Contemporary Implant Concepts in Aesthetic Dentistry — Part 1: Biologic Width

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The advent of osseointegrated implants has significantly impacted the way restorative dental procedures are formulated, planned, and implemented. Clinical experience and research with dental implantology as well as the continued evolution of materials, techniques, and their use enables a widening application of treatment. Aesthetic implant placement has been well documented in the treatment of fully and partially edentulous patients and can be predictably applied for single-tooth replacement, perio-prosthetic rehabilitation, and immediate tooth replacement. This article, the first in a four-part series, will address the impact of the biologic width on the management of implant treatment for edentulous ridges.

Learning Objectives:

This article discusses contemporary implant concepts as related to aesthetic treatment planning in edentulous sites. Upon reading this article, the reader should:

- Understand the role of the biologic width on aesthetic implant rehabilitation.
- Recognize the clinical considerations that must be addressed when placing implants in the aesthetic region.

Key Words: implants, biologic width, emergence profile, soft tissue

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Dental implants have significantly impacted restorative dentistry. Clinical experience and research with dental implantology as well as the continued evolution of materials, techniques, and their use enables a widening application of treatment. Aesthetic implant placement has been well documented in the treatment of fully and partially edentulous cases and patients who require single-tooth replacement, perio-prosthetic rehabilitation, and immediate tooth replacement. In fact, dental implants have revolutionized the restoration of missing or failing teeth.

Implant concepts have undergone (and continue to undergo) a significant evolution,[1] not only in terms of materials, surfaces, and designs but also in clinical and technical management. Clearer understanding of the soft tissue and bone responses to implants enables the clinician to better plan the aesthetic outcomes of implant treatment. This series of articles will discuss relevant contemporary implant concepts in aesthetic dentistry via a range of cases that address single-tooth replacement through complex restorative challenges. The differences in management and clinical outcomes of implant treatment in edentulous ridges will be contrasted to immediate implant concepts.

The primary restorative challenge is to develop an optimal biological, functional, and aesthetical solution.[2] More complex situations present a greater challenge, and practitioners must develop clinical and technical protocols that provide predictability and control throughout the treatment process.[1-7] Enhancement of the dental hard tissues is simplified when the patient's existing condition more closely resembles the ideal condition.[7] Restoration and maintenance of the soft tissues and bone surrounding implant restorations are, however, more challenging. In addition, the greater the degree of oral breakdown, the more complicated is the restorative process. Use of an interdisciplinary approach for diagnosis and treatment planning are, therefore, essential for restorative success.

A Systematic Approach to Treatment Planning

A staged treatment plan is typically required in complex cases.[1-2] While many of these stages may be implemented concurrently and the treatment requirements will vary from case to case, this staged approach enables control and predictability throughout the case management.

Stage 1 — Initial stabilization and control is achieved via hygienic and initial periodontal therapy, as well as primary restorative treatment (eg, fillings, cores, endodontics), to create a sound and healthy foundation for further restoration.

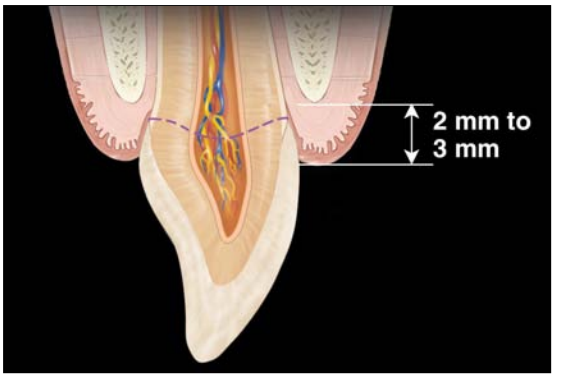

Figure 1. Illustration of the biologic width including the gingival sulcus, junctional epithelium, and connective tissue attachment to the alveolar bone crest level.

