CASE STUDY

Bone Sculpting to Achieve Papilla Regeneration Around Dental Implants

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Dental implants have moved into mainstream dentistry. They are now part and parcel of routine dental practice. The predictable success of dental implant therapy[1] has led to a rise in the number of dental implants being placed. Osseointegration is now almost taken for granted. However, the esthetic success of dental implants is not so predictable, and is therefore not taken for granted.

Achieving successful esthetic implants begins with a proper bony foundation in which to place the dental implant. Adequate bone must be present if one is to develop the proper emergence profile, soft tissue contour, crown-to-gingival relationships, and papilla formation (Figures 1A through 1C). Three possible situations are possible when implant therapy is considered:

- Bone is present at the time of implant placement.
- Bone is grafted before implant placement (site development).
- Bone is grafted at the time of implant placement.

If adequate bone for implant placement is not present (Figures 2 and 3), the clinician must decide whether to graft at the time of implant placement or to bone graft before implant placement. Grafting at the time of implant placement has the following advantages:

- The patient does not have to go through a separate surgical procedure.
- The amount of time from surgery to the final restoration is diminished.
- There is less cost to the patient.

However, the major disadvantage is surgical complication. Should the graft become infected or heal less optimally, the implant may fail. Worse yet, the implant may integrate but with less than optimal bone formation. An integrated implant with significant bone loss is not an ideal starting point for an esthetic restoration. In fact, it is a prescription for esthetic failure.

An adequate bony foundation is the starting point for an ideal implant restoration. Substantial alveolar bone in the proper position allows the clinician to place the implant in the ideal mesial-distal, facial-palatal, and occlusal-apical positions.[2] Thus, an ideal soft tissue profile may be achieved. In addition, the proper dental-gingival relationships can be created between the implant crown and the gingiva, and between the implant crown and the adjacent crowns. Dental gingival harmony is the therapeutic endpoint.

Last, but not least, a papilla must be present to ensure an esthetic restoration. The presence or absence of a papilla between implants or between an implant and a natural tooth depends on two variables, per the author's experience:

- the vertical distance between the contact point of the adjacent crowns and the crest of the alveolar bone
- the horizontal distance between the implants at the implant–abutment interface or between the implant and natural tooth at the level of the alveolar bone.

Tarnow and colleagues[3] demonstrated that as the vertical distance between the contact point of adjacent crowns and the crest of the alveolar bone increased, the papilla was less likely to fill the embrasure space and a black triangle would appear. If the vertical distance from contact point to alveolar bone measured 5 mm or less, a papilla would be present almost 100% of the time. The same has been found true with dental implants. To assure that a papilla is present, the distance from the contact point of adjacent crowns to bone should be around 5 mm.

The horizontal relationship between teeth has not been addressed in papilla regeneration. However, with adjacent implants, it has been determined that a distance of 3 mm is necessary to prevent bone loss and hence loss of papilla.[4] In an attempt to make papilla regeneration between dental implants more predictable, the following rules apply:

- Allow for a distance of at least 3 mm between adjacent implants.
- A distance of approximately 5 mm should exist between the contact point of adjacent crowns and the crest of the alveolar bone.

The reformation of papilla between prosthetically restored teeth has become a relatively predictable procedure. Similarly, the reformation of a papilla between a single implant and a natural tooth is much more straightforward. However, the reformation and

Figure 1A—The patient was missing tooth No. 9.

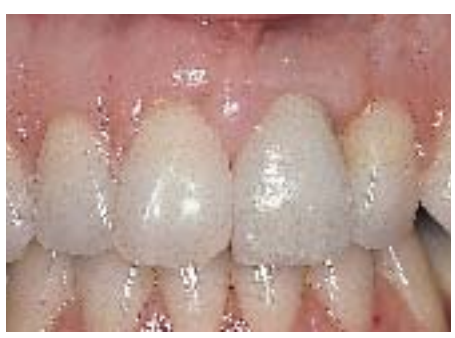

Figure 1B—Ideal papilla formation was seen in this patient with tooth No. 9 replaced with a dental implant.

Figure 1C—A smile view reveals the beautiful harmony and esthetics of the central incisors. (Restoration courtesy of Dr. Stephen Rothenberg, Darien, Connecticut.)

