Esthetic and periodontal benefits of zirconia implants

Drs. Paresh Patel, Apolinar Madrigal, and Gregori M. Kurtzman discuss challenges with implants in the esthetic zone

Introduction

Esthetics can be challenging under normal circumstances around natural teeth. When teeth are to be replaced with implants, especially in the esthetic zone, gingival tissue can complicate the desired results. Patients with thin and/or translucent gingival tissue, referred to as "thin tissue biotype," will allow show-through of the implant leading to a darker gingiva overlying that area and decrease the esthetics of the patient's smile (Figure 1). Those patients who have been missing the anterior tooth for a period of time, resulting in resorption of the facial plate even with a thicker gingival tissue, will lead to less bone over the implant on the facial aspect of the ridge. The result, as with thin tissue biotypes, is a darker shadow over the underlying implant that hampers the esthetic result and does not blend with the adjacent tissue over the natural teeth.

Esthetic issues with titanium implants in the esthetic zone

The old axiom — "the bone sets the tone, but the tissue is the issue" — has been voiced in implant dentistry for decades. But what lies in the bone, the implant, has a direct effect on the resulting esthetics and goes hand-in-hand with the bone and soft tissue. Titanium implants, no matter the brand, are a gray shade and may affect esthetics in the esthetic zone of some patients. Studies have reported that under healthy periodontal conditions on natural teeth, the facial thickness of bone covering the anterior roots is 1.73 mm or less.[1] Other studies found a mean thickness of the labial alveolar bone overlying maxillary anterior teeth — between 1 mm to 1.2 mm and between 0.5 mm to 0.8 mm for mandibular anterior teeth — creating the potential for more esthetic issues when replacing missing or to-be extracted in the lower anterior.[2,3] Bone thickness around the maxillary anterior teeth at 4 mm and 6 mm apical to the cementoenamel junction (CEJ) was significantly different in thick and thin gingival biotypes.

Educational aims and objectives

This article aims to discuss challenges with implants in the esthetic zone and possible solutions to these issues.

Expected outcomes

Implant Practice US subscribers can answer the CE questions on page XX or take the quiz online at implantpracticeus.com to earn 2 hours of CE from reading this article. Correctly answering the questions will demonstrate the reader can:

- Realize how some implant materials may appear as a gray shade and affect implant esthetics in patients with certain gingival types.
- Identify how to prevent peri-implantitis issues that could affect the esthetics and long-term survival of implants and the restorations.
- Realize some characteristics of the durability under function of zirconia implants.
- Recognize some connections between implants and the possibility of developing peri-implantitis.
- Observe how patients with certain biotypes can overcome certain esthetic challenges.

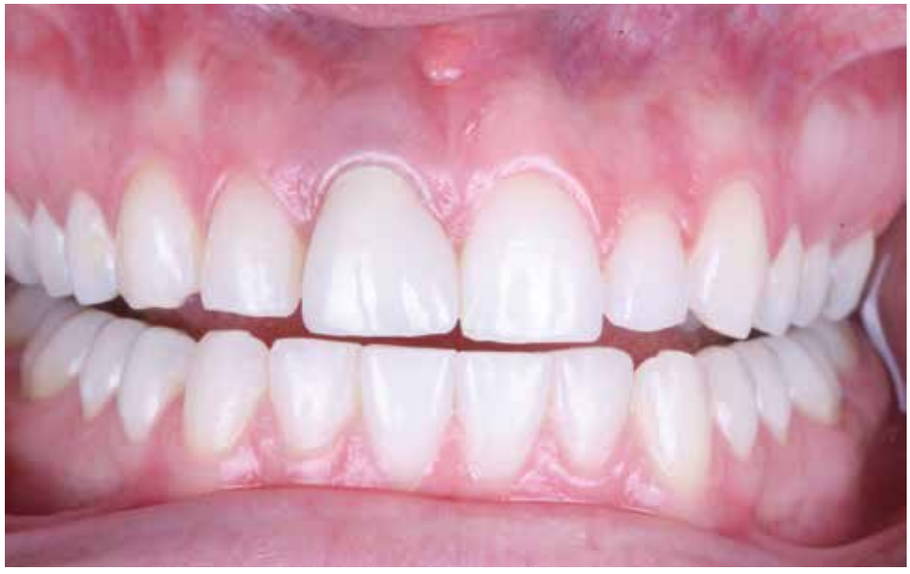

Figure 1: Discoloration of the gingiva at the right central incisor related to titanium implant show-through on a patient with a thin tissue biotype

