Tissue-Directed Placement of Dental Implants in the Esthetic Zone for Long-Term Biologic Synergy: A Clinical Report

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Implant dentistry steadily evolves as more is learned about the unique biologic interrelationship of the dental implant restoration and the surrounding hard and soft tissues. Important factors include the impact of the surface microtopography on biochemically-mediated cell differentiation, the unavoidable bacterial colonization of the implant-abutment (or crown) microgap, the vertical and horizontal dimensions of biologic width, and the histology of surrounding structures. The recipient site, implant design, surgical technique, and location of the restorative platform significantly influence the optimal esthetics and biologic stability of implant restorations. There are differing opinions among clinicians regarding the appropriate positioning of the implant restorative platform in the vertical and sagittal planes relative to the alveolar crest. An apical and palatal orientation of the coronal platform relative to the alveolar crest in the esthetic zone is generally advocated for favorable facial and proximal emergence profiles of the definitive crown. Tissue-directed implant placement primarily considers the long-term consequences of the implant restoration upon the surrounding hard and soft tissues. The goal is to develop optimal gingival contours and a definitive restoration in the esthetic zone that coexist in stable biologic synergy. The rationale and the specific prosthodontic and surgical protocols inherent in the tissue-directed concept are discussed in this report. INT J ORAL MAXILLOFAC IMPLANTS 2005;20:913–922

Key words: *biologic width, dental implants, gingival morphology, implant-supported dental prostheses, interdental papilla, osseous morphology, ovate pontics, single-stage implants*

Clinicians have realized that it is important to have an optimal gingival frame surrounding implant restorations to complete the illusion of natural teeth in the esthetic zone.[1–8] The osseous architecture surrounding healthy natural dentition follows the cementoenamel junction (CEJ) of teeth terminating, approximately 2 mm apically, with a 3-mm gingival tissue overlay. Although the interdental bone is typically 3 mm coronal to the midfacial bone, this scaffold alone does not account for the measured soft tissue height of 4.5 to 5.5 mm, a discrepancy of 1.5 to 2.5 mm of gingival scallop. This additional height is related to the presence of adjacent tooth attachments and the volume of the gingival embrasure. The classic study of Van der Veldon[9] found that denuded interdental papillae of healthy dentition consistently showed a rebound of an average of 4.3 mm into the gingival embrasure. The greater the distance from the coronal apex of the interdental papilla to the underlying bone, the less predictable complete obturation of the gingival embrasure becomes.[10]

Preservation of interproximal hard and soft tissues is profoundly influenced by the vertical and horizontal components of biologic width.[11–18] The necessity of bone to establish physiologic biologic width in the vertical dimension requires that the implant-crown interface be located at least 2 mm coronal to the osseous crest.[14] In natural dentition, Waerhaug[19] and Tal[20] demonstrated that interseptal bone will resorb approximately 2 mm apically and 1.5 mm laterally from bacterial plaque on the tooth surfaces. Similarly, the bacterial colonization associated with adjacent implant microgaps[21–23] would be expected to affect the preservation of interproximal bone and soft tis-

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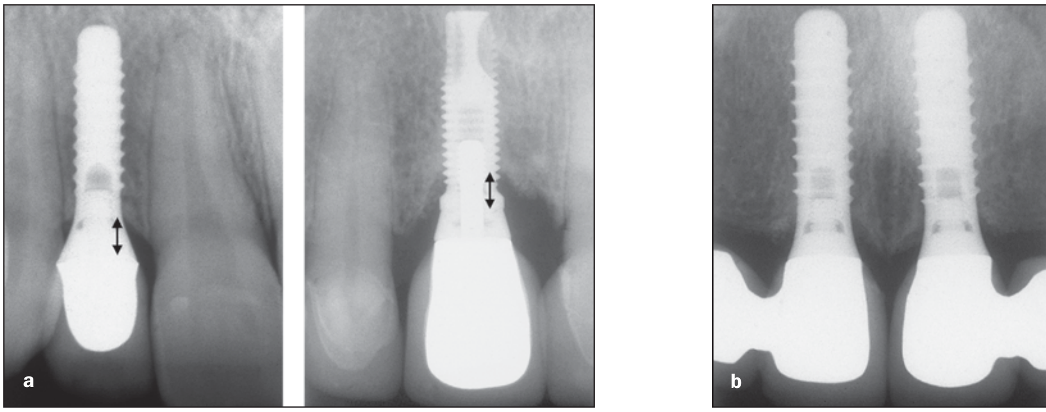


Figs 1a and 1b *(a)* Circumferential crestal bone loss of at least 2 mm caused by the effects of establishing biologic width apical to the implant-abutment (crown) microgap. This physiological response occurs with both 1- and 2-piece implants. *(b)* A radiograph of adjacent 1-piece single-stage implants placed more than 8 years ago demonstrates the stability of the osseous structure when the implant-crown microgap respects the proper dimensions of lateral and vertical biologic width. The interproximal bone peak is important for support and maintenance of the overlay papilla.

sue papillary height. Therefore, to preserve the interproximal bone scaffold, the recommended distance between adjacent implant-crown microgaps is at least 3 mm.[24]

Choquet and associates[25] evaluated the papilla height between single implant restorations and natural teeth. When the distance from the most coronal interproximal bone to the contact point between the implant restoration and natural tooth exceeded 4 mm, they found a significant loss in papilla height. This is a subtle difference from Tarnow and colleagues'[26] recognized study in natural dentition, which showed complete obturation of the interdental space when the bone to contact-point height was 5 mm or less. Of more significance is the papilla height relative to the proximal bone of adjacent implants, which Tarnow and associates[27] have shown to average 3.4 mm from the interimplant bone crest.

