Prosthetic Design Considerations for Anterior Single-Implant Restorations

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ABSTRACT

The anterior single-implant restoration provides a predictable solution for the partially edentulous patient. The two main approaches in prosthesis design for the single-implant restoration are the screw-retained and cement-retained restorations. Although both approaches have been proven to work from a standpoint of long-term implant stability, other considerations arise when esthetic outcome and ease of fabrication and delivery are discussed. To guarantee a predictable outcome, the dentist should choose a design that offers maximum prosthetic versatility. Combining prosthetic versatility with ease of delivery is often a clinical and laboratory challenge. Prostheses designs that provide the freedom to select a wide variety of restorative materials may be cumbersome to deliver and maintain and vice versa. This article reviews the advantages and shortcomings of each design and provides an alternative prosthesis design that combines the favorable aspects of these two restorations.

CLINICAL SIGNIFICANCE

Screw-retained and cement-retained prostheses are the common designs for single-implant restorations and possess clinical advantages and shortcomings. An alternative and affordable design, that is mainly beneficial when standard stock implants components are used, is presented. It enables the clinician to achieve optimal esthetics in the esthetic zone combined with a simple and time-efficient delivery.

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Restoring missing anterior teeth with dental implants is a routine and well-documented procedure.[1–6] The ability to achieve an indistinguishable restoration is a primary goal in the replacement of such a tooth. Regarding prostheses, achieving this goal also has to include ease of delivery and should balance simple design and clinical management. This requirement may seem uncomplicated, but contemporary designs and ease of clinical management are hard to combine. This article provides an overview of possible designs for the maxillary anterior implant-supported

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restoration for systems that include an implant and abutment complex, and it presents an alternative design for such a restoration.

CLINICAL CONSIDERATIONS

Once a dental implant is surgically placed and integrated, all the following procedures must be adapted to its position. Therefore, the concept of letting the restoration be the guide for surgical placement has gained immediate acceptance.[7] Three factors must be considered in the determination of the implant position: (1) buccolingual and mesiodistal position of the implant platform, (2) implant body angulation, and (3) apical position of the implant head, also known as countersinking. None of these three factors involves just routine positioning. Other factors such as the surgical site and the type of prosthetic design also affect the decision of where to place the actual implant. In general, contemporary approaches view the bony site as an extension of the desired restoration; thus, in cases of hard and soft tissue deficiencies, the implant placement should not be compromised. This is the essence of the "site development" concept.[8]

Buccolingual and Mesiodistal Position of the Fixture's Head

To simplify restorative procedures, the ideal buccolingual-mesiodistal position of the implant platform is at the root area of the tooth it replaces.[9] This center is measured at the level at which the implant head is positioned; that is, if the implant platform is placed in an apical position that is 3 mm apical to the cementoenamel junction of the tooth it is replacing, the proper buccolingual-mesiodistal position is at the center of the tooth root at this level. In the past, hard and soft tissue deficiencies at the labial aspect resulted in implant placement that was lingual to the ideal aforementioned position. Currently, labial deficiencies can be corrected surgically with high success rates and should not be a reason for lingual positioning of the platform.[10–13] The only reason for placing the platform slightly to the lingual aspect is if the clinician's method of choice is a screw-retained prosthesis.[14] However, one has to be careful positioning the implant lingually. Placing the implant too far to the lingual aspect will result in a restoration that has an abrupt buccal emergence profile, which does not facilitate proper oral hygiene. The amount of lingual displacement of the implant head in comparison to the ideal position is primarily dependent on the diameter of the access hole required for the abutment screw. The bigger the screw-access hole, the more lingually the implant is positioned.

Implant Angulation

The implant angulation can be described as the imaginary line through which the screw access traverses the crown. Even when this angle is corrected with an angled abutment, this line still traverses the crown at the original angulation. An implant positioned at the optimal buccolingual-mesiodistal position has an angulation in which the screw traverses the restoration at the incisal edge.[15] This angulation is optimal because the screw is in the center of the restoration in all dimensions, which enables the fabrication of a restoration with a gradual transition contour (also referred to as emergence profile) in all dimensions and that is easy to clean and maintain.

