

Objective Criteria: Guiding and Evaluating Dental Implant Esthetics



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The evolution of dental implant therapies is fully apparent. From the introductory concepts of tissue-integrated prostheses with remarkable functional advantages, innovations have resulted in dental implant solutions spanning the spectrum of dental needs. Current discussions concerning the relative merit of an implant versus a 3-unit fixed partial denture fully illustrate the possibility that single implants represent a bona fide choice for tooth replacement.¹ Interestingly, when delving into the detailed comparisons between the outcomes of single-tooth implant versus fixed partial dentures or the intentional replacement of a failing tooth with an implant instead of restoration involving root canal therapy, little emphasis has been placed on the relative esthetic merits of one or another therapeutic approach to tooth replacement therapy.² An ideal prosthesis should fully recapitulate or enhance the esthetic features of the tooth or teeth it replaces. Although it is clearly beyond the scope of this article to compare the various methods of esthetic tooth replacement, there is, perhaps, sufficient space to share some insights regarding an objective approach to planning, executing and evaluating the esthetic merit of single-tooth implant restorations.

Therapeutic success for dental implants has largely been described in terms of implant survival. Anterior single-tooth implant survival is high.³ Further documentation provides implant success criteria, defined by the reporting of marginal bone level data.⁴ Occasionally, prosthetic or restorative outcomes have been reported. Here, marginally less favorable data are reported for abutment complications of loosening or screw fracture.³ Less often, biologic data concerning the peri-implant mucosal responses are provided. A biologic width develops around implant crowns, and the associated peri-implant connective tissue inflammatory cell infiltrate reacts to plaque accumulation.⁵

The incidence of peri-implantitis and its effect on implant esthetics may not be fully appreciated. Recently, two esthetic scoring systems have been described.^{6,7} These or possibly other esthetic evaluations have not been widely deployed. Although Chang and colleagues⁸ examined patient-based outcomes for anterior single-tooth implants, there remain many unanswered questions regarding the esthetic requirements and related patient satisfaction concerning anterior single-tooth implants. In 2008, esthetic concerns dominated the discourse surrounding dental implants. An objective approach to planning, executing and evaluating therapy is warranted.

Meeting the goal of providing a single-tooth implant crown that equals or exceeds the esthetic value of the tooth it replaces requires identifying and addressing easily recognized anatomic constraints. The hypothesis underscoring an objective approach to single-tooth dental implant esthetics is that the majority of unresolved esthetic problems are because of the discrepancies of implant crown dimension and orientation. Most often, these reflect improper clinical management of peri-implant and peri-coronal soft tissue architecture.⁹ The application of time-proven and well-documented objective criteria for dental esthetics to the anterior single-tooth implant scenario can guide planning and ensure execution of implant placement, abutment design and crown formation to achieve the highest and most reproducible esthetic goals of the clinician and patient. The aim of this report is to describe how objective criteria can guide planning and execution of implant therapy and, more importantly, how a single aspect of dental implant planning and placement can negatively impact half of these objective criteria and lead to unacceptable implant-supported restorations.

Objective Criteria for Dental Esthetics and the Implant Scenario

In a classic (now out of print) textbook titled “Esthetic Guidelines for Restorative Dentistry,”¹⁰ Dr. Urs Belser describes the objective criteria for dental esthetics. More recently, an updated list and illustration of these criteria were published as a chapter in the textbook “Bonded Porcelain Restorations in the Anterior Dentition.”¹¹ These criteria (*Table 1*), together with the additional significance of identifying the midline and plane of occlusion as a prerequisite for ideal anterior dental esthetics, can provide an indelible guidance system for dental esthetics. In the process of evaluating single-tooth dental implant restorations in prospective and retrospective studies,¹¹⁻¹⁴ it became apparent that these criteria were equally valid to the dental implant restoration. The form of the dental implant-supported tooth requires careful consideration of these objective criteria (*Fig. 1*).

