



# ESTHETIC THERAPY WITH STANDARD AND SCALLOPED IMPLANT DESIGNS: THE FIVE BIOLOGIC ELEMENTS FOR SUCCESS

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## ABSTRACT

The field of implant dentistry has grown significantly in recent years. Balancing natural-looking esthetics with long-term function, however, remains a challenging task. The main focus of implant dentistry is on improving the survival rate, simplifying the treatment, improving the esthetic outcome, and reducing the treatment time. Developing a natural contour and anatomically dimensioned soft-tissue margin is critical to attaining an esthetic implant restoration. This article discusses the five elements to achieve natural implant esthetics: bone foundation, implant design and placement, soft-tissue profile, prosthetic tissue support, and ceramic art design.

**E**ndosseous implant design has remained relatively consistent since its introduction to the dental profession by Per Ingvar Brånemark and demonstrated a remarkable success rate and longevity.<sup>1</sup> Since then, the focus of implant dentistry has been on the improvement of the survival and success rate, simplification of the treatment, improvement of the esthetic outcome, and reduction of the treatment time.<sup>2-6</sup> To cope with the high esthetic demands of today's patient population, new concepts and components were developed.

New abutment designs in combination with the original implant fixtures and implants resembling the anatomy of the natural roots have been introduced.<sup>7</sup> But in a five-year study, Jemt reported he still found only 60 percent of the cases with full gingival support and the other 40 percent had incomplete papillae, long crowns, and recession of the soft tissue.<sup>8</sup> This was often caused by implants being placed too deep or tissues being lost during the functional phase.

On evaluation of the esthetic outcome with dental implants designed for

the absorbed ridge of the totally edentulous patient, several areas required change in order to improve the quality of implant esthetics in the partially edentulous patient: 1) the understanding of the effect of the biologic soft-tissue width on the implant and transgingival component; 2) the implant position in relationship to the surrounding bone foundation; 3) the bone apposition (osseointegration) area around the abutment-implant interface; and 4) the abutment materials utilized in the transgingival area.

## Biologic Soft-Tissue Challenge

This clinical challenge was revisited through an analysis of the biological tissue responses around the implant body and neck, the abutment, and the soft-tissue space. Around natural teeth, three



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**Acknowledgement /** Prosthetic consultation and work in this paper provided by Peter Wohrle, DMD, Newport Beach, Calif.



**Figure 1.** Buccal view of severe localized tissue loss after unsuccessful orthodontic extrusion of impacted canine.



**Figure 2.** Radiograph demonstrating the loss of vertical and horizontal bone and resorption of adjacent roots.



**Figure 3.** Radiograph showing the vertical bone augmentation treatment with autogenous bonegraft and a TR-PTFE membrane after removal of the hopeless lateral incisor.

distinct compartments, sulcular depth, junctional epithelium, and connective tissue, form a predictable and stable periodontal attachment.<sup>9</sup> This comprehensive biologic structure is known as the biologic width, a term that has been used in periodontal literature since the 1960s. Stable soft tissues, a reflection of osseous supporting structures, are required around natural teeth as well as dental implants, and these form the basis for an esthetically pleasing implant restoration. It has been shown that the principles of biologic width are also valid around dental implants.<sup>10,11</sup> The tissue compartments around endosseous implants have similar dimensions resulting in 3 mm to 4 mm of total soft-tissue height.

In long-term studies with totally and partially edentulous patients using one- and two-stage implants, approximately 0.7 mm to 1.5 mm of bone remodeling was observed during the first year, with subsequent bone loss of 0.1 mm per year.<sup>1,11-13</sup> The remodeling of the crestal bone around an implant is multifactorial; it depends on the vertical location of the implant-abutment interface in relationship to the bone and the state of the implant surface (smooth versus roughened surface).<sup>14</sup>

Placing the prosthetic table deeper into the bone (countersinking) results in increased bone loss compared to a more coronal placement. In two-stage systems, which are placed at or below bone level, the frequent exchanges of components (healing abutment, temporary restorations, impression copings, try-in of frameworks) can significantly disturb the epithelial and connective tissue layer and allow for apical migration of all tissue compartments resulting in increased bone loss.<sup>15,16</sup>