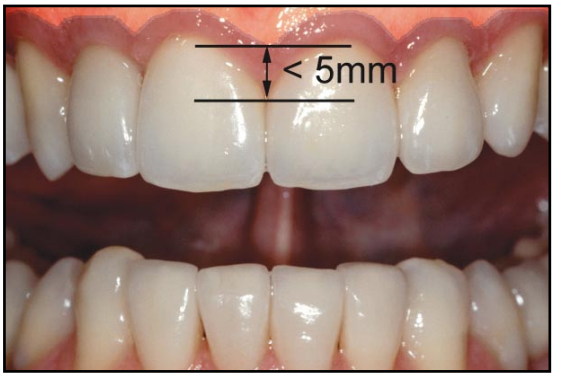

Figure 2. A complete papilla is found if the distance from the interdental bone to the apical aspect of the contact area is equal to or less than 5 mm. At 6 mm, the incidence of a complete papilla falls to 56%, and at 7 mm to 27%.

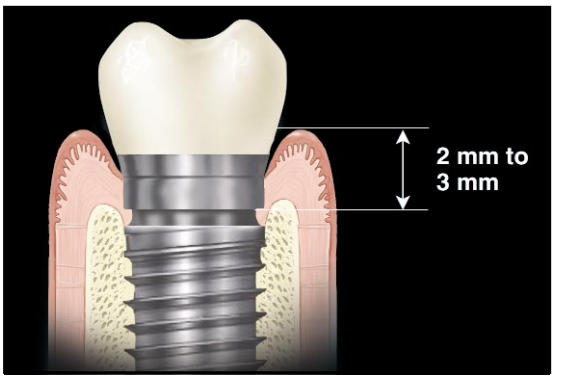

Figure 3. Illustration demonstrates the general peri-implant tissue arrangement following remodeling.

Stage 2 — Modification or enhancement of the oral situation to improve the foundation for restoration. Orthodontics (and possibly orthognathic surgery), surgical periodontics for disease control or aesthetic/restorative reasons (ie, ridge augmentation, crown lengthening,

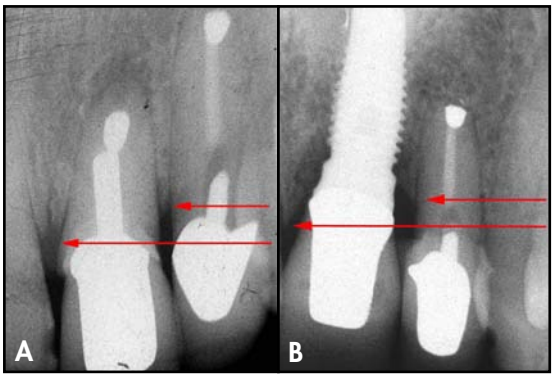

Figure 4A. Preoperative radiograph demonstrates a height variation in interproximal bone levels. 4B. Postoperative evaluation reflects a compromised result following implant placement.

Figure 5. Inadequate papilla was evident between the restored central and lateral incisors.

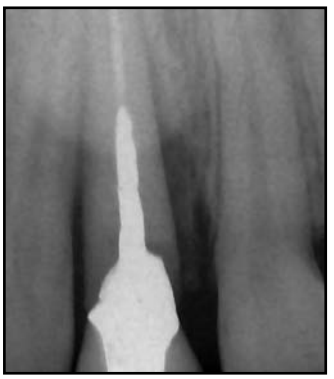

Figure 6. Case 1. Preoperative radiograph of a previously restored maxillary central incisor. Root caries and endodontic failure necessitated extraction.

root coverage), and implant placement along with any necessary bone grafting/augmentation may be involved at this phase.[8]

Stage 3 — Provisionalization and stabilization to provide a working prototype that protects the prepared teeth and facilitates soft tissue control, establishment and assessment of the occlusal scheme, and evaluation of the proposed aesthetic form of the restoration.[9-11]

Stage 4 — Definitive restoration.

Stage 5 — Ongoing recall and maintenance.

