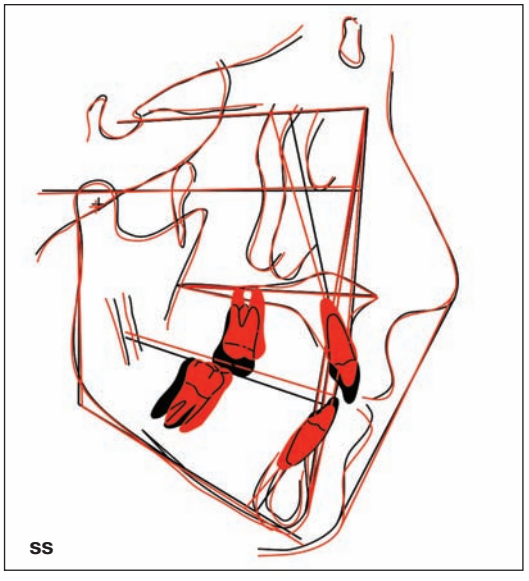


Fig 13-3 *(cont) (ii and jj)* Esthetic crown lengthening surgery and anterior TAD removal. The tooth position as it relates to the miniscrew demonstrates the amount of intrusion. *(kk)* During the completion phase, the maxillary arch had begun to cant downward on the right. *(ll)* Prerestorative orthodontics complete. *(mm and nn)* The brackets are removed, and provisional restorations are fabricated. Functional crown lengthening is performed on the mandibular left first and second molars, and the mandibular left third molar is extracted. →

Fig 13-3 *(cont) (oo)* Definitive restorations. *(pp)* Smile with ideal gingival architecture and display. *(qq)* Final natural smile. *(rr)* Animated smile. *(ss)* Cephalometric overlay of the preoperative and postoperative tooth positions demonstrating the significant absolute intrusion of the maxillary anterior and posterior teeth.



Discussion

This case exemplifies the advantage of a systematic approach to treatment planning. The Global Analysis Diagnosis system organizes the complex decisions into a sequential system that reduces diagnostic errors and minimizes missteps in planning. Because of the even excessive gingival presentation, the patient appears to have VME. However, the first question eliminated that when the ratio was 1:1. Once a diagnosis of DAE was reached, the smile design guidelines eliminated crown lengthening as an option to align the gingival architecture.

There are several additional important notes:

1. The vertical dimension of occlusion was maintained throughout the intrusion by eliminating the maxillary canines and second molars from the initial intrusion. Because the wear was so severe, the arch dimension had been lost. Intrusion had to be accompanied by expansion. The mandibular teeth become a guide to the amount of intrusion, the incisal angulation, and the arch width.
2. The problem with utilizing the canines as a marker for occlusal vertical dimension is that the smile quickly became unesthetic. Earlier intervention with bonding could have improved the smile, but with further tooth movement the bonding would have required modification or refabrication. This should be planned into the cost of the rehabilitation.
3. When the brackets are removed, the teeth must be retained immediately. In this case, an Essix appliance was fabricated when the brackets were removed for bonding. The day the bonding was completed, a new Essix was delivered. When the orthodontic treatment is completed, a retainer should be delivered within 24 hours. After provisional restorations are inserted and after new restorations are delivered, new retainers should be provided the same day.
4. The bonding of tooth form must follow the contours and angulations of the teeth, not the desired tooth position. If the restorative dentist attempts to correct the teeth, the final root positioning and tooth spacing will be incorrect.
5. In complex therapy, the restorative dentist is obligated to examine the patient and confirm that the orthodontic goals have been met before the brackets are removed. During the completion phase of prerestorative orthodontics, the patient is appointed with the restorative dentist before the orthodontic visit. If that sequence is followed, complications detected by the restorative dentist can be immediately addressed.
6. The patient's sleep and airway was monitored before, during, and after orthodontic treatment to determine the impact of her treatment. In this case, an overall improvement was documented.

Patient #4

Fig 13-4 *(a)* Preoperative facial view.

The patient is a 24-year-old caregiver and student. Her medical history is noncontributory. She has not received dental care since leaving for college. Orthodontics was completed in high school, along with routine periodontal prophylaxis. Her reason for seeking care: "I have always hated that I had short teeth. I met a lady through my work that said my teeth could be made longer."