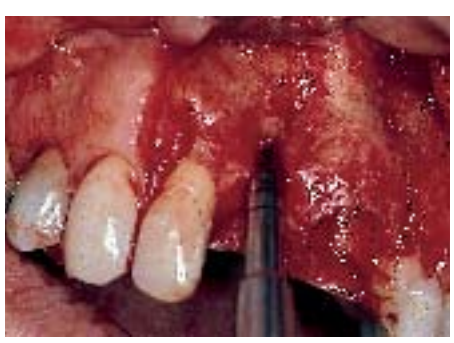

Figure 2—An osteotome was used to prepare the implant site of tooth No. 8. The atrophied ridge was expanded with the osteotome, allowing an implant to be placed in the area of tooth No. 8.

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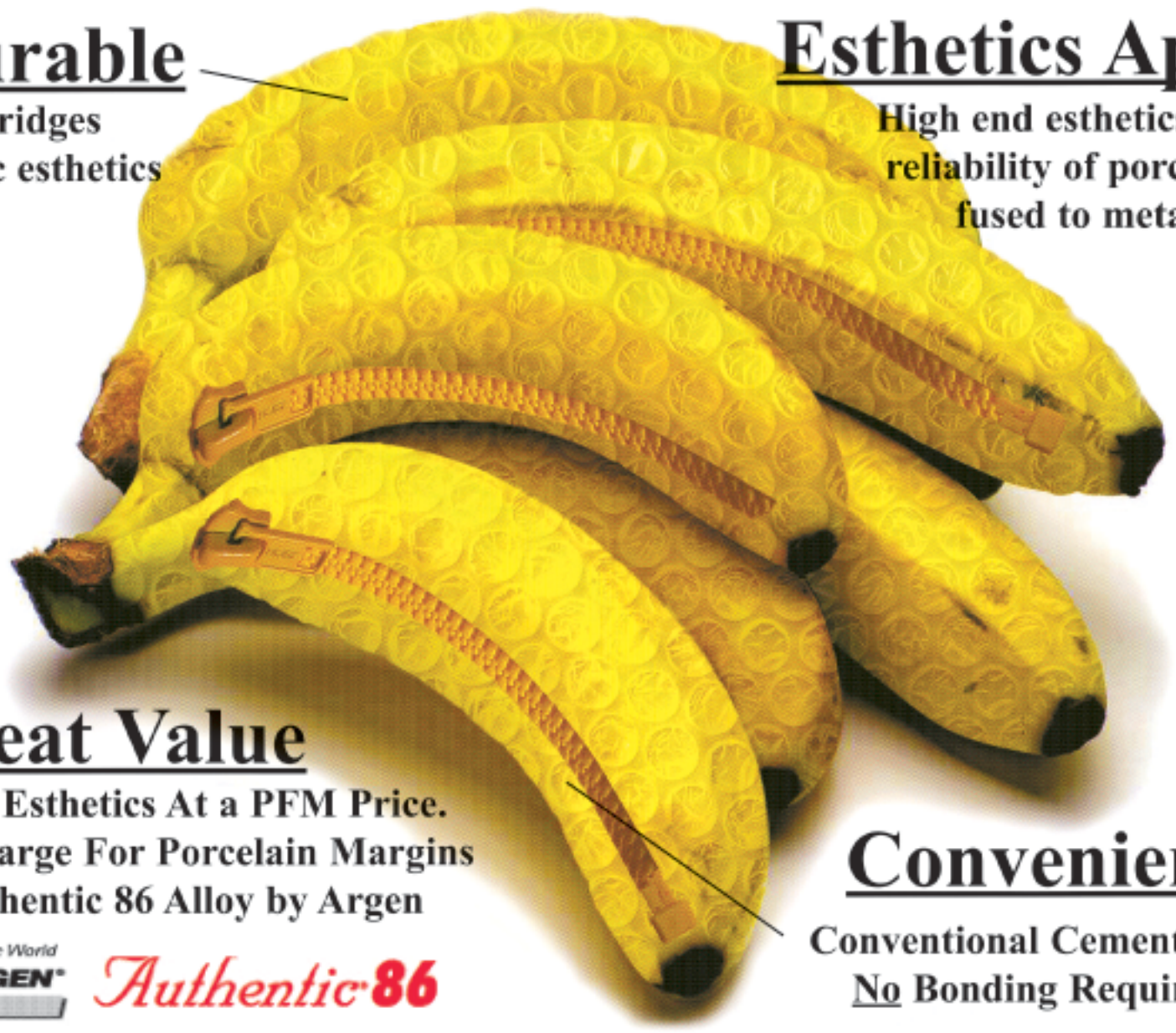