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Additionally, the thickness of crestal bone was significantly different between the two gingival biotypes with thinner bone in thin gingival biotype patients than in those with thicker gingival biotypes.[4] So, what lies within the bone has an effect based on its color on the esthetics of the overlying gingiva. As titanium has a gray color, a darkening results unless a minimum of 3 mm thickness of gingiva is present. But that does not occur with zirconia implants, which are white in shade and have a neutral effect on the gingival tone.

Attempts have been made to overlay the facial aspect of the ridge with osseous graft material or connective tissue to thicken what covers the implant within the bone to improve esthetics with titanium implants.[5-7] This may work in some patients but has potential complications. Those include a facial that is thicker than adjacent areas affecting the esthetics (eliminate one problem but substitute another for it), increased number of surgical procedures, and the costs involved for treatment. When compared with titanium, zirconia has a favorable esthetic and periodontal response.

These complex therapy concepts are unnecessary with zirconia implants. The peri-implant soft tissue around titanium and zirconia abutments showed color differences when compared to the soft tissue around natural teeth, and the peri-implant soft tissue around zirconia demonstrated a better color match to the soft tissue than titanium.[8] This can be extrapolated to the esthetics of the color of the implant itself. Zirconia implants have been offered as an alternative to titanium implants in these esthetic situations, with the white shade of the implant eliminating any potential for darkening of the gingival tissue and providing a more natural final esthetic result than possible with titanium implants.[9]

Case examples

Case 1: Anterior site with osseous defect following healing prior to implant placement

This 42-year-old female patient presented seeking a replacement for a missing left maxillary central incisor that had been extracted, and the site had completely healed. A depression was noted on the facial of the extraction site-related resorption during healing (Figure 2). Examination noted that some gingival display was visible when the patient smiled that could affect overall esthetics related to the thin tissue biotype and implant shown through that area of the gingiva following implant placement (Figure 3). Treatment options were discussed with the patient that included use of a zirconia implant to eliminate gingival darkening of the thin gingiva or use of a titanium implant that would require additional surgical procedures (connective tissue graft) to thicken the tissue and attempt to mask the darker implant placed at the site. After reviewing her options, the patient chose to pursue the zirconia implant without the need for connective tissue grafting.

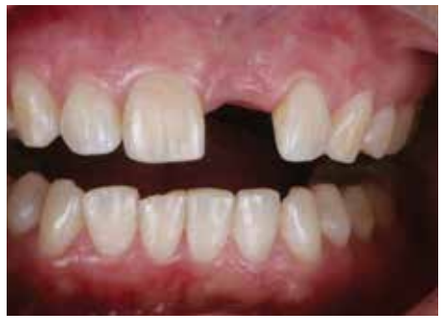

Figure 2: Patient with a thin tissue biotype missing the left central incisor, which has been treatment planned for implant placement

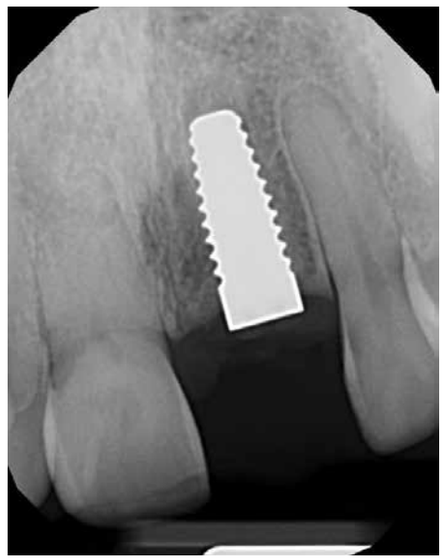

Figure 4: A zirconia two-piece implant (ZERAMEX) has been placed at the missing left central incisor

