Imaging Dentofacial Traits 4

Diagnostic imaging of the dentofacial complex serves two important functions in clinical orthodontic practice. First, as was discussed in Chapter 2, imaging is a fantastic tool for enhancing communication between the doctor and the patient and/or the patient's parents. Second, imaging allows visualization of anatomic relationships that might not have been readily discernible during the clinical examination, further enhancing the orthodontist's ability to assess variation in dentofacial traits. Imaging can be categorized as either dynamic or static. Dynamic imaging is acquired from digital videography. Static imaging is obtained from stereo photogrammetry, conventional computed tomography (CT), cone-beam computed tomography (CBCT), and digital or plaster modeling of the dentition. The goal of this chapter is to discuss the latest and most advantageous imaging methods used in contemporary orthodontic practice and to explain how these tools assist the orthodontist in describing the spatial orientation of dentofacial traits.

Clinical Imaging Techniques

Dynamic Imaging

Digital Videography

Digital video and desktop computer software enable the orthodontist to record and view the idiosyncrasies of facial animation, such as speaking and smiling. The animated smile occurs at a faster rate than the human eye can process in real time. In fact, it often happens in less than a second (Ackerman 2003). Essentially, digital video records the equivalent of 30 still frames per second. A 5-second video clip of the patient will yield approximately 150 still frames for analysis. Thus, a very short video clip affords the orthodontist visualization of the range of lip–tooth relationships during speech and smiling.

Digital video should be taken in a standardized fashion with the camera at a fixed distance from the patient and the patient in natural head position (Fig. 4.1).

Figure 4.1 Digital video should be taken in a standard-ized fashion with the camera at a fixed distance from the patient and the patient in natural head position. In the author's practice, the digital video camera is mounted on a converted push-grip microphone stand. This set-up permits greater mobility than a traditional tripod. A built-in level positions the lens perpendicular to the true hori-zontal. The imaging studio uses ambient lighting; however, most digital video cameras give the user the option of attaching a supplemental light source.

Figure 4.2 Digital video players allow slow motion assessment of the dynamic smile. This still frame of an unstrained posed social smile was acquired from Quick-Time Player Pro (Apple Computer, Inc., Cupertino, California).

Most digital video recorders have a view-finder and a liquid crystal display (LCD) for viewing the subject while recording. The orthodontist should compose the smile in the LCD such that the base of the nose, the base of the chin, and several millimeters lateral to the commissures form the boundaries of the smile. At the present time, an ear-rod from a radiographic head holder is used to stabilize the patient's head, which eliminates any blur-riness or chatter in the recording. Younger patients tend to bob their heads more than do adults when speaking. The patient is asked to say a short phrase and then asked to smile. Passive coaching encourages the patient to give a natural unstrained posed social smile followed by an enjoyment smile. The clinical assistant merely instructs the patient to "smile." Once the patient has given a natural unstrained posed social smile, the assistant will then ask for a "real big" smile in the hope of eliciting an enjoyment smile. The raw digital video is downloaded to the computer desktop, then compressed and saved in the .mov or .avi file type (Fig. 4.2). Digital video players allow slow motion assessment of the dynamic smile.

The orthodontist should review the video clip and select the smile frame that best rep-resents the patient's natural unstrained posed social smile. Quantitative and qualitative analysis of lip–tooth–gingival relationships as described in Chapter 3 are easily accom-plished with the aid of digital videography. As well, the orthodontist can review the video clip with the patient in order to famil-iarize the patient with his or her own smile. There are some preliminary data supporting the idea that clinicians can train their adult patients to give repeatable social smiles over time (Dong et al. 1999). However, there is questionable repeatability of posed social smiles in children. It has been postu-lated that adolescents undergo a matura-tional sequence in learning how to smile (Ackerman et al. 1998).

Static Imaging

Stereo Photogrammetry

Photogrammetry is defined as "the art, science, and technology of obtaining reliable information about physical objects and the environment through processes of recording, measuring, and interpreting photographic

images and patterns of recorded radiant electromagnetic energy and other phenomena" (McGlone 2004). Photogrammetry can also be thought of as the sciences of geometry, mathematics, and physics that use the image of a three-dimensional scene on a two-dimensional piece of film to reconstruct a reliable and accurate model of the original three-dimensional scene. Stereo photogrammetry is based on the concept of stereo-viewing, which is rooted in the fact that humans naturally view their environment in three dimensions. Each eye sees a single scene from slightly different perspectives. The brain deciphers the difference, makes a computation, and then conveys the third dimension.

Applying the sophisticated principles of stereo photogrammetry, the orthodontist can use a commercially available array of digital cameras to perform surface imaging of the patient's face (Fig. 4.3).

A quick scan will generate a clinically accurate three-dimensional digital model of the patient's face (Fig. 4.4).

Proprietary software is used for image manipulation and volumetric measurement. By rotating the image along its vertical axis on the computer screen, the orthodontist can simulate how observers perceive a patient's facial appearance. The three-dimensional rendering of the patient's face enhances the orthodontist's ability to discuss global and regional variation in dentofacial traits during the doctor–patient conference.
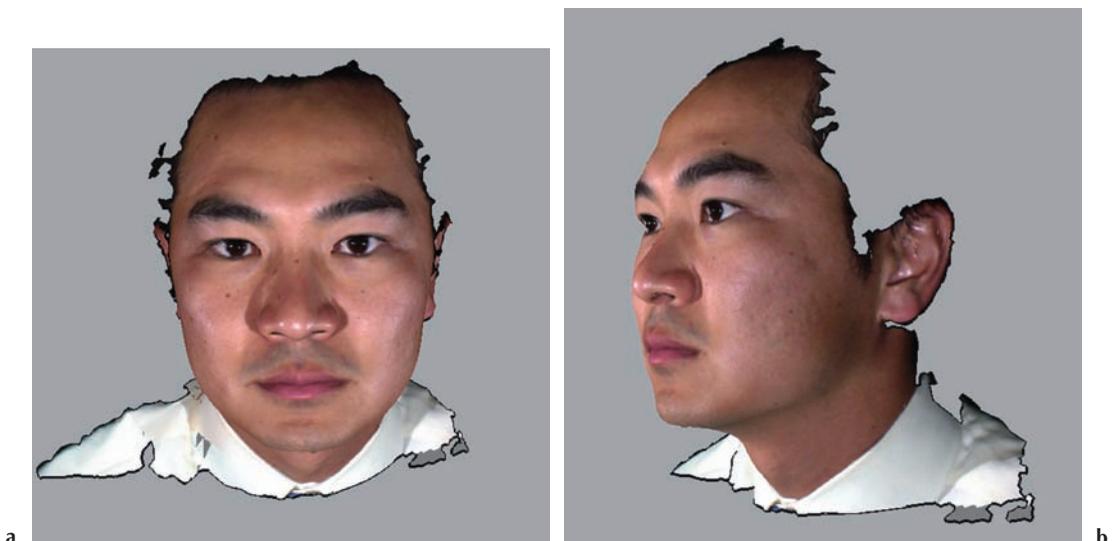
Figure 4.3 The 3dMD stereo photogrammetric scanner (3dMD, Atlanta, Georgia). It consists of an array of digital cameras used to perform surface imaging of the patient's face. A quick scan will generate a clinically accurate three-dimensional digital model of the patient's face.

a

b

Figure 4.4 An actual 3dMD facial scan. (**A**) Frontal view. (**B**) Oblique view. (Images courtesy of Dr. Hideo Nakanishi, Department of Orthodontics, Temple University School of Dentistry, Philadelphia, Pennsylvania.)