Dental implant placement is neither fully intuited from the anatomy of the residual alveolar ridge nor can it be divined from the existing volume of bone. Desired tooth position dictates implant placement and informs the clinician

TABLE 1 — Objective Criteria for Dental Esthetics

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|--------------------------------|--|
| ■ Gingival health | ■ Tooth characterization |
| ■ Balance of gingival levels | ■ Surface texture |
| ■ Gingival zenith | ■ Color |
| ■ Interdental closure | ■ Incisal edge configuration |
| ■ Interdental contact location | ■ Lower lip line |
| ■ Tooth axis | ■ Smile symmetry |
| ■ Basic features of tooth form | ■ Midline and occlusal plane orientation |
| ■ Relative tooth dimensions | |



Figure 1: Tooth form is objectively defined. The objective criteria for dental esthetics (*Table 1*) help guide decisions concerning ideal tooth form. The clinical photo of this implant crown replacing central incisor #8 reveals the significance of the many soft tissue items present as criteria defining dental esthetics. Note that much of the crown form is defined by the peri-implant mucosa. The lack of symmetry between the central incisors is due to the incorrect depth of implant placement and the 1 mm apical location of the gingival zenith. The incorrect soft tissue contour is represented by a more oval or triangular tooth form and a longer clinical crown when compared with the left central incisor. The more mesial location of the zenith has been compensated by the enhancement of the line angles and tooth character to correct the appearance of the tooth's long axis. The loss of attachment at tooth #7 results in the absence of gingival closure and cannot be accommodated by modifications of the implant procedure or crown #8. These objective limitations reduce the overall esthetic value of this tooth display.

regarding potential requirements for tissue augmentation. In considering the role of the objective criteria in planning for dental implant placement and recognizing that the depth of implant placement can dramatically affect one-half of these criteria, a potential objective strategy to esthetic planning for dental implant placement emerges. That strategy requires evaluation of the edentulous alveolar ridge and adjacent teeth in the context of the objective criteria for dental esthetics. Simply stated, dental implant placement can be guided by the location of the gingival zenith.

The Gingival Zenith as a Guide for Dental Implant Placement

The gingival zenith represents the most apical part of the clinical crown. It also represents both the faciolingual and the mesiodistal location of the crown in relationship to the edentulous ridge. As such, it has a remarkable influence on the morphology of the planned restoration. The gingival zenith affects other objective criteria, including the balance of gingival levels (too inferior or superior), the tooth axis (too distal or mesial), the tooth dimension (too inferior or superior), and the tooth form (triangular becomes ovoid if too inferior). Without the control of the gingival zenith, the clinician's ability to define dental implant esthetics is vastly diminished (*Fig. 2*).



Figure 2: In the left and right views, the retained "c" and "f" teeth reflect the absence of permanent cuspid teeth. The retained deciduous teeth have aided in the preservation of alveolar bone, but the location of the gingival contours are not correct and are unattractive. Using the present bone and gingival locations to guide implant placement would result in short clinical crowns. Redefining the gingival zenith of the permanent cuspid teeth is required.

Dental Implant Control at the Zenith

At least four factors affect the gingival zenith. First is the relative location of the tissues to the planned gingival zenith. Second is the depth of the dental implant placement. Third is the response of the buccal bone and mucosa to the implant procedure and components. Fourth is the prosthodontic management of the gingival zenith architecture.

The Relative Locations of Tissues and the Planned Gingival Zenith

Ideally, the planned gingival zenith is symmetric with the contralateral tooth and harmonious with the gingival levels of adjacent teeth. Unfortunately, most residual alveolar ridges are significantly resorbed.¹⁵ Important objective classification¹⁶ is useful and a Diagnostic Wax-Up permits the exact determination of the extent of resorption and permits planning to the key esthetic parameters. Interproximal tissue contours (papillae) appear to be supported by adjacent teeth connective tissue contacts, but peri-implant facial tissue contours are dependent on facial bone and co-dependent soft tissue morphology.