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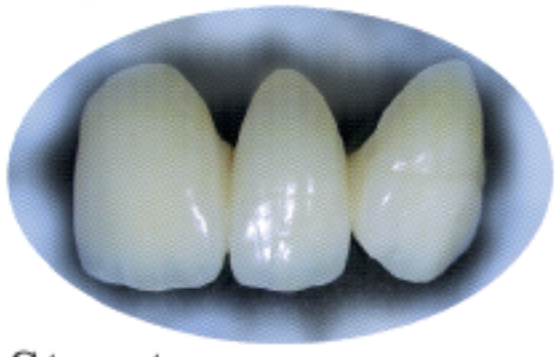

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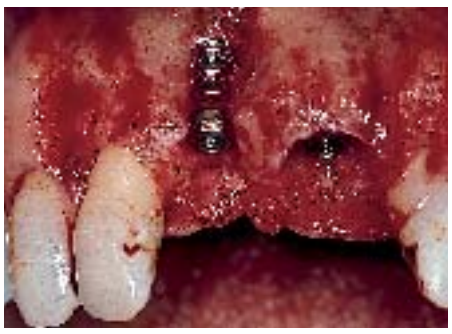

Figure 3—Implants were placed in ideal positions. Implants were 3 to 4 mm from the anticipated CEJ and from each other. Note the amount of bone present between the implants that would eventually support the interdental papilla.

Figure 4—View of the patient 3 days after being hit in the mouth by a 2 × 4 during an industrial accident. His lip had been recently sutured and he was wearing a new provisional restoration—a one-tooth cantilever with tooth No. 9 as a lone abutment.

Figure 5—Intraoral view of the provisional restoration.

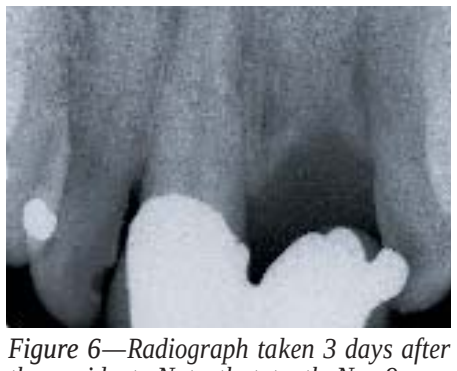

Figure 6—Radiograph taken 3 days after the accident. Note that tooth No. 9 was horizontally fractured. The patient lost tooth No. 8 more than 20 years earlier.

maintenance of a papilla between adjacent implants is often considered much more difficult. The purpose of this article is to demonstrate a predictable way to regenerate papilla between adjacent implant crowns. In addition, the concept of bone sculpting will be discussed along with the following case, which is used to demonstrate these concepts.

Case Study

The patient, a high school woodworking instructor, was referred for evaluation 3 days after trauma to the anterior maxilla (Figure 4). He had sustained a traumatic injury to the lip, maxillary anterior alveolus, and maxilla left central incisor when a 2 × 4 piece of wood catapulted from a table saw to his face.

The patient had lost his maxillary right central incisor 20 years earlier. This had been restored with a single cantilever tooth off a restored left central incisor. As an emergency procedure, a new provisional restoration was made (Figures 4 and 5) before his referral. Radiographs revealed that tooth No. 9 had a midroot horizontal fracture and was hopeless (Figure 6).

The Treatment Plan

Treatment planning is the sine qua non of predictable esthetic dentistry. The treatment plan is the template on which the clinician can develop an ideal restoration. The development of the treatment plan allows for excellent communication between the restorative dentist and the periodontist. This is essential to predictably create a restoration that will be esthetic. A treatment-planning template is provided in Table 1. It serves as a guide for implant dentistry. Alterations to the protocol may occur because of individual variations. However, the basic sequence is useful.