### Implant Position Challenges

Following tooth loss, the resorption of the residual ridge transforms a 3-D osseous structure into a ridge with a flattened topography.<sup>17</sup> In healthy patients, soft-tissue contours closely follow the underlying osseous structures forming a complete interproximal gingival papilla.<sup>18,19</sup> The final vertical position of an implant neck into a scalloped ridge or an extraction site can be a significant challenge as a deep or shallow position can compromise either interproximal bone or expose the buccal surface of an implant. Another consequence can be deep implant placement when working with a resorbed, flattened ridge. Additional, subgingival

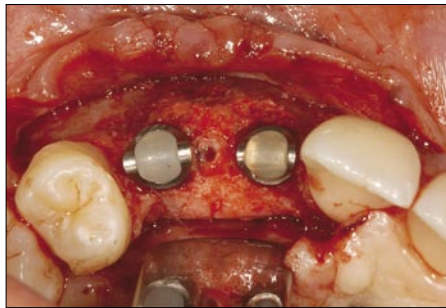
prosthetic manipulation may result in tissue inflammation and eventual bone resorption and, therefore, compromise long-term osseous support for the soft tissue.<sup>14-16</sup>

The fundamental requirement for the attainment of an esthetically pleasing implant supported restoration is the establishment of an ideal vertical implant position, which is in harmony with the surrounding bone and the soft-tissue thickness.<sup>5</sup> The main factors determining the vertical position relate to implant design, implant surface, and expected bone remodeling around the implant. Studies evaluating bone remodeling around dental implants show bone remodeling ranging from 0.7 mm to 1.5 mm.<sup>1,11-13,20</sup> This anticipated bone loss should be subtracted from the total peri-implant soft-tissue space of 3 mm to 4 mm. This results in an ideal position of the implant neck 2 mm to 3 mm apical to the lowest point of the desired buccal marginal gingiva.<sup>5</sup>

The bone crest must be located within 3 mm to 4 mm on the facial and 5 mm in the interproximal area to accomplish the required height of the free gingival margin and the interproximal papilla for the final restoration.<sup>5,21,22</sup> A dense keratinized tissue present (thick,



**Figure 4.** Buccal view of complete vertical bone regeneration after nine months of uneventful healing. Note the optimal vertical position of the implants 2 mm below the gingival margin of the surgical guide stent.



**Figure 5.** Occlusal view of complete horizontal bone regeneration and the optimal buccal lingual placement of the implants.



**Figure 6.** Secondary bonegraft placement with bovine deproteinized HA and a resorbable membrane supporting the soft tissues.

fibrotic tissue vs. thin, highly scalloped tissue) is preferred to establish stable soft-tissue margins.

### Esthetic vs. Biologic Challenges

For optimal esthetics, the implant should be placed as deep as biologically acceptable, while at the same time the abutment-implant should be kept away from the bone to minimize tissue trauma which would lead to remodeling. For prosthetic reasons and proper emergence profile, a minimum of 2 mm and a maximum of 4 mm from the implant prosthetic table to the future tissue emergence are required. This shallow depth is possible when an adequate soft-tissue thickness is present. Prosthetic biomaterials in the subgingival space influence the health and stability and therefore ceramic and titanium materials of normal or undersized dimensions are preferred.<sup>14-16</sup>

### Bone Foundation: 3-D Bone Grafting for Esthetic Soft-Tissue Support

Esthetic bone grafting to the implant site is indicated if the distance between the osseous crest and the desired future free gingival margin is more than 4 mm. This advanced implant therapy

has produced good results with bone grafts, GBR-procedures, and alveolar distraction osteogenesis. The surgical procedure needs to be executed with the utmost care in order to preserve maximum vascularity to the flap and the underlying bone. One of the treatment options is to use a GBR procedure with autogenous bone or a combination of autogenous and filler bone grafts covered with a barrier membrane.<sup>23,24</sup> This allows for the controlled regeneration of osseous structures in both horizontal and vertical directions. When using an implant, this technique may be used to recreate lost bone dimensions or enhance the overall horizontal and vertical dimension of the skeletal tissue. It is recommended to reconstruct the missing alveolar bone in a two-stage bone regeneration procedure unless the bone loss is moderate and mainly needs buccal augmentation. A two-stage bone regeneration procedure will minimize the risk of exposure of the bone graft material and/or the implant neck if soft-tissue problems occur during the healing period.

