SECTION I

Technology, Diagnosis, and Treatment Planning

CHAPTER 1

Diagnosis and Treatment Planning for Minimally Invasive Dental Implant Treatment

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Introduction

While the recent trend in dental implantology has been toward less invasive surgical procedures, an argument can be made that the prosthetic phase has become more complex. Our desire to provide patients with minimally invasive treatment options requires that the diagnostic aspects be completed comprehensively. There is no "minimally invasive" diagnosis. Treatment options may be more or less invasive, but the diagnosis needs to be thorough and complete. Despite significant advances in dental implant technology, implants remain endosseous anchorage devices intended for prosthetic reconstruction of missing teeth.[1]

Many diagnostic tools, including cone beam computed tomography (CBCT) imaging and dental implant planning software (see also Chapters 2 and 9), have been developed to provide clinicians with user-friendly and precise methodology to examine and virtually plan possible therapeutic interventions.[2] These technologies greatly facilitate communication with the patient and treatment team members.[3] Clinicians should, however, use caution when applying these technologies and develop an understanding of their advantages and limitations. Restorative management of dental implants requires a clear understanding of the final restoration design, planning for the phases of treatment and anticipating contingency plans.[4]

In addition, it is important to realize that minimally invasive surgery does not imply less complexity or that less skill and judgment are necessary. On the contrary, often more skill and judgment are required with minimally invasive approaches, and clinicians should be trained and competent in both minimally invasive and traditional approaches. Clinicians providing surgical care also should be competent in anticipating, preventing, and managing potential surgical and prosthetic complications. Thus, the skills and judgments of the treatment team remain paramount.

For successful implant treatment outcomes, there must be sufficient quality and quantity of supporting hard and soft tissues, the implants must be in the proper number, location, and orientation, and the prosthesis must be fabricated with detailed attention to esthetics, phonetics, occlusal function, and access for oral hygiene.[5] This chapter will address principles for the diagnosis and treatment planning for prosthetic reconstruction of commonly encountered clinical situations in the context of employing minimally invasive procedures.

The diagnostic process

Developing an accurate diagnosis is best achieved using a systematic process. Initial patient evaluation should begin with a subjective assessment, including chief complaint, history of the present illness or problem, and past dental and medical histories. A full discussion of the patient's immediate concern (chief complaint), expectations, goals, and desires (immediate, short and long term) regarding treatment can prevent misunderstandings and help to avoid disappointments. While it is important to pay attention to the chief complaint, it is equally important not to let the chief complaint prevent a comprehensive approach in the clinical decision-making process. For example, patients presenting for single tooth replacement may not appreciate the need for a full diagnostic work-up and any additional treatment that might be required to achieve an optimal result. Consultation or referral to a more experienced clinician or implant team may be indicated if there is any discrepancy between the alignment of treatment goals and expectations and the clinical reality.

Following a thorough subjective assessment, the collection of objective diagnostic data begins. A focused head and neck examination and dental/oral examination are completed, with special attention given to teeth opposing and adjacent to potential implant sites. A complete periodontal examination, including probing, should be a part of the diagnostic record. The periodontal evaluation also should include an esthetic evaluation of the gingiva, including gingival display, symmetry, and biotype. An occlusal evaluation is necessary, with special attention afforded to vertical space relationships, interdental spaces, attrition, deep bite, cross-bite, and any other issues that might potentially impact the prosthetic outcome.

Radiographic evaluation may include any or all of periapical radiography, panoramic radiography, and CBCT 3-D imaging of the affected jaw(s) and proposed implant site(s).[2] Following the initial diagnostic examination, more sophisticated planning may be required with the use of surgical guides or templates fabricated from diagnostic wax-ups and/or tooth set-ups and 3-D planning.[6] A record of the bite relationship should be taken in wax or a suitable elastomeric material, and diagnostic casts prepared. Mounting of these casts with a facebow transfer is ideal, especially if a diagnostic wax-up is being done.

Digital photographs are an important aspect in diagnosis to help communicate clinical and technical information to patients, dental

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colleagues, and laboratory technicians. Referring to a digital photograph will help to answer questions that can arise in the treatment after teeth have been removed or otherwise altered. Extraoral photographs should be taken from both lateral and frontal views with the lips in repose as well as during a full smile. Intraoral photographs should include an occlusal view of each arch, a frontal view with the teeth in full contact, and right and left lateral views. The camera system need not be elaborate or complex; however; a modern digital single-lens reflex camera with macro lens and a dedicated macro flash system will give the best results. In addition, it is suggested that a high-quality set of intraoral mirrors and lip retractors be available, and that both the dentist and clinical staff be trained in their proper use.

Following a thorough review of the findings and, if need be, consultation with specialists, a set of treatment options is developed. The clinician is required to put all the findings together and come up with possible solutions. As a part of the diagnosis, a risk assessment is completed, including the demands of the case and whether or not a minimally invasive treatment approach is appropriate and/or involvement of other experienced colleagues is indicated.

This process must be purposeful and lead to a plan with the patient's full understanding and support. A plan is rarely a single option, but rather a discussion encompassing multiple possibilities even though some options may be eliminated quickly based on a patient's desires (for example, a reluctance to accept a removable prosthesis). Some treatment options may require additions to the basic plan (for example, a patient requiring multiple implants to be placed in order to secure a prosthesis may require bone augmentation or reduction procedures prior to implant placement). The final plan should include an indication of advantages and disadvantages, expected prognosis, costs, and possible complications in order to adequately inform the patient prior to their consent.

Informed consent

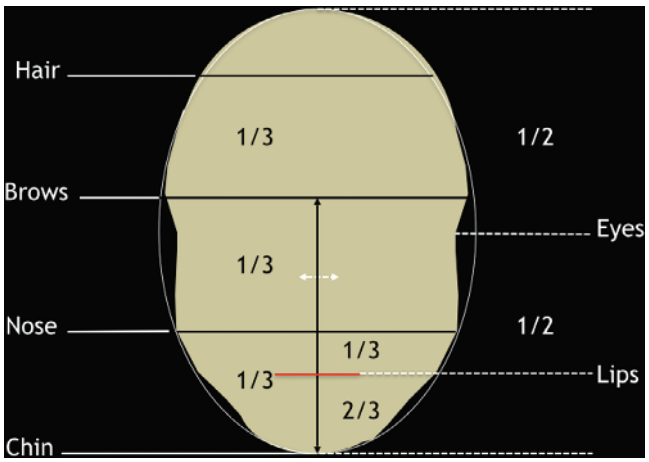
Informed consent involves more than simply presenting a few treatment alternatives. The patient should fully understand the associated risks, benefits, and limitations, including possible complications and alternatives for any treatment proposal. The first treatment option should always be "no treatment," and the implications of that decision should be considered and discussed. Many patients will be concerned regarding the anticipated esthetic outcome, and this should be discussed and documented fully in advance. There is no substitute for a set of mounted models with a diagnostic wax-up to directly visualize the proposed treatment. Digital photographs, 3-D imaging and planning, and a wax try-in or mock-up of the proposed treatment are important aspects of planning and informed consent. Patients should have an opportunity to have all of their questions answered, preferably with a friend or loved one in attendance, and this will often require more than one interaction. Diligence at this phase of treatment is critical to developing trust and rapport with the patient for those inevitable challenges that can occur.

Comprehensive evaluation and risk assessment

Comprehensive examination begins before the patient is seated in the dental operatory. Evaluation of the patient begins with interactions while standing and sitting upright during normal conversation. This is best facilitated in a consultation room with a home living room environment. Most patients begin adaptive responses and compensations when placed in the dental operatory and in a reclined position. The patient and clinician will benefit from a systematic approach and review of the findings.

Facial analysis

Evaluation of facial dimension includes inspection of facial symmetry from the frontal (Figure 1.1a), lateral, and three-quarter views. This inspection will allow confirmation that the facial thirds are harmonious (Figure 1.1b) and determination of the skeletal classification (Class I, II, or III).[7] Diagnosis of the facial type (brachiocephalic versus dolicocephalic) can have significant implications with the amount of bite force generated on posterior teeth and the importance of anterior guidance (deep bite versus open bite). Further examination and palpation of the head and neck include the muscles of mastication to evaluate for hyperactivity or myospasm, temporomandibular joint disorders affecting mandibular range of motion or discomfort, and to rule out the presence of any masses, suspicious lymphadenopathies, or sinus issues.



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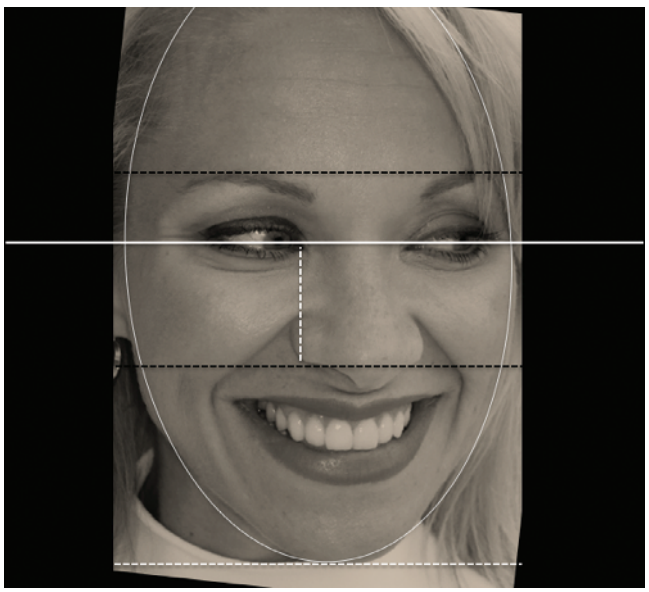

(b)

Figure 1.1 (a) Facial perspectives and proportions. (b) Facial perspectives and proportions projected over face.

Dento-facial analysis

Evaluation of the esthetic zone – *incisal plane*, *plane of occlusion*, *incisal edge position*, *dental/facial midlines*, *lip support*, and *gingival display* – is included in the dento-facial analysis[8] (Figure 1.2a). Digital photography is indispensable for this pretreatment evaluation. Careful and systematic investigation of these features may change what appears initially to be a simple, single-tooth case into a complex interdisciplinary restorative challenge with increased treatment risk. On frontal evaluation, the anterior incisal plane should be parallel to the interpupillary plane and curve upwards in the canine region to follow the contours of the lower lip and the Frankfort horizontal plane[9] (Figure 1.2b). The plane of occlusion should follow the interpupillary line, the curve of Spee, the curve of Wilson, and the curve of Monson[10] (Figure 1.3).

Incisal edge position and tooth display at rest are patient-specific. Consideration of empirically determined norms can be helpful as the amount of display is age and gender dependent, excluding other variables such as lip length and lip movement on animation.[11] Accepted guidelines for the position of the maxillary central incisal edge at rest

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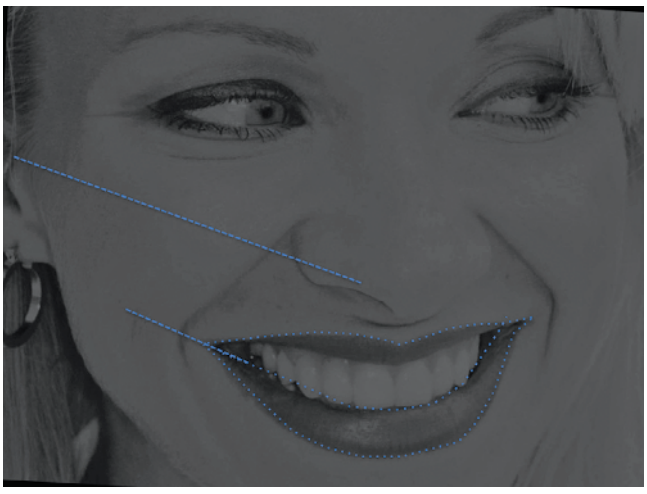
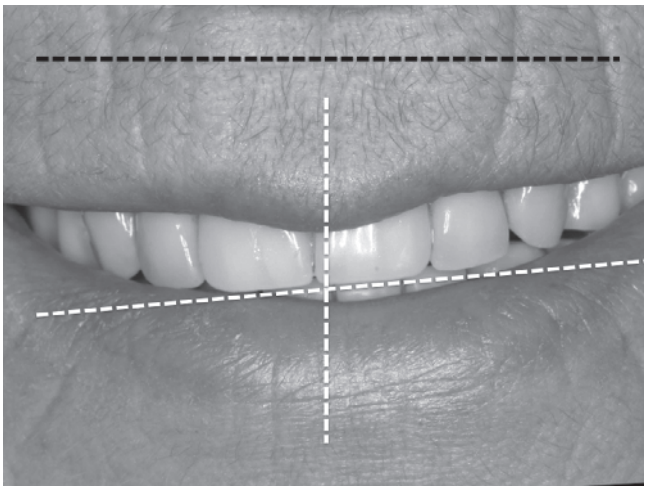


(b)

Figure 1.2 (a) Parallelism between interpupillary plane and overall anterior incisal plane. (b) Parallelism between Frankfort plane and posterior occlusal plane.



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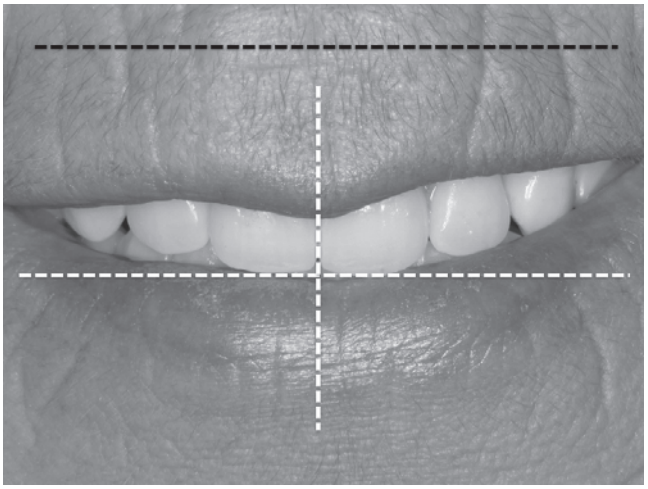


(b)

Figure 1.3 (a) Midline and anterior incisal plane discrepancies. (b) New midline and anterior incisal plane after correction.

is 3.4 mm in females and 1.9 mm in males "below the lip". If the patient has a "short" upper lip, then exposure can be as much as 3.65 mm; with a "long" upper lip exposure can be as little as 0.59 mm.[10] With aging, tooth exposure generally decreases due to lip laxity and decreased animation, and can be further reduced with incisal edge wear (see "Dento-gingival analysis" section). The accepted guidelines range from 3.37 mm of exposure for patients younger than 29 years of age to as little as 1.26 mm for those up to 50 years of age.