Five Questions

1. **Face height:** Midface, 68 mm / Lower face, 68 mm
2. **Lip length/mobility:** Length, 22 mm / Mobility, 7 mm
3. **Gingival line:** Straight
4. **Tooth length:** 7 mm
5. **CEJ detected:** No

Global Diagnosis

1. Altered passive eruption

Fig 13-4 *(cont) (b to f)* Preoperative views.

Regional Diagnoses

1. Caries on the maxillary right first and second molars and the mandibular right first molar
2. Microdontia of the maxillary lateral incisors
3. Pathologic incisal edge attrition on the maxillary left central incisor and mandibular central incisors from diurnal protrusive clenching
4. Class I occlusion with mandibular anterior crowding
5. Diastemas distal to the maxillary canines
6. Upper lip asymmetric over the left lateral incisor

Risk Assessment

1. Biomechanical: High
2. Functional: Moderate
3. Periodontal: Low
4. Dentofacial (esthetics): High

USE THE DIAGNOSTIC INFORMATION PROVIDED TO PLAN THE TREATMENT.

Treatment Plan

1. Implement a caries-control program.
2. Perform esthetic crown lengthening surgery on the maxillary teeth (first molar to first molar).
3. Start cognitive-behavioral therapy to reduce the habitual clench.

Fig 13-4 *(cont) (g and h)* Full-thickness flap reflection; bone is contiguous with the CEJ of the central incisors. *(i)* Osseous festooning interproximally and recontouring facially 2 mm apical to the CEJ. *(j)* Immediate postoperative view. *(k)* One-week postoperative view.

Fig 13-4 *(cont) (l to o)* Postoperative views after 1 month. *(p)* Postoperative view at 4 years.

Discussion

The patient was informed of the diurnal wear pattern on her left central incisor but chose not to pursue cognitive-behavioral therapy to reduce the frequency of protrusive tooth clenching. Her 4-year postoperative view demonstrates continued wear.

Her upper lip asymmetry was noted before treatment, and the crown lengthening procedure accentuated the problem. However, the patient chose not to proceed with Botox (Allergan).

Patient #5

Fig 13-5 *(a)* Preoperative facial view.

The patient is a 25-year-old part-time dental assistant and a mother. Her medical history is noncontributory. She is taking no medications and has no known drug allergies. She has no restorations and completed orthodontics when she was 15 years old. Her chief complaint: "I do not like how gummy my smile looks."

Five Questions

1. **Face height:** Midface, 62 mm / Lower face, 72 mm
2. **Lip length/mobility:** Length, 18 mm / Mobility, 6 mm
3. **Gingival line:** Downward on the maxillary lateral incisors
4. **Tooth length:** 11 mm (central incisors), 7 mm (lateral incisors)
5. **CEJ detected:** No on the maxillary lateral incisors