Controlling the Depth of Implant Placement

Decisions concerning the depth of implant placement should be based on the biologic understanding of the tissue responses to the implanted device. Assuming a steady state peri-implant bone level, it is well known that a biologic width forms at the dental implant¹⁷ and that the buccal dimension of the biologic width formed at an abutment is approximately 3 mm.¹⁸ The ideal depth of the implant placement is suggested to be 3 mm apical to the planned gingival zenith. The implant/abutment interface should also reside 2 mm palatal to the zenith to ensure adequate thickness of bone and mucosa to support tissue form.¹⁹ This “3:2 rule” further suggests to the clinician when bone grafting or soft tissue augmentation should be performed. If bone is not present at approximately this position from the gingival zenith, bone grafting procedures should be considered in preparation for ideal esthetics (Fig. 3).

Without apology for the following circular logic, controlling the depth of placement is achieved by defining the gingival zenith. Managing the gingival zenith at the time of implant placement sets the stage for ideal anterior single-tooth esthetics. Whether William’s theory of tooth form has merit,²⁰ the characterization of teeth as square, ovoid or triangular is based on the peri-coronal architecture. An often unrecognized truth about dental implant esthetics is that tooth form is largely defined by the peri-implant mucosal architecture.



Figure 3: The location of the gingival zenith should be symmetrical with the contralateral tooth and in harmony with the adjacent teeth. As shown in this illustration, the gingival zenith should be located approximately 3 mm from the implant/abutment interface. This permits a subgingival crown margin at the facial aspect of the implant and provides at least 2.5 mm for the development of the biologic width in a supercrestal position. Placement of the implant/abutment interface in a deeper location will result in loss of bone and facial peri-implant mucosal recession.

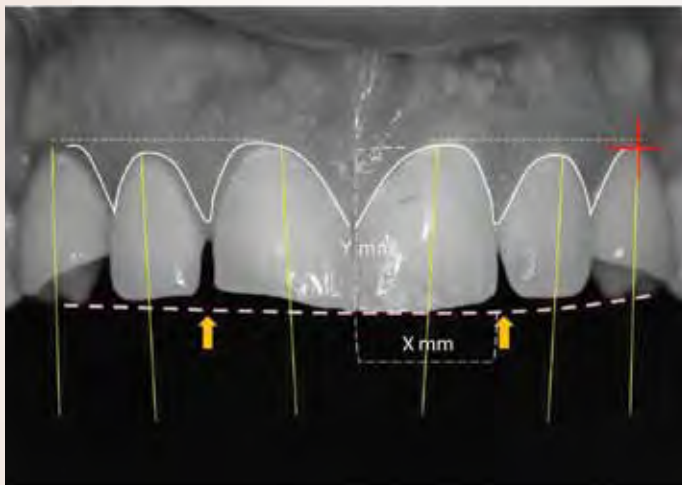


Figure 4: A simple photograph (representing the situation illustrated in Fig. 2) can be used to objectively evaluate the clinical situation to make a complete esthetic diagnosis. Note that the mirror image of the right and left gingival contours do not match. Note also that the orthodontist has provided good spacing for the central and lateral incisors; it is clear that relative to tooth #10, tooth #7 is distal in its location. The gingival zenith on tooth #11 has been marked to indicate how its position guides overall esthetic value of the implant restoration, presently represented by provisional crowns without occlusion.

Controlling Peri-Implant Mucosal Architecture

A reproducible procedure should be imposed onto the artistic philosophy of each clinical exercise. For the single-tooth dental implant, this process begins with an esthetic diagnosis. The diagnosis is nothing more than the assessment of the objective criteria as displayed by the preoperative condition of the patient. Suggested is the use of clinical digital photographs upon which simple evaluations can be superimposed (Fig. 4).

Perhaps the most prognostic indicator of eventual esthetic success through symmetry is gained by evaluation of the connective tissue attachment at the adjacent teeth. Careful assessment using a periodontal probe and diagnostic periapical radiograph are needed. Loss of attachment of greater than 1 mm is clinically discernible and difficult to regenerate. This step is essential because interproximal peri-implant mucosal contours (papillae) are



Figure 5: Study casts of the interim situation and the diagnostically waxed cast. The location of the gingival zenith is directed by the process of diagnostic waxing. This is confirmed by the evaluation of the intraoperative study cast.

greatly dependent on adjacent tooth contours. Together with study casts indicating the extent of alveolar ridge resorption, a thorough prognosis and treatment plan can be provided to the patient.