Conventional Computed Tomography

CT is a method of patient imaging in which a thin x-ray beam rotates around the patient. Small detectors measure the amount of x-rays that pass through the particular area of interest. A computer analyzes the data to construct a cross-sectional image. These images can be stored, viewed on a monitor, or printed on film. In addition, stacking the individual images, or slices, can create three-dimensional models of patient anatomy. As the CT scanning takes place, the table will advance the horizontally lying patient at small intervals through the scanner. Modern spiral CT scanners can perform the examination in one continuous motion. Generally, complete scans will only take a few minutes. However, additional contrast-enhanced or higher-resolution scans will add to the scan time. The latest multidetector scanners can image an entire body, head to toe, in less than 30 seconds.

CT and three-dimensional imaging techniques are essential for assessing impacted teeth (Ericson and Kurol 1988, Chen et al. 2006). From a diagnosis and treatment-planning standpoint, the orthodontist must precisely establish the spatial position of an impacted tooth in relation to adjacent roots and other anatomical structures and then devise a mechanotherapy that avoids collateral damage. From a risk management standpoint, the clinician should know if there is any existing root resorption or pathology that has occurred due to the ectopically erupting or impacted tooth and then inform the patient of the risks associated with orthodontically assisting the eruption of that tooth (Fig. 4.5).

Conventional planar radiography is incapable of predictably detecting whether initial resorption has occurred on the palatal or labial aspect of roots adjacent to impacted teeth. Many therapeutic misadventures could be avoided by using CT imaging to guide surgical exposure and orthodontic movement of ectopic teeth.

Cone-Beam Computed Tomography

CBCT is specifically designed to image the hard tissues of the dentofacial complex. Conventional CT scanning is achieved through a helical fan-beam, providing thin-sliced images in the axial plane. The CBCT technique involves the patient seated in the scanner with the x-ray source and reciprocating detector synchronously moving around the patient's head in a single 360-degree scan (Fig. 4.6).

CBCT provides the orthodontist with a "real-time" image in the axial plane as well as two-dimensional images in the coronal, sagittal, and even oblique planes. This process is referred to as multiplanar reformation (Scarfe et al. 2006). CBCT data are also receptive to reformation in a volume, rather than a slice, which provides three-dimensional reconstructions (Fig. 4.7).

CBCT provides distinct images of highly contrasted anatomical structures and in particular is very useful for evaluating bone (Sukovic 2003) (Fig. 4.8).

The advantages of CBCT versus CT are (1) x-ray beam limitation (lower radiation dose) (Cohnen et al. 2002), (2) image accuracy (higher resolution due to isotropic voxels [equal in three dimensions]), (3) rapid scan time (averaging 10–70 seconds), (4) images that can be viewed immediately on the computer screen in a clinical office setting, (5) reduced image artifact (due to any metal in the oral cavity), and (6) lower cost. For these reasons, CBCT is rapidly supplanting conventional CT and conventional radiography in clinical orthodontic practice. The practice of routinely taking lateral radiographs of the skull is unwarranted. These two-dimensional plane films provide tremendously little insight into the three-dimensional spatial orientation of the hard-tissue components of the dentofacial complex.

Modeling the Dentition

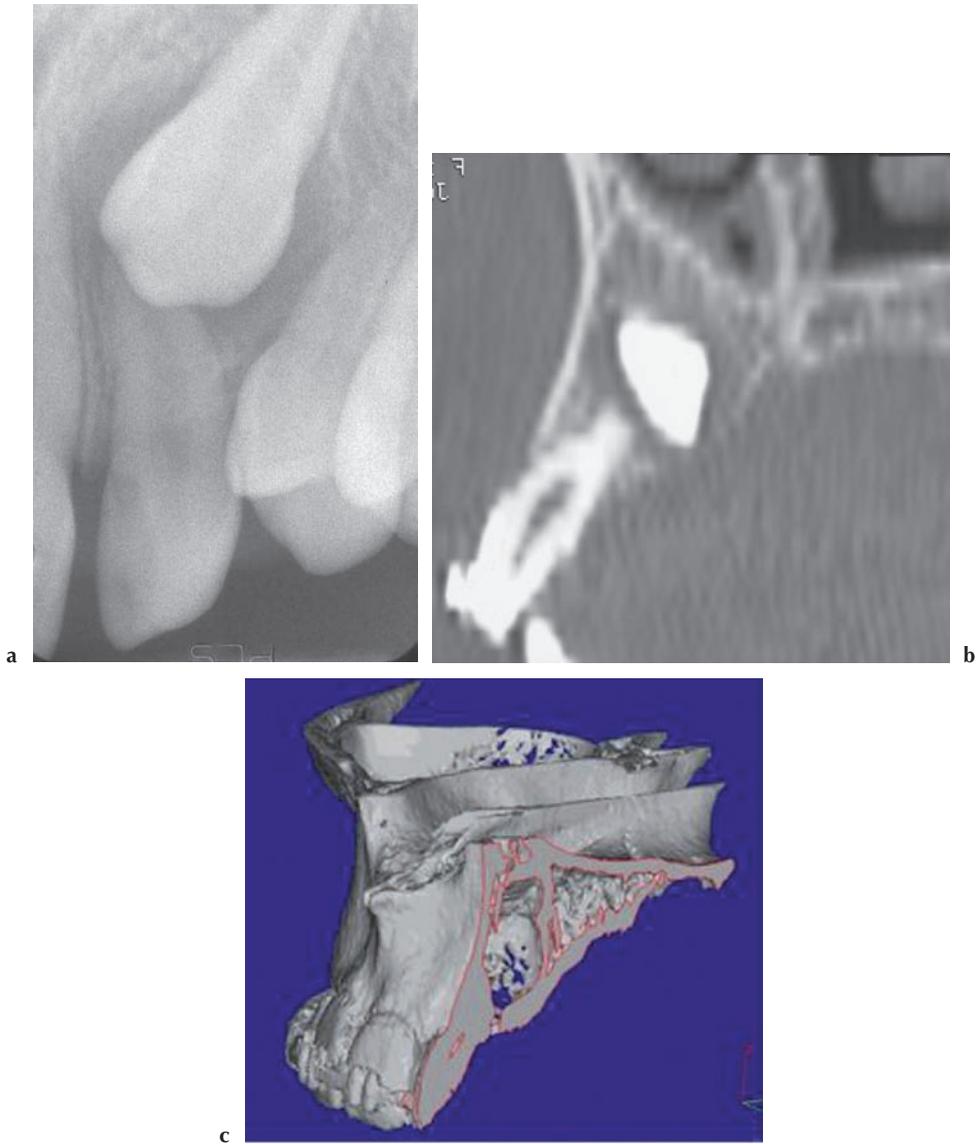Plaster models of the teeth, the traditional diagnostic record from the inception of

Figure 4.5 CT and three-dimensional imaging techniques are essential for assessing impacted teeth. From a diagnosis and treatment-planning standpoint, the orthodontist must precisely establish the spatial position of an impacted tooth in relation to adjacent roots and other anatomical structures and then devise a mechanotherapy that avoids collateral damage. (**A**) A periapical x-ray indicates that tooth No. 11 is ectopically erupting. The tooth was not palpable intraorally and other radiographs determined that it was palatally impacted. (**B**) A slice from a spiral CT scan clearly shows resorption of the root of tooth No. 10. (**C**) A three-dimensional reconstruction of the patient's maxilla, sectioned through the long axis of tooth No. 10. The crown of tooth No. 11 has been subtracted from the image showing the damage to the adjacent root of tooth No. 10.