Excessive apical placement of the interface microgap will cause circumferential bone loss of at least 2 mm and could potentially cause apical recession of the facial marginal gingiva and a reduction in papillary height, with subsequent esthetic compromises (Fig 1a). A more coronal location of the microgap results in long-term stability of the surrounding osseous scaffold and the overlying soft tissue (Fig 1b).

OPTIMIZING THE IMPLANT RECIPIENT SITE IN THE ESTHETIC ZONE

In response to the need for favorable soft tissue profiles around implant restorations, many surgical techniques have been presented to enhance the interproximal papillae. Andreasen and coworkers[28] and Palacci[29,30] reported on a rotated pedicle graft technique to increase the interproximal volume at the transmucosal abutment connection in the 2-piece submerged implant. Adriaenssens and colleagues[31] described a gingival flap design they have labeled the palatal sliding strip flap, performed at the second-stage surgery of the 2-piece dental implant to enhance the papilla between implants in the anterior maxilla. Kinsel and associates[32] illustrated a surgical technique to increase the amount of attached gingiva in the interproximal region for the completely edentulous patient during the placement of multiple single-stage implants. The excess crestal keratinized tissue remaining in the nonsubmerged protocol is retained and rotated mesially into the space between the adjacent implants.

Unfortunately, despite these innovative surgical procedures, the final papillary heights between adjacent implants are often less than stellar, even with adequate underlying osseous support. One possible explanation may be related to the histologic features of the structures surrounding dental implants. Buser and associates[33] and Berglundh and colleagues[34] compared the vascular supply around teeth and implants. Around teeth, the vascular supply is derived from the supraperiosteal vessels lateral to the alveolar process and from within the periodontal ligament. However, the implant soft tissue blood supply originates from the terminal branches of larger vessels from the bone periosteum at the implant site. While peri-implant soft tissues lateral to the implant had sparse blood vessels, soft tissue lateral to root cementum was highly vascularized. A zone of avascular connective tissue was found directly adjacent to the implant surface. In addition, connective tissue fibers insert into the dentin coronal to the bone, which provides support for the soft tissues surrounding teeth. These histologic features may explain why the interproximal papilla, which consistently fills the interdental space in natural dentition when the underlying bone is 5 mm or less to the contact point, is difficult to duplicate surgically in the case of adjacent dental implants.

All successful soft tissue grafting and regenerative procedures must have adequate blood supply to maintain graft vitality. Any compromise in the vascularity of the recipient site may cause necrosis. Periodontal procedures to correct esthetic deficiencies that are predictably successful in natural dentition may have an increased risk of failure around implants, with the potential for a result worse than the original defect. Therefore, the preservation or augmentation of the soft tissue prior to implant placement is of paramount importance to obtaining optimal gingival contours surrounding the definitive restorations. Once a favorable recipient site is developed, a modified tissue-punch technique that minimally disrupts blood supply, as opposed to the reflection of a full-thickness flap, can be used to uncover the underlying bone prior to the implant osteotomy.

THE SCALLOPED IMPLANT RESTORATIVE PLATFORM

Currently, there is considerable interest in a parabolic 1-piece implant that would minimize proximal bone loss caused by biologic width impingement while allowing intrasulcular placement of the palatal and facial margins.[35,36] Holt and colleagues[35] presented a series of hypothetical implants with parabolic restorative platforms that conformed to the osseous architecture found in the esthetic zone. The authors recognized that predictable, long-term maintenance of the surrounding hard and soft tissues is problematic with the rotational restorative platforms of current dental implants, as opposed to the normal scalloped CEJ of natural teeth. It was postulated that bone loss and apical recession of the gingival margins could be reduced by a redesign of the coronal platform of implants.

Unfortunately, a 1-piece implant with a coronal platform that follows the parabolic osseous structure typically found surrounding natural teeth leads to certain compromises. The osseous architecture varies in coronal height between the mid-facial, proximal, and mid-palatal bone. Therefore, several variations of the implant's coronal platform would have to be manufactured. Secondly, proper orientation of the parabolic platform requires either a press-fit cylinder or a narrow thread-pitch screw that allows at least 90-degree rotation of the implant body without excessive apical movement of the implant body. A press-fit implant may lack sufficient primary stability following placement, preventing immediate provisional restoration. Both the cylindric press-fit and narrow thread-pitch designs have limited resistance to shear forces between the bone-implant interface, which may compromise the long-term survival of the implant.

