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Treatment guidelines for aesthetic implant therapy

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Thorough and accurate diagnoses are essential for providing optimal, state-of-the-art dental treatments that have predictable prognoses and long-term clinical success. Over the past 40 years, osseointegrated dental implants have proven to be a clinically successful treatment for edentulous and partially edentulous patients. Advances in hard- and soft-tissue grafting, membranes, bone morphogenic proteins, and implant macrogeometry and surfaces have enabled implants to be used in clinical situations today that were once unimaginable. Patient expectations have also increased as the science has advanced; however, ill-planned and non-optimally placed implants still pose challenges for both patients and clinicians alike. This article outlines treatment guidelines for achieving aesthetically and functionally optimal maxillary anterior implant restorations.

Key Words: aesthetics, treatment guidelines, implants

Introduction

Medical and dental treatment commences with obtaining medical/dental histories via questionnaires and/or verbal interviews. Questions regarding patients’ past dental history should be aimed at determining the rate and progression of intraoral processes, including periodontal disease, pulpal disease, dental caries, and tooth loss. Past dental records, treatment notes, radiographs, casts, and photographs can be extremely helpful in identifying tooth positions, lip lines, and symmetries/asymmetries. They can also help determine what patients liked and/or disliked about their restorations.

Aesthetics are certainly subjective, but some established principles can be applied by clinicians and patients in order to achieve aesthetically optimal results. Knowingly or unknowingly, clinicians and patients use a framework of aesthetic parameters. Rufenacht described the relationship between objects made visible by contrasts as “composition.” He identified dental, dentofacial, and facial compositions. Dental compositions might include images of anterior teeth in centric occlusion (Fig. 1). Dentofacial compositions could be close-up images of patients smiling without lip retractors (Figs. 2-4). Facial compositions could be full-faced photographs.

One factor in facial/dental aesthetics is symmetry, i.e., regularity in the arrangement of forms or objects. Two types of symmetry have been identified: horizontal and radiating. Horizontal symmetry contains similar elements from left to right or right to left in a defined sequence. Figures 5-7 are examples of asymmetrical elements. Radiating symmetry is a design that extends from a central...
point, with symmetry on the right and left sides. Aesthetic smiles may have components of both.

Pythagoras defined a formula that provided a ratio between two parts in a harmonious relationship. He called this ratio (1:1.618) the Golden Proportion. Much more recently (1993), Preston reported that less than 20% of a study population had dental relationships that fell within the Golden Proportion. Although teeth may have shapes and relationships relative to adjacent teeth in the vertical and frontal planes that do not conform to the Golden Proportion, they may still be aesthetically pleasing. Ultimately, Preston considered that a viewer’s attention is drawn to proportions. The beauty of a smile will be affected by a number of relationships and elements linked to perceived aesthetic concepts.

An individual patient’s ability to have a pleasant, aesthetically pleasing smile depends on the quality of the dental and soft-tissue elements, the relationships that exist between teeth and lips during smiling, and how all of the above integrate into the facial composition. Matthews stated that the anatomy of a smile is an integral part of dentistry. Understanding and achieving aesthetic smiles involve close scrutiny of all elements of the oral region. It is not enough to establish the size of teeth based on high and low lip lines, the size of the mouth, and the best shade to blend with the patient’s age and complexion. In order to create harmonious smiles, dentists must maintain or create normal curvature of the lips, proper exposure of the red zone of the lips, an undistorted philtrum, and undisturbed naso-labial grooves. These entities, maintained in harmony with teeth that are visible during smiling, constitute the anatomy of a smile. In order to develop optimal smiles, the smile must be understood, recorded, and analyzed so that desirable aspects may be preserved and undesirable components changed into desirable components. Preoperative photographs are essential to obtaining these goals.

The amount of tooth exposure during rest, speaking, and smiling, as well as the amount of gingival tissues (if any) exposed under the same conditions, are critical to creating and maintaining aesthetic smiles. The amount of exposure depends on body posture, muscle tone, tooth size, and arrangements. Vig and Brundo reported the results of a population survey in which they noted significant decreases in the amount of maxillary incisor display with advancing age (3.92mm exposed for people 10-15 years of age versus 0.25mm exposed for people 31-36 years of age). Decreasing maxillary incisor exposure contributed to the perception of aging of individuals in their 40s. Teeth may be lengthened but only within the parameters of other aesthetic and functional factors. The researchers also reported that tooth exposure for female participants averaged 3.4mm as compared to an average of 1.91mm for males. Vig and Brundo suggested that clinicians take these findings into account when designing smiles.
According to Rufenacht, the perfect smile is characterized by a tooth/lip relationship with approximately half of the maxillary incisors visible at rest, the maxillary incisal edges parallel to the upper border of the lower lip, and an upper lip with an upward curvature. These specifications do not take into account Vig and Brundo’s results regarding the age-dependent nature of incisal display. The commissures should be symmetrically aligned with the inter-pupillary line, according to Rufenacht. Tooth proportions are also important in smile evaluation. Ward stated that the width/length ratio should be between 75 and 80% and recommended a Golden Proportion width ratio of 60%. Ward cautioned that these ratios are separate and distinct and should not be considered synonymous.