Assessment of the *facial and dento-facial midlines* for alignment will reveal any significant horizontal or vertical asymmetry, and any orthodontic, orthognathic, and/or facial plastic surgical treatment that may be indicated[12] (see Chapter 20). If significant dental asymmetry is found, orthodontic treatment (see Chapter 20) and/or prosthetic restoration of adjacent or opposing teeth may be required (Figure 1.4).

A key determinant of esthetic risk in implant therapy is the amount of *gingival display* exhibited during a full smile.[7] If there is no exposure of the dento-gingival margin, the primary esthetic considerations are limited to tooth shade, tooth width, and incisal edge anatomy.[13] Conversely, if there is full exposure of the gingival margin, then the entire dento-gingival complex must be considered, and the esthetic demands of the case will increase exponentially. If it is

(a)

(b)

Figure 1.4 (a) Anterior smile view of preoperative disharmony. (b) Anterior smile view after camouflage of disharmony harmony.

determined that there is altered passive eruption, vertical maxillary excess, or excessive gingival display due to hypermobility of the lip, then periodontal crown lengthening, fixed prosthetic enhancement, surgical, or orthodontic treatment options are best addressed preoperatively along with anticipated limitations in treatment outcome.

Dento-gingival analysis

Gingival plane

Generally, a patient's maxillary anterior teeth display similar gingival length and proportions. The maxillary canines and central incisors may have slightly longer gingival contours than the lateral incisors with relatively more tooth exposure. (Figure 1.5a–c) The maxillary anterior teeth are progressively inclined to the distal, placing the gingival zeniths slightly distal to the midpoint of the tooth width. Tooth shape, tooth positions, and loss of bone or soft tissue support will cause discrepancies in gingival and/or papilla height. Generally, the closer to the midline these discrepancies occur, the more significant their impact will be. Facial angulation or positioning moves the gingival margin apically. Schematics representing tissue defects and gingival levels can aid diagnosis and risk assessment in treatment planning (Figure 1.5b–g) Options to manage gingival height discrepancy include orthodontic treatment, prosthetic soft tissue manipulation with long-term provisional restorations, and/or gingival surgery.

Modification of the gingival levels is often desirable and should be considered during the treatment planning process.[14] Figure 1.6a and b shows a young female patient who presented with a significant asymmetry in the esthetic zone. On dento-facial and dento-gingival evaluation of her smile, the proportions of the maxillary right canines and lateral incisors became the focus of the treatment objectives. Because the left canine and lateral incisor presented with pleasing proportions, a reasonable approach was to reproduce them to the degree possible on the right side (Figure 1.6c and d). The treatment plan in this case consisted of gingivoplasty to increase the length of the right crowns relative to the contralateral teeth. Restorative treatment included narrowing the width of the right lateral incisor and increasing the width of the cuspid to achieve more pleasing proportions (Figure 1.6e). These changes were first evaluated by digital superimposition of a mirror image of the left cuspid and lateral incisor teeth onto the right side. Thereafter, the teeth were prepared and restored with provisional restorations (Figure 1.6f).

Lip support

In addition to support from alveolar bone and soft tissue, the upper lip is mainly supported by the gingival two-thirds of the anterior maxillary teeth, not the incisal one-third. The shape and volume of the anterior maxillary alveolus (relative undercut and proclination) and the effects of aging with altered muscle tone also will effect labial position and mobility on animation.[11]

Gingival biotype

Gingival biotype is another key determinant in esthetic risk.[15] Patients exhibiting a thin, scalloped gingival biotype are more likely to have translucency of the underlying restorative material and/or buccal soft tissue recession over time and, as a result, may show exposed implant components.[16] (See also Chapter 3.) The possible need for modification of the gingival biotype (see also Chapter 8), either preoperatively or following completion of the treatment, is best discussed before treatment begins.

Interdental papilla

Normal interdental papilla reformation following implant restoration is one of the most challenging outcomes in implant dentistry. The height and symmetry of interdental papillae following implant restoration are determined by the height of the interproximal bone crest of the adjacent tooth or implant.[17] A single tooth implant placed between two healthy natural teeth has the best prognosis for reforming esthetically pleasing papillae. In such situations, papillae with 4.0–4.5 mm of soft tissue height can be anticipated (see further discussion in "Planning for ideal implant position" section). Tooth shape is also an important factor in predicting the presence or absence of esthetically pleasing interdental papillae. Square crown forms typically have shorter, thicker papillae and interproximal contacts, which may extend into the middle third of the clinical crown.[13] Conversely, teeth with long, tapered crown shapes have thinner and more delicate papillae, and the interproximal contact zone may be limited to the incisal third of the crown. In this latter situation, when an extraction is done even in a minimally traumatic fashion, recession of papillae and incomplete soft tissue fill between crowns is a common finding.

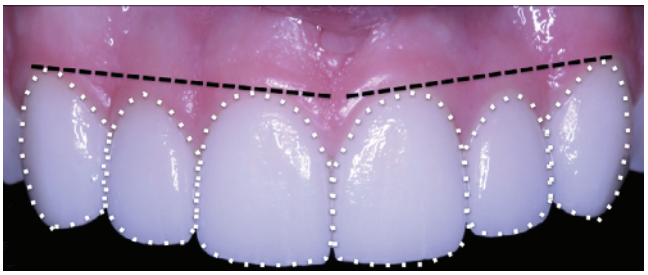
Maxillary central incisor position

This is the key to anterior esthetics, and is the foundation for the diagnostic and treatment processes. Concepts such as dominance (relative size/shade), symmetry, proportions, and incisal edge position must be understood and applied if esthetic success is to be achieved.[5]

Tooth proportion

Tooth proportion may ultimately be influenced by factors beyond the control of the implant surgeon, such as orthodontic positioning and tooth migration. Guidelines for ideal proportions include a

(a)



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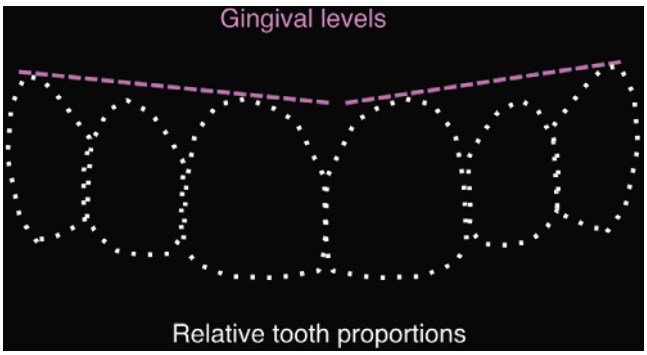

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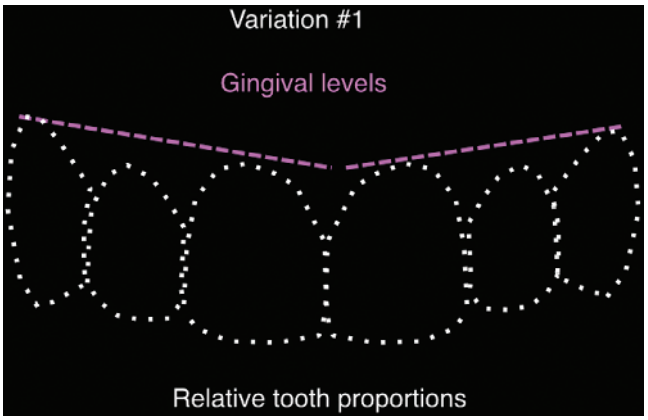

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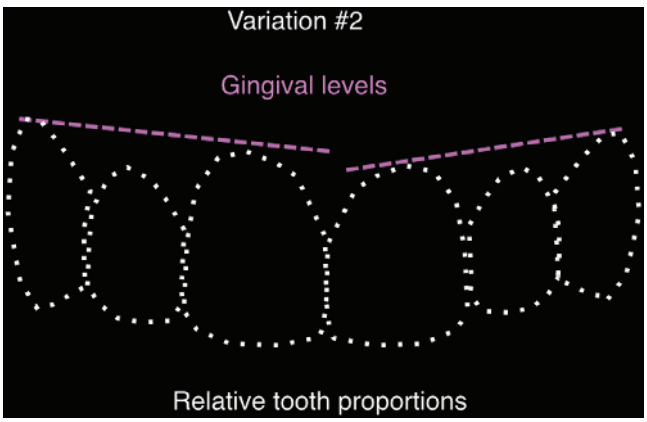

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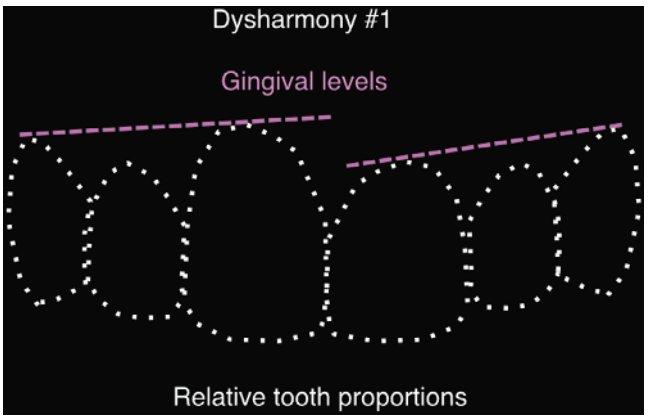

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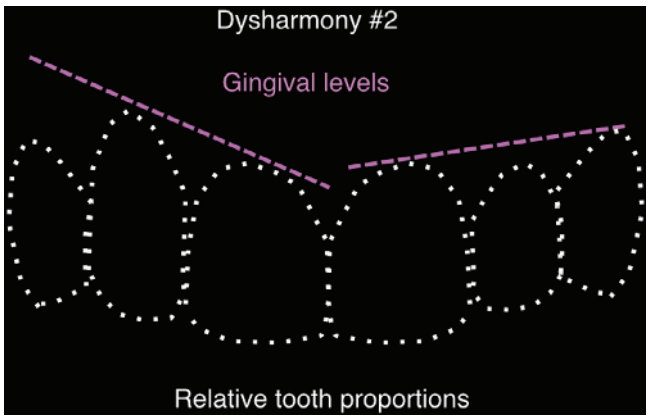


(g)

Figure 1.5 (a) Esthetic dento-gingival presentation demonstrating the free gingival margin of maxillary anterior dentition. (b) Same as (a) with teeth outlines drawn. Imaginary lines joining gingival margins of canines to centrals; laterals should ideally be shorter or even with this line. Note that the planes slope downward towards the midline. (c) Diagrammatic representation of (b). (d) Variation #1 (of gingival levels): the right canine is longer gingivally, but perspective is maintained. (e) Variation #2: the right canine and central incisor are longer gingivally, but the gingival plane remains in relative harmony as it slants downward. (f) Dysharmony #1: the right central incisor is significantly longer than in (c), creating a more significant unilateral asymmetry because of the upward plane toward midline. (g) Dysharmony #2: right central incisor is very long gingivally creating visual tension away from ideal plane.

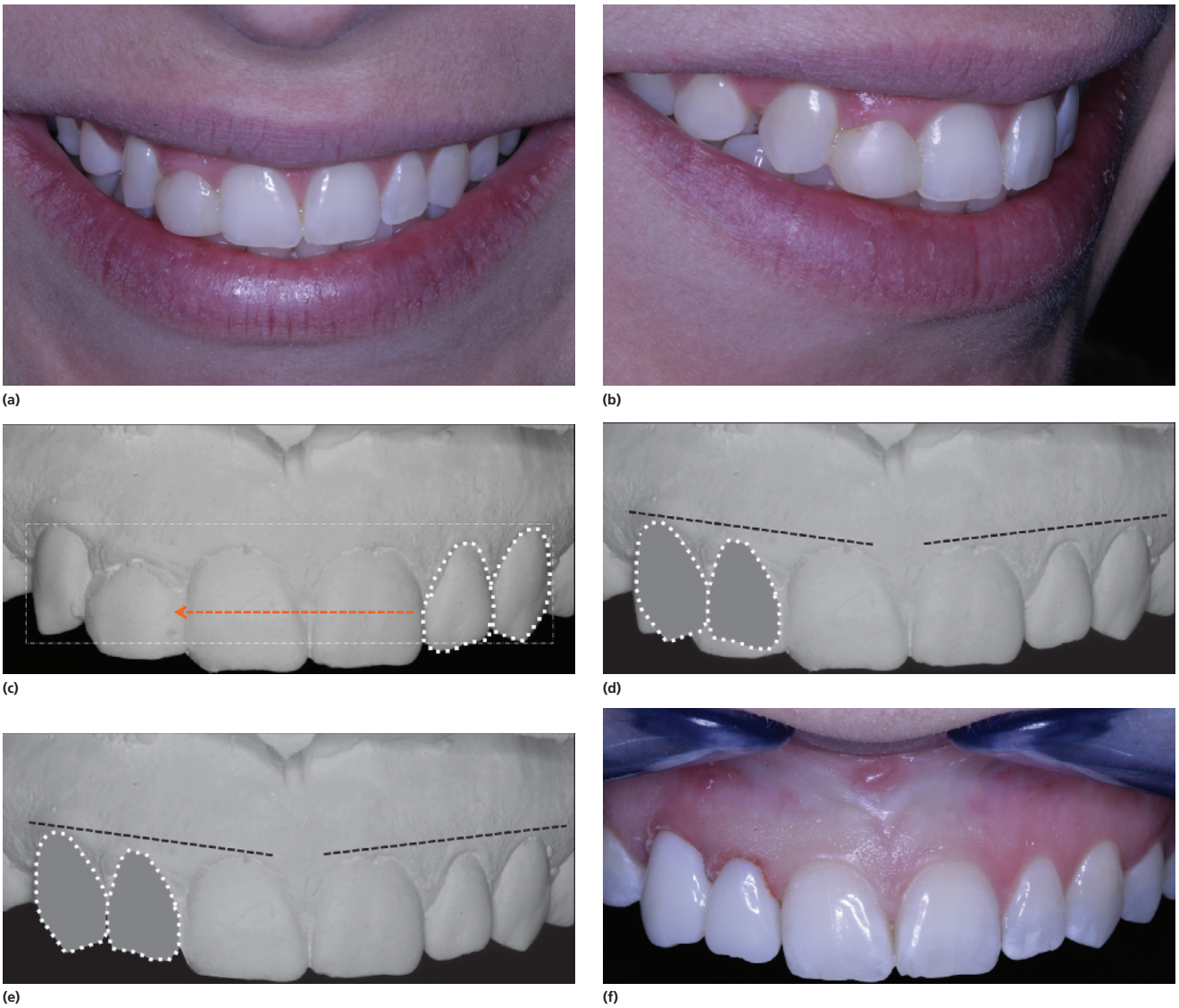


Figure 1.6 (a) Anterior smile view demonstrating significant white and pink disproportions of the right lateral incisor. (b) Right lateral smile view. (c) Esthetic analysis on laboratory study cast. (d) Esthetic superimposition of the left canine and lateral incisor mirror images over the right canine and lateral incisor sites. (e) Same as (d) but with preoperative right canine and lateral incisor teeth eliminated. (f) Anterior retracted dentition of provisional crowns immediately post-insertion; note slight tissue recontouring with diamond gingivoplasty at the right lateral incisor.

width : length (W : L) ratio of 75–80% (Figure 1.7a). For diagnostic purposes, a W : L ratio greater than 85% is indicative of a "short, square" tooth form, while a W : L ratio less than 75% is indicative of a "long, narrow" tooth form (Figure 1.7b and c).