Surgical Treatment

Tooth No. 9 was determined to be hopeless because it had a vertical root fracture. It was determined that it would be extracted and an implant would be placed into the extraction site. Immediate implants have been shown to have a success rate similar to that of delayed implant placement.[5] Tooth No. 8 was also to receive an implant. Before surgery it was not known whether an implant could be placed, because the tooth had been lost for more than 20 years and it was not known how much ridge resorption might have occurred during this time. A therapeutic contingency involved grafting the tooth No. 8 site for a future implant.

After local anesthesia, a full-thickness flap was elevated to expose the underlying alveolar ridge (Figure 7). Significant atrophy of the alveolar ridge was noted in the area of tooth No. 8. Bone augmentation with ridge expansion was indicated. Using a Summers Osteotome Kit (3i Implant Innovations Inc.) the ridge was expanded according to Summers'[6] principles. The ridge was too narrow to complete expansion with an osteotome. However, the use of an osteotome would allow enough increase in ridge volume for an implant to be placed and stabilized (Figure 3).

Machine Titanium Threaded Implants (3i Implant Innovations Inc.) were placed in the areas of teeth Nos. 8 and 9. They were placed approximately 4 mm apical to the anticipated cemento-enamel junctions (CEJs) of the implant crowns. This would allow a proper emergence profile for the final restoration.[2] From a restorative perspective, both implants were in good positions. However, they were not completely in bone. Implant No. 8 was stable but had nine threads exposed on the labial (Figure 3). Implant No. 9 was embedded in bone, but had a circumferential defect (Figure 8).

Table 1—Treatment Plan Template

1. Clinical and radiographic evaluation.
2. Joint consultation between periodontist and restorative dentist.
3. Fabrication of provisional restoration.
4. Implant placement and bone regeneration, if necessary.
5. Two to 6 months of healing.
6. Second-stage surgery including bone sculpting and placement of EP Temporary Healing Abutments®.
7. One month of healing.
8. Implant level impression.
9. Placement of permanent abutments and provisionalization.
10. Papillary maturation.
11. Final impressions of abutments and impression of provisional restoration.
12. Temporary cementation of the final prosthesis.

Bone Grafting

Bone regeneration is necessary around both implants to have a predictable stable result. Autogenous bone was harvested from the osteotomy sites using a bone trap (Osseous Coagulum Trap, Quality Aspirators) and placed into sterile saline. A combination of 50% autogenous bone and 50% demineralized freeze-dried bone allograft (American Red Cross) was then placed over the labial surface of implant No. 8 and into the extraction site of tooth No. 9, filling the void around the implant (Figure 8). An expanded polytetrafluoroethylene (e-PTFE) membrane (Gore-Tex® oval 6, W.L. Gore & Associates Inc.; distributed by Nobel Biocare USA) was placed over the graft and stabilized with two miniscrews (Figure 9). Stability of the use of a membrane in conjunction with a bone graft is often the most predictable method to obtain bone regeneration.[7] The author has found that the use of a membrane in conjuction with a bone graft is the most predictable method to obtain bone regeneration around implants.

Primary closure is also essential to eliminate the possibility of bacterial infiltration and subsequent infection (Figure 10). A connective tissue graft was harvested from the hard palate and placed over the membrane and occlusal surfaces of the implants. It was stabilized with a 5-0 gut suture (Ethicon Inc.) to prevent its egress. Primary closure was then achieved using Gore-Tex® CV-5 sutures. These sutures allow for synching of the flap and excellent adaptation. The e-PTFE sutures also do not wick bacteria. Wound

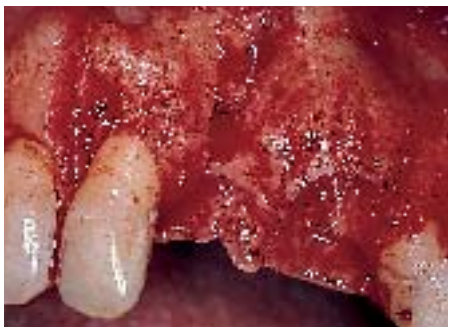

Figure 7—Surgical view on the day tooth No. 9 was extracted and implants placed at teeth Nos. 8 and 9. A large full-thickness flap has been elevated, providing adequate access for implant placement and bone grafting.