Global Diagnoses

1. Long lower third of the face
2. Short upper lip
3. Altered passive eruption of the maxillary lateral incisors

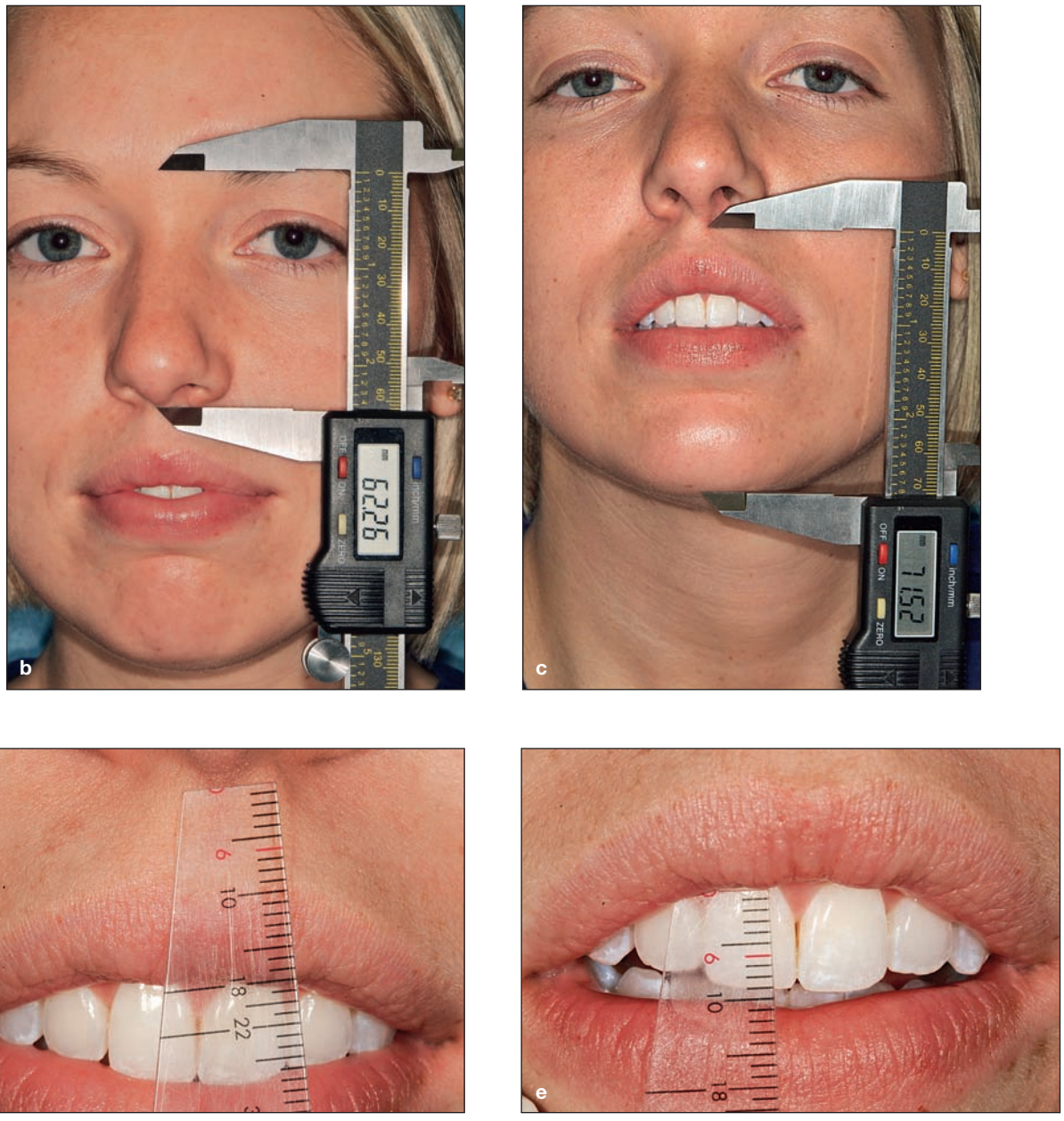


Fig 13-5 *(cont) (b to h)* Preoperative measurements required to complete the "five questions."

Regional Diagnoses

1. Generalized intrinsic white staining
2. Minor incisal edge wear on the mandibular central incisors

Risk Assessment

1. Biomechanical: Low
2. Functional: Low
3. Periodontal: Low
4. Dentofacial (esthetics): High

USE THE DIAGNOSTIC INFORMATION PROVIDED TO PLAN THE TREATMENT.

Treatment Plan

1. Use Botox to attempt to mask the short lip and VME. If acceptable, continue to use Botox at 3- to 6-month intervals. If not acceptable, refer for orthognathic surgery consultation.
2. Perform esthetic crown lengthening on the maxillary lateral incisors.

Fig 13-5 *(cont) (i)* Postoperative smile. Botox has satisfactorily managed the gummy smile. *(j)* Final animated smile presentation.

Discussion

There are two important points of note:

1. VME is treated with orthognathic surgery. In this case, however, it was determined that the esthetic and functional advantages of surgery did not outweigh the surgical risk.
2. The altered passive eruption on the lateral incisors is more visible with the smile altered. Without a systematic diagnostic scheme, details like this may be missed until they become obvious, which can be too late. In this case, the patient was aware of the condition but declined esthetic crown lengthening surgery.

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