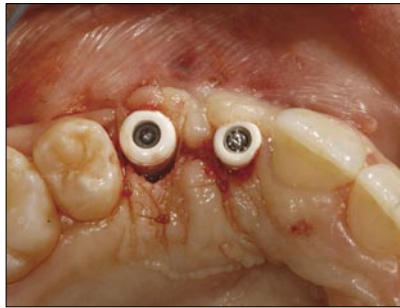
### Bone Graft Material of Choice

According to published reports, autogenous bone is the golden standard as a

grafting material.<sup>25</sup> The use of autograft is characterized by excellent biocompatibility, no risk of disease transmission, excellent space monitoring properties, and an osteoconductive scaffold for osteoblasts during the bone formation period. However, harvesting of the graft material complicates and prolongs the surgical procedure, and there is always a risk of donor site morbidity. The autograft removal, particularly from the chin area, can induce short to medium term paresthesia in the mandibular anterior dentition. Therefore, the mandibular ramus is preferred as a donor site. A frequently utilized harvest technique is the removal of bone from the external oblique ridge with the "Audi" trephine method or using a bone scraper.<sup>26</sup> Bone from the tuberosity, the lower portion of the nasal aperture, or any endentulous area is generally used for smaller graft volumes. A cortical bone graft from the ramus will result in the slowest amount of bone turnover, whereas osseous coagulum collected from the implant drill procedure and tuberosity bone will result in the highest amount of bone resorption. The use of other bone graft materials has also been proposed. Application of allografts and bovine HA-grafts has been demonstrated to be



**Figure 7.** Uneventful healing of bonegraft and implant site.



**Figure 8.** Occlusal view of minimal invasive uncovering procedure after four months of healing and attachment of healing abutments.



**Figure 9.** Prosthetic posts which were attached on same day of uncovering and used to support temporary prosthesis.

successful, but long-term results in the treatment of largely exposed implant surfaces and ridge defects with these types of grafts are not yet available. A safe treatment modality is the layering bone graft technique in which the exposed implant surface or the critical bone deficient area is first grafted with autogenous bone material while the outer periphery of the defect is grafted with a bone filler material.

### Implant Design: Design and Surface Improvements

Elimination or reduction of bone remodeling and maintenance of present or regenerated bone is the ultimate motive for designing and using dental implants with a biologic neck design in esthetic implant therapy.<sup>25,26</sup> An appropriately designed implant body and neck uses an enhanced surface to develop an optimal bone apposition area which is osteoconductive and allows for bone apposition and soft-tissue stability.<sup>20</sup> Two new implant concepts are presently used: 1) a scalloped implant with interproximal higher margins and 2) a flat-top implant neck with an enhanced, roughened surface placed at the bone level and an abutment material, design and utilization which

respects the soft and hard tissue. Both implant concepts are indicated for the treatment of patients exhibiting 3-D jaw bone topography, or when rebuilding lost interproximal bony peaks is required. Between natural teeth, a critical distance of 5 mm or less between the interproximal bone level and the most apical point of the contact area of the teeth is required to maintain a complete fill of the papilla.<sup>21</sup>

Adjacent implants require interproximal bone between the implants above the traditional flat prosthetic table to serve as the support for the interimplant soft-tissue papillae. Until now, this has been particularly difficult to achieve when restoring two or more adjacent implants. When a scalloped implant is placed in a flat, deficient bone site in the ideal biological position and the interproximal scalloped bone apposition surfaces are exposed, interproximal grafting can be attempted.<sup>27</sup>

The soft-tissue biological space around an implant is situated between the crestal bone and the gingival margin. It measures from 3 mm to 4 mm in height and interacts with the enhanced titanium neck design and a ceramic or titanium abutment. Consequently, the abutment-implant interface is disturbed

minimally to prevent tissue trauma and the abutment is kept narrow at the mating part with the implant to maintain a stable distance to the underlying osseous structures around the implant. The soft-tissue biologic space allows for the undisturbed approximation of the soft tissues during maturation and ensures that fibers that form are not disrupted during the restorative process.