Figure 4.6 The i-CAT cone-beam computed tomography (CBCT) system. The CBCT technique involves the patient seated in the scanner with the x-ray source and reciprocating detector synchronously moving around the patient's head in a single 360-degree scan. (Image courtesy of Imaging Sciences International, Inc., Hatfield, Pennsylvania, and their public relations firm, Gregory FCA Communications, Ardmore, Pennsylvania).

orthodontics, have always been used to view the relationships of the teeth from any orientation (Fig. 4.9).

Currently, virtual models of the dentition viewed on a two-dimensional computer screen are replacing plaster models in clinical practice (Fig. 4.10).

Impressions are taken and then sent to a commercial facility for three-dimensional scanning. Virtual models are created, and the orthodontist can manipulate and measure
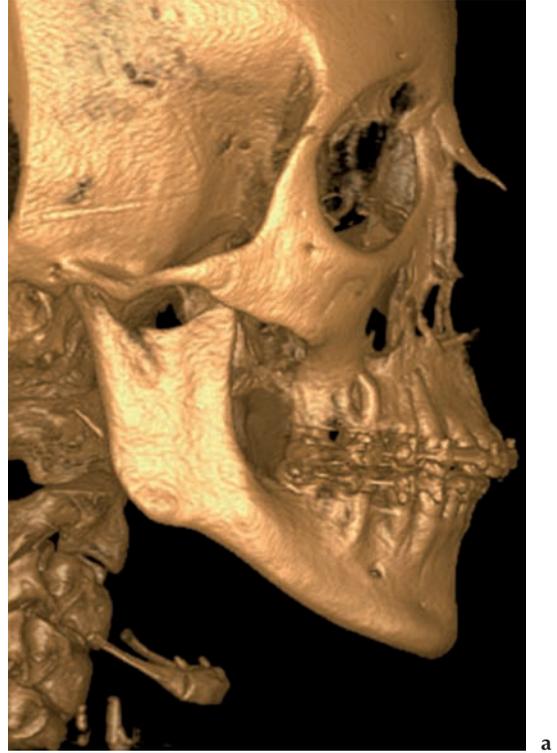
Figure 4.7 A three-dimensional image of the hard tissues of the dentofacial complex in (**A**) lateral and (**B**) oblique views, which were derived from an i-CAT CBCT scan using 3-DVR (three-dimensional volume-rendering software). (Images courtesy of Imaging Sciences International, Inc., Hatfield, Pennsylvania, and their public relations firm, Gregory FCA Communications, Ardmore, Pennsylvania).
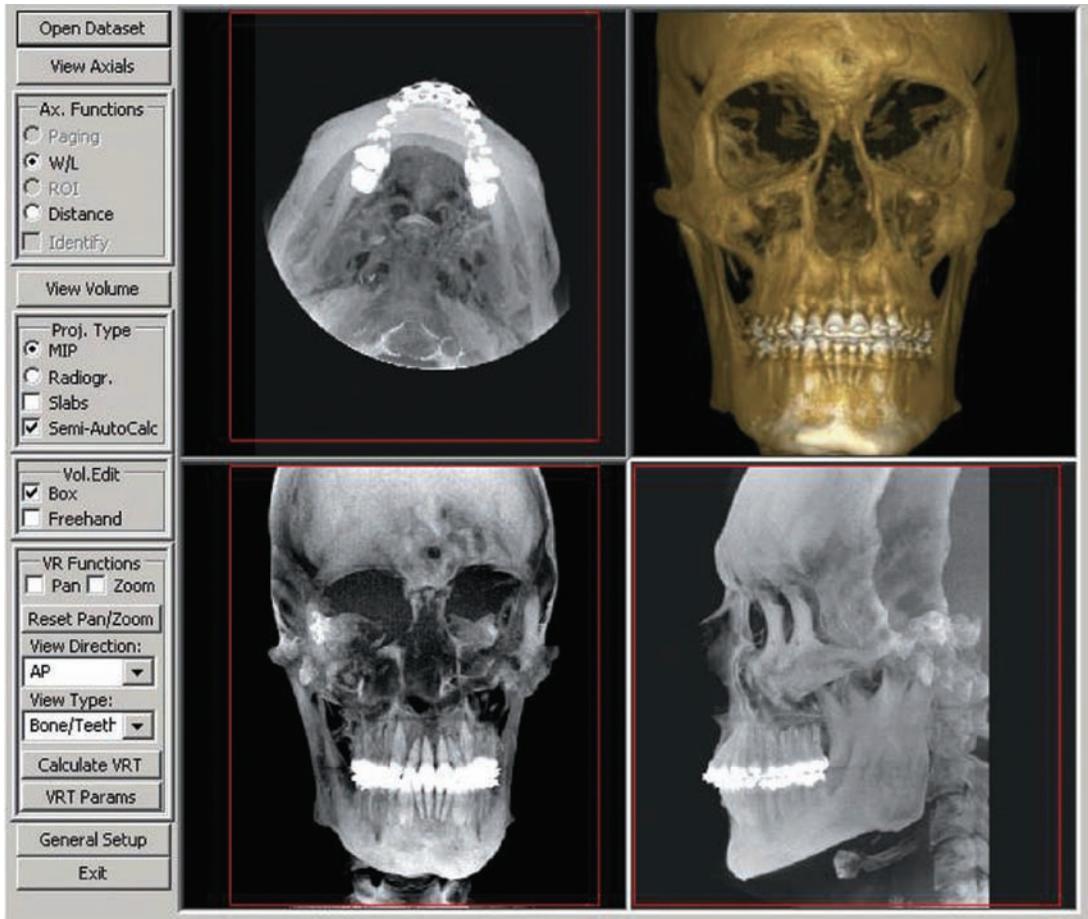
Figure 4.8 A collection of images taken from an i-CAT CBCT scan. The two lower images are maximum intensity projections (MIP). MIP is a thickening technique that displays only the highest voxel value within a particular thickness. It produces a "pseudo" three-dimensional structure and is excellent for depicting the surface morphology of the dental and skeletal hard tissues. (Images courtesy of Imaging Sciences International, Inc., Hatfield, Pennsylvania, and their public relations firm, Gregory FCA Communications, Ardmore, Pennsylvania).

them using proprietary software. In the future, a scan directly in the mouth will eliminate alginate impressions of the teeth in order to produce virtual models. Using a mouse, the orthodontist can rotate the on-screen virtual models, simulating three-dimensional plaster models.