Biologic Width

The concept of biologic width has been well described in the literature, and the vertical dimension of the dentogingival complex has been established as a stable physiological dimension.[9,12] The biologic width comprises the sulcus depth, junctional epithelium, and connective tissue attachment up to the alveolar bone crest. These parameters provide useful guidelines and a clearer understanding of the relationships of gingival tissue to the underlying bone.[13] Normal, healthy subjects demonstrate an adequate biologic width when a 2-mm to 2.5-mm distance is present from the base of the gingival sulcus to the height of the crestal bone. In the absence of any periodontal disease or recession, there is a normal variation in biologic width around a given tooth from the labial to the interproximal regions. The interproximal gingival sulcus depth and junctional epithelium may be of increased width, and the distance of the gingival margin to the bone crest may vary according to the position of the tooth in the arch and the degree of scallop of the cementoenamel junction (CEJ). According to the literature, the level of the interdental bone crest on the teeth in the interproximal area significantly influences the presence and level of the interdental papillae (Table) (Figures 1 through 3).[14]

Biologic Width of Implants

The peri-implant tissue complex has been similarly investigated in order to gain an understanding of the bone and soft tissue relationship to implants.[15-17] The concept of biologic width around implants has now been established as well.[18-20] A recent investigation evaluated the impact of the position of the implant-abutment interface

Table

The Role of Interdental Bone on Papilla Development

Distance From Interdental Bone to Apical of Contact Area	Incidence of the Papilla Being Completely Present
5 mm or less	100%
6 mm	56%
7 mm	27%

Figure 7. Implant placement was facilitated to replace tooth #8(11) following minimal flap elevation to maintain the integrity of the interdental papillae.

Figure 8. The provisional was refined and contoured to support the soft tissues and apply gentle pressure on the interproximal tissues for an aesthetic gingival contour.

Figure 9. Evaluation of the provisional restoration demonstrated adequate formation of soft tissue contours and papillae.

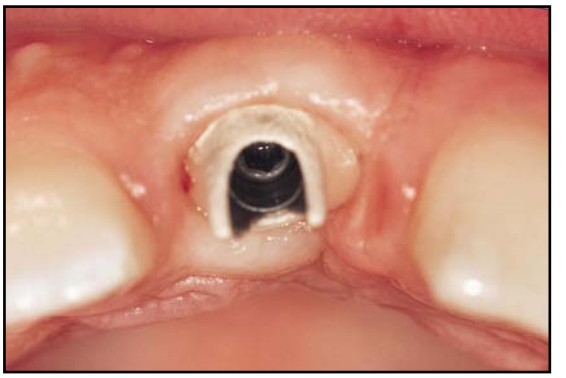

Figure 10. Occlusal view demonstrates proper abutment placement.

relative to the crestal bone and peri-implant tissues.[20] The investigation indicated that the biologic width around implants varied according to the depth and position of the interface. When the implant-abutment connection was placed at the gingival level supracrestal to the alveolar bone (ie, as in a conventional single-stage implant placement), the biologic width measurement was similar to that of natural dentition. When the interface was placed at a deeper level (ie, as in a standard submerged implant design), however, the biologic width increased accordingly. The primary difference was observed in the depth of the junctional epithelium height, which extended just apical to the interface. The sulcus depth and connective tissue attachment width appeared stable regardless of the level of the interface. It was, therefore, determined that implant placement with the implant-abutment placed interface supracrestal to the bone facilitated maintenance of the biologic width with minimal apical bone resorption.

In the aesthetic zone, however, the implant level should always be placed subgingivally, regardless of whether the fixture is a one- or two-stage design. This allows the clinician to produce the proper emergence profile and soft tissue contours around the implant restoration. As a general rule, the implant head should be placed 3-mm apical to the desired labial gingival margin position in order to allow development of the desired emergence profile and aesthetics.[21-25] This factor will influence anterior implant placement in the aesthetic zone as opposed to the crestal bone level or CEJ of the adjacent teeth. The interproximal biologic width dimension will, however, be increased by the flat nature of the implant-abutment connection and interface, while the gingival margin of anterior teeth is scalloped. While this feature may present a potential weakness in the maintenance of long-term peri-implant health, current clinical experience does not appear to indicate a significant concern in this regard.