Clinical considerations, such as the presence of a thin buccal cortical plate, may result in an implant that is angulated so that the screw traverses the restoration buccally to the incisal edge. Various manufacturers have designed implant abutments that can compensate up to 25° of the ideal angulation without the need for custom-fabricated abutments.

Implant Countersinking

The apical positioning of the implant platform below the soft tissue is performed to make the implant-abutment attachment invisible. The amount of this countersinking is primarily dependent on the width of the implant platform and the buccolingual-mesiodistal width of the restoration.[16] The implant is countersunk to provide enough length to form a gradual emergence profile from the implant platform to the height of contour of the restoration. Theoretically, the wider the implant, the less it has to be countersunk. However, there is a limit to the implant width that a buccal cortical plate at a given site can accommodate. Even if there is room for a very wide implant, the superficial placement of this wide platform may result in an optical reflection, a "show through," of the implant through the thin bony plate. Once created, such an esthetic deficiency cannot be corrected. Clinical reports seem to indicate that the recommended amount of countersinking of implants replacing maxillary incisors is around 2 to 4 mm.[8,15,16] For maxillary central incisors, 2 to 4 mm of countersinking have been suggested for an implant with an average platform diameter of about 4 mm, and also for a narrower implant platform diameter for restoring maxillary lateral incisors.

PROSTHESIS DESIGN CONCEPTS

Single-implant restorations can be screw or cement retained. Both were introduced in the late 1980s and early 1990s, both are acceptable, and both have unique advantages and disadvantages.

Screw-Retained Restorations

Stephen Lewis and colleagues enabled dentists to restore the partially edentulous patient with dental implants in a simplified manner with the UCLA abutment.[14] This abutment consisted of a castable component that attached to the implant platform, either not engaging the antirotational mechanism in multiple units, or engaging the antirotational mechanism on the implant platform in a single-implant restoration. This novel approach for restoring the partially edentulous patient is one of the building blocks of single-implant restorations. This prosthesis design was advocated for both anterior and posterior implants,[17] but when it is used for anterior implants, it requires an implant angulation that facilitates access to the screw; thus, the implant platform is positioned lingually to the ideal position. The UCLA abutment concept was also innovative in that it enabled the restorative team to overcome unfavorable implant angulation,[18] and it was later extended into cemented and/or segmented designs.[19] Screw-retained restorations allow the clinician to retrieve the restoration, if needed, in a simple manner. However, it is the authors' opinion that the real advantage of the screw-retained restoration is the simple clinical management of the restoration at the delivery appointment. Since the screw-retained restoration is a one-piece prosthesis, it is simply placed and screwed in.

Despite the aforementioned advantages, this design has some shortcomings. The main one is the lack of versatility in design. In most situations, the restoration is a one-piece porcelain-fused-to-metal restoration. First, the metal framework is waxed and then cast in a gold alloy; second, porcelain is fused to this abutment. Although some ceramic abutments can be used as a foundation to which porcelain is added to form an all-ceramic screw-retained restoration (Ceradapt®, Nobel Biocare AB, Gothenburg, Sweden), they are available only for a very limited number of implants lines.[20–23] There are two potential drawbacks to the use of a gold alloy–based abutment. First, although an acceptable clinical fit with a cast component is an attainable goal,[24] this fit is inferior to that of machined components.[25] Even if the cast component has a prefabricated gold alloy base, the risk for damage due to improper waxing, poor investing, poor casting, or devesting still makes this option secondary to machined components. Second, the potential for an unfavorable mucosal attachment to the gold alloy exists.[26] Thus, although an all-plastic component is very affordable, it should be used only if the following component is not available. Most manufacturers offer a plastic abutment with a gold alloy base. In comparison to cast-mating surfaces of the plastic abutment, the gold alloy base offers a precise machined fit. The use of such an abutment is a much safer choice and justifies the cost difference between the two. However, even the premachined gold alloy base is not better than completely machined components. Third, there is the potential for a lack of proper mucosal attachment in comparison to titanium-based and ceramic-based abutments.[26] Although these concerns have not been verified in a human clinical study, one should consider them when selecting an abutment material.