Tooth shape

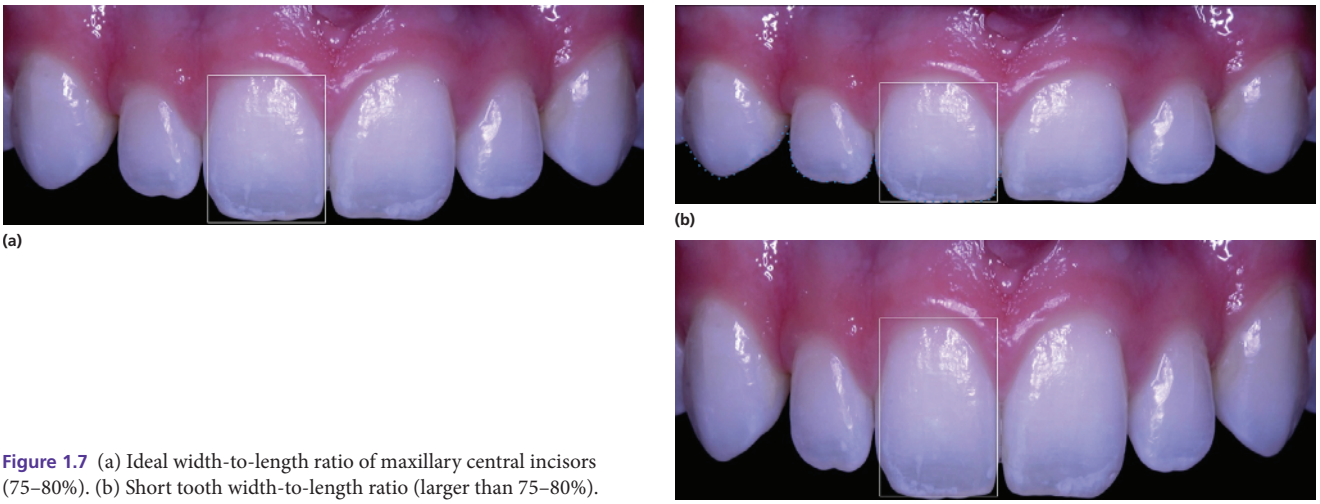
Tooth shape includes considerable variations in form: round/ovoid, square, or tapered. The shape influences the position of the contact point with the adjacent teeth and embrasure depth. Restoration with a square-shaped crown form fills the embrasure space with restorative material and moves the interproximal contact point apically. As noted previously, tooth shape plays a role in the dimensions of interdental papillae.[13] Patients with a square tooth form typically have a "high crest" bone anatomy, whereas triangular-shaped or ovoid crown forms are more likely to have a "low crest" bone anatomy with a longer zone of soft tissue attachment, and are at higher risk of unfavorable papilla reformation and recession.[13]

Axial inclination

The axial inclination of the maxillary anterior teeth tends to be progressively distal, and this fact will influence the contours of the gingival soft tissue, with the gingival zeniths of the anterior maxillary teeth slightly distal to the mid-tooth width (as discussed previously). This outcome may be difficult to achieve with a dental implant due to size, shape, and proximity limitations. Soft tissue manipulation with long-term provisional restorations (see also Chapter 4), and/or gingival surgery (see also Chapter 8), may be helpful in this regard and should be considered in the initial restorative treatment plan.

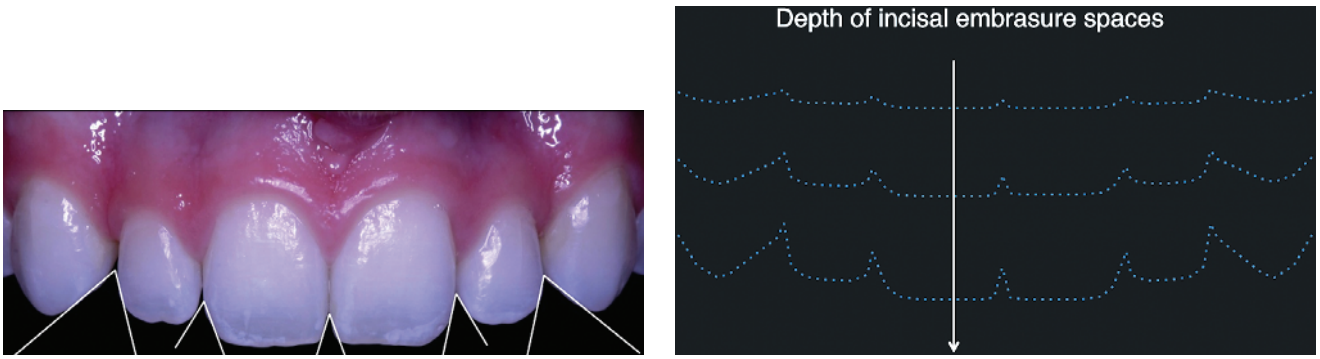
Incisal embrasure anatomy

Incisal embrasure anatomy also can influence tooth proportion and shape. The relative angles and depth of a youthful adult incisal embrasure anatomy are shown in Figure 1.8a. With aging and incisal wear, the incisal embrasure depth becomes reduced, and it may even disappear with extreme wear (Figure 1.8b). If lengthening the tooth



(a) (b) (c)

Figure 1.7 (a) Ideal width-to-length ratio of maxillary central incisors (75–80%). (b) Short tooth width-to-length ratio (larger than 75–80%). (c) Long tooth width-to-length ratio (smaller than 75–80%).

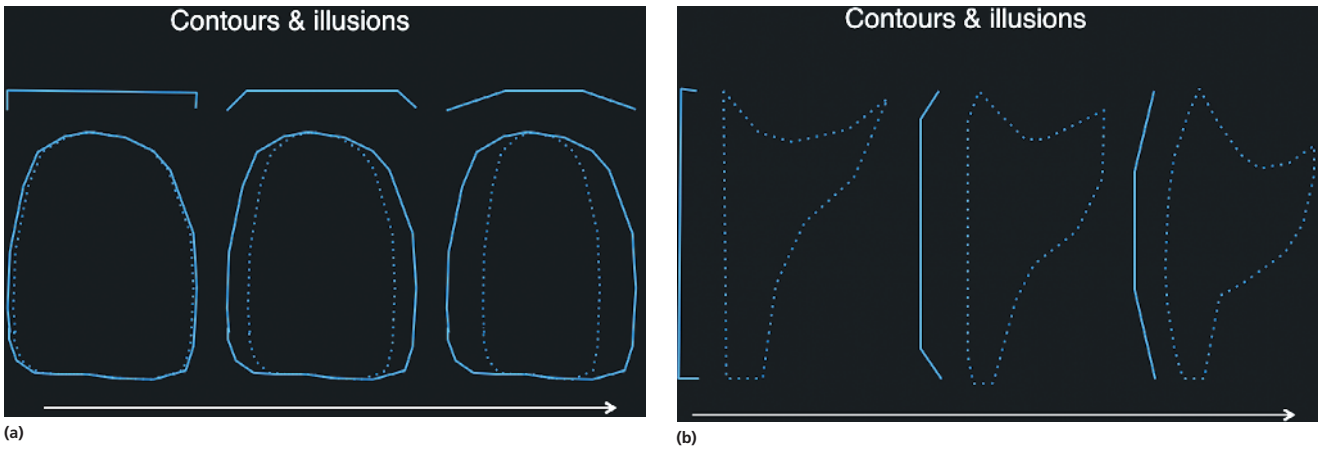


(a) (b)

Figure 1.8 (a) A youthful incisal embrasure anatomy. (b) Variation in incisal embrasure anatomy and depth of incisal planes; the flatter the embrasures (top of figure), the more worn/aged teeth will look. The deeper the embrasures (bottom of figure), the younger the dentition will appear.

is not an option, a simple and effective way to provide a more youthful appearance is to deepen the existing incisal embrasures interproximally. For a more natural appearance, the incisal embrasure of the maxillary lateral incisor should be more pronounced.

Prosthetic modifications of contour and illusion can be used to improve harmony and solve width and/or height imbalances at single or adjacent tooth/implant sites.[7] Moving the facial height of contours inward will "round" a tooth, making it look "narrower"; accentuating the labial planes will also "round" a tooth, making it look "shorter" (Figure 1.9). While these techniques often can help rescue a challenging treatment scenario, the patient should be advised in advance as to the possible limitations of therapy.



(a) (b)

Figure 1.9 (a) Mesio-distal contours: given a particular width for a tooth to occupy a desired space, moving the facial height of contours inward will "round" a tooth, making it look "narrower" (and vice versa). (b) Gingivo-incisal contours: given a particular length for a tooth to occupy a desired space, accentuating the labial planes will also "round" a tooth, making it look "shorter" (and vice versa).

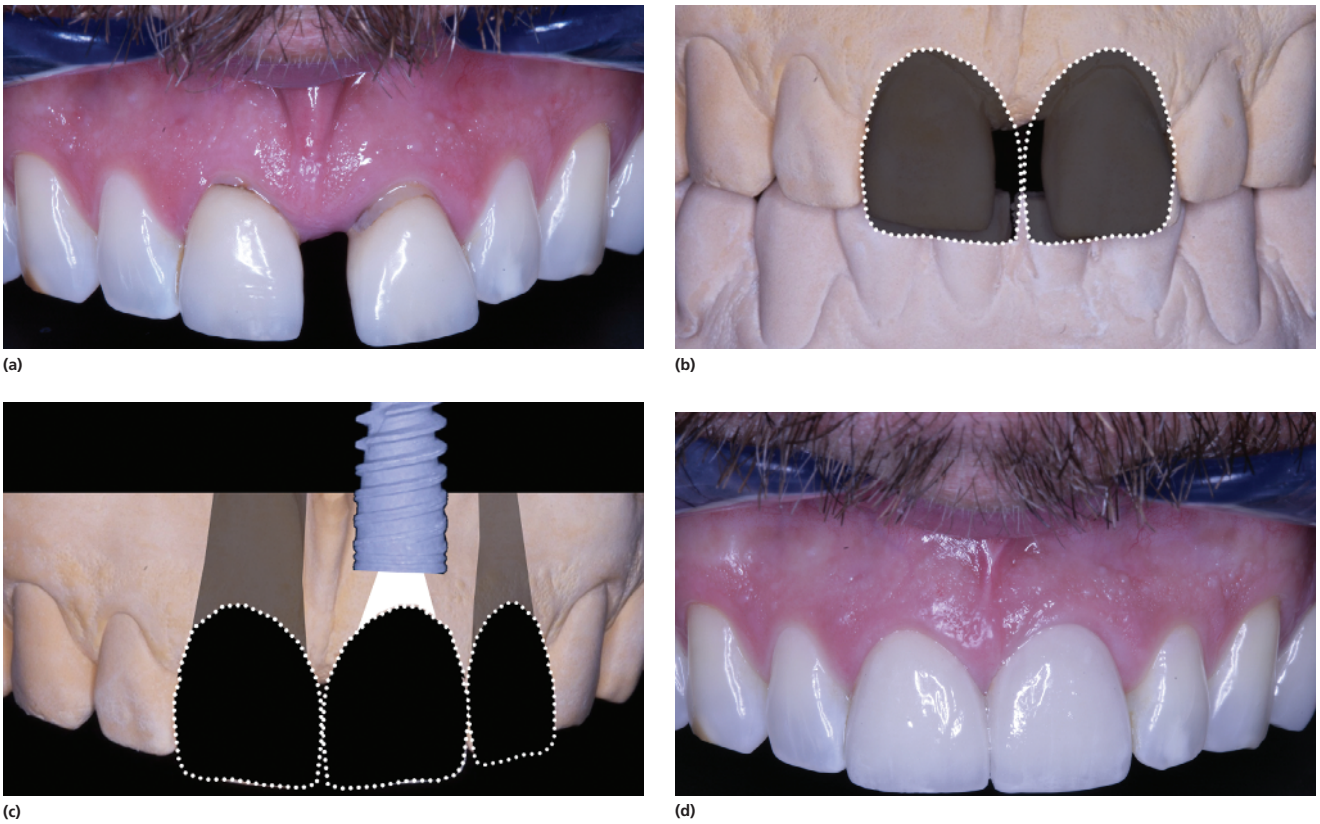


Figure 1.10 (a) Anterior retracted preoperative image demonstrating a hopeless maxillary left central incisor with a large midline diastema. (b) Esthetic analysis on laboratory study cast; idealized right and left centrals incisors superimposed over the existing sites. (c) Planning for dental implant position with planned tooth proportion changes. (d) Retracted anterior view of definitive results right and left centrals incisors. The patient accepted slightly larger than ideal central incisor restorations in order to avoid having to restore the lateral incisors.