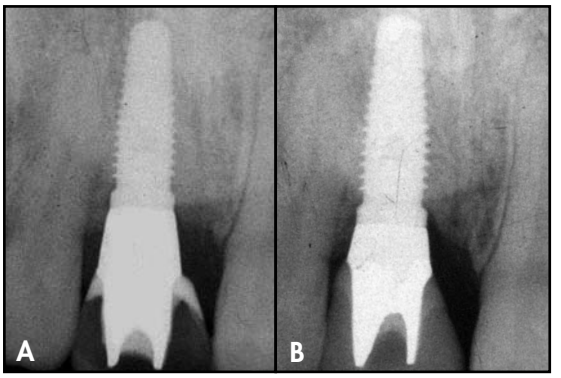

Figure 11A. Radiograph of the immediate abutment and provisional crown prior to remodeling. 11B. Postoperative radiograph exhibits biologic remodeling 2 years later.

Figure 13. Case 2. Preoperative appearance demonstrates the presence of a flat ridge due to the patient's edentulism.

Figure 12. Postoperative appearance of the definitive crown restoration demonstrates aesthetic emergence and soft tissue contour.

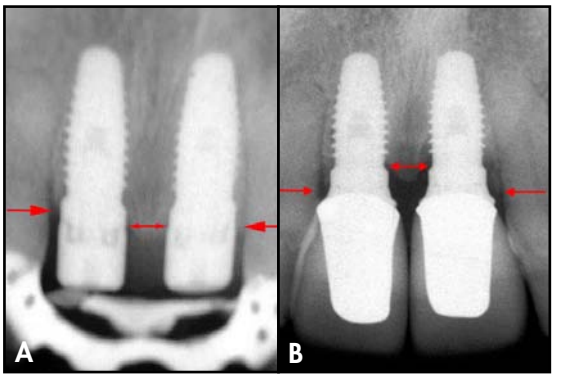

Figure 14A. Radiographic bone levels following implant placement. 14B. Postoperative radiograph following 2 years of function demonstrates remodeling of the bone and apical shrinkage of the interproximal bone peak.

The two primary differences between implants and teeth that impact the situation between adjacent implants are:

1) The scalloped gingival margin evident in each natural tooth in which the anterior region is more pronounced. The biologic width on the interproximal aspect of implant restorations is, therefore, far greater than on the labial or palatal aspect. While scalloped implant designs are currently being developed, many implant systems remain limited in this regard.[22]
2) The microgap present between the implant and abutment. The biologic width will begin apical to this region and accounts for the remodeling of bone 2-mm to 3-mm apical to the implant-abutment interface. This can be clinically observed as remodeling to the first thread or the start of the rough surface.

Clinical Application

The aforementioned concepts have been applied to varying clinical situations involving dental implants. Choquet et al demonstrated that similar principles can be successfully applied to situations where there are teeth present adjacent to the implant site (eg, single-tooth implants).[25] The papilla can be predictably re-established or maintained if the distance between the interdental bone peak to the apical aspect of the contact area between the teeth is 5 mm or less. The implication is that the teeth adjacent to the implant maintain the bone and papilla, and the level and presence of the papilla is, therefore, dependent on the level of the bone on the adjacent tooth.

The application of these concepts to tooth and implant treatment planning has enabled clinicians to develop more coherent treatment planning protocols with regard to implant position relative to the gingival tissue in the aesthetic zone (Figures 4 and 5). The literature has further identified a horizontal component to the

biologic width that implies a minimum 1.5-mm distance between an implant and adjacent tooth to allow for maintenance of the interproximal bone peak.[25-26] When placing multiple implants, approximately 3 mm will be necessary between adjacent implants in order to maintain the interproximal bone peak and papilla. The danger of placing the implant closer to the adjacent tooth or closer to an adjacent implant is that the bone loss will become more horizontal than vertical and cause the loss of any bone support for the papilla.