### Implant Placement

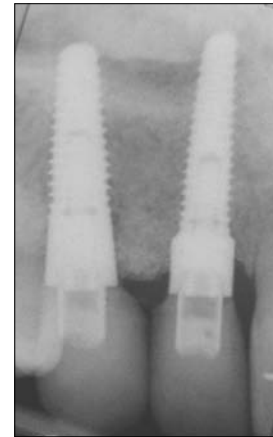
Of utmost importance is the primary stability and the optimal position of the implant. The ideal position of an implant takes four different planes into account: apicocoronal, mesiodistal, facial-oral, and implant angulation. The most natural position of an implant is to be an extension of the final esthetic crown. To support this ideal tooth emergence profile and to achieve optimal natural esthetics, it is mandatory to perform a diagnostic wax-up and a subsequent fabrication of a surgical guide prior to implant placement. The design of the template must be such that the desired future gingival margin is visible during the diagnostic, as well as during the surgical phase so that exact measurements can be taken during implant placement.



**Figure 10.** Frontal view of temporary prostheses on two implants after six months of soft-tissue maturation. Note positive tissue level and mucogingival health.



**Figure 11.** Frontal view of the cementation of two full ceramic restorations on the dental implants. Note harmony of soft tissues and tooth design and ceramic final result.



**Figure 12.** Radiograph of the scalloped implants after one year of functional loading. Note the maintenance of bone level around the neck of the implants resulting in soft-tissue support and an esthetic, pleasing end result. (Prosthetic and ceramic work performed by Peter Wohrle, DMD, Newport Beach, Calif.)

The ideal vertical position of the implant neck is 2 to 3 mm apical to the desired gingival margin on the midfacial. This esthetically oriented vertical implant placement will result in a varying amount of bone coverage depending on the amount of bone present at the implant site and, therefore, may necessitate bone grafting.

In implant sites with adequate existing bone morphology, the bone apposition area of the implant will be placed into the bone while the soft-tissue apposition area protrudes slightly above the bone. In implant sites with existing bone loss, the surgeon has a choice between placing the implant into the residual bone, resulting in a longer crown, or placing the implant in the biologic/prosthetic correct position, grafting the deficient areas either at the time of implant placement, or preferably prior to implant placement. A similar decision needs to be made when existing mesial and distal interproximal bone levels are at varying levels. The surgeon can choose to either augment the deficient site or place the implant in relationship to the lower interproximal bone level, which would result in remodeling of the other more coronal site.

Placement of the implant too far facially or orally will compromise the buccal bone plate and make it difficult to receive a proper thickness of tissue on the facial, and even risk bone resorption and soft-tissue recession. An ideal facial-oral position is 2 to 3 mm lingual to the buccal contour of the final crown with a buccal bone tissue support on the implant of 2 mm.

The mesiodistal implant position takes into account distances between natural teeth and implants (2 mm) and between adjacent implant (3 mm to 4 mm).<sup>22</sup> The angulation of the implant is positioned to follow the occlusal form of the tooth and to allow for a natural emergence profile of the implant crown, but minor angulation problems can be modified in the laboratory phase.

#### **Indications for Use of Enhanced Surface Flat or Scalloped Scalloped Implant and Abutment Designs**

A natural esthetic implant outcome is based on long-term stable soft tissue supported by a 3-D osseous foundation. This principle gives a scalloped or enhanced flat top implant and abutment design a potential advantage in the anterior esthetic smile zone and

in bone areas with a scalloped profile versus traditional implant design and placement techniques.

The obvious advantage of the biological implant designs is expressed when placing multiple adjacent implants. The design can assist in maintaining or regaining previously lost interproximal osseous structures when a membrane protected bone graft is placed between the exposed bone apposition areas of adjacent implants.

The longest documented scalloped implant case has been in function for more than five years with stable bone and soft-tissue support and a pleasing esthetic result.<sup>27</sup> Most cases with the scalloped implant design have been performed since 2002 and several prospective studies are in progress.<sup>28</sup> The enhanced neck design of a flat top implant with a properly designed abutment material and with minimal trauma done during the prosthetic phase can also stabilize the bone and soft tissues in the esthetic zone.