Various dental implant manufacturers have developed scalloped abutments that are connected to the coronal portion of the implant body. Although the parabolic shape of the restorative platform more closely follows the curvilinear profile of the hard and soft tissues, the implant-abutmant interface will cause crestal bone resorption as biologic width is established, irrespective of the location of the crown margins.

TISSUE-DIRECT PLACEMENT OF THE SINGLE-STAGE IMPLANT

Currently, there are implant designs that are rotationally symmetrical but allow the clinician to modify both the implant abutment and body while maintaining the crown microgap at least 2 mm from the underlying osseous crest. However, the concept of intraoral preparation of the solid abutment and implant shoulder requires a return to prosthodontic protocols that have been consistently successful in full-coverage crown restorations of the natural dentition.

A comparison between a Straumann standard single-stage implant (Institut Straumann, Waldenburg, Switzerland) and a maxillary central incisor is shown in Fig 2. The most apparent differences are the facial-palatal dimension (4.8 mm versus 7 mm) and the absence of a curvilinear CEJ. However, the tapered coronal neck favorably simulates the emergence profile of a natural tooth.

In the sagittal view, an obtuse angle is formed when a line is drawn from the root apex to the proximal midpoint of the CEJ to the facial-incisal line edge. This angle must be compensated for in the fabrication of the implant restoration (Fig 3). If the implant body were placed parallel to the tooth root, then the solid abutment would penetrate through the incisal facial third of the crown. However, this angulation has the advantage of duplicating the facial emergence profile of the natural tooth and locates the microgap in a more coronal position relative to the proximal bone crest.

Alteration of the angulation of the implant, which positions the coronal shoulder palatally, would have adverse consequences (Fig 4a). The facial-gingival contour of the crown would need to be excessively oversized to simulate a natural tooth. This would result in plaque retention problems, possible apical migration of the marginal gingiva, and esthetic compromises at

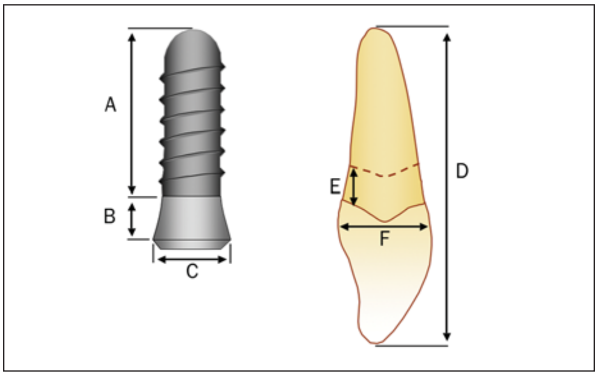


Fig 2 A comparison of a standard single-stage dental implant and a maxillary central incisor. The implant has a rough, threaded surface that ranges from 8 mm to 14 mm in length (A). The polished neck is 2.8 mm in length (B) and 4.8 mm in diameter (C). The average maxillary central incisor tooth has an overall length of 24 mm (D), a parabolic CEJ that is 2 mm coronal to the alveolar crest (E), and a midpalatal to midfacial width of 7 mm (F).

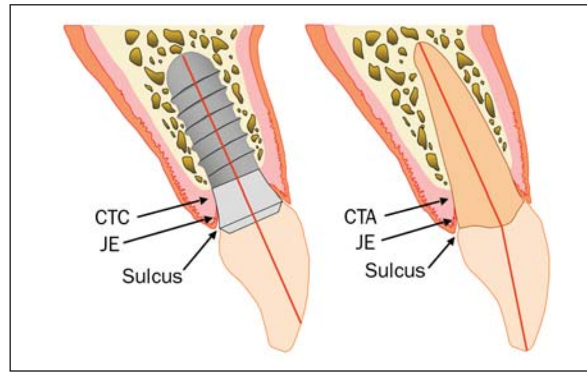
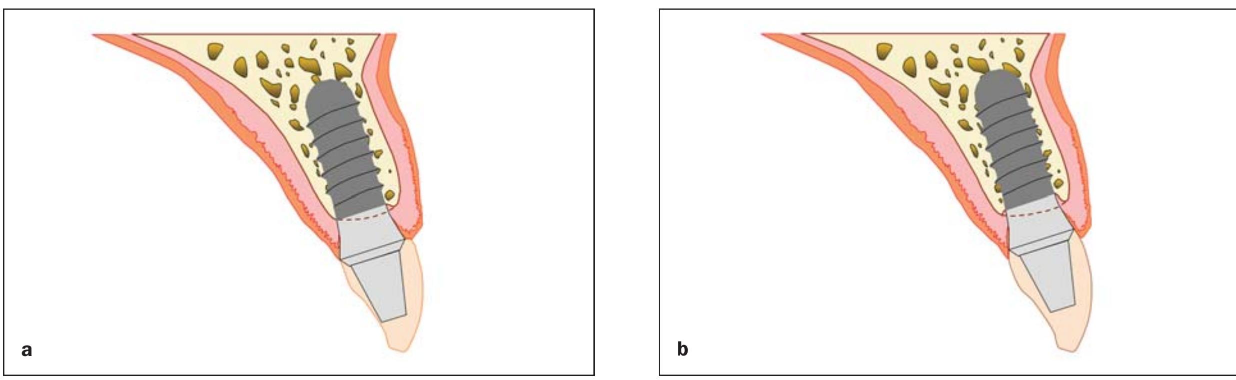