Case Presentations

Case 1

A 17-year-old female patient presented with a failing root in the maxillary right central incisor that was previously treated with a post-and-core restoration (Figure 6). Secondary caries, endodontic failure, and insufficient sound tooth structure to enable a proper ferrule effect were also evident. The patient's condition was further complicated by the need for orthodontic treatment to correct a Class II, division 1 malocclusion. Implant placement at this point was, therefore, inappropriate until the teeth were orthodontically shifted. The tooth was atraumatically removed, the socket was carefully curetted to remove all granulation tissue, and a bone allograft (eg, Biogran, 3i Implant Innovations, Inc, Palm Beach Gardens, FL; BioOss, Osteohealth, Shirley, NY) was positioned to preserve the ridge form and bony architecture. A provisional cantilever fixed partial denture (FPD) was bonded to the adjacent central incisor during the orthodontic phase to align the teeth and create a symmetrical space for the missing central incisor. This FPD design permitted tooth movement and retraction of the incisors while maintaining the edentulous space.

Once orthodontic treatment was completed, a healed and mature marginal ridge was present. The adjacent teeth appeared healthy, and the soft tissue and bone levels were normal. This provided adequate bone and soft tissue for development of a predictable result.

Placement of an immediately loaded 4.3-mm × 13-mm HA-coated implant (eg, Replace, Nobel Biocare, Yorba Linda, CA; Osseotite, 3i Implant Innovations, Inc, Palm Beach Gardens, FL) was implemented once orthodontic treatment was completed (Figure 7). The provisional was relined (eg, Quicktemp, Schottlander, Hets, UK; Integrity, Dentsply/Caulk, Milford, DE) and refined chairside with flowable composite (eg, Tetric Flow, Ivoclar Vivadent, Amherst, NY; Flow-It! ALC, Pentron Laboratory Technologies, Wallingford, CT). The provisional was then cemented onto a prefabricated angled abutment using a temporary cement (Figure 8). The provisional

Figure 15. Postoperative appearance 2 years after crown replacement. The incisal edges were restored with a stratified composite technique. Note the shorter midline papillae between the implant as compared to the natural teeth.

Figure 16. Case 3. Preoperative view of dentition in need of extensive rehabilitation. Note the healed flat edentulous ridge.

Figure 17. A surgical template was used to accurately position the implants. Note the proper spacing of the implants to maintain an interdental bone peak.

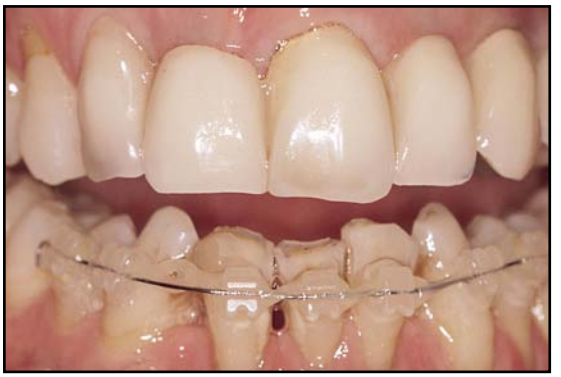

Figure 18. A provisional FPD was placed over the implants using the teeth as abutments.

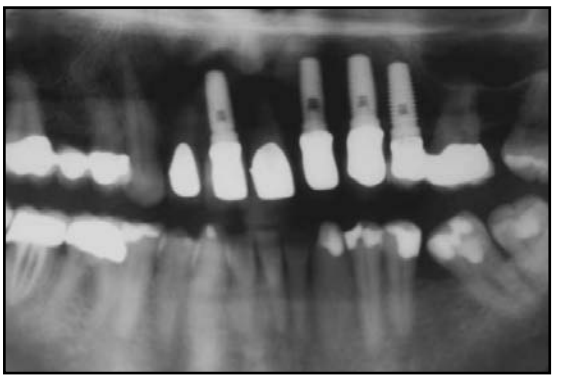

Figure 19. Postoperative panoramic radiograph demonstrates successful osseointegration of multiple adjacent implants.