For the situation of the single anterior missing tooth, it is not possible to fully appreciate these criteria unless a fully contoured crown is waxed in the edentulous space (*Fig. 5*). Following the diagnostic waxing, it is possible to understand the relationship between the proposed gingival zenith location and the existing mucosa. The relationship of the gingival zenith to the underlying bone can only be determined by bone sounding with a diagnostic template in place or, preferably, by use of volumetric imaging (e.g., Cone Beam Computed Tomography) with a radiopaque image of the gingival zenith in place (*Fig. 6*). This assessment is critical. Without underlying bone to support the buccal contour in full dimension, the esthetic volume of the edentulous space ultimately will be deficient (*Fig. 7*). Based on the location of the planned gingival zenith, therefore, decisions regarding the need for bone augmentation, socket preservation and/or soft tissue augmentation procedures can be prudently accessed.

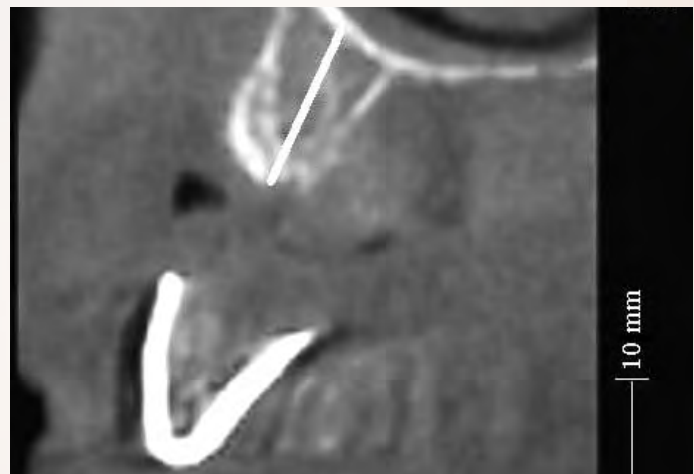
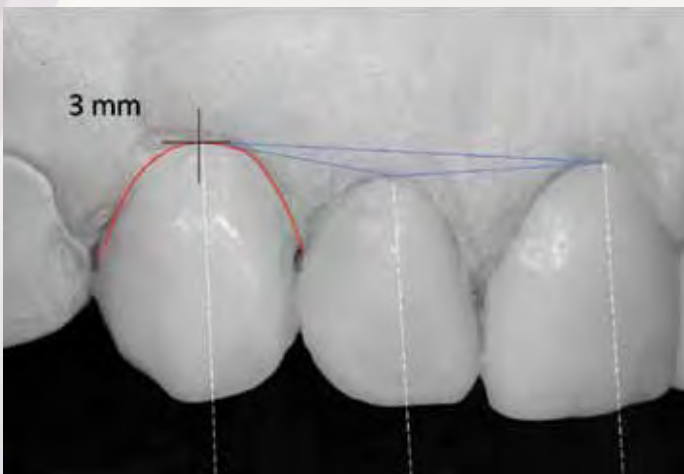


Figure 6: On the left, detailed evaluation of the diagnostically waxed cast shows that the concepts revealed by the objective esthetic evaluation have been translated to the cast. This includes the harmonious arrangement of the gingival zenith and the proper location of the cuspid zenith in the buccolingual as well as the apicoincisal direction. Bone should be present 3 mm apical to the gingival zenith. At right, an unrelated Cone Beam Computed Tomography image of a canine site exemplifies the examination of the required gingival zenith/bone relationship. In this example, insufficient bone for an esthetic restoration exists. The planned restoration's zenith is 8 mm from the alveolar crest. The resulting crown would be approximately 14 to 15 mm in length (versus the average of 10 to 11 mm). Bone augmentation would be indicated.