The patient in Figure 1.10 presented for implant consultation to replace a hopeless maxillary left central incisor. The right central incisor had a favorable prognosis. The primary esthetic challenge was a large midline diastema developed following buccal migration of the left incisor secondary to advanced periodontal disease (Figure 1.10a). Prior to treatment, a digital plan was presented to the patient for approval, and to determine if additional treatment of the adjacent teeth would be required to achieve ideal proportions and symmetry (Figure 1.10b and c). The patient accepted slightly larger than ideal central incisor restorations in order to avoid having to restore the lateral incisors (Figure 1.10d).

In cases having a long tapered crown shape and significant interproximal bone and papilla loss, restoration of the teeth adjacent to the implant with veneers or full-coverage restorations may be required in order to move the interproximal contact point apically. This change can achieve a more overall esthetic result, but can result in less than ideal tooth esthetics and squarer proportions. If complex restorative treatments are required to achieve ideal esthetics, it is preferable to advise the patient of this possibility during the treatment planning stage, and have all members of the implant team involved in the decision-making process.

Figure 1.11a–c presents a patient with significant occlusal and esthetic compromise resulting from years of parafunctional occlusal habits combined with chemical erosion and periodontal attachment loss. Performing preoperative direct restorative mock-up procedures can allow these patients to be presented with potential treatment options. In this instance, composite resin was layered and cured onto the incisal aspects without the use of etching or adhesive (Figure 1.11d). Orthodontic wax was used to fill in the open interproximal spaces or "black triangles," creating the illusion that those spaces had been closed (Figure 1.11e and f). This intraoral mock-up was evaluated by the patient, documented with photographs, and duplicated with an alginate impression for the creation of a mock-up cast. The desired final contours were completed with a diagnostic wax-up, allowing predictable replication of contours by the laboratory technician. The definitive porcelain restorations with modified shape and proportions are shown in Figure 1.11g and h.

Inter-arch and vertical space

Inter-arch and vertical space requirements can be one of the most confounding aspects of implant restorative treatment planning, making it imperative to complete a thorough analysis of the inter-arch space in all excursions of the mandible. For single restorations, adequate occlusal thickness for the restorative

(a)

(b)

(c)

(d)

(e)

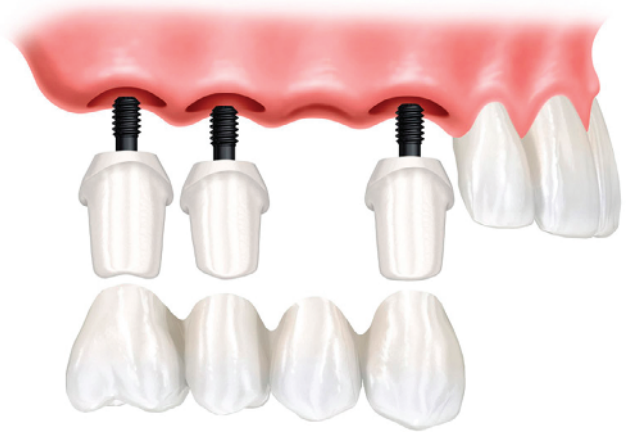
(f)

(g)

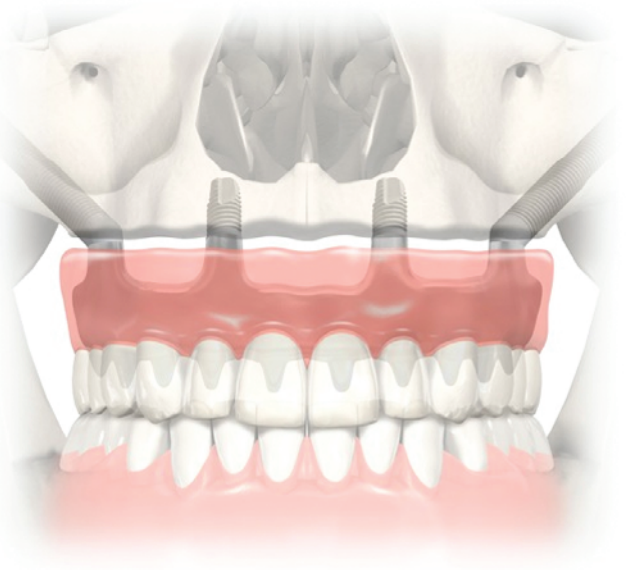
(h)

Figure 1.11 (a) Anterior smile view presents a patient with significant occlusal and esthetic compromise resulting from parafunctional occlusal habits combined with chemical erosion and periodontal recession. (b) Right lateral smile view. (c) Retracted view of the maxillary teeth. (d) Retracted maxillary anterior "mock-up" with rapid freehand addition of composite resin (without bonding agent). (e) Retracted maxillary anterior "mock-up" with white orthodontic wax pressed into gingival embrasures. (f) Anterior smile view of completed rapid "mock-up." (g) Anterior retracted view of completed definitive restorations with modified shape and proportions. (h) Right lateral smile view of completed definitive restorations.

material is mandatory[18] (Figure 1.12a). For zirconium or metal, a minimum of 1.0 mm is required. For lithium disilicate and porcelain-fused-to-metal (PFM) restorations, a minimum of 1.5 mm thickness is required. The cross-sectional areas required for connector zones for splinted multiple unit restorations are 12 mm^2 for short-span zirconia/PFM and 20 mm^2 for longer span zirconia bridges and PFM restorations. Modification of inadequate inter-arch dimension and an abnormal occlusal plane due to extruded opposing teeth can be completed with restorative and/or orthodontic procedures, although the vertical depth of implant placement also must be considered for single restorations. Vertical surgical bone reduction may be needed to achieve adequate prosthetic space for full-arch implant rehabilitations (Figure 1.12b).



(a)



(b)

Figure 1.12 (a, b) Inter-arch and vertical space requirements for prosthesis design need to account for the vertical height of the abutment, major connector, and restorative materials. *Source:* Nobel Biocare. Reproduced with permission of Nobel Biocare, Yorba Linda, CA.

Occlusal stability

Occlusal stability can be improved by idealizing the maxillary anterior cingulum region to provide a stable platform for light centric contacts of implant crowns with the incisal edges of the mandibular anterior teeth. Similarly, recreating simple cusp-to-fossae occlusal contacts in posterior implant restorations should be the goal.

Anterior guidance

Anterior guidance describes the role of the anterior teeth to provide disclusion of the posterior teeth during mandibular movements. The angle of this guidance should be steep enough to achieve posterior disclusion as well as adequate vertical space between the posterior teeth during disclusion. To minimize the effects of potentially damaging forces, the angle of the anterior guidance should be kept to a minimum to reduce lateral and protrusive forces exerted on the anterior teeth.[19] The use of facebow-mounted casts will aid diagnosis, restoration development with the aid of provisionals, and preservation of this critical relationship for use by the laboratory technician.

Phonetics

Natural tooth position and the contours of a fixed or removable prosthesis will influence the quality of speech. Poor tissue profile design with fixed bridges also can lead to difficulty in home-care access and professional maintenance. Poor planning can lead to exaggerated thickness of a removable overdenture or fixed bridge, making it difficult for patients to tolerate the contours and adapt functionally. Improperly designed air space (inadequate pontic design) under a fixed prosthesis (particularly in maxillary arch) can lead to air escape at the tissue level, causing difficulty with pronunciation of silibants.[20] Evaluation of esthetics and phonetics is dynamic, and requires the patient to pronounce "E," "M," "S," "F," and "V" sounds. Having the patient pronounce "E" will exaggerate lip movements and permit easier visualization of the full extent of the esthetic zone. "M" sounds are used to determine the relaxed rest position (vertical dimension of occlusion at rest), as well as the amount of tooth display at rest. In order for "S" sounds (i.e. closest speaking space or vertical speech dimension) to be clear and not "SH-like," the edges of the mandibular anterior incisors should come in "near" contact ("almost" touching) with the lingual of the maxillary incisal edges. Variations can be addressed and corrected as necessary. Finally, for correct pronunciation of "F" and "V" sounds, the incisal edges of the maxillary central incisors ideally need to make contact with the dry–wet line of the lower lip.

Dynamic evaluation of these sounds helps the clinician determine the angulation of the incisal third of the maxillary teeth/implant crowns. The use of provisional restorations can be helpful in facilitating prosthesis design, allowing minor adjustments and a trial period prior to the definitive restoration. Variations expected with each patient can be addressed and corrected. Esthetic zone analysis and the balance of dento-gingival esthetics also require this functional phonic assessment.

The esthetic zone: pink and white esthetic concepts

The esthetic zone is on display during normal speech or animation. Included in the esthetic zone are the "white" esthetics[21] (teeth – presence or absence, symmetry, proportions, etc.) and "pink" esthetics[22] (gingiva – presence or absence, symmetry, color, texture, etc.). White and pink esthetic scores can be helpful for

objective assessment as well as in clinical research.[23] However, the overall esthetic outcome is multifactorial and depends on patient expectations and the levels of gingival display. A fundamental challenge in contemporary esthetic implant dentistry is providing a restoration with the proper balance of soft and hard tissue esthetics. Soft tissue contours are critical in high demand cases, and are only predictable with adequate underlying bone support.[24] Bone augmentation, soft tissue augmentation, or a combination are often required in order to provide the foundation for the restoration of esthetic balance (see also Chapters 5, 7, and 8). These augmentation procedures are time-consuming, involve significant financial commitment, and often require the involvement of multiple specialists.

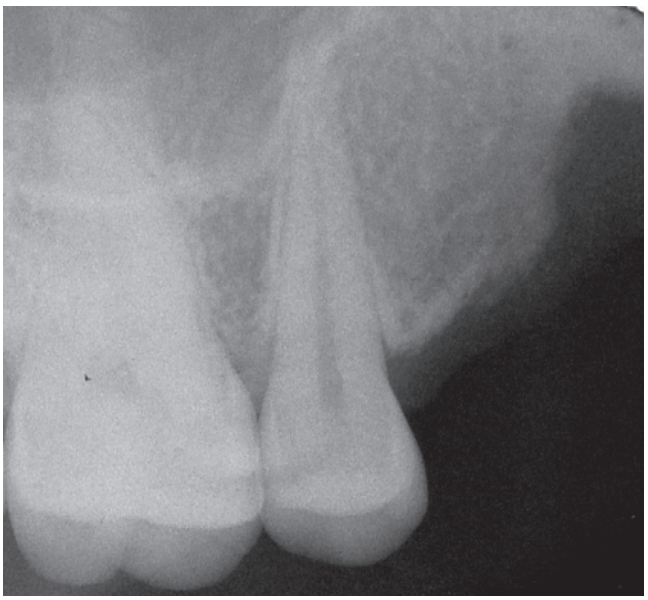
At times, minimally invasive treatment philosophy may dictate a different approach from traditional implant reconstructions. A patient requiring extensive bone augmentation and soft tissue procedures to reconstruct a large alveolar defect may benefit from a less invasive treatment with short, narrow, or angled implant placement (see Chapters 10–12). These techniques can be used with a prosthesis designed with pink porcelain or pink acrylic for replication of the gingival contours.[25] Similarly, a patient with severe periodontal bone loss desiring a full-arch reconstruction may benefit from a less invasive treatment such as a full-arch, screw-retained prosthesis supported by four implants compared with a traditional fixed prosthetic approach involving bilateral bone augmentation and eight or more implants (see "The failing dentition/completely edentulous patient" section and Chapter 12).

A patient who was treated with a minimally invasive approach is demonstrated in Figure 1.13. The patient suffered a traumatic injury to the anterior maxilla. Clinical and periapical radiographic images showed a significant bone and soft tissue defect after loss of the right lateral incisor, canine, and first premolar teeth (Figure 1.13a and b). It was possible to reconstruct this large defect with an implant-supported restoration including a pink esthetic fixed prosthetic with excellent white and pink balance and shade match (Figure 1.13c). The use of a screw-retained prosthesis allowed for periodic removal as needed for prosthesis maintenance and repair.

Placement of the transition line between the prosthetic teeth and soft tissue is an important consideration with the use of pink porcelain or acrylic for replacement of missing soft tissue. Often, the transition line can detract from an otherwise acceptable result. In patients with a low lip line, the vertical or horizontal placement of the transition line is usually not critical. However, all patients should be evaluated for possible maximum display of the prosthesis during an exaggerated smile ("E" sounds). If the transition line is in view, acceptability of the esthetics should be discussed and finalized with the patient. If a horizontal transition line is unacceptable, the implant position may need to be more apical or a labial flange can be used to modify the prosthesis to move the transition line apically with the use of a bar overdenture prosthesis design (see Figure 1.20 and discussion further on). This also requires adequate prosthetic space but allows for adequate hygiene maintenance. The addition of a flange to a fixed prosthesis will result in poor prosthesis contours and limit access for hygiene and professional maintenance, even with the use of a screw-retained prosthesis in these challenging scenarios. Planning and appropriate implant positioning must be determined by the prosthetic plan.

(a)

(c)



(b)

Figure 1.13 (a) Clinical and (b) periapical radiographic images show a significant bone and soft tissue defect after traumatic injury with the loss of the right lateral incisor, canine, and first premolar teeth. (c) It was possible to reconstruct this large defect with an implant-supported restoration using a pink esthetic fixed prosthetic with excellent white and pink balance.

Planning for ideal implant position

The *interproximal space* between implants and/or teeth is an important consideration for bone and soft tissue stability.[17] Dental implants have no periodontal attachment apparatus with the associated blood supply to help to maintain the interproximal height of bone that is critical for predictable soft tissue levels. Table 1.1 provides a summary of the key dimensions and a classification for tooth and implant spacing and interproximal vertical soft tissue height.[26]

These tissue levels are the result of the bucco-palatal bone width[27] and the vertical and horizontal crestal bone remodeling secondary to the establishment of the biologic width around implants[28] (see Chapter 8, Figure 8.3a and b). For an implant adjacent to a natural tooth, an interproximal distance of 1.0–1.5 mm is required to avoid interproximal bone loss. Between adjacent implants, an interproximal distance of 3.0–3.5 mm must be maintained to prevent or minimize interproximal bone loss.[29] If adjacent implants are placed too close, exaggerated vertical bone loss can result due to merging of the two zones of horizontal crestal remodeling between the implants.[28] Platform-switching and implant design modifications also can help to minimize this remodeling when these crucial interproximal distances cannot be achieved[30] (see further discussion in Chapters 3 and 4).