The software technology for digital modeling is still in its infancy and has not fully replicated the diagnostic advantages of conventional plaster models. For instance, model surgery prior to fabrication of splints for orthognathic surgery still requires the use of plaster models. However, there are several orthodontic systems on the market that use digital modeling for appliance fabrication, wire construction, bracket placement, and prediction of tooth movement. The hope in the future is that digital modeling will facilitate the fabrication and application of highly efficient and effective custom-made orthodontic appliances.
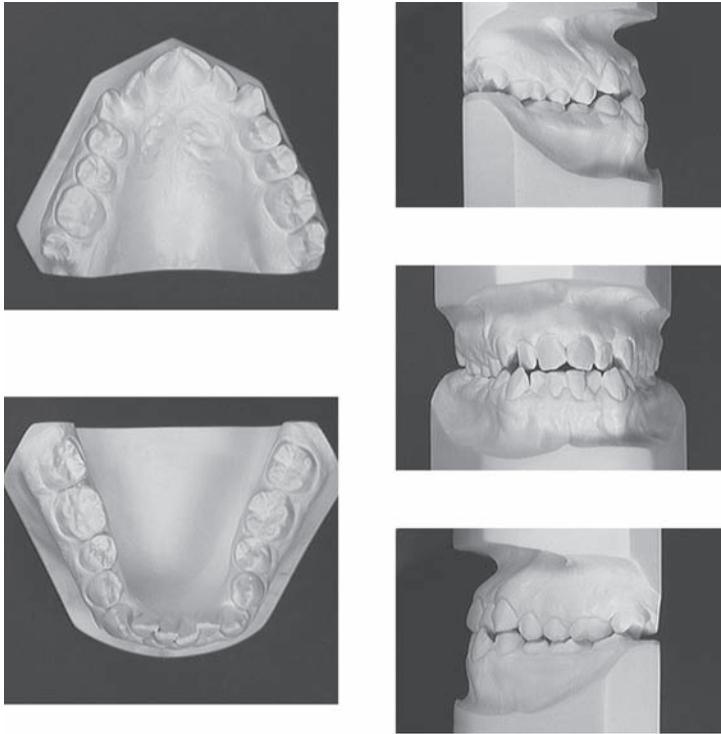
Figure 4.9 Plaster models of the teeth, the traditional diagnostic record from the inception of orthodontics, have always been used to view the relationships of the teeth from any orientation.

The Spatial Orientation of Dentofacial Traits

Pitch, Roll, and Yaw

The advent of CBCT and stereo photogrammetry makes it possible to directly view three-dimensional relationships within the dentofacial complex (Fig. 4.11).

Historically, orthodontic diagnosis addressed only three of the six characteristics required for describing the position of the teeth in the face and the orientation of the head. A total description of these relationships is analogous to what is required to describe the position of an airplane in space (Ackerman et al. 2007).

Three-dimensional movement in space is defined by translation (forward/backward, up/down, right/left) combined with rotation about three perpendicular axes (pitch, roll, and yaw) (Fig. 4.12). By adding these rotational axes into the characterization of dentofacial traits, the orthodontist has greater accuracy in description (Fig. 4.13).