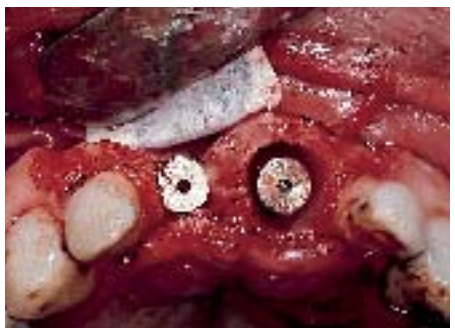

Figure 8—Occlusal view of the implants in place before placement of the bone grafting material. The implant in the area of tooth No. 9 was completely housed within bone. However, a circumferential defect was present and regenerated with the application of a bone graft. A membrane was not needed.

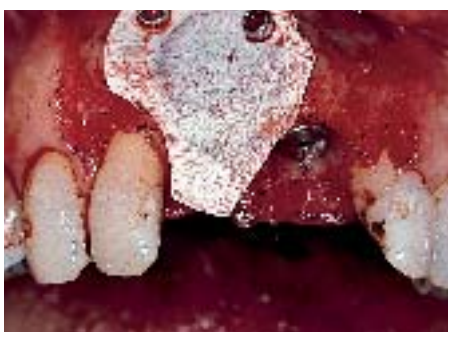

Figure 9—Facial view of the e-PTFE membrane in place. Note that the membrane does not cover the implant in the area of tooth No. 9. Two mini-screws were used to stabilize the membrane.

Figure 10—Primary closure was achieved using e-PTFE sutures. The vertical incisions allowed the flap to be elevated occlusally. A connective tissue graft also was harvested from the palate and placed beneath the flap to assure primary closure.

healing is much improved, because these sutures cause minimal irritation to the epithelium. The vertical incisions were closed with 5-0 gut sutures, as they were in alveolar mucosa. Healing was extremely rapid in this tissue. Nonresorbable sutures can be very difficult to remove when within alveolar mucosa because of the rapidity of the healing. Therefore, a resorbable suture was used.

Second-Stage Surgery Including Bone Sculpting

Six months were allowed to pass before the implants were uncovered, thus allowing for optimal bone regeneration. A full-thickness flap was elevated and the e-PTFE membrane removed (Figure 11). Complete bone regeneration was noted beneath the membrane. The immediate implant placed within the alveolar bony housing was completely regenerated (Figure 11). It was necessary to remove bone to access the cover screws of the implants, and additional bone also would have to be removed to create a smooth emergence profile. The removal of bone to achieve the proper soft tissue contour (bone sculpting) can be accomplished three ways (Table 2).

All three bone sculpting methods work. Hand instru-

mentation is the most tedious and time consuming. If the bone is thick, it is not always practical to rely solely on hand instrumentation. High-speed rotary instruments such as finishing burs and Neumeyer burs are very efficient. However, the platform of the implant is not protected and may be damaged during the procedure. Bone profiling instruments (3i Implant Innovations Inc.) create a smooth emergence profile efficiently and safely. This is the author's bone sculpting technique of choice.

Bone profilers were used to create a smooth emergence profile (Figure 12). The bone was sculpted; this was possible because the implants were placed a little greater than 3 mm from each other and slightly beneath the crest of bone. A peak of bone was created to guide the soft tissues of the gingiva to form a papilla. If the implants were placed within 3 mm of each other, it was likely that the bone would resorb and the peak of bone (Figures 12 and 13) would be lost, per the author's experience. Hence, the papilla would shrink and a dark triangle would form between the implant crowns. After the completion of the bone sculpting, EP Temporary Healing Abutments® (3i Implant Innovations Inc.) were placed (Figure 13).