Fig 3 Generally, the soft tissue structures surrounding the single-stage implant are similar to natural dentition. Also important is the obtuse angle that is formed when a line is drawn from the root apex to the proximal midpoint of the CEJ to the facial-incisal line edge. CTC = connective tissue contact, JE = junctional epithelium, CTA = connective tissue attachment



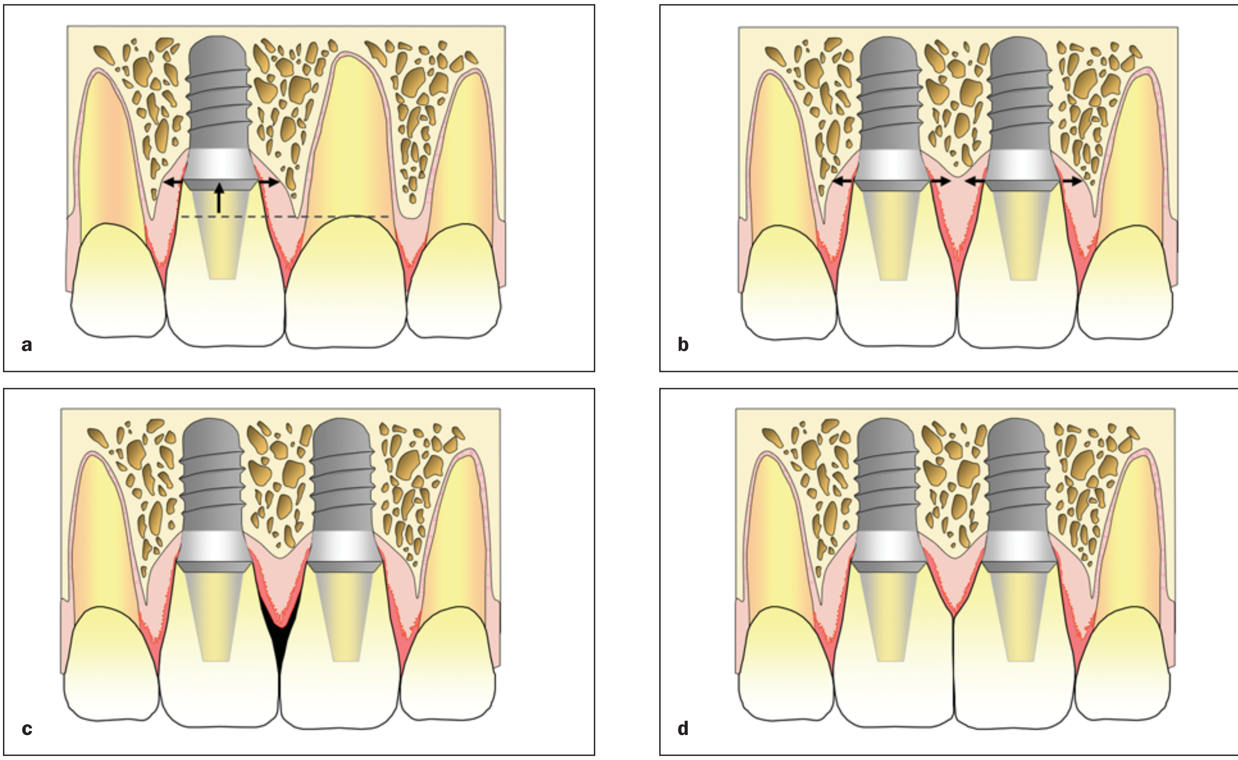
Figs 4a and 4b *(a)* Palatal inclination of the implant to position the center axis of the solid abutment through the incisal edge of the crown leads to an excessively convex facial emergence profile with the associated periodontal and esthetic complications. *(b)* If the restorative platform were placed apically to allow a more gradual facial emergence of the crown, circumferential crestal bone loss would be expected because of the impingement of the microgap upon biologic width.

the crown-gingival contact. Additionally, the junction between the rough and smooth surfaces would be apical to the proximal bone, leading to resorption. Placing the platform more apically improves the abrupt change in the facial emergence profile but leads to subsequent circumferential bone loss as biologic width is established 2 mm from the microgap (Fig 4b).