In summary, the advantages that the screw-retained restoration offers are ease of delivery and retrievability. These advantages are offset by the lack of prosthetic versatility in design, the manual labor and precision required to fabricate the abutment, and the potential for poor mucosal attachment.

Cement-Retained Restoration

The cement-retained restoration is a two-piece prosthesis, an abutment and a crown; the angulation of the implant is such that the long axis of the implant is directed at the proposed incisal edge of the restoration.[15] The biggest advantage that the two-piece abutment-crown design offers is clinical versatility. One can select from a variety of abutment and crown materials and mix and match between them to achieve a combination of proven biocompatibility of titanium or ceramic abutment and any crown material that will be suitable to the specific case. This is a big contrast to the screw-retained restoration, which offers the same combination regardless of the case specifications.

Another advantage is that the implant can be positioned ideally without concern for a screw access; thus, the desired emergence profile can be created.

Few concerns are related to this design. If the clinician uses a provisional cement, it can wash out, and the crown can loosen. In some situations, the loss of loose crowns has been reported.[27] Re-cementation of such a restoration is not necessarily a simple task. Within a few minutes of the crown's loosening and its subsequent dislodgment, the peri-implant tissue collapses around the abutment making re-cementation a time-consuming procedure. One possible solution is to use permanent cement, after properly torquing the screw. The downside is that if the abutment screw comes loose after permanent cementation, a complete remake of the restoration is required.

However, it is the authors' opinion that the biggest challenge with a cemented restoration is the complexity in clinical delivery and/or recementation. As mentioned, the desired countersinking of the implant platform is about 2 to 4 mm at the midbuccal area. Because of the scallop of the gingival tissues, this countersinking can be about 5 to 7 mm from the tip of the papilla to the implant platform at the interproximal area of an anterior tooth. Unless the abutment margins closely follow the gingival scallop, maintaining a clean working field during cementation and, even more so, cleaning the cement excess can be extremely challenging. Use of a computer-aided design/computer-aided manufacturing (CAD/CAM) custom-designed titanium abutment (Procera abutment, Nobel Biocare AB; Atlantis abutment, Atlantis Components, Inc., Cambridge, MA, USA) or custom-designed CAD/CAM ceramic abutment (Procera abutment) overcomes this challenge since such an abutment can be designed to follow precisely the gingival scallop. Such abutments should be considered as treatment options in patients with highly scalloped tissues.

In summary, the greatest advantage of the cement-retained restoration, using a titanium or ceramic abutment, is prosthetic versatility and the proven biocompatibility of the abutment.[26] However, clinical management of the restoration at the delivery and in-crown dislodgment are the biggest challenges.

Alternative Design

To create a successful restoration, one that is a hybrid of both of the screw- and cement-retained designs, one must avoid the disadvantages of each. One disadvantage of the screw-retained restoration is the lingual placement of the implant platform. The placement must provide enough room to create a screw–access hole in the restoration. This hole is as large as the inner diameter of the abutment. Regardless of the system used, the abutment screw–mating surfaces that engage the screwdriver occupy only part of the overall screw head (Figure 1). If the hole in the crown can be made small enough to allow the engagement of only the abutment screw–mating surfaces, then the hole will be small

Figure 1. The mating surfaces of the abutment screw occupy only part of the overall diameter of the screw head.

enough not to necessitate any offset in the implant position. Whereas some implant screwdrivers have a thin shank, others are designed with a wide shank that fills most of the inner diameter of the abutment (Figure 2). For the alternative design, the wide shank of the screwdriver is uniformly milled to the diameter of its tip that engages the abutment screw (Figures 3–5).

This alternative design includes a two-piece restoration, as with the cement-retained restoration, but with a hole at the crown. The size of the hole and its location are of extreme significance. If the hole in the crown is small enough, the implant can be positioned in almost an ideal position, thus avoiding unfavorable ridge-lap formation. The size of the access hole in the crown must be just big enough to enable the screwdriver to engage the mating surfaces of the abutment screw, but smaller in diameter than that of the screw head.