Figure 7: Final esthetics at the left central incisor with placement of a zirconia implant (ZERAMEX), a zirconia abutment, and ceramic crown with prevention of gingival darkening in a thin tissue biotype, which often is found with titanium implant placement

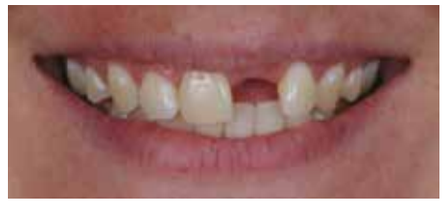

Figure 3: The patient's smile line demonstrates gingival display at the missing left central incisor, which may potentially create an esthetic issue with her thin biotype and placement of a titanium implant

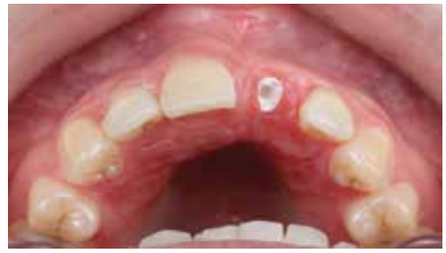

Figure 5: Following a healing period to allow osseointegration of the implant, the implant was uncovered to initiate restoration of the zirconia implant. Note the facial concavity compared to the adjacent natural central incisor resulting from osseous resorption during the period of extraction and implant placement, spanning over a year with the thin tissue biotype over the entire anterior segment of the arch

Figure 6: Zirconia abutment placed into the zirconia implant, noting lack of gingival discoloration related to the thin tissue biotype, which frequently occurs with placement of a titanium implant affecting the overall esthetics

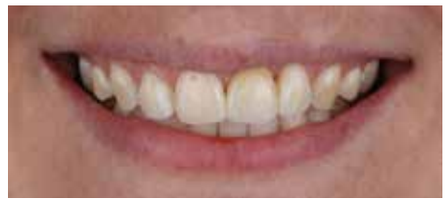

Figure 8: Natural esthetics achieved in a patient with a thin tissue biotype with utilization of a zirconia implant (ZERAMEX) zirconia abutment and ceramic crown

A two-piece zirconia implant (ZERAMEX®, Spreitenbach, Switzerland) was placed under local anesthetic with minimal tissue reflection, a tissue-level healing abutment was placed, and the site closed to allow for healing (Figure 4). Following a 16-week healing period, the healing abutment was removed from the implant to begin the restorative phase. A lack of inflammation was noted in the soft tissue around the implant demonstrating biocompatibility and host response (Figure

5). A closed-tray impression was taken for customization at the lab of the zirconia abutment and the final crown. A customized zirconia abutment was fabricated by the lab and fixated to the implant with a VICARBO® carbon fiber screw (ZERAMEX) (Figure 6). A BruxZir® zirconia ceramic crown (Glidewell Labs, Newport Beach, California) was returned from the lab and luted to the abutment head with Premier® Implant Cement™ (Premier Dental Products, Plymouth Meeting, Pennsylvania) with the resulting treatment providing a natural esthetic without gingival darkening from the underlying implant in this thin biotype patient and without the need for grafting to mask the implant within the bone (Figures 7 and 8).

Case 2: Immediate implant placement

A 37-year-old female patient presented with a nonrestorable right lateral incisor that presented with a vertical root fracture necessitating extraction. Placement of an implant at time of extraction was discussed with the patient and depending on insertion torque placement of an immediate provisional restoration. The patient had a thin tissue biotype and some discoloration related to show-through of the dark root underlying the tissue and thin overlying bone at the site.