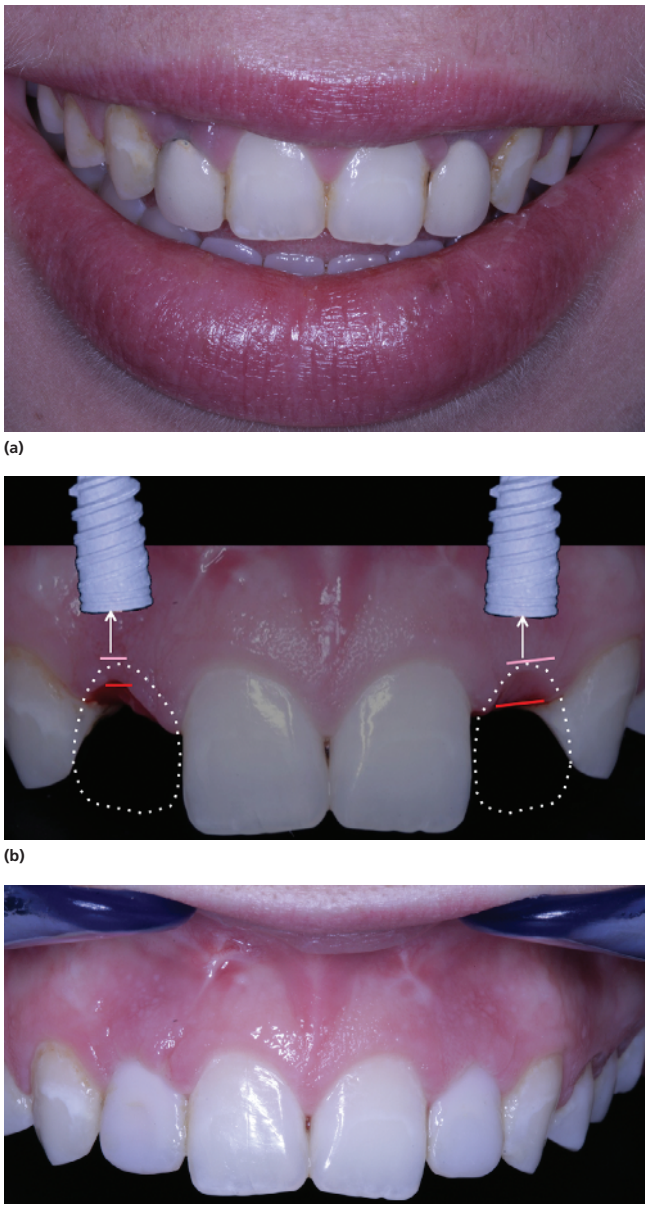
The ideal *corono-apical position* or depth of placement of the implant prosthetic platform should be 2.0–3.0 mm below the gingival zenith of the proposed implant restoration.[1] The patient shown in Figure 1.14 presented with an esthetically displeasing conventional bonded bridge replacing the maxillary lateral incisors bilaterally. With careful planning for the final level of the free gingival margins of the right and left maxillary lateral incisors, appropriate implant placements were achieved. Figure 1.14b shows an anterior retracted clinical view with superimposed proposed implants in position, with the red lines representing the desired height of the free gingival zeniths. The dotted white lines represent the desired outlines of the new restorations. The provisional crowns are shown in Figure 1.14c after initial soft tissue maturation.

Bucco-lingual implant positioning also is important in maintaining esthetic and functional stability.[31] In the esthetic zone, the buccal plate thickness of natural teeth measures between 0.5 and 2.5 mm at the crest.[32] Preserving this buccal bone or augmentation with hard tissue grafting at implant placement should ensure that a thickness of 2.0 mm or greater is maintained to have predictable and stable hard and soft tissue contours over the facial aspect of the implant.[24] Relationships of the osseous crest and correct bucco-lingual implant placement and trajectory are demonstrated in Figure 1.15. This male patient presented with a chief complaint of a non-restorable, endodontic-treated maxillary left central incisor.

Table 1.1 Salama *et al.* classification of predicted height of interdental papillae

Class	Restorative environment	Proximity limitations (mm)	Vertical soft tissue limitations (mm)
1	Tooth–tooth	1.0	5.0
2	Tooth–pontic	N/A	6.5
3	Pontic–pontic	N/A	6.0
4	Tooth–implant	1.5	4.5
5	Implant–pontic	N/A	5.5
6	Implant–implant	3.1	3.5

Source: Salama H, Salama MA, Garber D, Adar P. The interproximal height of bone: a guide-post to predictable aesthetic strategies and tissue contours in anterior tooth replacement. Pract Periodontics Aesthet Dent. 1998; 10: 1131–1141.[26]



(a)

(b)

(c)

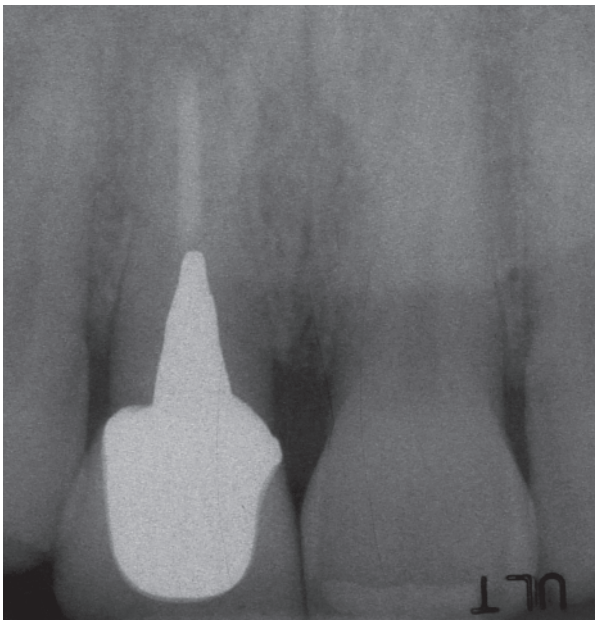
Figure 1.14 (a) Anterior smile view preoperative resin-bonded PFM bridges replacing teeth 7 and 10. (b) Anterior retracted view with superimposed proposed implants 7 and 10 (red lines represent free gingival margins of preoperative restorations; pink lines represent desired height of free-gingival zeniths; dotted white lines represent desired outlines of new restorations 7 and 10). (c) Anterior retracted view of provisional implant crowns 7 and 10 after soft tissue maturation.

(Figure 1.15a) There was significant recurrent decay within the canal preparation (Figure 1.15b). The surrounding soft and hard tissues appeared adequate for a planned implant-supported restoration. The interproximal bony peaks were intact 4.5 mm apical from the desired interproximal contact zones on the mesial and distal (Figure 1.15c). The osseous crest was located 3.0 mm away from the buccal and lingual free gingival margins.

Digital treatment planning included superimposition of the left central incisor mirror image over the edentulous space (Figure 1.15d and e) to evaluate the mesio-distal space requirements.

(a)

(b)



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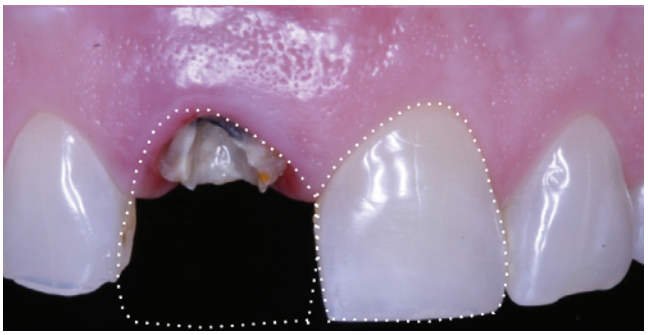

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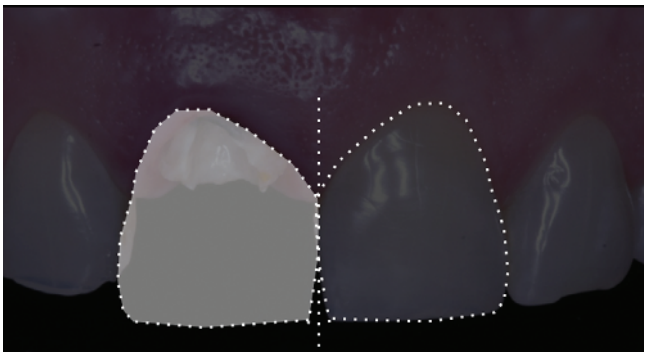

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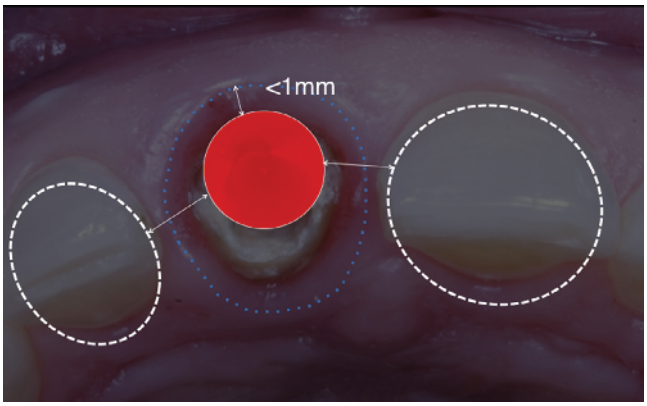

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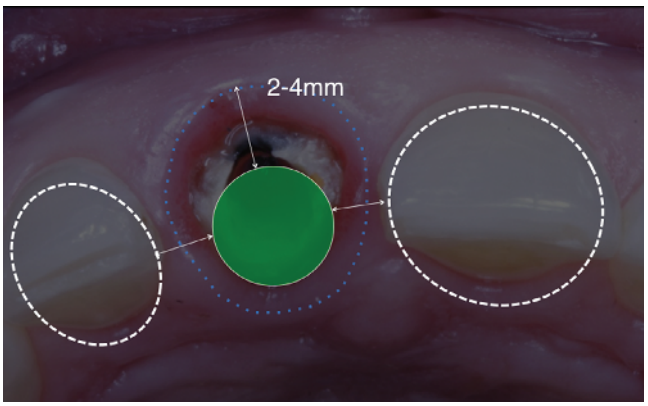
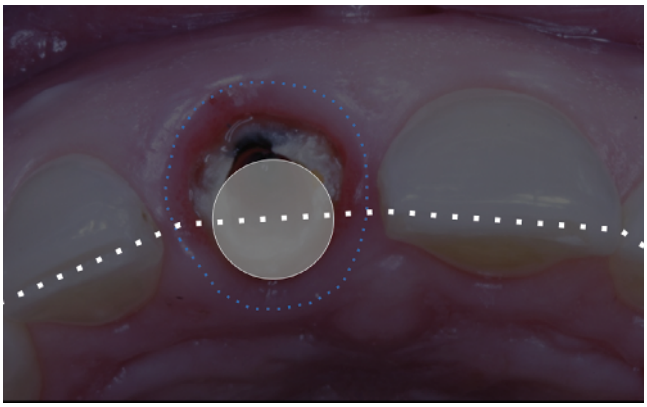


(g)

Figure 1.15 (a) Retracted anterior preoperative view of failing maxillary right central incisor. (b) Occlusal view of root fragment after removal of the failing crown. (c) Preoperative periapical radiograph showing intact interproximal bone. (d) Anterior retracted view with superimposed mirror image tracing for tooth shape analysis. (e) Superimposed mirror image tracing for tooth shape analysis with proposed midline and the shaded outline of the proposed restoration. (f) Occlusal view of dangerous bucco-lingual positioning for implant placement in the esthetic zone (too facial). (g) Occlusal view of idealized bucco-lingual positioning for implant planning in the esthetic zone, maintaining at least 2 mm facial gap.

(*Continued*)



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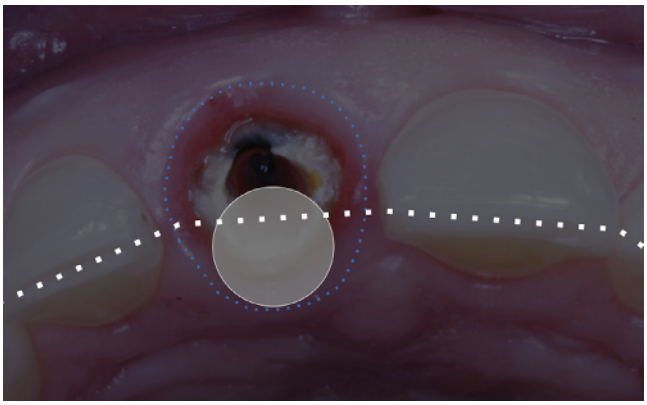
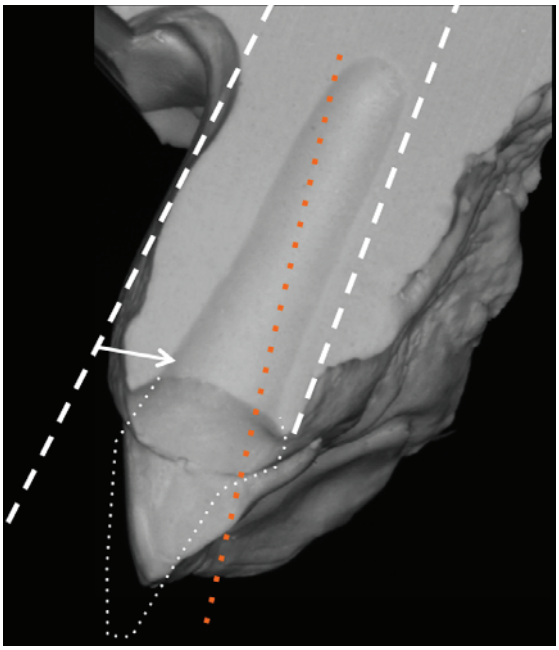


(i)