Figure 7: (A) Intervening veneer preparations for teeth #7-10 were performed in the enamel only. The provisional crowns are removed and impression copings are placed for fixture-level impressions of the Astra Tech dental implants. (B) ZirDesign™ abutment delivery in the well-formed residual alveolar mucosa. The provisional crown should aid in the creation of the gingival contours. The form of the provisional crown should reflect both the clinical crown marginal contours as well as provide ideal submucosal transition contour. In most cases, the interproximal surfaces of the abutment and crown should be concave or flat, whereas the buccal contours are slightly convex in support of the buccal architecture. The interproximal contours must accommodate sufficient interproximal tissue mass to support contours. (C) Provisional crowns reflect the contours of the diagnostic waxing and have been used to direct soft tissue changes at the implants as well as the mesial aspects of teeth #7 and #9.

Prosthodontic Management of Peri-Implant Mucosal Architecture

With an implant positioned properly in the alveolus, the control of peri-implant tissues is enhanced morphologically by enforcing the remodeling of tissues using properly contoured abutments and provisional crowns (Table 2). To ensure proper healing and to limit inflammation, properly polished abutments of titanium or zirconia should be sculpted to support the soft tissue form, and thus, the cervical contour of the crown. Typically, the abutment will possess concave features, with the possible exception being a convexity of the buccal surface. This is particularly important in developing the contours of any provisional restoration for a dental implant. Morphologic refinement is established using the provisional crown and, again, the submucosal contours should be refined to be more root-like (concave interproximally) to support ideal tissue form. No particulate materials should be introduced into the sulcus, and all debris should be

TABLE 2 — Factors Controlling Buccal Peri-Implant Tissues

- Initial presentation (Seibert classification)
- Implant position capability (relative to planned gingival zenith)
- Bone formation and resorption at the implant
- Peri-implant mucosa integration
- Character of the implant abutment interface
- Inflammation
- Local factors (plaque, etc.)
- Patient factors (biotype)
- Abutment form
- Submucosal contour of the provisional crown
- Bone modeling/remodeling
- Potential adjacent tooth eruption



Figure 8: (A) Facial view of final restorations on implants #6 and #11, and teeth #7-10. All-ceramic crowns were bonded to ZirDesign™ implant abutments and veneers were bonded to #7-10. The photograph was made three months after delivery of the definitive prostheses. (B) One-year evaluation of the restoration/tissue relationships of #6-8 and (C) #9-11. The form and color of the peri-implant mucosa is in part due to the choice of the zirconia abutments and modification of the tissues during the immediate provisionalization period. The thick biotype contributes to the predictability of tissue responses illustrated here. The restorations were produced by Lee Culp, CDT.

carefully washed from the implant and sulcus prior to the delivery of the abutment and crown. The provisional crown should be highly polished, well adapted to the abutment margin and free of extruded cement (*Fig. 7*).

Assessment at the Provisional Phase of Implant Restoration

Excellent esthetics frequently involves iterative processes. For implant crowns, attempts to provide highly esthetic crowns to properly contoured peri-implant mucosa directly from a fixture-level impression is not likely to achieve great expectations. It is important to provisionalize implants with provisional or definitive abutments and achieve the planned tissue architecture described earlier. After a period of tissue healing (6 to 8 weeks) or adaptation (3 to 4 weeks), objective assessment should be performed. Only after reviewing potential opportunities for refinement should the final impression of the implant or abutment be made. Several suggestions for capturing the form of the peri-implant mucosa include the placement of rigid materials into the sulcus. This is not recommended if the peri-implant tissues display little inflammation and tissue prolapse (*Fig. 8*). Regardless of the method chosen, the sulcus should be carefully examined and debrided after the impression is made. The provisional restoration should be replaced with little or no displacement or disruption of the peri-implant mucosa.

Delivery and Assessment of the Final Prosthesis

The goal of the laboratory procedures includes the preservation and possible directed enhancement of the peri-implant mucosal form created by the clinician, maintenance of the designated incisal edge position and incisal embrasures, and the creation of the designated abutment and crown. The prepared abutment and crown may be delivered to complete the restorative procedure.

With a major goal being to preserve the peri-implant mucosal architecture with the gingival zenith as a reference point, it is important to evaluate possible tissue displacement when a final abutment is placed. Only modest, if any, blanching should be evident using this protocol following a careful provisionalization process. If tissues are displaced apically, it suggests that the abutment is improperly contoured and is most likely convex in form. The abutment can be modified and the tissue contours can be evaluated again. Abutment delivery is, therefore, a critical step in the control of the peri-implant mucosal form.