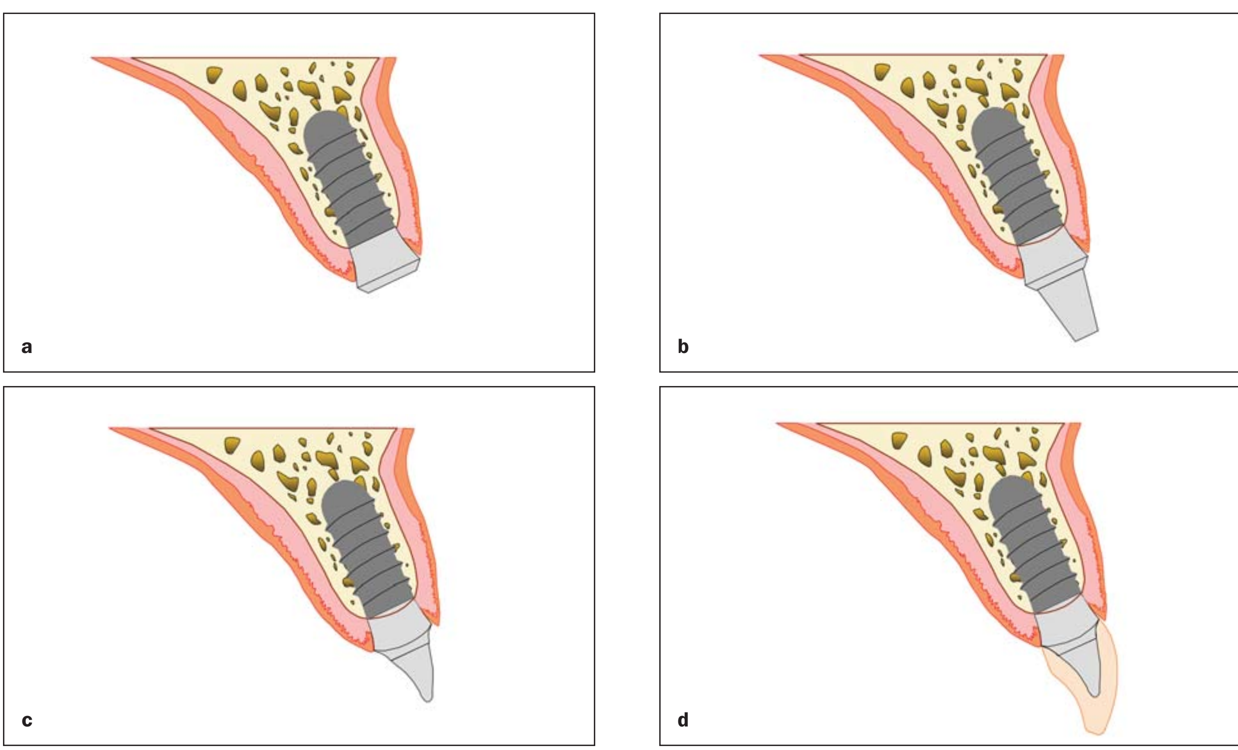
Clinicians commonly recommend that the coronal portion of the implant body be positioned 3 mm apical to the CEJ of the contralateral natural tooth.[37,38] The impact upon the surrounding bone and soft tissue is illustrated in Figs 5a to 5d. The alveolar crestal bone resorbs at least 2 mm apically and 1.4 mm laterally. The clinical appearance of this process in the single implant restoration is often not affected because of the maintenance of the proximal bone by the adjacent teeth (Fig 5a). However, the inevitable bone resorption has more potential negative esthetic consequences with adjacent implant restorations (Figs 5b to 5d). Proximal bone loss reduces the vertical support for the interdental papilla. Should this tissue recede apically, the result is an open gingival embrasure (Fig 5c) or restorations with excessively long proximal contacts (Fig 5d). Both are deviations from the clinical appearance of healthy natural dentition.