Dental and gingival aesthetics are separate, interdependent entities. A defect or fault in one cannot be compensated for with excellence in the other. Treatment protocols must consider periodontal, aesthetic, and prosthetic factors. Clinicians must take into account the total picture, including the amount of gingival tissue displayed during speaking, smiling, and at rest.

1. Central incisor proportions: Generally, the width of maxillary central incisors should be 75-80% of their lengths (Fig. 8). The classical “Golden Proportion” of 1:1.618 (about 62%) is now thought to be the exception rather than the rule. The average length of central maxillary incisors is 11.3mm, average mesiodistal width is 9mm, and average mesiodistal width at the CEJ is 6.5mm. The average length of maxillary lateral incisors is 10.1mm, average mesiodistal width is 7mm, and average mesiodistal width at the CEJ is 5mm.

2. Facial and dental midlines: The maxillary midline should be consistent with the facial midline (Fig. 9).
3. Axial inclinations: Maxillary central incisors are generally the most vertical of the anterior teeth. Figure 10 is an example of an inconsistent vertical alignment of the maxillary anterior teeth.

4. Maxillary incisal edge and lower lip contours: The incisal edges of the maxillary incisors typically should follow the contours of the lower lip, as exemplified in Figure 11.

5. Maxillary interproximal contact areas: Interproximal contacts should be closest to the incisal edges of the maxillary central incisors and then move apically as one progresses posteriorly from the maxillary midline (Fig. 12). The interproximal contacts in Figure 13 do not conform to this principle and thus are less aesthetic.

6. Arch forms: In many cases, drawing a line through the cusp tips of the maxillary canines can provide valuable information about the likely aesthetic results. The right and left sides should be symmetrical, as is seen in Figure 14. In Figure 15, a line connecting the cusp tips of the maxillary canine teeth would be tilted, indicating an asymmetrical smile. More of the patient’s right canine would be visible to someone standing in front of the person.

7. Maxillary posterior crown heights: Clinical crowns should decrease in height distally, as is illustrated in Figure 16. In contrast, when the clinical crown heights do not decrease in height posteriorly, the result will be unaesthetic. The maxillary canine in Figure 17 is shorter than the lateral incisor, and the first premolar is as long as the lateral incisor and much longer than the canine.

8. Anterior gingival symmetry: Several principles can be formulated pertaining to this area.
a. Anterior gingival symmetry is generally more critical for teeth closer to the midline.
b. It is more critical in patients with high lip lines.
c. Clinical crown heights for maxillary lateral incisors should be shorter than those for maxillary central incisors and canines.
d. The greatest vertical height of the maxillary central incisors should be just distal to the middle of the maxillary incisors.

The maxillary canine teeth are the longest anterior teeth, the maxillary lateral incisors are the shortest, and the maxillary central incisors are longer than the lateral incisors but shorter than the canine teeth. Although the clinical crown heights in Figure 18 are slightly inconsistent, the overall result appears symmetrical. In contrast, the uneven gingival margin levels in Figure 19 significantly compromise the aesthetics.

Anterior Aesthetic Considerations
Single-tooth replacement in contemporary dentistry is often accomplished with osseointegrated implant-supported restorations. Predictable peri-implant aesthetics require an understanding and preservation of the osseous and gingival tissues surrounding the failing teeth. Patients have become increasingly demanding regarding anterior aesthetics, even though the size of the defects and number of teeth lost may be substantial. Achieving acceptable aesthetics requires a thorough course of treatment, including diagnosis, treatment planning, surgery, and restorative and preventive care (Figs. 20 and 21).³

Kois identified the following key elements as requisites for developing predictable anterior aesthetics with endosseous dental implants:¹⁰
- Relative tooth position
- Gingival contours
- Biotype
- Tooth shape
- Position of the osseous crest