Finally, the crown can be evaluated in the usual and customary manner. Included is a very useful checklist for this procedure that applies the objective criteria for dental esthetics.^{6,7} It will focus attention beyond the issues of delivering an implant crown, and it reaffirms the maintenance of peri-implant mucosal architecture (*Table 3*).

A Procedural Review

Integration of the concepts discussed earlier indicates that for all anterior implants, there is a set of procedures that can ensure esthetic success (*Table 3*). The process begins with an esthetic diagnosis to reveal the limitations present and to suggest steps to overcome esthetic limitations before initiating implant therapy. The key features to observe include adjacent tooth connective tissue attachments. Further evaluation requires that a diagnostic waxing be performed to suggest the ideal restorative form. The designated gingival zenith can then be used to identify the critical crown-to-bone relationship, today using volumetric radiographic imaging techniques. If the ideal gingival zenith is greater than 3 mm incisal and 2 mm buccal from the existing bone crest, bone augmentation procedures may be considered. The gingival zenith, therefore, becomes the therapeutic reference point. A positive esthetic result is suggested when the adjacent tooth attachment levels are intact and there is adequate bone relative to the reference point. Using a surgical guide, the implant can be accurately positioned to the zenith reference point. At the appropriate time (after immediate placement, one-stage surgery or two-stage surgery), an abutment can be placed to permit the formation of biologic width along the abutment and to begin to properly contour the peri-implant tissues. The provisional crown should be used to direct proper morphologic development of the peri-implant mucosa and control the crown's ultimate form. Finally, the definitive restoration should impart color, translucency, contour and surface texture that embellish or match the adjacent and contralateral anterior teeth.

Conclusion

An objective approach to dental implant therapy is warranted. Recent application of objective criteria suggests that further control of the anterior dental esthetics might be achieved. For example, the level of the peri-implant soft-tissue margin came to lie within 1 or 2 mm of the reference tooth in no more than 64 percent of the implant-supported replacements. The color of the peri-implant soft tissue matched that of the reference tooth in no more than just over one-third of cases.⁶ More recently, Meijndert and colleagues⁹ reported that only 66 percent of single-implant crowns in 99 patients were rated acceptable by a prosthodontist, despite high patient satisfaction.

TABLE 3 — Procedural Control of Peri-Implant Mucosal Architecture

- *Esthetic diagnosis using objective criteria*
- *Determination of the adjacent connective tissue attachment*
- *Diagnostic Wax-Up with emphasis on peri-implant mucosal architecture (evaluation of the residual alveolar ridge)*
- *Assessment of bone-to-prosthesis relationship (CBCT/bone sounding)*
- *Possible bone and/or soft tissue augmentation to support objectively defined crown form*
- *Ideal placement of the implant relative to the planned gingival zenith*
- *Creating the ideal peri-implant mucosal architecture using well-formed provisional crowns and abutments*
- *Selection of abutment and crown materials to support peri-implant mucosal health*
- *Removal of cement from the sulcus*

This may be the result of soft tissue changes. For example, the measured mean apical displacement of facial soft tissue was 0.6 mm one year after crown placement on abutments at flat-to-flat dental implants (Cardaropoli and colleagues).²¹ In contrast, Cooper and colleagues¹³ reported the stability of the facial soft tissue contour at conus design implant/abutment interfaces throughout a three-year period after dental implant placement and provisionalization.

It may be possible to exert clinical control over the facial soft tissue contours that control single-implant esthetics. Recognizing the initial limitations and guiding treatment planning by the use of the objective criteria for dental esthetics are essential to this process. Targeting the clinical and biologic factors affecting these criteria, particularly the buccal tissue contour, may improve single-dental implant esthetics. The influence of component selection is suggested but remains unproven. Nonetheless, the controlling depth of implant placement, managing peri-implant mucosal biology by limiting inflammation, and managing peri-implant mucosal morphology through ideal abutment selection and provisionalization extend the clinical control of single-tooth dental implant esthetics.

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