Figure 20. Postoperative evaluation 6 years following restoration demonstrates aesthetic maintenance of soft tissue. Note the shortened papilla between the implant restorations and reduced gingival scallop.

crown was kept slightly out of occlusion and free from contacts during protrusive movements, and the tissues were allowed to heal for 6 months (Figure 9).

A transfer impression of the fixture head was created, and a custom-machined, castable abutment was fabricated. A porcelain neck and shoulder were fired onto the abutment, and the substructure was opaqued (Figure 10). The abutment was tried in and appropriately modified to ensure that the tissue was correctly supported and the shoulder margin shoulder was placed approximately 1-mm subgingival labially and level with the gingival margin palatally to facilitate simplified removal of the excess cement following cementation of the final crown (Figure 11). The definitive all-ceramic restoration was then cemented using a transparent glass-ionomer cement (eg, Fuji 1, GC, America, Alsip, IL; Vitrebond, 3M ESPE, St. Paul, MN) (Figure 12).

Case 2

A 27-year-old female patient presented with anterior edentulism that was previously treated with a partial removable denture (Figure 13). The healed ridge was flat, and loss of the natural bone and tissue scallop was evident. Thus, while a reasonable result could have been achieved by implant restoration, the papilla between the central incisors would not be completely restored. The teeth were restored using two 4.3-mm × 10-mm implants (Replace, Nobel Biocare, Yorba Linda, CA) with porcelain-fused-to-gold crowns cemented onto modified prefabricated abutments (Figures 14 and 15).

Case 3

A 52-year-old male patient presented for fixed aesthetic restoration of the compromised dentition (Figure 16). The papillae adjacent to the missing central incisor was, interestingly, maintained as was the gingival tissue scallop around the remaining anterior teeth. In contrast, the maxillary left side demonstrated a flat ridge, and an adequate ridge width was evident.

The maxillary arch was restored with a combination of crowns, FPDs, a veneer on the maxillary right canine, and placement of implants for the maxillary right central incisor, left lateral incisor, canine, and first premolar. This was further complemented by orthodontic treatment of the mandibular arch, where the extruded right lateral incisor was removed and a simple fixed appliance was utilized to align the mandibular arch. The remaining incisors were then restored with porcelain veneers. Endodontic treatment was performed to restore the mandibular right second molar and a number of crowns on the mandibular posterior teeth (Figures 17 through 20).

Discussion

The use of a single-stage approach that incorporates immediate provisionalization (ie, immediate loading) procedures requires the presence of sufficient bone quality and sound implant support; a tapered implant design, though not essential, also facilitates the development of acceptable primary stability.[1,27] While it is not yet understood what constitutes adequate primary stability, various removal torque values, or even resonance frequency measurements have been suggested. Clear guidelines for this are, however, yet to be established.

In clinical situations where two or more adjacent implants are present, the definitive papilla height is diminished by the apical positioning of the interimplant bone crest.[1,25,26] The inevitable complication that arises when placing adjacent implants, particularly in the maxillary central and lateral incisor regions, is that the connective tissue attachment begins apical to the abutment-implant microgap and appears to produce recession of the interimplant bone. This condition makes it difficult, if not impossible, to develop complete interimplant papilla. While forthcoming scalloped margin implant designs may address this concern, this remains to be proven. The primary issue in conventional implant treatment (ie, placement of implants into healed edentulous ridges) is that the papilla height will be shorter than the adjacent teeth, as there is no scallop to fully develop the higher peak interproximally. Although a degree of scallop can be achieved, this is generally less pronounced than around natural teeth.

Conclusion

Increased understanding of the peri-implant responses of the bone and soft tissues to implants enables improved planning and management of the aesthetic outcomes of implant treatment. This article discussed the impact of this on the management of implant treatment of edentulous ridges. The next article in this four-part series will discuss the indications, applications, and limitations of immediate implants, and will contrast the primary features, as well as the aesthetic implications, of immediate implants with implants placed in edentulous ridges.

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