The wound was sutured and allowed to heal for 4 weeks. Four weeks after implant exposure, a papilla was already beginning to form, despite the absence of a

TABLE 2—BONE SCULPTING TECHNIQUES

- Hand instrumentation with chisels and curets.
- High-speed rotary instrumentation using finishing burs and Neumeyer burs (Brasseler USA®).
- Bone profiling instruments.

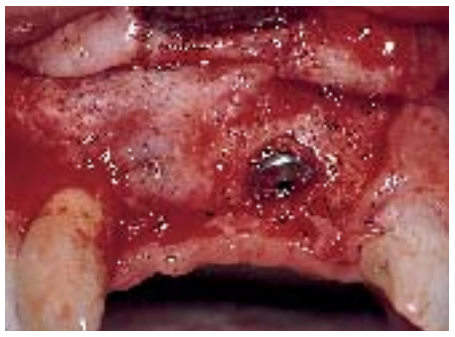

Figure 11—Second-stage surgery was performed at 6 months. Complete bone regeneration occurred on the facial surface of the implant in the area of tooth No. 8. Seven previously exposed labial threads were now covered with bone. The implant in the area of tooth No. 9 also was well integrated.

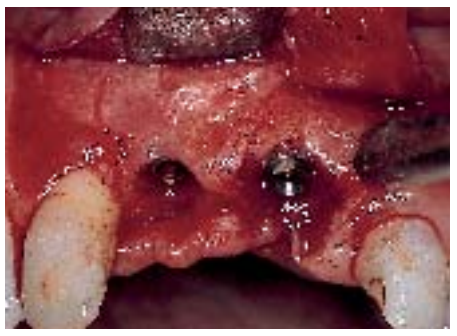

Figure 12—The platforms of the dental implants after bone removal, removal of the cover screws, and bone sculpting. There is a peak of bone between the implants. A smooth emergence profile could now be achieved.

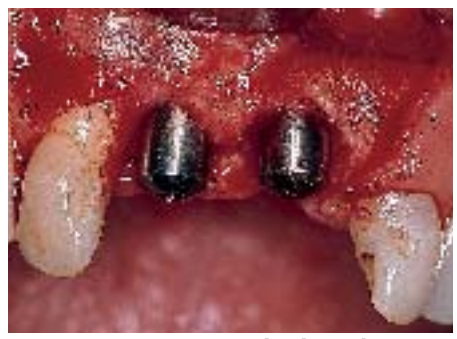

Figure 13—Temporary healing abutments were placed. Resultant papilla would form between the implants.

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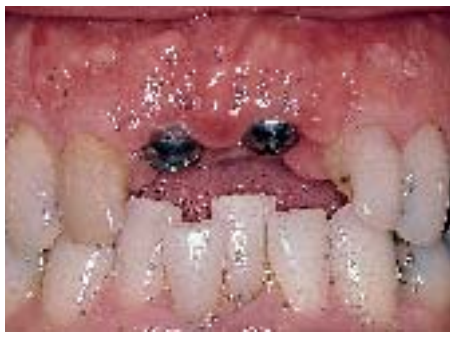

Figure 14—View 4 weeks after the second-stage surgery. The soft tissue was healing and a papilla was beginning to form, despite the absence of a provisional restoration.

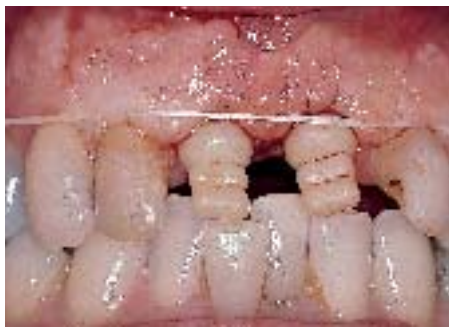

Figure 15—Permanent abutments were placed and the patient was about to receive the provisional restoration. A piece of floss was used to help visualize the dental gingival-marginal relationships.

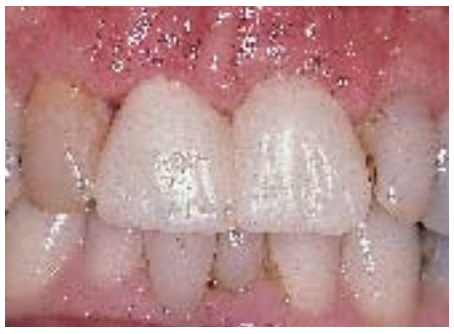

Figure 16—The provisional restoration in place. Papillae were maturing and the appropriate dental-gingival relationships were achieved. The patient had been wearing the provisional restoration for 2 months. He was now ready for final impressions.