The tooth was atraumatically extracted under local anesthetic in a flapless technique (Figure 9). The osteotomy was prepared and a 3.5 mm x 10 mm two-piece zirconia implant (ZERAMEX XT) was placed into the site (Figure 10). A two-piece zirconia implant offers comparable flexibility of titanium implants — the implant can be placed and allowed to heal before initiation of the restorative phase, and immediate loading required in one-piece zirconia implants is avoided. Additionally, the smaller diameter implant used in this case can accommodate narrower ridges and permit greater thickness of bone on the facial then achievable with wider diameter zirconia implants available. An osseous gap was noted crestally between the implant and facial extraction wall, which was filled with Geistlich Bio-Oss® (Geistlich Pharma, Zürich, Switzerland), and a provisional abutment was placed onto the implant and screw access hole filed with a piece of Teflon® tape to prevent provisional resin blockage to the fixation screw (Figures 11 and 12). A screw-retained provisional crown was fabricated intraorally, then removed, and contour was completed to develop the emergence profile extraorally (Figure 13). The screw-retained provisional restoration

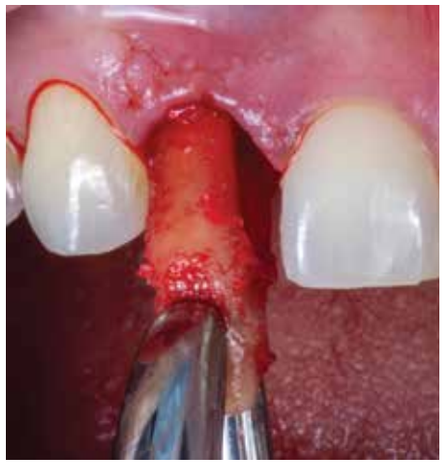

Figure 9: Extraction of a failing right lateral incisor with plan to place immediate implant at the site

Figure 10: A zirconia implant (ZERAMEX) is being inserted into the prepared osteotomy in the immediate extraction socket

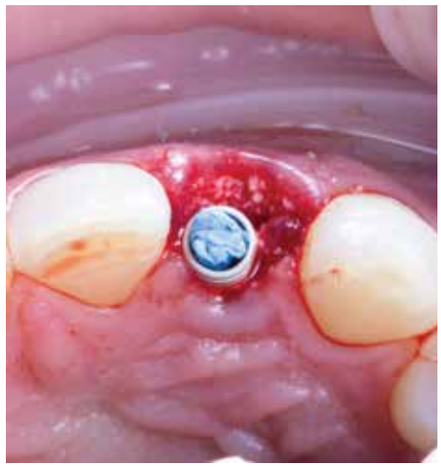

Figure 11: Osseous graft has been placed in the gap between the zirconia implant (ZERAMEX), which has a provisional abutment seated on the implant and facial socket wall

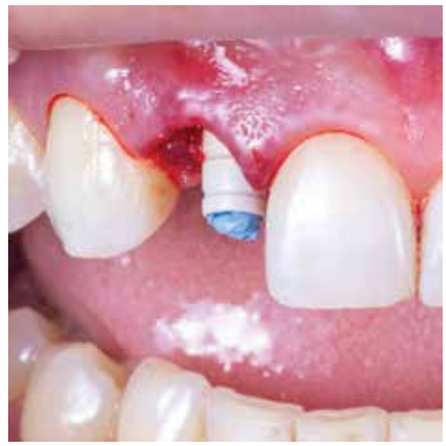

Figure 12: Facial view of the provisional abutment seated on the zirconia implant (ZERAMEX) at the immediate placement into the extraction socket following placement of osseous graft into the facial gap at the osteotomy

Figure 13: Provisional screw-retained crown with proper emergence profile ready to be placed on the immediate implant