PREPARATION OF THE IMPLANT ABUTMENT AND RESTORATIVE PLATFORM IN SITU

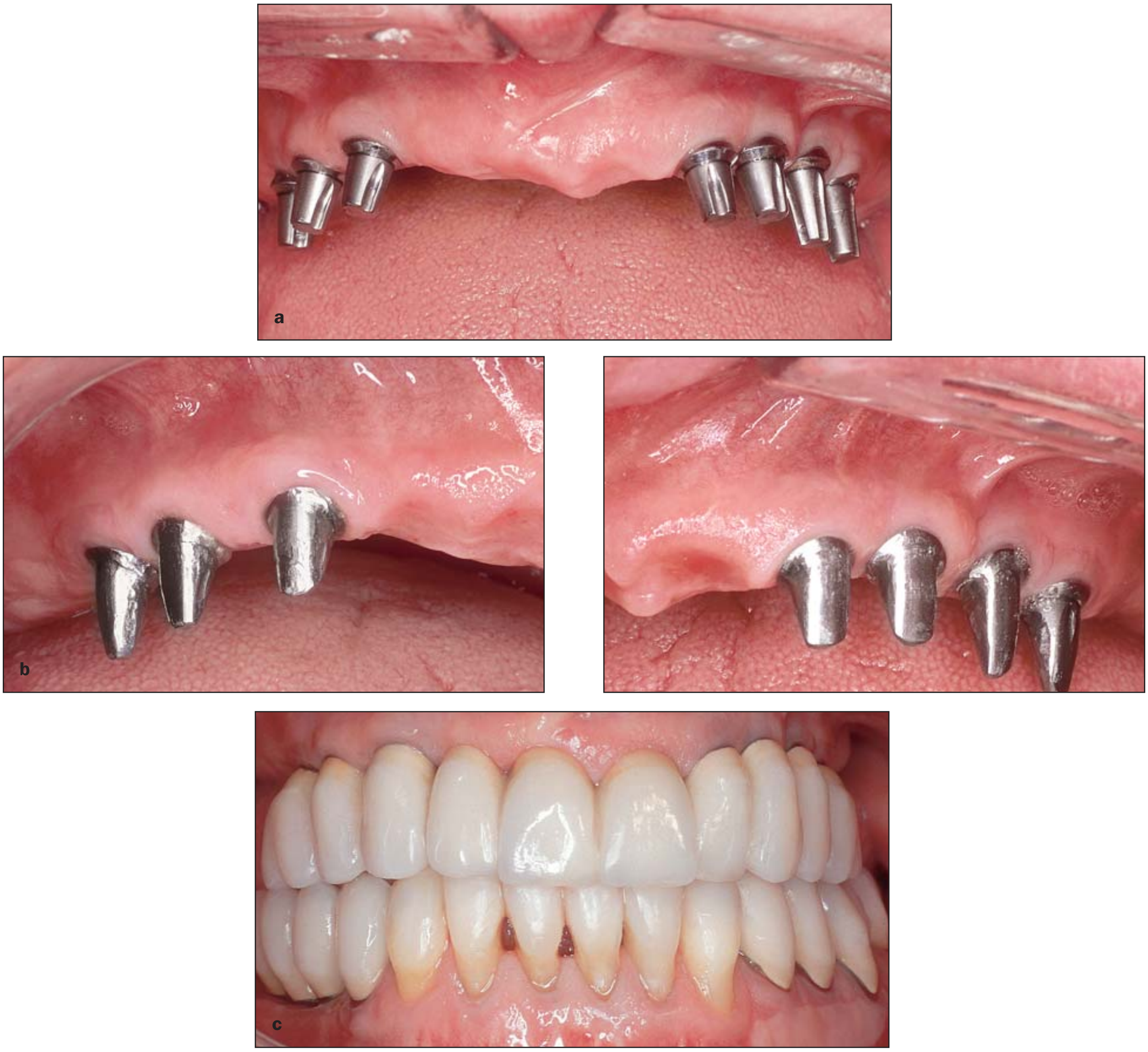
Clinicians have recognized that the 1-piece, single-stage implant design is particularly well suited to abutment and implant coronal platform modification.[39–41] Intraoral preparation of the solid abutment and, if necessary, the implant platform provides adequate space for a properly contoured crown restoration, helps the maintenance of physiologic biologic width, and controls the precise location of the intrasulcular crown margin.



Figs 5a to 5d The lateral and vertical components of biologic width lead to predictable bone resorption. *(a and b)* Although recession of the interproximal soft tissue is lessened by the bone support from the adjacent teeth, the potential consequences are more pronounced with adjacent implant restorations. *(c)* The inevitable loss of interdental bone reduces the papillary scaffold with apical recession of the soft tissue. *(d)* To close the gingival embrasure, the restorations must have excessively long proximal contact.



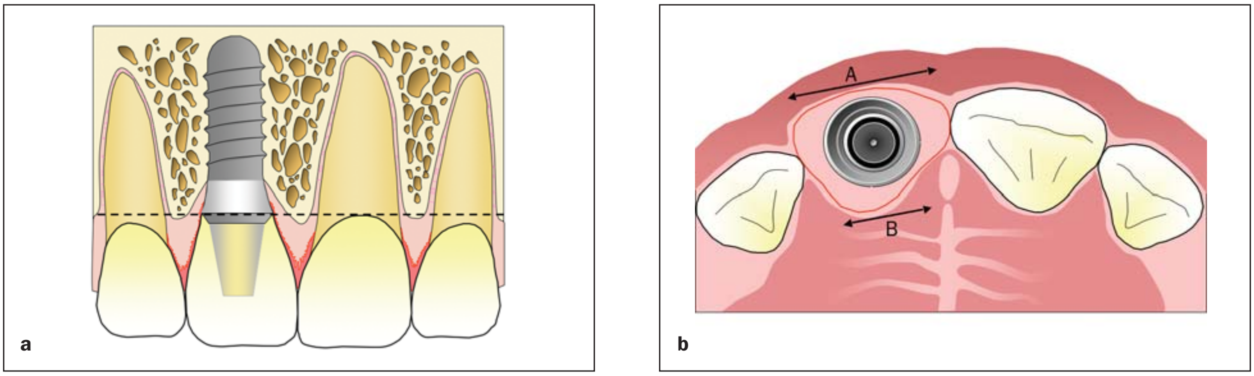
Figs 6a to 6d *(a)* The implant body is oriented at the same angulation as a natural tooth root. *(b)* The recipient site is flattened so that the rough surface is completely surrounded by bone. In the maxillary anterior region, where the osseous architecture is highly scalloped, the facial and palatal aspects of the restorative platform may be coronal to the marginal gingiva. *(c)* The solid abutment and the implant body are prepared intraorally. *(d)* The gingival margin is at least 2 mm coronal to the osseous crest, follows the parabolic architecture, and maintains proper biologic width.