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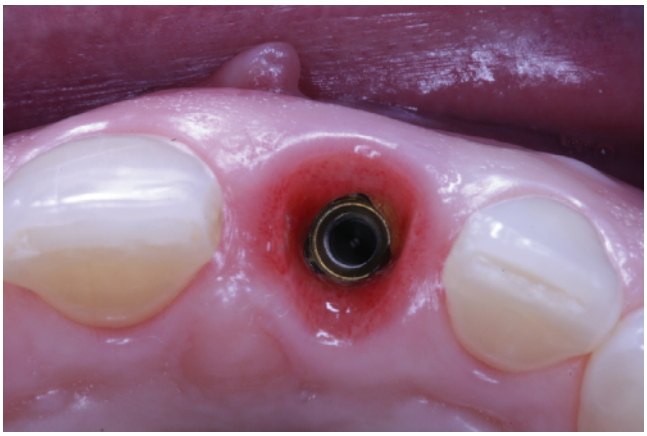

(k)

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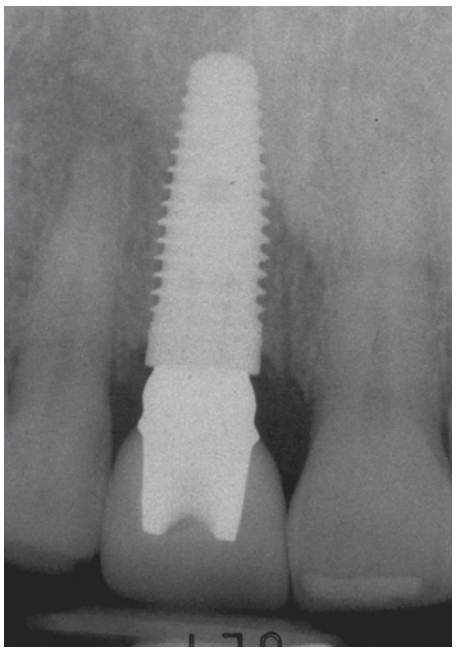


(m)

Figure 1.15 (Continued)
(h) Occlusal view of analysis of bucco-lingual angulation with the access hole location for planned restoration through the incisal edge of the future crown. (i) Occlusal view of analysis of bucco-lingual angulation with the access hole location for planned restoration through the cingulum of future crown. (j) Lateral view of the study cast with a sagittal view representation of (i) showing implant angulation relative to desired restored crown anatomy. The location of the access hole for screw retention is visualized through the cingulum. (k) Occlusal view of the implant and peri-implant soft tissues 4 months post-extraction with an immediate fixed provisional restoration. (l) Anterior retracted view of definitive implant crown at the central incisor. (m) Periapical radiograph of definitive implant restoration.

Correct bucco-lingual positioning of the implant fixture was critical for stable bone and soft tissues and a predictable esthetic result. Ideally, the buccal surface of the implant fixture, when measured at the restorative margin, should be located at least 2.0 mm lingual to the buccal plate contour. If the buccal plate thickness is less than 2.0 mm there is increased risk of soft tissue recession and exposure of the implant abutment. Facial positioning is at risk for horizontal remodeling and recession (Figure 1.15f). A reference line can be made tangent to the buccal bone contours of the adjacent teeth. Implant positioning should be at least 2.0 mm lingual to this reference, and bone augmentation is often necessary (Figure 1.15g).

Bucco-lingual angulation must also be considered in the choice of screw or cement retention for the provisional and definitive restorations. The advantages of screw retention in avoiding peri-implant inflammation and bone loss are well known.[33] In Figure 1.15h, the angulation shown would have resulted in the retention screw emerging at the incisal edge of the restoration (i.e. too far to the buccal). In order to allow adequate restorative material thickness at the incisal edge, a retention screw access opening must be through the cingulum of the restoration, and this dictates that the implant osteotomy be more upright and palatally-positioned (Figure 1.15i). Correct implant positioning with regard to apical trajectory is required in order to achieve optimal positioning of the retention screw for screw-retained implant restorations (Figure 1.15j). This positioning allows an optimal facial bone gap dimension for grafting with immediate implant placement (see Chapters 18 and 19). At 4 months post-extraction, implant placement and immediate provisionalization were undertaken. Figure 1.15k shows the occlusal view of the implant position and peri-implant soft tissues. A periapical radiograph and clinical images demonstrate the definitive implant crown (Figure 1.15l and m).

Implant size selection is dependent on the residual bone volume and desired prosthetic emergence diameter of the tooth to be replaced.[1] Ideally, 3-D imaging should be completed preoperatively to evaluate surgical anatomy of the proposed implant site(s) (see Chapter 2). Implant length should be selected to stay a minimum of 2.0 mm away from the floor of the nose, sinus, and roof of the inferior alveolar canal or from known undercuts. Implant diameter should be selected to maintain the facial and interproximal surrounding bone dimensions as described previously. Often, choosing a slightly narrower diameter implant in favor of maintaining a greater facial and interproximal bone volume can be prudent. Anticipated occlusal loads for a given site also should be taken into consideration, as well as the mechanical risks of using narrow-diameter or short implants versus bone augmentation and the use of standard-diameter/length implants[34,35] (see Chapter 3).

Treatment planning

After review of the diagnostic findings, critical evaluation includes assessment of the patient's anatomy for the presence of any bone or soft tissue defects (see Flowchart 1.1). What are the *patient's expectations,* and are there esthetic zone demands? (See Flowchart 1.2.) Provisional options must be considered with fixed, immediate, or removable appliances and a contingency plan made in the event that a fixed prosthesis is not possible based on the actual surgical outcome. Implications from any *soft tissue transition line* planned for the prosthesis, tooth display, and teeth missing, as well as the patient's age, desires, attrition, and previous dental treatments must be understood (see Flowchart 1.3). Any need to modify incisal edge position of teeth, to employ crown lengthening, and/or to increase vertical dimension of occlusion to enhance esthetics and phonetics must be confirmed. Patients with severe attrition and/or a failing dentition may have exaggerated freeway space or significant dentoalveolar extrusion that will adversely affect the maxillary central incisor position or not allow adequate prosthetic space, requiring occlusal plane changes or treatment with bone reduction and a full arch restoration (see Flowchart 1.4). It is important to assess the skill and experience level of the treatment team to ensure that a minimally invasive treatment approach is indicated and can be completed in a predictable fashion.

The single missing tooth

If a *single tooth* is to be extracted, there must be adequate bone at the buccal plate and interproximal areas to support the buccal soft tissues and interproximal papillae. Esthetic zone demands should be understood (see Flowchart 1.1). With a *soft tissue defect* at a single tooth site, investigation and correction of any underlying bone defect must be addressed whether by bone and soft tissue augmentation as staged procedures (see Chapters 5–8) or with orthodontic supereruption of the adjacent tooth/teeth (see Chapter 20). Slight modification of crown contours and/or the restoration of adjacent teeth may be required to adequately close an existing diastema or compromised embrasure space (Figure 1.9). Use of artificial pink tissue replacement is possible, although often challenging (Figure 1.13).

The female patient in Figure 1.16a and b presented with an implant-supported restoration that had been done after traumatic loss of her maxillary left central incisor. There were significant hard and soft tissue defects present, and the left lateral incisor was rotated to the mesial. There was asymmetry of the maxillary central incisors and a moderately high lip line. No treatment and several treatment options were discussed, including: (i) orthodontic forced eruption of the right central incisor and left lateral incisor to enhance the surrounding tissue, tooth alignment, and rotation; (ii) a conventional fixed bridge supported by the left lateral and right central; (iii) conventional removable partial denture; and/or (iv) prosthetic illusion to minimize the effect of the soft tissue defect with a conventional resin-bonded laminate on the adjacent lateral incisor and alteration of the contours of the replacement crown and left lateral incisor.

Esthetic analysis of two treatment options under consideration can be seen in Figure 1.16c and d, and demonstrates the potential crown contours and gingival level predictions. Treatment option 1 required correction of the gingival recession defect at the left lateral incisor and restorations with contour modifications at the left central and lateral incisors as well as a composite restoration gingivo-mesially at the right central incisor (Figure 1.16c). Treatment option 2 would maintain a longer left lateral incisor to avoid further surgery/orthodontics to correct the gingival recession defect and partially compensate for the slightly longer gingival (apical) margin at the left central incisor (Figure 1.16d). This option would minimize treatment time, the number of procedures, and cost. Owing to the previous extended treatment time (1.5 years at presentation), the patient chose option 2. By slightly altering the facial crown contours and proportions (for the implant crown, facial laminate veneer for the adjacent lateral incisor, and a composite bonding of the right central incisor), the actual size discrepancies were optically minimized by subtle illusions. The treatment resulted in improved symmetry and proportions, as seen in the retracted (Figure 1.16e) and full smile views (Figure 1.16f).

The hopeless tooth

This patient shown in Figure 1.17a–c presented with significant internal root resorption on the right maxillary central incisor.

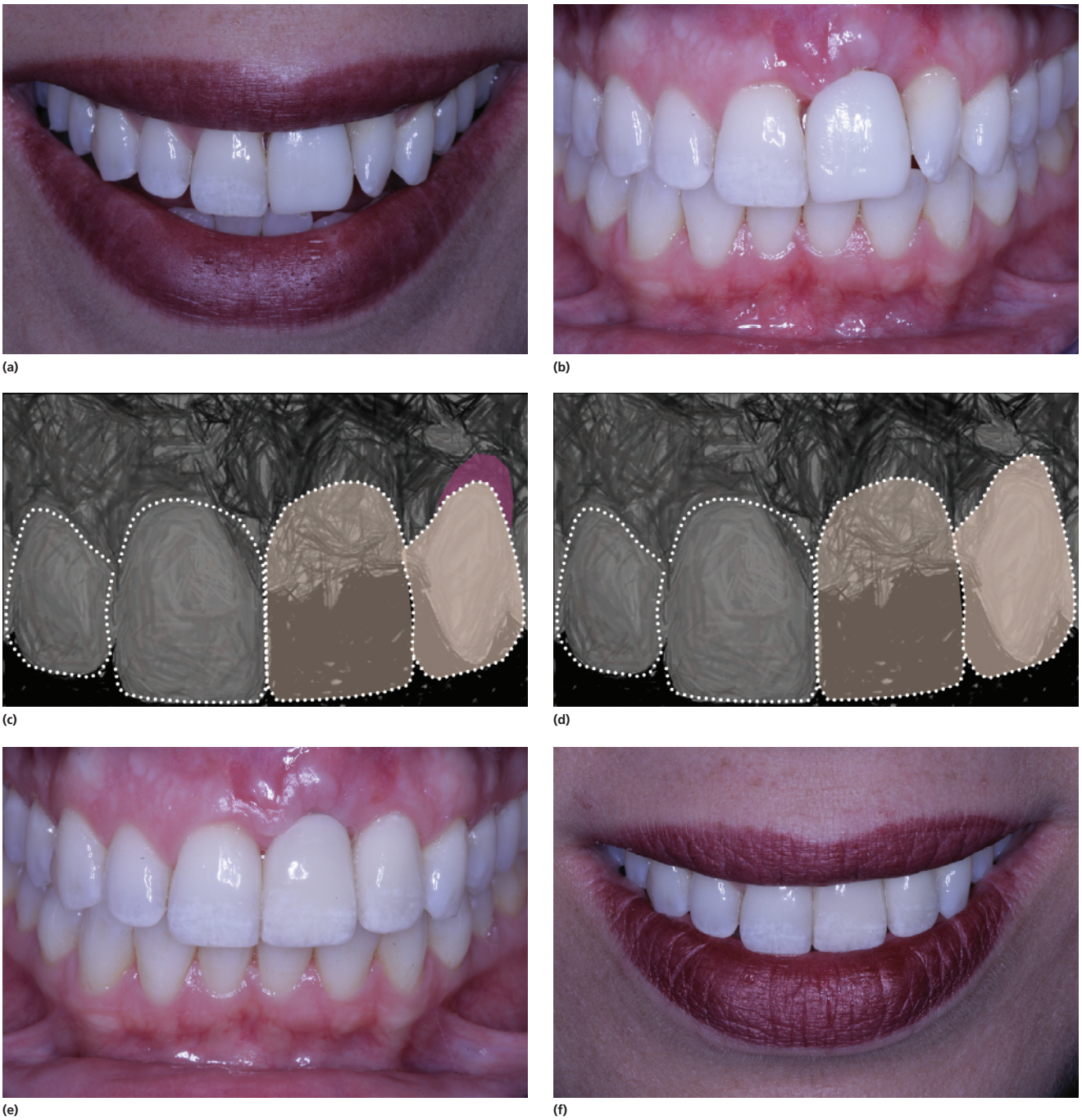


Figure 1.16 (a) Smile view of this female patient after traumatic loss of her maxillary left central incisor. (b) Anterior retracted view of an implant-supported restoration at the maxillary left central incisor, with anterior dental asymmetry and compromised bone and soft tissue levels. (c) Esthetic analysis of treatment option 1 with restoration of gingival recession defect at the left lateral incisor and restorations with proposed contour modifications at the left central and lateral incisors as well as composite gingivo-mesially at the right central incisor. (d) Esthetic analysis of treatment option 2 maintains a longer left lateral incisor to avoid further surgery/orthodontics to correct gingival recession defect. This also partially compensates for the slightly longer gingival (apical) margin at the left central incisor. (e) Anterior retracted view of definitive results after restorations with contour modifications at the left central (implant-supported crown) and lateral incisors (conventional laminate) as well as composite gingivo-mesially at the right central incisor. (f) Anterior smile view of definitive results.