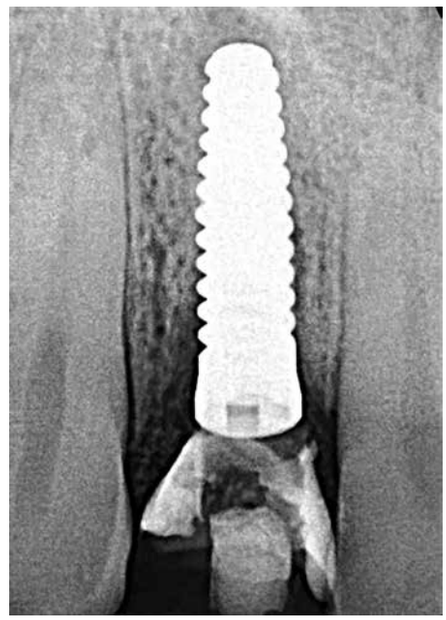

Figure 14: Periapical radiograph of the immediate placed zirconia implant (ZERAMEX) and provisional restoration at the time of surgical placement

Figure 15: Screw-retained provisional crown on the immediate implant at time of surgical placement of the zirconia implant and provisionalization demonstrating inflammation at the gingiva

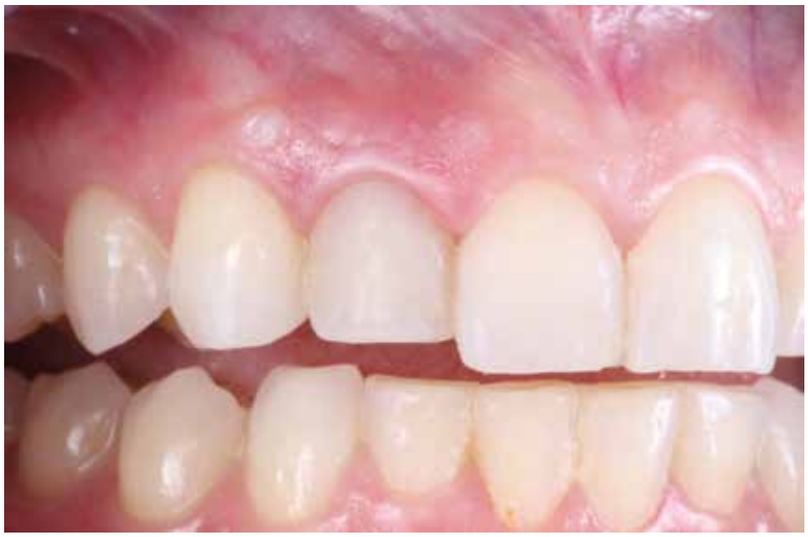

Figure 16: Two-week postoperative check of the immediately placed and provisionalized zirconia implant (ZERAMEX) demonstrating an absence of gingival inflammation, with healthy soft tissue at the site

was inserted, and a radiograph was taken to verify mating of the provisional restoration and implant and to document bone levels at implant placement (Figure 14). Clinically, minimal inflammation was noted on the facial at the immediate placement, and the soft tissue support mimicked the tooth being replaced (Figure 15).

Postoperative examination at 2-weeks post-implant placement and immediate provisionalization demonstrated a facial arch contour in harmony and gingival tone blending with the adjacent sites in this thin-tissue biotype patient (Figure 16). The final ceramic restoration was placed at 4 months post-implant immediate implant insertion demonstrating a natural tone to the gingiva and bone overlying the implant replicating natural esthetics (Figure 17).

Periodontal concerns

Patients frequently require implant placement due to inadequate homecare over time leading to either periodontal disease of the natural tooth or structural breakdown related to caries and repeated restorations leaving insufficient tooth structure to maintain the tooth. Homecare may be improved by patients, but often they fall back into old habits. Providing replacement of the missing teeth with materials are easier to maintain by patients in the case of implants aids in preventing peri-implantitis issues that will affect the esthetics and long-term survival of the implants and the restorations upon them.

Dental implants that are made from titanium or zirconia are available, and both materials have demonstrated successful clinical use over long periods of time with similar biocompatibility and osseointegration.[10] It is well accepted that the bacteria and their products in plaque (oral biofilm) are associated with periodontal inflammation around both natural teeth and dental implants. In the case of implants, this may lead to peri-implantitis with associated bone loss and osseous support of the implant and potential loss of that implant.