With this design, the restorative team can fabricate an abutment and crown of different materials to create the best esthetics for a case. After the function and the esthetics of this restoration are verified, the crown is cemented to the abutment extraorally with permanent cement. Since the hole provides access only to the mating surfaces of the abutment screw but is smaller in diameter than the head of the screw, the screw must be inserted into the abutment prior to cementation. Following extraoral cementation, the one-piece restoration is screwed to the implant using the small screw access in the crown with the specially milled screwdriver shank. The clinical details of managing the restoration are described in the following case presentation.

Figure 2. Some screwdrivers have a shank that is close to the inner diameter of the abutment and is much wider than the mating surfaces of the abutment screw.

CASE PRESENTATION

A 45-year-old patient was referred to the authors' practice with a root canal treatment on a maxillary central incisor and extensive root resorption (Figure 6), probably due to old trauma to the tooth. Although no mobility was present, the tooth was splinted to the adjacent teeth by the referring dentist because of the high risk of coronal fracture (Figure 7). The tooth could not be restored and was extracted. Owing to root anky-

Figure 3. The shanks of the two screwdrivers on the left were milled to the diameter of the mating surfaces on the abutment screw (the two screwdrivers on the right).

Figure 4. A screwdriver in its original diameter will require a large hole in the final crown, and accommodating it will result in an offset position of the implant.

Figure 5. Following the milling, the screwdriver shank can be used to engage the abutment screw through a very small access hole in the crown.

Figure 6. Preoperative radiograph of a resorbed maxillary central incisor.

Figure 7. Preoperative buccal view of the maxillary central incisor.

Figure 8. Buccal view of the extraction site. Note the extensive bony defect.

Figure 9. Buccal view of the provisional restoration fabricated of the extracted tooth.

losis, a segment of bone at the buccal aspect was removed during the extraction. The bony deficiency (Figure 8) necessitated bone grafting, and following the required healing time for the graft material, a tapered implant was placed. Because of the compromised quality and quantity of bone at the implant site, additional grafting material was used, and the implant was covered for proper healing and integration. Six months after the placement, the implant was uncovered, and a provisional restoration, fabricated from the extracted tooth that was fitted over an abutment, was delivered (Figure 9). Following soft tissue maturation and proper site development, a fixture level impression was made. A straight titanium abutment was modified on the soft tissue simulated master cast. Figures 10 and 11 illus-

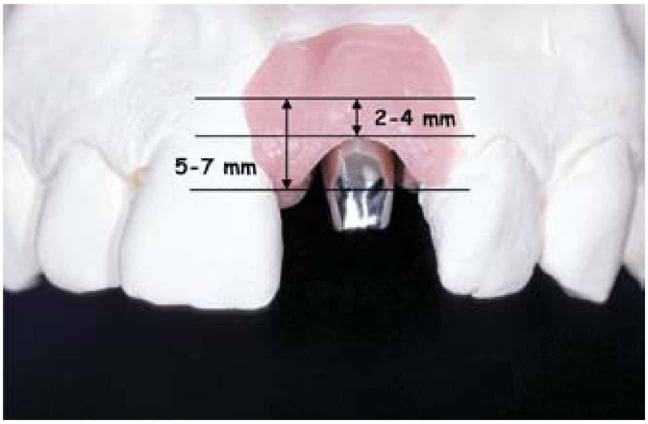

Figure 10. Buccal view of the master cast with prepared titanium abutment. Note distance from tip of the papilla to the implant platform, demonstrating the possible challenge in cement removal from this area.