Orientation of the Head and Lines of Occlusion

Although the importance of evaluating dentofacial traits in all three planes of space was emphasized during the clinical examination, the orientation of the head as well as of the teeth and jaws was not fully discussed. Natural head position (NHP) is the most rational physiologic and anatomic orientation for evaluating the face, jaws, and teeth (Moorees and Kean 1958). NHP is obtained by having the individual fix his or
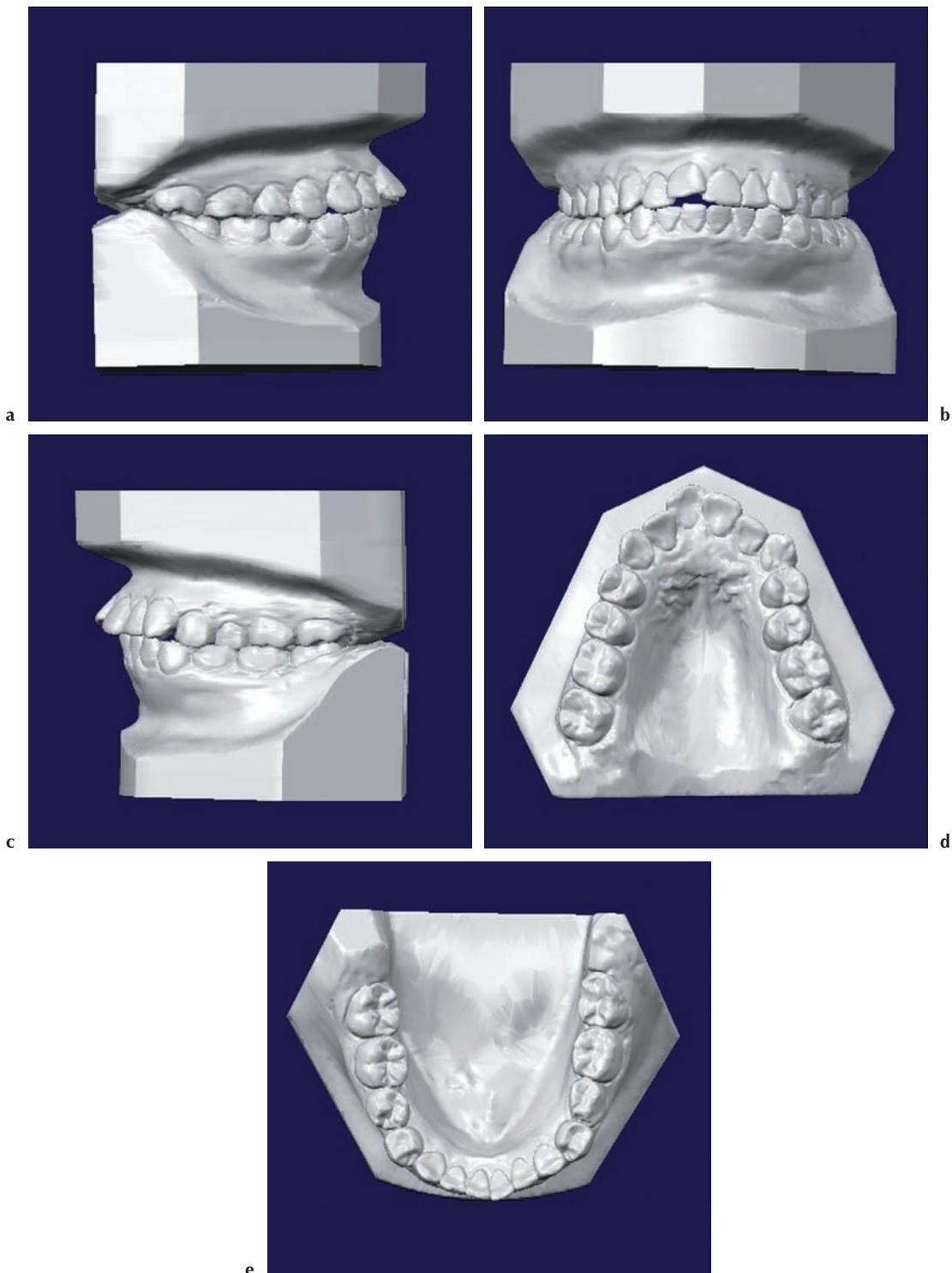
Figure 4.10 (**A–E**) Virtual models are created via a scan of alginate impressions. The orthodontist can manipulate and measure digital models using proprietary software. These images of digital models represent the traditional views used for occlusal analysis. (Images taken from a digital patient record created by OrthoCAD Digital Models, Cadent, Carlstadt, New Jersey.)
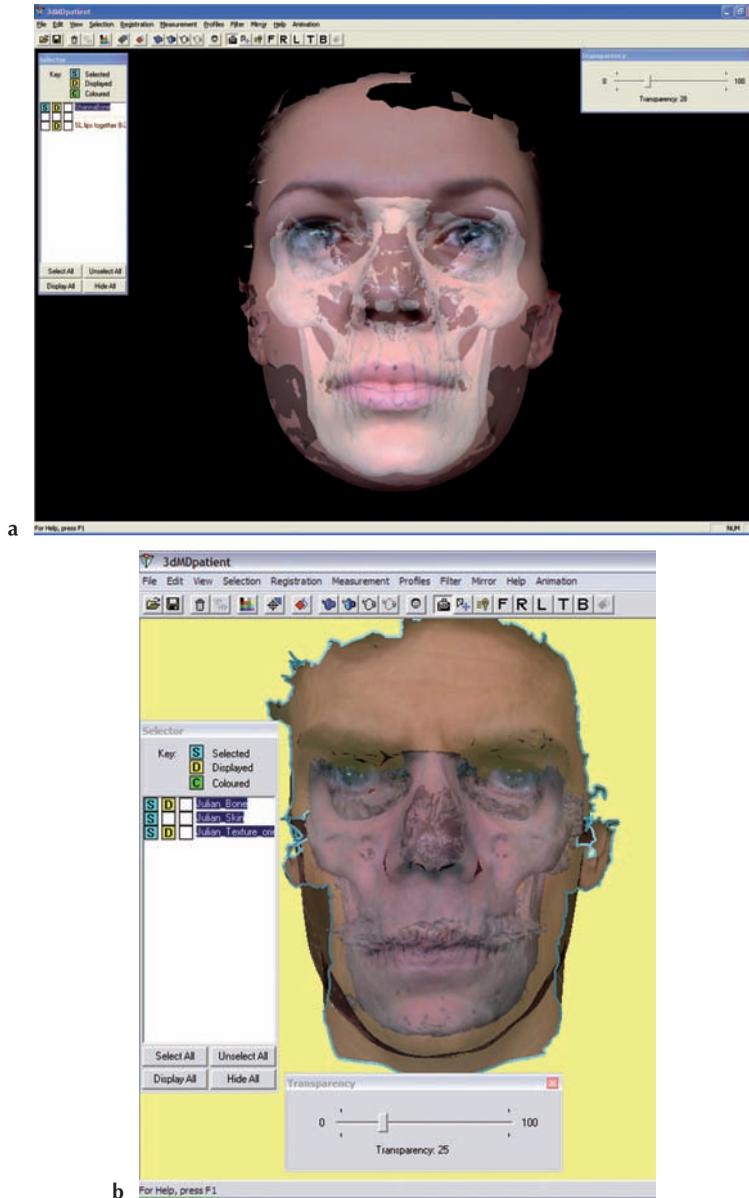
Figure 4.11 The advent of CBCT and stereo photogrammetry make it possible to directly view three-dimensional relationships within the dentofacial complex. (**A**) An integrated image using scans from the i-CAT CBCT system and the 3dMD system. (**B**) Proprietary software allows the clinician to adjust the transparency of the soft-tissue layers, which improves visualization of hard–soft tissue interrelationships. (Images Courtesy of Imaging Sciences International, Inc., Hatfield, Pennsylvania, and their public relations firm, Gregory FCA Communications, Ardmore, Pennsylvania)

her gaze at a distant object or at his or her own eyes in a wall-mounted mirror. Once the patient's visual axis is focused, the head will be oriented in NHP. Clinical examinations should be done with the head in NHP, imaging should be taken in NHP, and the orientation of three-dimensional images should be corrected to NHP. With the patient in NHP, the teeth and jaws can be oriented to the rest of the dentofacial complex using what is termed the *functional line of occlusion.*
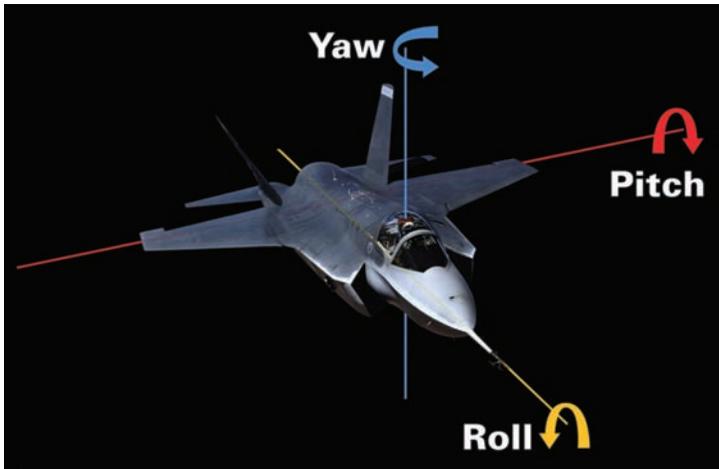
Figure 4.12 Three-dimensional movement in space is defined by translation (forward/backward, up/down, right/left) combined with rotation about three perpendicular axes (pitch, yaw, and roll). A complete description of a plane's orientation in space requires consideration of all six attributes. (Reprinted from Ackerman, J.L., Proffit, W.R., Sarver, D.M., Ackerman, M.B., Kean, M.R. Pitch, roll, and yaw: Describing the spatial orientation of dentofacial traits. *Am J Orthod Dentofacial Orthop* Vol. 131, 2007, with permission from the American Association of Orthodontists.)