This relates to the difference in fiber orientation in the gingival attachment when comparing natural teeth to implants. Natural teeth have those fibers originating in the gingival tissue attached to the tooth's root in a perpendicular direction to the tooth's long axis creating a resistant barrier to bacterial progression apically. However, those fibers are oriented in a parallel direction around implants, providing a less resistant barrier to progression of periodontal issues that may lead to peri-implantitis.[11-13] Peri-implantitis has been closely associated with the bacteria in oral biofilm and the inflammation that ensues when in proximation to the gingival tissues.[14]

Studies have demonstrated that biofilm adhesion on implants fabricated from zirconia are superior to titanium surfaces with respect to initial bacterial adhesion and biofilm formation.[15-17] No inflamed or multinucleated cells were present in studies with zirconia implants, demonstrating their high biocompatible and osteoconductive properties.[18] An increasingly troubling percentage of titanium implants are diagnosed with peri-implantitis following 10 years in function, with a low number lost for primarily reasons other than biofilm-induced infection.[19]

Figure 17: Final ceramic restoration on the ZERAMEX zirconia implant demonstrating a natural tone to the gingiva and bone overlaying the implant replicating natural esthetics

The literature has reported that titanium may undergo corrosion and release of titanium ions. Although titanium is perceived to be "biocompatible" related to the presence of a passive oxide film over the metal surface, deterioration can lead to the release of titanium ions.[20] This surface deterioration can result in peri-implant inflammation. Bacteria found in the oral biofilm creates an acidic environment that leads to corrosion of the implant surface supracrestal to the bone.[21] It has been reported that greater levels of dissolved titanium have been detected in plaque around implants with peri-implantitis compared with healthy implants — thus, indicating an association between titanium dissolution and peri-implantitis.[22-25] Zirconia has not been reported to have acidic breakdown from the bacteria in the biofilm and has no ion release that can contribute to inflammation and eventual onset or peri-implantitis.

Surface modifications of the implant surface during manufacturing has been reported to result in higher hydrophilicity, further increasing the speed of

osseointegration of titanium and titanium-zirconium implants. Surface modifications of zirconia and alumina-toughened zirconia implants also have an influence on osseointegration speed. Zirconia implants with modified surfaces display features of osseointegration similar to those of titanium implants.[26,27]

The bio-inert properties of the zirconia implant aid in rapid proliferation of the gingival fibroblasts leading to formation of a stable mucosal barrier to prevent periodontal issues related to biofilm present gingivally.[28,29] Zirconia implants have been reported to inhibit bacterial adhesion and biofilm formation on its surface. This relates to its hydrophobicity, bio-inert properties, with reduced surface free energy and surface wettability.[30] Various studies have reported a reduction in the number of cocci and rods associated with zirconia implants (increase in levels of *Streptococcus mutans* with less *Streptococcus sanguis*) compared to titanium implants. This enhances perio-integration around zirconia implants, while preventing the development of peri-implant bone resorption and peri-implant soft inflammation associated with peri-implantitis.[31,32]

Modified zirconia implants show a resistance to torque forces (improved stability in bone) similar to that of oxidized implants and a four- to fivefold increase compared with machined zirconia implants. The findings suggest that surface-modified zirconia implants can reach firm stability in bone.[33] Modified zirconia surfaces demonstrate faster osseointegration than that on untreated zirconia implant surfaces.[34] Additionally, bone-implant contact (BIC) and resistance torque (RT) of zirconia implants in most of the studies analyzed when compared with titanium implants did not show statistical differences.[35,36]

Submerged zirconia and titanium implants (two-piece), the implant surface showed an intimate connection to the adjacent bone, with both implant types achieving a BIC of 53%. For the non-submerged zirconia implants (one-piece), some crestal epithelial downgrowth was reported, with a resultant BIC of 48%. Highest relative peri-implant bone-volume density (rBVD) values were reported for submerged zirconia (80%), followed by titanium (74%) and non-submerged zirconia (63%). The results suggest that unloaded zirconia and titanium implants osseointegrate comparably, within the healing period studied.[37-38]

Comparable osseointegration between the two implant materials, and with the availability of two piece implants, zirconia implants are an alternative to traditional titanium implants.