Relative Tooth Position
Clinicians need to be aware of three planes of space in diagnosing and planning implant treatment: incisal/apical, mesial/distal, and facial/lingual. Up to 2mm of apical migration of the facial peri-implant soft tissues may be expected after tooth extraction. Teeth with adequate attached gingiva have a more favorable prognosis than do teeth with minimal attached gingiva. The proximity of adjacent teeth is also critical during the diagnostic and treatment-planning phases, especially for maintaining interdental papillae. Teeth with root proximity have thinner interproximal bone and may be more susceptible to crestal bone loss postoperatively. If teeth are labially inclined, little
or no alveolar bone may exist. This worsens the prognosis for maintaining the peri-implant soft tissues. Such patients would likely benefit from bone and/or soft-tissue grafting prior to or in conjunction with implant placement.

**Gingival Contours**

Gingival shapes have been classified as high, normal, and flat. Kois reported in a clinical study of 100 patients that the average normal scallop was 4-5mm apical to the free gingival margin of natural teeth and that bone crests were more than 2mm apical to the cemento-enamel junctions. He postulated that as the gingival scallop increased, so did the risk of peri-implant soft-tissue recession and post-extraction bone loss.

Choquet et al, reporting on the results of a retrospective evaluation of papilla levels adjacent to single-tooth implants in the anterior maxillae, found that when measurements from the interproximal contact areas to the interproximal heights of bone (IHB) were 5mm or less, papillae were present almost 100% of the time. When the distances were greater than or equal to 6mm, papillae were present 50% of the time or less. The mean distance between the IHB and the most coronal papilla level (interproximal soft-tissue height) was 3.85mm (SD=1.04). When comparing conventional and modified surgical techniques, the relation shifted from 3.77mm (SD=1.01) to 4.01mm (SD=1.10), respectively. The researchers concluded that the results clearly demonstrated the influence of the location of the IHB on the presence or absence of papillae between implants and adjacent teeth.

**Biotype**

Peri-implant soft-tissue biotypes have been defined as being either thick or thin. Cosyn et al reported on the results of a three-year clinical study that assessed the overall outcomes of immediate single-implant treatment in anterior maxillae. Thirty consecutively treated patients with thick gingival biotypes, ideal gingival levels/contours, and intact socket walls at the time of tooth extraction were treated with single-tooth replacement in the aesthetic zone by two experienced clinicians. The results included 25 patients at the three-year recare appointments. One early implant failure occurred; the cumulative implant-survival rate was 96%. Radiographic examinations revealed average interproximal crestal bone loss of 1.13mm mesially and 0.86mm distally. Mean mesial/distal papilla shrinkage and midfacial soft-tissue recession relative to the preoperative conditions were 0.05, 0.08, and 0.34mm respectively. Advanced midfacial recession (more than 1mm) was found in two cases (8%). Five cases (21%) were considered to be aesthetic failures, while the outcomes for five were judged to be (almost) perfect. The remaining 14 (58%) demonstrated acceptable aesthetics.
The authors concluded that their protocol provided predictable outcomes for well-selected patients over at least a 3-year time frame, with almost full papillary regrowth and low risks for midfacial recession. Lee et al also concluded that soft-tissue biotype is an important parameter to consider in achieving aesthetic implant restorations, improving immediate implant survival, and preventing future mucosal recession.13

However, Kan et al reported on the results of a 2-8 year clinical study regarding facial gingival tissue stability following immediate placement and provisional restoration of maxillary anterior single implants and noted that peri-implant soft-tissue responses seemed to be limited to facial gingival recession and did not influence the volume or heights of interproximal papillae or proximal bone levels.

**Tooth Shape**
Kois identified tooth shapes as square, tapered, and triangular.10 He stated that tooth shapes may impact soft-tissue contours both coronal and apical to the free gingival margins. Coronly, clinical crowns may affect the volume and heights of gingival embrasures. Kois considered square teeth to have the most favorable impact on soft-tissue contours due to the likelihood of such teeth being larger, with greater interproximal contact areas. He believed that square teeth have less of a risk of black triangles post-extraction. Kois stated that triangular teeth have the highest risks of black triangles because their interproximal contact areas tend to be more incisal and generally require more tissue to completely fill the gingival embrasures. However, he also noted that triangular teeth tend to have greater separation between roots and therefore may have more and thicker interproximal bone. He did not know whether this correlated with a greater...
tendency for vertical crestal bone loss or maintenance of interproximal bone heights.