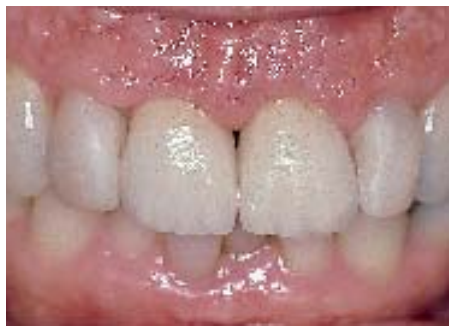

Figure 17—The final restoration in place, 2 days after temporary cementation. The gingival tissues were still slightly inflamed and complete papillary regeneration had not yet been achieved. Within 1 year, the papilla and soft tissue would be stable. (Laboratory work courtesy of Precision Dental CeramX: Jim Mallick, CDT, and Tim Anrico, CDT, both of Fairfield, Connecticut.)

fixed provisional restoration (Figure 14).

Provisionalization

The patient was now ready for provisionalization. Initial soft tissue healing was now complete and the gingival tissues were stable. An impression was made of the implants at the level of the platform. This was transferred to the laboratory and custom UCLA abutments (3i Implant Innovations Inc.) were made, or machined prepable abutments could be chosen. A provisional restoration was made to fit the custom or machined abutments and delivered to the restorative dentist. The permanent abutments were placed (Figure 15), followed by placement of the acrylic provisional restoration (Figure 16). The patient was then allowed to heal in the provisional until the dentist and patient were both satisfied with the tooth-to-soft-tissue relationships. During this phase of care, the provisional restoration can be modified to help guide the soft tissue. The goals of therapy of the provisional phase are:

- development of a dental papilla
- obtaining a smooth emergence profile
- achieving dental-gingival harmony
- creation of proper tooth shape, size, and contour.

The above requirements must be met before impressions are taken for the final restoration. In no instance should final impressions be taken until an ideal provisional restoration has been achieved. The provisional restoration is a template for the final restoration. All too often, too little attention is paid to the provisional restoration. If ideal esthetics are not achieved in the provisional, it is unlikely that ideal esthetics will be obtained in the final restoration.

Final Impressions and the Final Restoration

Final impressions included impressions of the permanent abutments and of the soft tissue. A soft tissue model should be fabricated to allow the laboratory to create a restoration with the proper emergence profile. In addition, final impressions should also include an impression of the provisional restoration. The laboratory now has the abutment impression as well as an impression of the provisional. The provisional impression serves as a template for the laboratory to make the final restoration.

The final restoration was made with a high degree of predictability. This sequence of events minimizes laboratory makeovers. It saves time for the patient, dentist, and laboratory, and makes esthetic rehabilitation predictable and hence, more enjoyable.

The final restoration became a recapitulation of the provisional restoration (Figure 17). Papilla reformation had been achieved between the implant crowns as well as between the implant crowns and the natural teeth. The height of contour of the central incisors was equal to the height of contour of the canines and apical to that of the lateral incisors (Figures 17 and 18). All this is possible because the treatment plan template was followed.

Bone profilers were used to create a smooth emergence profile.

Radiographically, a smooth emergence profile was evident (Figure 19). In addition, the peak of alveolar bone between the implants could be visualized; this supported the papilla. The distance from implant crown contact point to bone was 5 mm and the distance between implants was between 3 and 4 mm. The initial parameters of papilla regeneration between implants were fol-

Figure 18—Smile view of the patient with the new implant crowns. Compare to Figure 2. Ideal dental-gingival relationships were achieved.