Figure 4.13 Three-dimensional analysis of the orientation of the head, jaws, and dentition is incomplete without also considering the three rotational axes of pitch, roll, and yaw in addition to the antero-posterior, transverse and vertical planes. (Reprinted from Ackerman, J.L., Proffit, W.R., Sarver, D.M., Ackerman, M.B., Kean, M.R. Pitch, roll, and yaw: Describing the spatial orientation of dentofacial traits. *Am J Orthod Dentofacial Orthop* Vol. 131, 2007, with permission from the American Association of Orthodontists.)
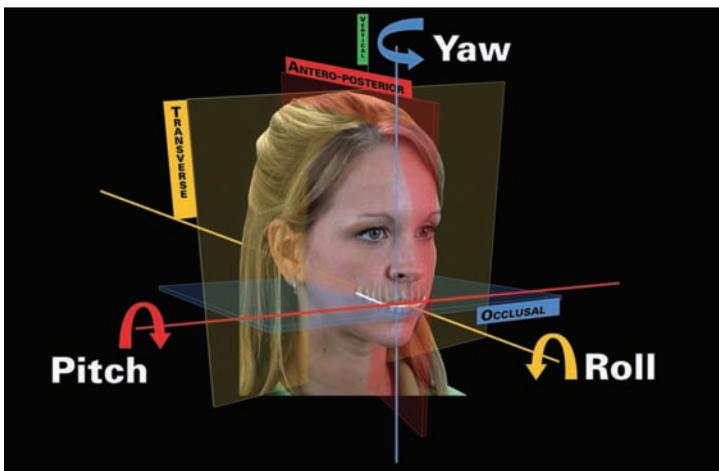
For more than a century, there has been a quest in orthodontics for a practical and reliable method of orienting the teeth to the jaws and face. It was postulated that if the buccal occlusal line of the mandibular dental arch was coincident with the line of the central fossae of the maxillary dental arch and if the teeth in the arches were well aligned, ideal occlusion would result (Angle 1899). These lines, referred to as the functional line of
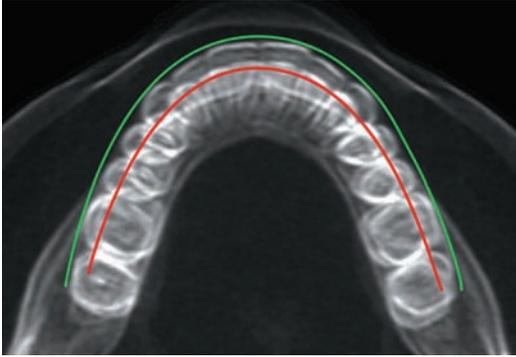
Figure 4.14 A submental-vertex CBCT view of an individual with normal occlusion. Angle's line of occlusion (red) runs along the buccal cusps and incisal edges of the mandibular teeth, and along the central fossae and cingulae of the maxillary teeth. Perfect alignment of the maxillary and mandibular lines is the condition for Angle's ideal occlusion. If a patient has an asymmetry characterized by rotation of the maxilla, mandible, dentition, or any of the above around the vertical axis, it can be detected in this radiographic projection. The second line (green), which follows the facial surfaces of the maxillary teeth, is the esthetic line of the dentition. It is valuable in evaluating lip–tooth relationships and the orientation of the dentition relative to pitch, roll, and yaw. (Image courtesy of Dolphin Imaging and Management Solutions, Chatsworth, California; reprinted from Ackerman, J.L., Proffit, W.R., Sarver, D.M., Ackerman, M.B., Kean, M.R. Pitch, roll, and yaw: Describing the spatial orientation of dentofacial traits. *Am J Orthod Dentofac Orthop* Vol. 131, 2007, with permission from the American Association of Orthodontists.)

Figure 4.15 A cross-sectional "block" of a CBCT image can be manipulated on the computer screen around all three rotational axes. This image is a different perspective of the same image shown in Figure 4.14. (Images courtesy of Dolphin Imaging and Management Solutions, Chatsworth, California; reprinted from Ackerman, J.L., Proffit, W.R., Sarver, D.M., Ackerman, M.B., Kean, M.R. Pitch, roll, and yaw: Describing the spatial orientation of dentofacial traits. *Am J Orthod Dentofac Orthop* Vol. 131, 2007, with permission from the American Association of Orthodontists.)

occlusion, are hidden from view when the maxillary and mandibular teeth contact. The functional line of occlusion describes the positions of the teeth within the dental arch and serves as a reference for assessing arch form, arch symmetry, and curve of Spee (Fig. 4.14).

There is a significant distinction between the occlusal plane and the functional line of occlusion. The occlusal plane is a flat two-dimensional construction, versus the line of occlusion, which is a three-dimensional structure created by the curve of Spee and lack of bilateral vertical symmetry. When the upper and lower lines of occlusion are misaligned, one cannot describe their relationship using planes.
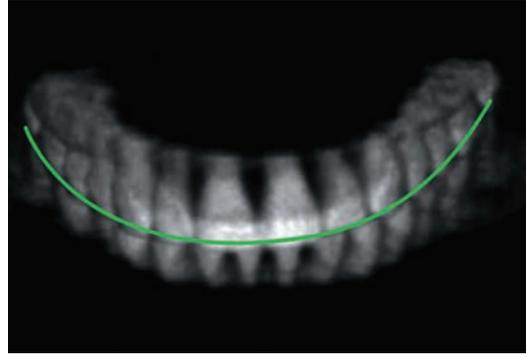
The functional line of occlusion illustrates arch form, arch width, and symmetry. It does not describe the position of the anterior teeth relative to the facial soft tissues, that is, anterior tooth display and smile arc. In order to describe the dental and soft-tissue contributions to anterior tooth display, another line must be used. This line, the *esthetic line* of the dentition, follows the facial surfaces of the maxillary anterior and posterior teeth (Fig. 4.15).

The orientation of both the functional line of occlusion and the esthetic line of the dentition should be described using an *x*, *y*, *z* coordinate system in combination with pitch, roll, and yaw.

In this system, an excessive upward/downward rotation of the esthetic line of the dentition would be denoted as *pitch* (up or down, anteriorly or posteriorly). What is often referred to as a transverse cant of the occlusal plane, viewed relative to a skeletal reference plane like the interocular line or a soft-tissue reference plane like the intercommissure line, is described as *roll* of the esthetic line of the dentition and the func-

Figure 4.16 The advent of three-dimensional imaging enables the orthodontist to precisely visualize the orientation of the functional line of occlusion. An image similar to Figure 4.15 was extracted from digital models. The clinician is able to gain the same spatial information without the patient being exposed to x-ray radiation. (Images courtesy of OrthoCAD Digital Models, Cadent, Carlstadt, New Jersey; reprinted from Ackerman, J.L., Proffit, W.R., Sarver, D.M., Ackerman, M.B., Kean, M.R. Pitch, roll, and yaw: Describing the spatial orientation of dentofacial traits. *Am J Orthod Dentofac Orthop* Vol. 131, 2007, with permission from the American Association of Orthodontists.)

tional line of occlusion (up or down on one side or the other). Rotation of the functional line of occlusion and the esthetic line of the dentition to one side or the other, around a vertical axis, is described as *yaw*. The effect of *yaw* is visualized in dental and/or skeletal midline deviations, with a unilateral Angle Class II or Class III molar relationship. *Yaw* was omitted from previous classifications because it was difficult to detect during clinical examination and was rarely visible in conventional diagnostic imaging. The advent of three-dimensional imaging enables the orthodontist to precisely visualize the orientation of the functional line of occlusion (Fig. 4.16).

Clinical Practice Considerations

The orientations of both the line of occlusion and the esthetic line of the dentition are

essential for diagnosis, treatment planning, and mechanotherapy. From a treatment standpoint, the orientation of the line of occlusion has far-reaching clinical significance (Burstone and Marcotte 2000). Interactions of the functional and esthetic lines are encountered routinely in the effect of interarch elastics, which tend to tip the line of occlusion up or down in either the anterior or posterior regions of the arch.