Studies have reported success rates that are comparable between the two implant materials with no difference found in the rate of osseointegration between the different implant materials.[39,40] No statistically significant differences between zirconia and titanium have been reported after a healing period of 4 and 12 weeks. The RT values of both implant types increased significantly from the 8-week to the 12-week healing period.[41] Additionally, zirconia and titanium implants demonstrate a similar soft- and hard-tissue integration capacity providing comparable options from a biointegration and periodontal health standpoint.[42]

The overall implant success rate of zirconia implants after 5 years of follow-up was 95%.[43] This is supported by other more recent studies reporting a survival rate was 98.5% at 3 years in function,[44] and 94.3% at 5 years.[45] Furthermore, a two-piece zirconia implant, ZERAMEX (ZERAMEX, Miami, Florida) exhibited an average success rate of 99.4%. A study indicated an average success rate of ZERAMEX T (96.4%) and of ZERALOCK™ (98.4%) demonstrating comparable success to reported values for titanium implants.[46,47]

The present two-piece zirconia implants show a similar bone integration compared to the titanium implant with similar surface morphology after 4 and 16 weeks of loading.[48,49] This provides the option of a delayed loading approach that presented objections with some clinicians with one-piece zirconia implants. This is not available with one-piece zirconia implants that require immediate loading due to the supracrestal restorative head and presented objections with some clinicians. Additionally, orientation of the restorative head in a one-piece implant may complicate restoration due to the angulation of the head in relation to angle the implant was placed in the maxillary anterior, which itself relates to the "triangle of bone" present to accommodate the implant.

Durability under function

Some practitioners have expressed concern about the durability of zirconia implants under functional loading in comparison to their titanium counterparts. Investigations of one-piece zirconia implants reported modification of the implant head resulted in a decrease in fracture strength. However, within the limits of in vitro investigations, it can be concluded that those zirconia implants will withstand functional loading over an estimated period of 20 years.[50] Nevertheless, even the lowest values of mean fracture strength of these implants were able to withstand average occlusal forces even after an extended interval of loading.[51] Two-piece zirconia implants demonstrate greater fracture resistance than one-piece implants.[52] Two-piece implants also allow the practitioner to delay loading the implants and have custom abutments fabricated should angulation need correcting between the implant axis and prosthetic axis. Additionally, the carbon fiber reinforced fixation screw, the potential weak point compared to a metal fixation screw found that hydrothermal aging and dynamic loading did not result in screw fracture.[53,54] Ensuring a durable connection between the implant and abutment.

Conclusion

Patients who present with thin tissue biotypes can be challenging with implants in the esthetic zone related to dark show-through of the implant. This can also be related to gingival tissue that is thin in consistency or translucent in masking ability of the underlying bone and what it contains. A thin facial plate over the implant even in those patients with adequate tissue thickness may also complicate esthetics. Zirconia implants offer a more esthetic alternative in those clinical situations with the "white" shade of the implant neutralizing any potential show-through and allowing a better blend with the adjacent sites. These implants should be

considered in those patients where placement of a titanium implant can hamper the esthetics related to darkening of the gingiva and bone covering the implant.

Implants fabricated from zirconia demonstrate lower biofilm than titanium implants. Oral biofilm has been intricately linked to periodontal disease around natural teeth as well as implants. Implants, whether fabricated from zirconia or titanium, demonstrate lower oral biofilm adhesion than around natural teeth, allowing the patient with consistent oral homecare to maintain implants of either material long-term. Clinical long-term success and fracture resistance of two-piece zirconia implants has been reported that is comparable under functional loading with implants fabricated of titanium. Comparable osseointegration between the two implant materials, and with the availability of two-piece implants, zirconia implants are an alternative to traditional titanium implants. As zirconia implants do not undergo corrosion and ion release, peri-implantitis is eliminated from that potential periodontal avenue. IP

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