Kois concluded:

a. Implant crowns should mimic the contours of the contralateral teeth.

b. A balance should be struck between supporting the peri-implant soft tissues and putting too much pressure on them.

c. The facial contours of implant restorations should be flatter than natural tooth contours to minimize apical displacement of the peri-implant soft tissues.

Position of the Osseous Crest

According to Kois, one of the key factors in anterior aesthetics relative to implant placement is the vertical distance from the osseous crest to the peri-implant soft-tissue margins, especially the height of the interdental papillae. He thought greater distances increased the risk of peri-implant soft-tissue loss (recession) and stated that if the vertical distance in the midfacial region from the soft tissues to the osseous crest was less than 3mm, one could expect less than 1mm of soft-tissue recession after extraction and immediate implant placement. He also stated that distances of up to 4mm from the interproximal bone height to the interproximal contact areas presented less risk of decreased soft-tissue volume and a gingival black triangle. He noted that these measurements should be based on the adjacent teeth, not the missing tooth.

Nisapakultorn et al reported on the results of a clinical study in which they identified factors affecting soft-tissue levels around anterior maxillary single-tooth implants. They followed 40 single-tooth implants in anterior maxillae, 75% of which replaced maxillary central incisors. Postoperatively, the facial mucosal margins were 0.5±0.9mm more apical than those of the contralateral natural teeth. Half or more of papillae were filled in 89% of the cases. Consistent with Kan et al’s findings, Nisapakultorn et al reported that the midfacial regions were more influenced by biotype than the interproximal areas. Papillae levels around single-tooth anterior maxillary implant restorations appeared to be mainly influenced by the interproximal height of bone of the adjacent teeth.

Clinical Relevance

This article identified some of the factors pertinent to developing optimal anterior aesthetic implant restorations in partially edentulous patients. Treatment guidelines were suggested. However, for greater insight into anatomy, surgical protocols, and implant loading protocols, readers are urged to review current textbooks and literature.

References


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† The contributing clinician has a financial relationship with BIOMET 3i LLC resulting from speaking engagements, consulting engagements, and other retained services.
Replacement of a hopeless maxillary central incisor with immediate implant placement and provisional restoration

Pär-Olov Östman, DDS, PhD†

The 82-year-old female patient presented to the clinic with a maxillary right central incisor that was failing due to fracture of the tooth root. Clinical and radiographic examination revealed adequate bone volume to accommodate an implant. The treatment plan included immediate provisional restoration of the implant if adequate primary stability could be obtained. This was accepted by the patient, and the treatment was performed as follows:

Fig. 1
Using a periotome and without raising a soft-tissue flap, the hopeless tooth was carefully extracted.

Fig. 2
Following preparation of the osteotomy, a 5mm diameter x 4.1mm platform x 15mm long 3i T3® Tapered Implant with DCD® was placed.

Fig. 3
A 4.1mm platform PreFormance® Post was placed into the implant and modified intraorally for fabrication of an immediate cement-retained provisional restoration.

Fig. 4
The gap between the implant and the facial bone plate was grafted with Endobon® Xenograft Granules, and the original crown was fitted to the modified PreFormance Post.

Fig. 5
Three months later, excellent soft-tissue healing was evident, and fabrication of the definitive restoration began.

Fig. 6
A BellaTek® Encode® Healing Abutment was placed into the implant to be scanned for fabrication of a BellaTek Definitive Abutment.
The scan data was sent to the BellaTek Production Center for design of the definitive abutment. The virtual abutment design file was sent to 3M Lava for fabrication of a digitally printed SLA model.

The scan of the healing abutment was viewed in the 3M Lava software.

The digitally printed SLA model with the abutment replica was returned to the dental laboratory to fabricate the definitive crown.

The definitive BellaTek Abutment was milled in titanium and nitride-coated at the BellaTek Production Center.

The definitive zirconia crown was tried on the BellaTek Abutment to confirm the fit.

The patient received the definitive abutment and crown. A periapical radiograph taken at the one-year follow-up appointment is shown (inset).

Professor Östman received his dental degree from the University of Umeå, Sweden. He received his PhD degree in the department of Biomaterials, Institute for Surgical Sciences, Sahlgrenska Academy, Gothenborg University, Gothenborg, Sweden. He is a Visiting Professor at the Department of Periodontology and Oral Implantology, Dental School University Hospital Faculty of Medicine and Health Sciences University of Ghent, Belgium and head of the “Team Holmgatan” private practice clinic in Falun, Sweden.

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