The orientation of the functional line of occlusion and esthetic line of the dentition affect anterior tooth display during speech and smiling. The *pitch* and *level* of the functional line of occlusion are both important determinants of treatment for undesirable anterior tooth display. For example, the anterior teeth could be pitched too far down, or the whole maxillary dentoalveolar complex could be positioned too far up or down although its *pitch* is normal. The intercommissure line (Morley and Eubank 2001) is a useful reference line for evaluating *pitch* and its effect on anterior tooth display and lip–tooth relationships. Patients with an anterior open bite often have a functional line of occlusion that is tipped down posteriorly and/or an accentuated curve of Spee (Fig. 4.17).

The etiology of a "crooked" smile may be due to "*roll*" of the skeletal maxilla, the maxillary teeth and alveolar process, or an asymmetric elevation of the upper lip. *Roll* of the functional line of occlusion is best visualized on the digital video frame representing the natural unstrained posed social smile (Fig. 4.18).

The intercommissure line is the best frame of reference for evaluation of *roll*. Clinically, the patient with this type of discrepancy will show more tooth mass below the intercommissure line unilaterally as well as more gingival display unilaterally.

Previously, diagnostic imaging techniques were insufficient to visualize discrepancies in maxillomandibular *yaw*. When an orthodontist encountered a major midline shift, a unilateral Class II or Class III molar relationship, or a true unilateral crossbite, they were
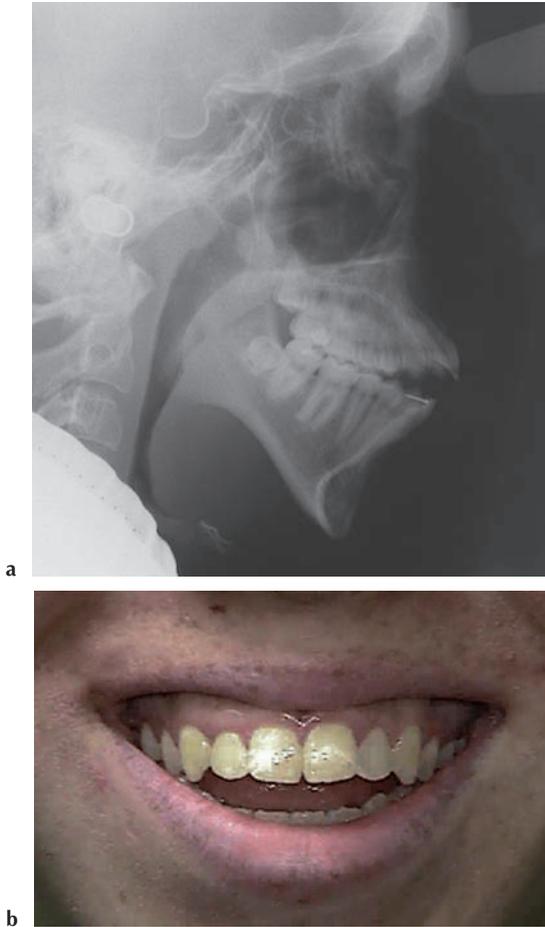
a

Figure 4.18 *Roll* of the functional line of occlusion is best visualized on the digital video frame representing the natural unstrained posed social smile. The inter-commissure line is the best frame of reference for evaluation of *roll*. Clinically, this patient shows more tooth mass below the intercommissure line on her right side.
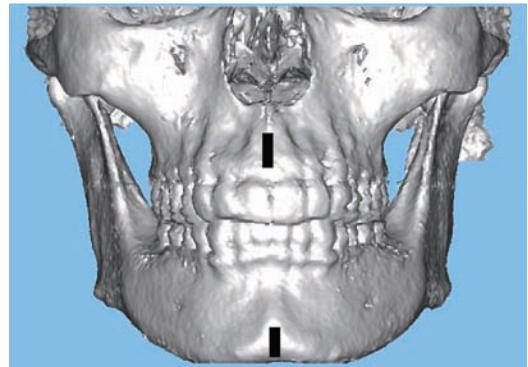

b

Figure 4.17 Patients with an anterior open bite often have a functional line of occlusion that is tipped down posteriorly and/or an accentuated curve of Spee. (**A**) In this particular patient, the lateral radiographic projection clearly shows the accentuated curve of Spee. (**B**) A still frame of the same patient, taken from a digital video clip, illustrates the effect of downward posterior *pitch* on anterior tooth display. Note the increased gingival display in the posterior segments.

Figure 4.19 The extent of *yaw* can be visualized with three-dimensional imaging and will determine whether treatment involves asymmetric mechanics, asymmetric extractions, unilateral bone anchorage, or orthognathic surgery. In this example, the dental midlines are coincident but an underlying skeletal maxillomandibular yaw exists. (Images courtesy of Imaging Sciences International, Inc., Hatfield, Pennsylvania, and their public relations firm, Gregory FCA Communications, Ardmore, Pennsylvania.)

unable to discern whether maxillomandibular *yaw* was the underlying cause of that discrepancy. Now, the extent of *yaw* can be visualized with three-dimensional imaging and will determine whether treatment involves asymmetric mechanics, asymmetric extractions, unilateral bone anchorage, or orthognathic surgery (Fig. 4.19).

Integration of Imaging into the Clinical Database

The complete clinical database consists of information derived from the doctor–patient interview, direct clinical examination, and diagnostic imaging. In general, the challenge for the orthodontist is to integrate the differ-

ent data sources and compose a problem-based classification of dentofacial traits. Far too often, orthodontists spend inadequate time on clinical examination and rely heavily on data acquired from diagnostic imaging. To reiterate, the majority of diagnostic data should be taken *directly* from clinical examination. The goal of imaging is to ascertain information about the spatial orientation of dentofacial traits that might not have been possible with use of the human eye alone. At present, imaging technology cannot fully replicate the three-dimensional live patient. The experienced clinician will use the aforementioned imaging techniques to supplement the wealth of data acquired from in vivo examination of the patient.

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Beyond Normal: Enhancement of Dentofacial Traits

6

The scope of enhancement orthodontics ranges from the treatment of a single dento-facial trait to the "extreme makeover" of dentofacial appearance involving plastic and reconstructive surgery, orthognathic surgery, orthodontics, periodontics, and advanced cosmetic dentistry. The following 10 case studies illustrate a spectrum of enhancements seen in everyday orthodontic practice. All of the patients had some recognizable variation in a dentofacial trait or traits, which affected their functioning in a social context and caused a decrement in their state of orthodontic health (wellness). Enhancement orthodontic outcome is detailed in a three-step process. First, the primary characteristic (orthogonal analysis) of the orthodontic problem is listed. Second, the specific variation in the dentofacial trait is described. Third, the method and type of enhancement used are enumerated.

Case Study 6.1

See Figures 6.1 through 6.6 and Table 6.1.

Orthogonal Analysis

See Table 6.2.