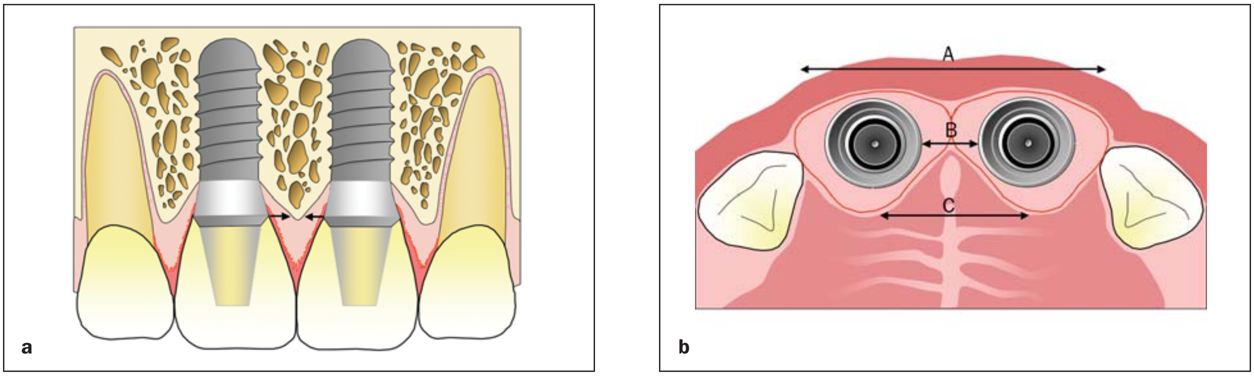
Figs 7a to 7c Clinical case of multiple single-stage implants with solid abutments placed into the maxillary arch at the same angulation as natural dentition. *(a)* Note the intrasulcular location of the implant shoulders interproximal to the soft tissue levels. *(b)* The implants and solid abutments are prepared with the gingival margins placed at facial tissue levels. *(c)* The definitive fixed prosthesis shows favorable gingival health and esthetics. The facial and interproximal margins of the restorative platform can be prepared to within 2 mm of the osseous crest.

The tissue-directed placement of a single-stage implant with a 2.8-mm-high polished collar and subsequent preparation are shown in Fig 6a through 6d. In the sagittal plane, the implant is placed parallel to the root of a natural tooth. The proximal surface of the restorative platform is positioned at least 2 mm coronal to the alveolar bone (Fig 6a). If the osseous architecture is highly scalloped, the facial and palatal margins may be supragingival (Fig 6b). In situ preparation of the solid abutment and implant body allows the development of a parabolic shape that follows the circumferential outline of the osseous crest and is unique to the patient (Fig 6c). The restoring clinician has control over the apical extension of the intrasulcular margin. The definitive crown has the facial and palatal contours that simulate a natural central incisor tooth while maintaining the location of the implant-crown microgap within 2 mm of the surrounding crestal bone (Fig 6d).

A clinical example of the preparation of single-stage implants with solid abutments in the maxillary arch is shown in Figs 7a through 7c. The implants were placed parallel to the cortical bone with the restorative platforms in the proper facial and apical positions (Fig 7a). Using 16-fluted finishing burs (#H375R-023, #7408-023, #ETUF 6.014; Brasseler USA,



Figs 8a and 8b *(a)* The vertical position of the implant's restorative platform is parallel with the midfacial CEJ of the contralateral natural tooth. *(b)* The typical mesiodistal distance is 8.5 mm (A), while the width of the implant restorative platform is 4.8 mm (B). The implant shoulder is centered between the adjacent teeth with the facial position in line with the normal tooth root. Note that the palatal extension of the crown restoration will be deficient because of the inherent discrepancy in the root diameter.



Figs 9a and 9b *(a)* In the case of adjacent implants, loss of bone occurs laterally when the microgap of the adjacent restorative platforms is within 3 mm, compromising the osseous support for the interproximal papilla. *(b)* Two central incisors have a combined width of 17 mm (A). The separation between the restorative platforms should be between 3 to 4 mm (B); the facial extension should be in line with the normal position of the central incisors. The center-to-center distance of the implants will range from 8 to 9 mm (C).

Savannah, GA), the restoring clinician completes the preparation of the solid abutments and intersulcular gingival margins (Fig 7b). The cooling spray from the dental handpiece adequately controls the heat generated through the metal and does not cause adverse affects to the adjacent peri-implant tissues.[42,43] The definitive fixed prosthesis shows favorable gingival health (Fig 7c). A maximum of 0.8 mm of the standard single-stage implant shoulder can be removed while maintaining the crown-implant interface within 2 mm of the osseous crest. Therefore, loss of the bone supporting the overlying soft tissue would not be expected to occur.