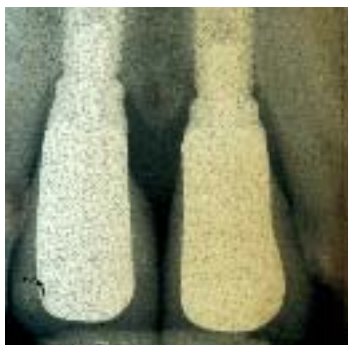

Figure 19—Radiograph of the implants with the final restoration. Note the peak of bone between the implants. This would serve as support for the gingival papilla. Also note the smooth emergence profile, from the platform of the implants to the CEJs of the implant crowns.

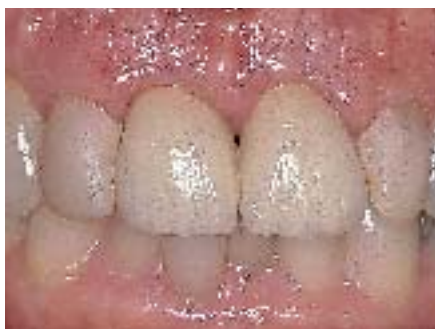

Figure 20—Intraoral view of the implant restorations 1 year after cementation. Note that there has been about 1 mm of labial gingival recession. The gingival tissues have matured and the papillae now fill the embrasure space between the implants and between the implants and natural teeth, an ideal esthetic result. (Restoration courtesy of Dr. Stephen Guss of Fairfield, Connecticut.)

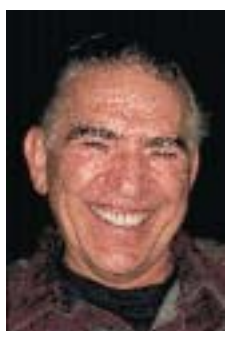

Figure 21—Postoperative view, full-face smile.

lowed. The result is an esthetically pleasing restoration (Figures 17, 18, and 20) and a happy, smiling patient (Figure 21).

Over time, soft tissues continue to mature. Soft tissues may recede during the first year after the implant crown is cemented.[8] Six years after the cementation of the restoration, the patient showed about 1 mm of labial gingival recession and complete fill and maturation of the papilla between the implants (Figure 20).

Conclusion

Predictability in esthetic implant dentistry is possible. This article outlines a treatment plan template that should serve as a guide for communication, as well as treatment. The concept of bone sculpting and its clinical significance is essential in laying the foundation for an esthetic, functional restoration.

Excellent communication between restorative dentist, implant surgeon, dental laboratory, and patient is essential if predictable results are to be achieved. Each step of the treatment planning process is only as strong as the preceding step. The success of the final crown rests on the quality of the provisional, which in turn rests on the quality of the laboratory-fabricated crown and abutment—which rests on the quality of the bone and soft tissue, the quality of the surgical technique, and the quality of the treatment plan. All elements of the dental treatment plan should be strong to allow for an esthetic implant restoration. ◯

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Product References

Product: Summers Osteotome Kit, Machine titanium threaded implants, Bone profiling instruments, EP Temporary healing abutments®, UCLA abutments
Manufacturer: 3i Implant Innovations Inc.
Address: 4555 Riverside Drive, Palm Beach Gardens, FL 33410
Phone: 800.342.5454
Fax: 561.776.1272

Product: Osseous Coagulum Trap
Manufacturer: Quality Aspirators Inc.
Address: 1419 Goodwin Lane, Duncanville, TX 75116
Phone: 800.858.2121
Fax: 972.298.6592

Product: Demineralized freeze-dried bone graft
Manufacturer: American Red Cross Tissue Services
Address: 7401 Lockport Place, Lorton, VA 22079
Phone: 800.693.6272

Product: Gore-Tex® oval 6, Gore-Tex® CV-5 suture
Manufacturer: W.L. Gore & Associates Inc.
Distributor: Nobel Biocare USA
Address: 22985 Eastpark Drive, Yorba Linda, CA 92887
Phone: 800.891.9191
Fax: 800.451.9047

Product: 5-0 plain gut suture
Manufacturer: Ethicon Inc.
Address: US Route 22 West, Somerville, NJ 08876
Phone: 800.225.2500
Fax: 732.562.2212

Product: Neumeyer burs
Manufacturer: Brasseler USA®
Address: 1 Brasseler Boulevard, Savannah, GA 31419
Phone: 800.841.4522
Fax: 912.927.8671