Adequate contours of hard and soft tissues were present for an implant-supported restoration, and consideration was made for a minimally invasive treatment plan (see Flowchart 1.1). Extraction and immediate implant placement for a screw-retained crown included an immediate, non-functional provisional crown with indirect fabrication from a modified study cast (Figure 1.17d). After 4 months healing, Figure 1.17e and f show the frontal and occlusal views. The definitive screw-retained porcelain-fused-to-zirconia restoration displays the emergence contours typical of this anatomic location, and the ideal screw access location can be seen after insertion on the master cast (Figure 1.17g and h). The definitive screw-retained restoration is seen in clinical and periapical

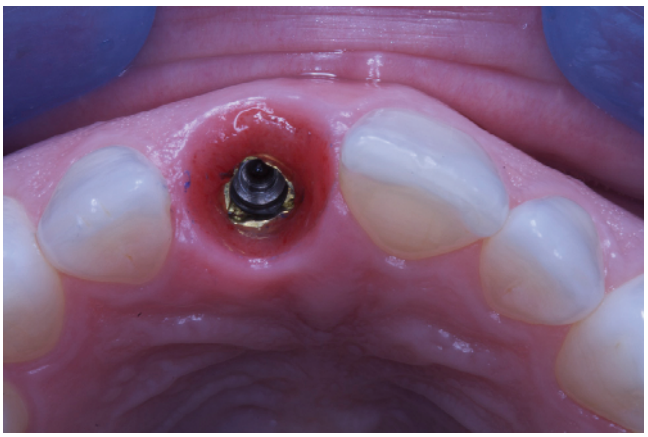
(a)

(b)

(c)

(d)

(e)



(f)

Figure 1.17 (a) Anterior smile view of patient with a failing right maxillary central incisor. (b) Retracted anterior view showing adequate contours of hard and soft tissues present. (c) Periapical radiograph demonstrating a large lesion secondary to internal resorption of the right maxillary central incisor and adequate interproximal bone heights. (d) Extraction and immediate implant reconstruction was completed with placement for screw retention of an immediate non-functional provisional crown. (e) The frontal and (f) occlusal views demonstrate the excellent soft tissue response on removal of the provisional crown 4 months after immediate implant placement with immediate provisional restoration.

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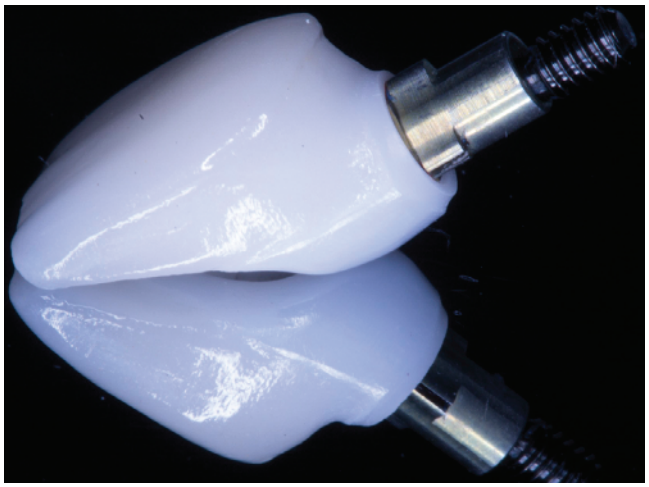

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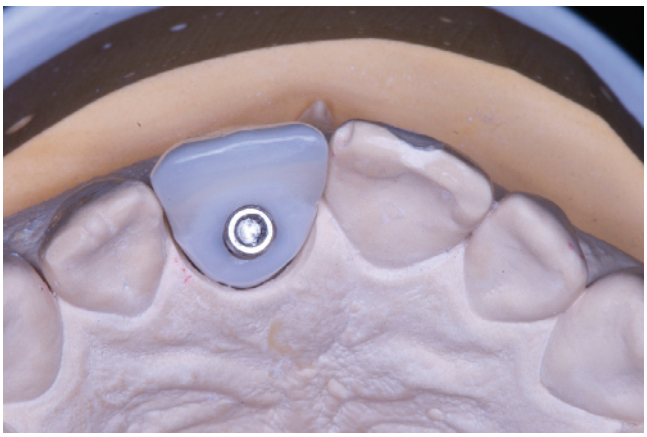

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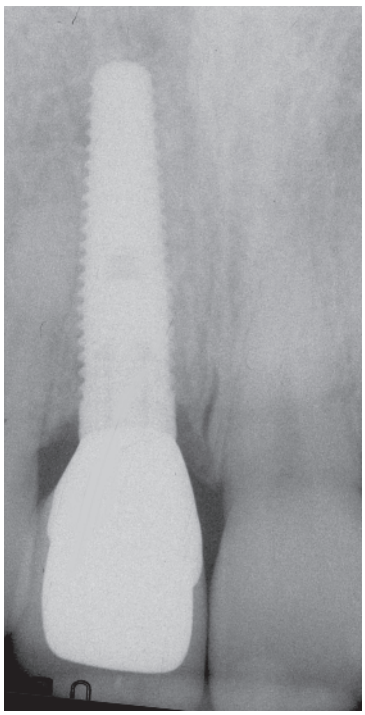


(i)

(j)

Figure 1.17 (Continued)
(g) Definitive porcelain-fused-to-zirconia screw-retained crown displays the emergence contours typical of this anatomic location. (h) Definitive screw-retained crown, and the ideal screw access location is shown on the master cast. (i) Periapical radiograph of definitive restoration at the right central incisor shows excellent bone contours and implant positioning with screw retention. (j) A retracted anterior view demonstrates the definitive result with excellent bone and soft tissue contours and implant positioning after immediate implant placement with immediate provisional restoration.

radiographic images to have excellent bone and soft tissue contours after this minimally invasive treatment (Figure 1.17i and j).

Multiple missing teeth

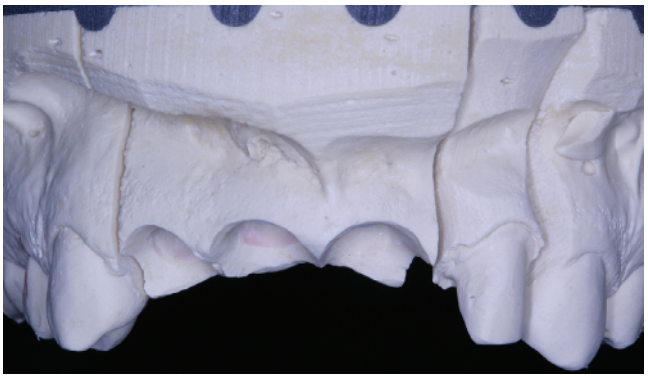
After completion of the diagnostic evaluation of sites with more than one missing tooth, compromises detected with interdental spaces, tooth proportions, and other parameters may require orthodontic treatment, surgical augmentation, and/or prosthetic modifications of adjacent teeth using contour and illusions to improve harmony (see Flowcharts 1.2 and 1.3). Often, staging treatment with initial site augmentation can allow a subsequent minimally invasive approach with guided surgery (see Chapter 9). A comprehensive review of the limitations and predictability of the treatment options should be discussed with the patient.

The patient seen in Figure 1.18a and b presented complaining of an unacceptable implant restoration. Examination revealed implant-supported fixed restorations at the right and left central and right lateral incisors and a restored natural left lateral incisor. There was asymmetry with tooth shape and size discrepancies contributing to an overall displeasing esthetic result. Discussion addressed the esthetic limitations of having adjacent implants in the esthetic zone, and possible treatment options included: (i) restoring the existing adjacent implants with a definitive prosthesis; (ii) submerging one or more implants and converting the affected site(s) to a pontic(s); or (iii) removing and replacing some or all of the implants. Often, in such challenging circumstances, consideration of a diagnostic provisional phase can be helpful in assessing the teeth, soft tissues, and patient expectations (see Chapter 4). The diagnostic provisional restoration used in this patient had improved contours to attempt to correct the esthetic deficiencies and assess the soft tissue and patient responses (Figure 1.18c). The new provisional was designed with the contact points 3.0–3.5 mm crestal to

(a)

(b)

(c)



(d)

(e)

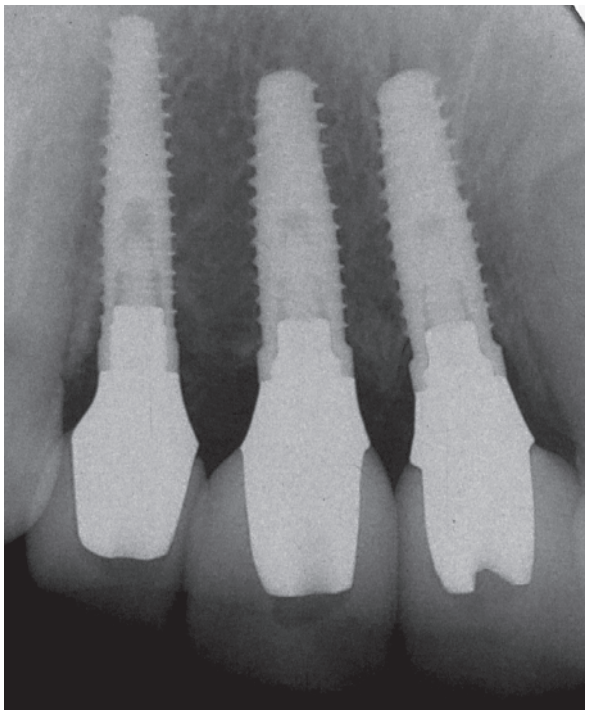
(f)

(g)

Figure 1.18 (a) Preoperative smile and (b) retracted view revealed implant-supported fixed restorations at the right lateral and central, and left central incisor locations, with a restored natural left lateral incisor. Apparent tooth shape and size discrepancies and asymmetry were noted, contributing to an overall displeasing esthetic result. (c) Clinical right lateral view of provisional anterior restorations 1 week after placement, designed to correct the esthetic deficiencies, with the contact points 3.0–3.5 mm crestal to the interproximal bone peaks. (d) Anterior and (e) lateral views of customized master cast demonstrating peri-implant tissue profiles on individual implant crowns (right and left central and right lateral incisors) and conventional crown (left lateral incisor). (f, g) Clinical lateral smile views and

(*Continued*)

(h)



(i)

Figure 1.18 (Continued)
(h) retracted anterior view of the definitive restorations in position with improvement of the white and pink esthetic balance. (i) Periapical radiograph of definitive restoration after insertion.

the interproximal bone peaks. These changes satisfied the patient's chief complaint and allowed the provisional to act as a guide for the final restorative procedures.

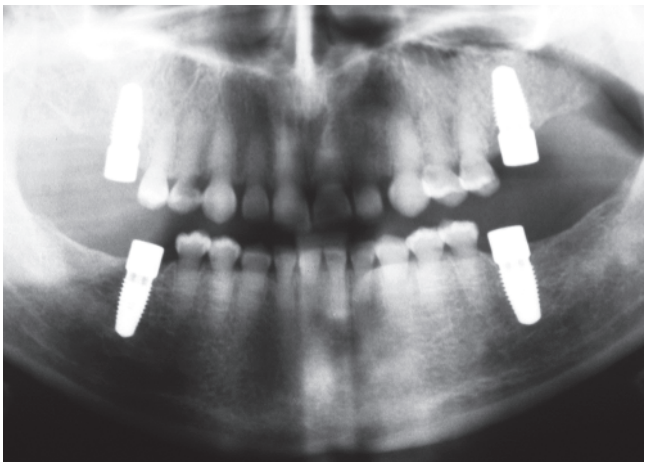
During fabrication of the definitive prosthesis, emphasis was placed on transferring the tissue height information to the dental laboratory with custom impression copings and the idealized fixed provisional bridge as the impression transfer. The master cast was modified with custom peri-implant soft tissue emergence profiles at the central and right lateral incisors and a conventional crown at the left lateral incisor (Figure 1.18d and e). Clinical and periapical radiographic images of the definitive restorations are seen in Figure 1.18f–i.

The failing dentition/completely edentulous patient

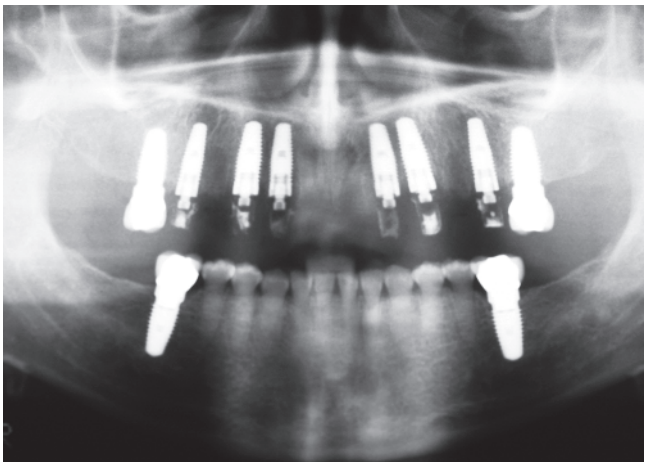
Treatment considerations for the failing dentition or a fully edentulous patient represent the comprehensive application of prosthetic dentistry principles. Soft tissue display on animation increases the esthetic demand and care in establishing an acceptable prosthesis to the soft tissue transition line (see Flowchart 1.4). The esthetics and phonetics will be determined by the maxillary central incisor positions as the foundation. Minimally invasive treatment options can include implant placement at the time of tooth extraction with two implants placed to support an overdenture after osseointegration is achieved. From a minimally invasive perspective, an immediate implant-supported fixed prosthesis can be ideal. This approach is well-accepted for implant placement at the time of tooth extraction or for fully edentulous patients. The indications for four, six, or more implants are discussed further in Chapters 12 and 21. With adequate primary implant stability, anterior–posterior spread, and adequate prosthetic space, immediate provisional restoration is highly predictable in the mandible. In the maxilla, computed-tomography-guided surgery can be a great asset with planning and completion of the procedure and provisional restoration (see Chapter 9). Alternatively, when planning for fixed full-arch reconstructions, sequential implant placement can be completed in the posterior regions with immediate non-loaded provisional restorations in the premolar esthetic areas. After osseointegration, the posterior segments can be restored with immediate implant and provisional reconstruction of the anterior sites (see Chapter 19). This can allow for continual wear of a fixed prosthesis in the esthetic zone during an extended transition period to an implant-supported, full-arch fixed prosthesis. Figure 1.19a–c show panoramic radiographs of a patient who received sequential immediate implant reconstruction in the maxilla.