An implant placed into the central incisor position had the facial extent of the coronal platform in line with the contralateral tooth and was centered between the adjacent teeth (Fig 8a). The facial margin of the platform was placed in line with the CEJ of the adjacent tooth. This may result in a coronal position of the margin if the osseous architecture is thin and highly scalloped (Fig 8b).

When 2 or more adjacent implants are placed, establishing optimal facial and interproximal gingival contours of the recipient sites prior to implant placement is especially important. The reduced blood supply of the tissue adjacent to the coronal portion of the implants jeopardizes the regenerative capabilities of the surrounding gingiva. Again, the facial extent is in line with the natural tooth, and the interproximal distance should be between 3 to 4 mm (Figs 9a and 9b). The location of the restorative platform preserves the underlying facial and proximal bone, which supports the soft tissue contours.

SURGICAL TECHNIQUE TO PRESERVE AND ENHANCE THE GINGIVAL PROFILE

Because of the difficulty of correcting gingival deficiencies following implant placement, favorable soft tissue contours must exist prior to surgery (Fig 10a). The ovate pontic of either a fixed or removable pros-

Figs 10a to 10i *(a)* Because of the compromised vascularity surrounding dental implants, the prospective implant sites should be optimally developed prior to implant placement. *(b)* The tissue-punch technique was used instead of the reflection of a full-thickness facial flap, minimizing the disruption of the blood supply. *(c)* The facial tissue incision was placed over the center of the implant site and connected with the palatal incision. *(d)* The gingival tissue and periosteum were completely removed and the bone flattened. *(e,f)* The adjacent implants in the central incisor region were separated by 3 mm and the lengths of the implants were determined by subtracting the tissue thickness from the depth of the gauge to the gingival margin. The elliptical incision allowed facial movement of the excess keratinized tissue once the implants were seated, which was evident by the blanching of the gingiva. *(g)* The lateral incisors and second molars that had served as interim abutments for the provisional fixed prosthesis were extracted the day of implant placement. *(h)* The solid abutments and implants were prepared, and the definitive fixed prosthesis was delivered. *(i)* The radiograph shows the positive osseous architecture supporting the soft tissue that is found surrounding natural dentition.

thesis aids in accomplishing this goal.[44–50] Use of a surgical technique without flap reflection conserves crestal tissue and minimizes disruption of blood supply to maintain the gingival frame (Figs 10a to 10d). Adjacent implants are separated by 3 mm (Fig 10e).

Following the final osteotomy, the tapered coronal neck of the implant displaces the excess keratinized soft tissue facially as the implant is seated. The increased thickness of facial tissue creates the appearance of a natural root prominence, reduces the risk of apical migration of the facial gingiva, and eliminates the potential gray "show through" of the implant body (Fig 10f). Once the implants are placed and the solid abutments inserted, the lateral incisors and second molars that served as interim abutments for the full-arch provisional fixed prosthesis were extracted.

The completed preparation has adequate reduction and margin placement for the definitive porcelain fixed prosthesis (Figs 10g and 10h). The positive osseous architecture supports the overlying soft tissues (Fig 10i). When the implant recipient site is optimally prepared and the supporting bone level remains stable, the gingival contours do not have a propensity to recede apically over time.

The present state of the art of implant dentistry, coupled with the ever-increasing esthetic expectations of patients, continually challenges the treatment team. Successful implant therapy is no longer judged simply by whether or not the implant becomes osseointegrated. Precise duplication of the color, contour, and vitality of natural dentition may ultimately result in an esthetic failure if the optimal gingival profile and underlying supporting osseous structures are absent or recede apically over time.

Dental implants do not lend themselves to the unique parabolic shape analogous to the CEJ of natural teeth that follows the normal osseous architecture. Attempts to develop an implant with a curvilinear (parabolic) coronal platform are problematic because of the compromises that must be made for proper orientation and the inherent variations of individual alveolar bone contours. However, many implants currently manufactured have the design properties necessary to allow the clinician to modify intraorally both the implant abutment and body for precise placement of the intercrevicular margin, thus ensuring long-term biological synergy.

CONCLUSION

Tissue-directed implant dentistry represents a paradigm in conventional protocols. That is, the final form of the prosthesis is envisioned first, and all subsequent procedures are designed to accommodate optimal implant placement, hard and soft tissue support, and proper gingival contours to achieve long-term biologic synergy. Important considerations include:

- Recognizing that the reduced vascularity of the soft tissue structures surrounding dental implants may compromise subsequent corrective gingival surgical procedures following placement of the restoration
- Developing and maintaining the soft tissue contours at the prospective implant site prior to surgical placement
- Using a surgical technique that minimizes disruption of the blood supply of the optimized gingival contours
- 3-dimensional positioning of the implant body and restorative platform that lessens the biologic width influences on alveolar bone loss, thereby preserving support for the overlaying soft tissues
- Incorporating an implant design with a restorative platform and smooth surface collar placed significantly coronal to allow selective removal of the implant shoulder without adversely affecting the structural integrity of either the implant or its restorative components.

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