trate the possible difficulty that can arise in cement removal from the interproximal areas when fabricating a traditional cement-retained restoration using standard components in situations with highly scalloped tissues. The fabricated crown was porcelain fused to metal with a small access hole that was big enough to accommodate the modified shank screwdriver (Figure 12). The completed abutment-and-crown complex was tried in to check esthetics, and the occlusion was adjusted. Following the completion of the try-in, the abutment and crown were removed and the abutment was air abraded to enhance mechanical retention (Figure 13). The abutment was seated on the master cast, and the screw access was protected with a cotton pellet. Next, the crown was cemented to the abutment on the master cast with permanent cement. Following the setting of the cement, the cotton pellet was removed through the access hole in the crown, and the one-piece cemented restoration was delivered as a screw-retained restoration. The screw was torqued according to the manufacturer's recommendation, and the screw access was sealed with a provisional resin restorative material (Fermit, Ivoclar Vivadent, Amherst, NY, USA). A 3-month postoperative

Figure 11. Occlusal view of the master cast with prepared titanium abutment. Note the distance from the papilla tip to the abutment shoulder, a common challenge in cases with highly scalloped tissues.

Figure 12. Palatal view of prepared abutment and porcelain-fused-to-metal restoration. Note that the small access hole in the crown does not require a significant offset in implant angulation.

Figure 13. After try-in and occlusal adjustment, the abutment is air abraded for increased retention. The abutment screw is then inserted into the abutment, and the crown is cemented to the abutment extraorally.

Figure 14. Three-month postoperative buccal view.

Figure 15. Three-year postoperative radiograph.

view is presented in Figure 14, and a 3-year postoperative radiograph is presented in Figure 15.

SUMMARY

Both the cement-retained and screw-retained designs are acceptable treatment modalities for single-implant restorations. However, each of these presents some clinical and laboratory challenges that range from a lack of prosthetic versatility to difficulties in cement removal. This article presents a simple alternative design that does not necessitate the use of custom components and combines the ease of delivery of the screw-retained restoration and the prosthetic versatility of the cement-retained restoration.

DISCLOSURE

The authors have no financial interest in any of the companies whose products are mentioned in this article.

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COMMENTARY

PROSTHETIC DESIGN CONSIDERATIONS FOR ANTERIOR SINGLE-IMPLANT RESTORATIONS

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The authors have outlined an innovative technique modification for a single-tooth implant restoration. This approach is drawn from the understanding that a machined metallic interface of the same metal (titanium) provides for an optimum fit and preload of the abutment screw. With all implant manufacturers making machined titanium abutments for single-tooth use and few manufacturers making ceramic or machined gold abutments, this technique has a practical application. In fact, the first generation of single-tooth abutments produced for the US market was designed for cementation outside the mouth and then intraoral placement and abutment screw retention. The technique outlined in this article is an update of that concept. The current authors do acknowledge that this technique will not be applicable in all instances.

Cemented crowns on implant abutments present clinical challenges, all of which have been outlined nicely in this article. The authors are correct in stating that a cemented technique allows the implant placement to be situated ideally within the confines of the intended tooth replacement when the implant long axis is directed toward the incisal edge or slightly toward the labial aspect. Even an implant with a long axis directed toward the cingulum can be restored with a cemented restoration if the proximal walls are of adequate length. However, of the three possible implant positions, only the latter could be restored with this technique because a lingual screw chamber is a prerequisite. Although this would limit the application of this technique in some practices, it should be placed on the list of available protocols in any practice.

The real advantage of this technique seems to be minimization of the metal abutment collar without concern for the effects of cementation, as these are mitigated by the extraoral approach. This would permit ideal subgingival contours in ceramics and would place less emphasis on an ideal abutment margin preparation relative to the free gingival margin. Ceramic crown contours occasionally need to be modified by the addition of contour. This is not possible with a precontoured metallic abutment.

The modification of the screwdriver will not affect its function or ability to apply torque; therefore, this is not a technique concern. The only possible frustration would be the placement of the screw into the abutment before cementation as this procedure needs to be carefully monitored to prevent cement infiltration beside the screw head. In addition, the seating of the crown-abutment complex should be tried before cementation, especially by inexperienced hands, to evaluate interproximal tooth contacts as a source of interference with complete screw torque.

In summary, this technique should be one of many that complete a repertoire for every restorative dentist performing single-tooth implant restorations.

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