#### **Soft-Tissue Profile — Biotype**

Soft-tissue stability is seen around esthetic implant treatment with less than 1 mm soft-tissue remodeling on the facial and possibly even an increase

of the papilla volume area, when a good amount of surrounding bone and a thick soft-tissue dimension is present.<sup>29</sup> Prior to any soft-tissue grafting, the existing bone substructure must be evaluated to ensure that it is able to support soft-tissue graft placement. Sites that lack hard-tissue support must be reconstructed before initiating this treatment phase. In the maxillary arch, sufficient hard tissue must be present to support the 4 mm of soft tissue that is required to develop optimal esthetic results and maintain the biologic width around implants. To develop a natural emergence profile for the definitive restoration, it is essential to evaluate the quality of soft tissue, and if thin, to increase the amount of keratinized tissue and the volume of the soft tissues. It is similarly important to overcontour the soft tissues and to wait three months for soft-tissue maturation, as soft tissues tend to remodel during subsequent restorative procedures.<sup>30</sup> A general guideline is to overbulk the restorative implant site by at least 1 mm; a guideline for this level is an imaginary line drawn between two healthy gingival papillae of the adjacent teeth to an edentulous space. The possibility of using connective tissue grafting in conjunction with bone grafts or without should be evaluated at every surgical phase, and if necessary performed to prepare for a thick esthetic emergence profile.<sup>5</sup>

### Prosthetic Tissue Support and Ceramic Art Design

A variety of prosthetic options ranging from standard cemented to screw-retained crown techniques can be used on a standard or scalloped implant. Essential is the use of sound biological prosthetic principles to guarantee tissue integration and stability at the bone

and soft-tissue level. Biocompatible abutment materials like alumina or c.p. titanium allow for a formation of a healthy, mucosal attachment which includes well-dimensioned epithelial and connective tissue portions that are about 2 mm and 1-1.5 mm high, respectively. At sites where abutments made of gold alloy or dental porcelain were used, no proper attachment forms at the abutment level, but the soft-tissue margin recedes and bone remodeling can occur.<sup>16</sup> Atraumatic abutment insertion with early final seating are also key to establish these biological principles. Findings indicate that the multiple dis- and subsequent reconnections of the abutment component of the implant compromises the mucosal barrier and results in a more "apically" positioned zone of connective tissue and bone loss.<sup>15</sup> The one-time shift from a healing abutment to a permanent abutment results in the establishment of a healthy transmucosal attachment, the dimension and quality of which does not differ from those of the mucosal barrier formed to a permanent abutment placed during a second-stage surgery.<sup>31</sup>

Full porcelain-layered ceramic restorations are placed with minimal subgingival placement so that only one margin is in the deeper tissues between the implant-abutment and the second margin between crown and abutment is shallow, within 0.5 mm of the gingival margin following traditional perioprosthetic techniques. This allows for ease of cement rest removal and prevents dental porcelain to be deep within the tissues reacting negatively on tissue stability.<sup>15</sup>

### Complications

Surgical complications are reported for a variety of implant placement and

bone reconstructive techniques, and therefore need to be considered. Some specific complications have been noted with implant placement in the esthetic zone. These complications are: 1) implant failure, bone graft failure, loss of integration or nonintegration. These are found in the same low percentage as with other osseointegrated implants; 2) bone loss in the bone apposition neck area. In some cases, this leads to soft-tissue shrinkage and a gray shadow from the titanium surface. In other cases, the bone remodeling allows for normal soft-tissue height with no esthetic compromise; 3) loss of gingival papilla support and/or exposure of interproximal implant shoulder. This can be seen in cases with simultaneous bone grafting in which the procedure has failed and has resulted in exposure of the titanium shoulder; and 4) malposition of an implant resulting in a difficult prosthetic and nonesthetic solution or in a need to remove the implant.

### Conclusion

The correct implant placement based on biologic surgical and prosthetic principles is essential. This must be achieved by atraumatic soft- and hard-tissue management and prosthetic technique. Esthetic implant therapy demands high precision and delicate tissue handling from both surgical and prosthetic aspects. The argument for using biological designed implant products in patients with a need for a stable esthetic implant crown is convincing. The scalloped or enhanced surface implant and abutment design may be placed in immediate extraction or in healed sites. It may be placed in single units or multiples. It is intended to preserve osseous structures, stabilize soft tissues, and enhance the overall esthetic outcome.

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