Despite the many advantages of fixed restorations, implant-supported removable prostheses can be a viable and less costly alternative. As often required in the maxilla, the flange of an overdenture can be used to hide the transition line. Another advantage is that a removable prosthesis may be utilized with smaller vertical space requirements than a conventional hybrid restoration (cast or milled titanium superstructure processed with acrylic and plastic teeth). As patients age, utilization of a removable bridge (i.e. Marius bridge, spark erosion bar designs, machined-milled designs with plungers, etc.) becomes particularly beneficial, as these prostheses can be designed so as not to move under function but require little force for removal (see Flowchart 1.4). However, the patient should understand the challenges involved in fabricating a removable prosthesis that does not have some degree of movement. Resilient attachments can be designed with a precision metal housing incorporated into the intaglio surface of the denture to help ensure long-term stability and serviceability, and to prevent prosthesis fracture. Figure 1.20a and b demonstrates an implant-supported maxillary precision bar prosthesis secured with plungers in bilateral molar regions.

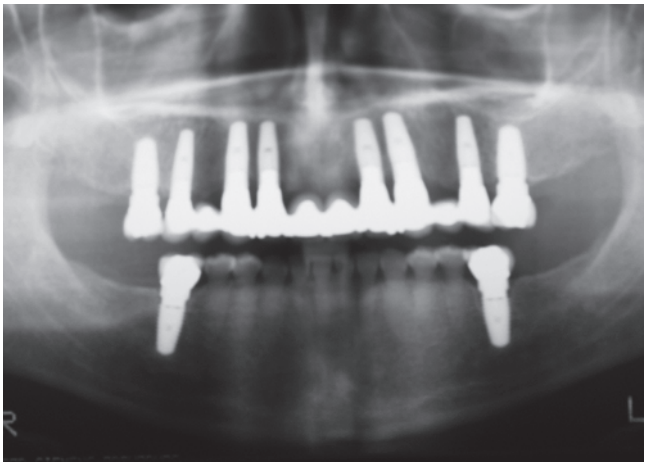
Vertical space and interarch dimensions require careful consideration as there is typically a need for more prosthetic space with a hybrid design with cantilever components (14 mm) than with



(a)



(b)



(c)

Figure 1.19 (a–c) Panoramic radiographic series demonstrating sequential implant reconstruction of the maxilla maintaining fixed esthetic provisional restoration through the treatment phases. © Daniel R. Cullum.

a removable bar overdenture or conventional PFM or zirconia bridges. The total height requirements for all implant and prosthetic components must be considered, including the abutment and/or bar, the retentive component and/or bar, the bar superstructure, the denture base acrylic, the pink restorative material, and the teeth (see Flowchart 1.4). All components must be used with due consideration to their material strength, flexion, and wear. For example, a full-arch zirconia appliance in the mandible opposing a complete upper denture can result in wear of maxillary plastic denture teeth, potentially compromising the maxillary smile esthetics over time. Further considerations include reparability and durability. A hybrid restoration with a cast framework is highly reparable

(a)

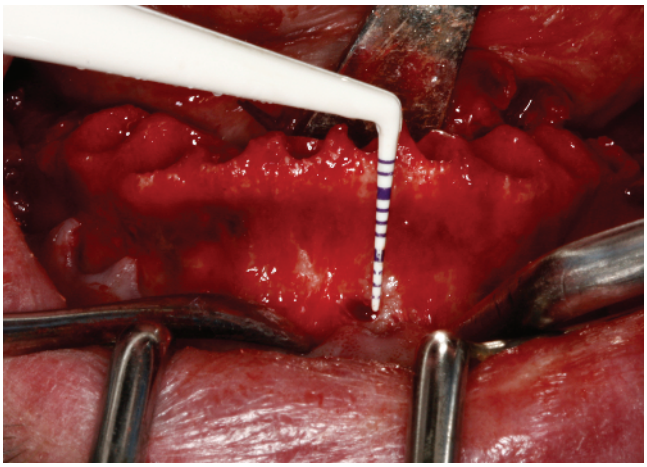
(b)

Figure 1.20 (a, b) Clinical images of an implant-supported maxillary precision bar prosthesis design secured with plungers in the bilateral molar regions. Restoration by Earl Ness DDS MSD. © Daniel R. Cullum.

and can be re-processed with changes in tooth or base dimensions, whereas a PFM or zirconia restoration cannot. Patients with clenching or bruxing habits may benefit from a resilient plastic occlusal surface of a hybrid restoration. Some patients and clinicians prefer the esthetic results of a PFM or zirconia restoration, and patients may require indefinite night guard use with these reconstructions.

Immediate extraction cases, particularly when tooth loss is secondary to severe attrition and/or non-restorable caries, often display loss of vertical dimension over time due to loss of tooth structure and simultaneous dento-alveolar extrusion (Figure 1.21a and b). In these complex cases, simply opening the vertical dimension is insufficient, often resulting in esthetic and functional compromises, including inadequate maxillary incisor display (see Flowchart 1.4). In these cases, the surgical plan must account for required prosthetic space, and bone reduction may be required (Figure 1.21c). After implant insertion, the direct abutment pick-up technique can be used for immediate prosthesis fabrication incorporating a prosthetic design that corrects maxillary incisal edge position (Figure 1.21d–f).

(a)



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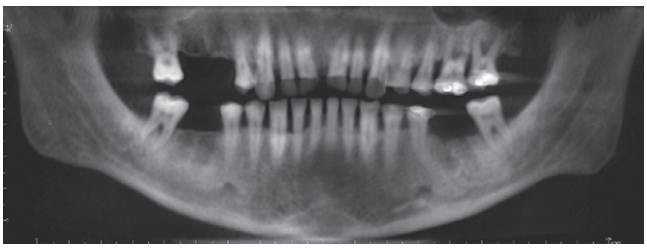

(b)

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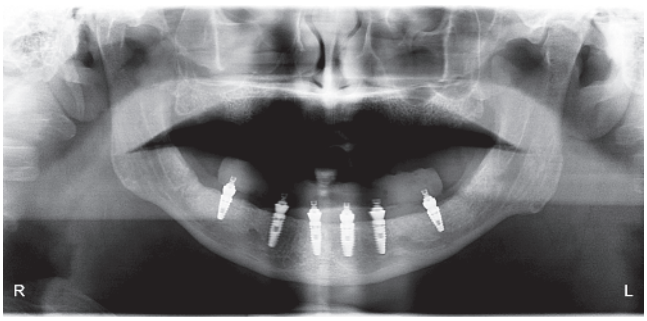

(f)

Figure 1.21 Preoperative (a) clinical and (b) radiographic views of a patient with severe attrition and non-restorable caries with loss of vertical dimension with wear of tooth structure and simultaneous alveolar extrusion. This resulted in limited vertical space available for the restoration and increased mandibular incisor display. (c) Residual alveolar height prior to 12 mm bone reduction for adequate prosthetic space. (d) The immediate post-treatment image with implant placement and immediate prosthesis fabrication demonstrating the corrected maxillary incisal edge position. (Restoration Dr K Hintz.) (e) The 10-day post-treatment clinical result with implant placement and immediate prosthesis insertion. (f) The 3-month post-treatment radiograph with implant placement and immediate prosthesis fabrication demonstrating six implants placed for maximum anterior–posterior spread. © Daniel R. Cullum.

The provisional phase can greatly facilitate final prosthesis design and patient satisfaction.

Conclusions

The prosthetic aspects of diagnosis and treatment planning can become more complex if less invasive surgical procedures are anticipated. Clinical evaluation of facial, dento-facial (including the esthetic zone), dento-gingival (gingival architecture, teeth, and occlusion), and phonetic implications must be undertaken. Many diagnostic tools are available, including CBCT imaging, and will help in planning possible therapeutic interventions. Developing an accurate diagnosis is best achieved using a systematic process that is purposeful and meant to gain the patient's full understanding and support. A plan is rarely a singular option, but rather a discussion encompassing multiple possibilities. Application of the concepts of prosthetic camouflage and illusion, white and pink balance, prosthetic space, and prosthesis soft tissue transition lines should be considered. Skill and judgment remain paramount, and minimally invasive approaches require clinicians to be proficient and able to anticipate, prevent, and/or manage potential surgical and prosthetic complications. This chapter has discussed principles for the diagnosis, treatment planning, and prosthetic restoration of commonly encountered clinical situations in the context of employing minimally invasive procedures.

Acknowledgments

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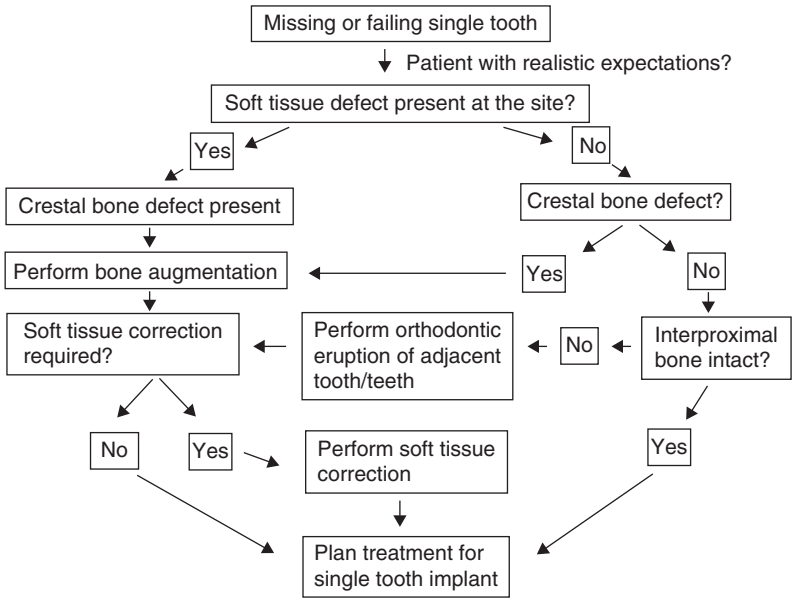
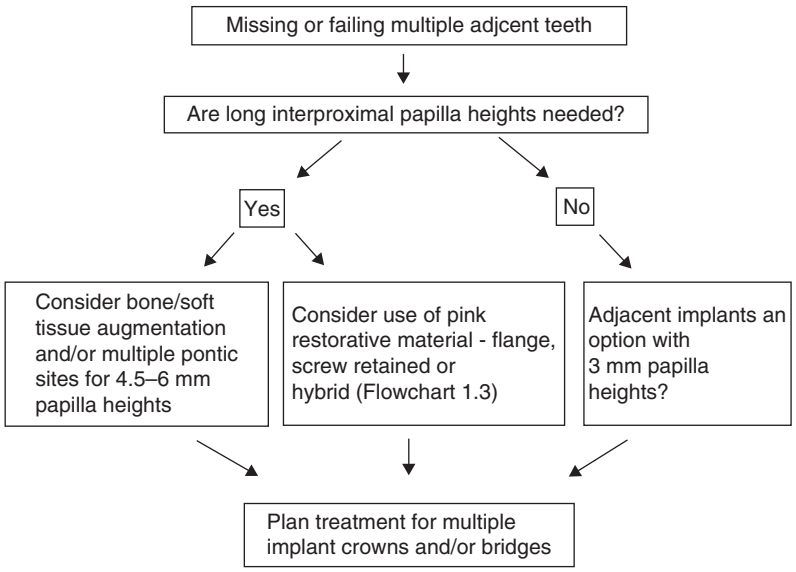
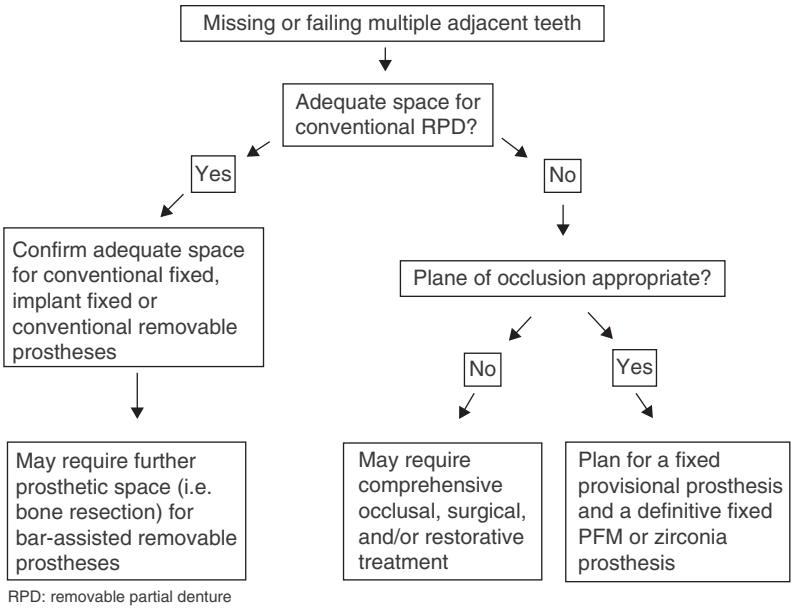


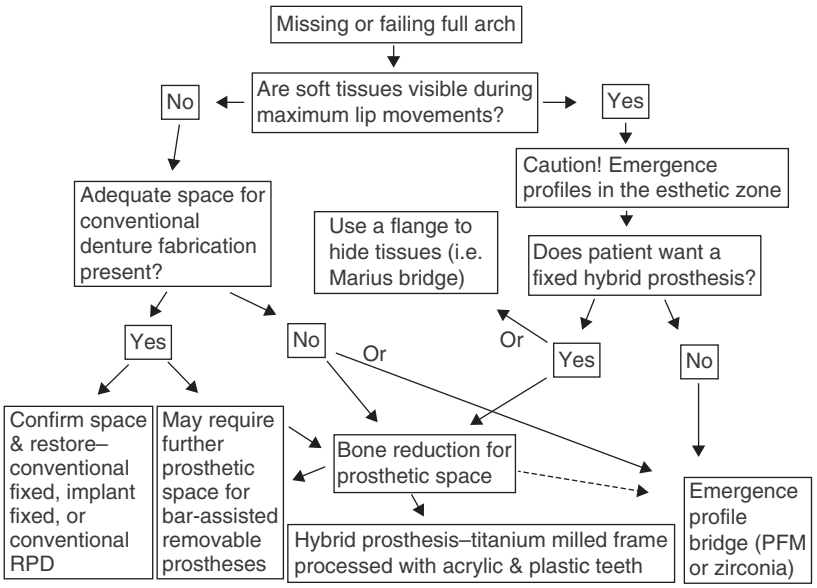
Flowchart 1.1



Flowchart 1.2



Flowchart 1.3



Flowchart 1.4

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