Problem List (Rank Ordered by Patient Preferences)

Labioverted maxillary left permanent lateral incisor (tooth No. 10)
Mild mandibular arch perimeter deficiency

Treatment Options

1. Level and align maxillary and mandibular arches
2. Level and align maxillary arch
   Mandibular Hawley retainer to prevent continued crowding
3. No treatment

Unified Final Treatment Plan

Level and align maxillary arch
Mandibular Hawley retainer to be worn at night only

Therapy

Modified straight wire appliance
Direct bond ↑ fixed appliance (first molar to first molar)
Successive leveling archwires

Actual Treatment Time

Four months

Retention

Direct bond palatal wire between tooth No. 9 and tooth No. 10
Maxillary Hawley retainer to be worn at night only
Mandibular Hawley retainer to be worn at night only

Enhancement Outcome

See Table 6.3.

Commentary

This patient's chief concern was limited to a variation in one well-defined dentofacial trait. The labioverted maxillary left permanent lateral incisor (tooth No. 10) was negatively affecting incisor display. Limited orthodontic treatment was utilized to align tooth No. 10, improving the appearance of the patient's smile. It was explained to the patient that the fixed palatal wire between tooth No. 9 and tooth No. 10 should remain in place for an indefinite period of time.

Figure 6.1 The patient's chief concern and reason for seeking orthodontic advice.

Figure 6.2 (**A**) Facial view during social smile. (**B**) Three-quarter facial view during social smile. Note the labioverted maxillary left permanent lateral incisor (tooth No. 10).

Figure 6.3 Maxillary occlusal view.

Figure 6.4 Tooth No. 10 has been leveled and aligned via maxillary fixed appliance therapy. (**A**) Front occlusal view. (**B**) Maxillary occlusal view.

Figure 6.5 Post-treatment. (**A**) Facial view during social smile. (**B**) Three-quarter facial view during social smile.

Figure 6.6 A bonded palatal wire between tooth No. 9 and tooth No. 10 is an adjunct to the removable Hawley retainer prescribed for the patient. Tooth No. 10 will require indefinite retention.

Table 6.1 Patient Data

Age	13 Years, 7 months
Chief complaint	"Cosmetic—alignment and color"
Medical history	Hypothyroid, takes Synthroid Pyelonephritis
Dental history	Oral hygiene within normal limits
	Low caries rate
	Dental visits at 6-month intervals

Table 6.2 Orthognal Analysis

Dentofacial appearance	Maxillary left permanent lateral incisor (tooth No. 10) negatively affecting anterior tooth display
Alignment	Labioverted maxillary left permanent lateral incisor (tooth No. 10)
	Mild mandibular arch perimeter deficiency
Transverse	No deviation
Sagittal	No deviation
Vertical	No deviation

Table 6.3 Enhancement Outcome

Primary Characteristic	Specific Variation	Enhancement
Dentofacial appearance	Unattractive anterior tooth display (labioverted tooth No. 10)	Anterior tooth display improved through alignment of tooth No. 10
Alignment	Labioverted tooth No. 10	Aligned tooth No. 10

Case Study 6.2

See Figures 6.7 through 6.12 and Table 6.4.

Orthogonal Analysis

See Table 6.5.

Problem List (Rank Ordered by Patient Preferences)

Mild mandibular arch perimeter deficiency
Maxillary diastemata
Butterfly maxillary permanent central incisors

Treatment Options

1. Level and align maxillary arch
   Condense space in maxillary arch
   Level and align mandibular arch
2. Level and align mandibular arch
3. No treatment

Unified Final Treatment Plan

Level and align maxillary arch
Condense space in maxillary arch
Level and align mandibular arch

Therapy

Modified straight wire appliance
Direct bond ↑↓ limited fixed appliances (2 × 6, canine-to-canine and first molars)
Successive leveling archwires
Working movement (elastomeric thread to close space)

Actual Treatment Time

Six months

Retention

Direct bond palatal wire between tooth No. 8 and tooth No. 9
Maxillary Hawley retainer to be worn at night only
Fixed lingual canine-to-canine retainer bonded to each tooth (No. 22 to No. 27)

Enhancement Outcome

See Table 6.6.

Commentary

This patient was referred to the orthodontist for assessment of crowding in the anterior portion of the mandibular arch. Her dentist had noted an increase in crowding during the second transitional period of dentitional development. In the doctor–patient interview, the patient expressed more concern over the progressive crowding than the maxillary diastemata. After weighing all of the information provided to her at the doctor–patient conference, the patient and parent decided to address both the mandibular crowding and the maxillary spacing.

When closing diastemata, an assessment of the patient's periodontal biotype is critical. In this case, the patient had a thick/flat periodontal biotype. Tooth contacts in this biotype are broader both incisogingivally

and faciolingually. This anatomic feature facilitated space closure without the appearance of a "black triangle" incisal to the interdental papilla between tooth No. 8 and tooth No. 9. The frenum attachment in this case did not require resection. It was explained to the patient that space closure in orthodontics is a very unstable type of tooth movement. As a result, it was recommended that the fixed palatal wire between tooth No. 8 and tooth No. 9 remain in place for an indefinite period of time.

PSYCHOSOCIAL AND PHYSICAL GROWTH STATUS

Chief Concern: TEETH CROWDING

Reason for seeking orthodontic advice:

[✓] Information
[✓] Treatment at this time
[ ] Clarification of previously received information or conflicting information
[ ] Continuation of treatment

Figure 6.7 The patient's chief concern and reason for seeking orthodontic advice.

a   b

Figure 6.8 (**A**) Facial view during social smile. (**B**) Three-quarter facial view during social smile. Note the butterfly pattern of the maxillary right and left permanent central incisors (teeth No. 8 and No. 9).

Figure 6.9 (**A**) Front occlusal view. (**B**) Maxillary occlusal view. (**C**) Mandibular occlusal view.

Figure 6.10 Maxillary and mandibular limited fixed appliances in place. The maxillary midline diastema has been closed. Note the development of an interdental gingival papilla between teeth No. 8 and No. 9.

a

b

Figure 6.11 Post-treatment. (**A**) Facial view during social smile. (**B**) Three-quarter facial view during social smile.

Figure 6.12 Post-treatment front occlusal view.

Table 6.4 Patient Data

Age	13 Years, 8 months
Chief complaint	"Teeth crowding"
Medical history	Noncontributory
Dental history	Oral hygiene within normal limits
	Low caries rate
	Dental visits at 6-month intervals

Table 6.5 Orthognal Analysis

Dentofacial appearance	Prominent maxillary midline diastema negatively affecting anterior tooth display
	Butterfly maxillary permanent central incisors
Alignment	Maxillary diastemata
	Mild mandibular arch perimeter deficiency
Transverse	No deviation
Sagittal	No deviation
Vertical	No deviation

Table 6.6 Enhancement Outcome

Primary Characteristic	Specific Variation	Enhancement
Dentofacial appearance	Unattractive anterior tooth display (diastema, butterfly incisors)	Anterior tooth display improved through diastema closure and tooth alignment
Alignment	Diastema between teeth No. 8 and No. 9	Closed diastema between teeth No. 8 and No. 9
	Crowding teeth No. 22 through No. 27	Aligned teeth No. 22 through No. 27