PEEK-based restoration for monotype zirconia implants

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Introduction

For more than 40 years, the most commonly used dental implants have been commercially pure titanium and titanium alloy implants, and these are still considered to be the best and most reliable in the field of implant dentistry.[1]

The current demands in dentistry for components with no metal alloys, along with the rise in reports of allergies and sensitivity of several patients, have resulted in the development and application of new materials. A good example of non-metal implants is zirconia implants, also known as zirconium oxide implants.[2,3] Their biocompatibility and astonishing mechanical properties make them suitable for several situations.

Zirconia implants are considered to be one of the newest and most exciting developments in dental implantology. Multiple studies have shown that zirconia implants induce little to no peri-implant tissue inflammation and allow for high levels of epithelial attachment. Additionally, these implants are more natural-looking, hence, they provide improved aesthetics. Furthermore, they do not have metal components, which makes them ideal for people with metal sensitivities and patients who prefer their implants to be metal-free.

However, zirconia implants lack the flexural strength of metal alloys, and using zirconia or ceramic crowns to restore zirconia implants can potentially lead to complications, such as excessive forces being transmitted to the peri-implant bone or even implant and/or prosthetic failure.

Avoiding underlying bone overload from direct spread of functional forces is important and has thus resulted in the development of materials with the ability to absorb forces. One proposed prosthetic option is the combined utilisation of a composite bonded to a PEEK restoration on zirconia implants not only because of the biocompatibility, but also owing to its mechanical and physical properties.[4,5]

In this clinical report, we propose a solution that could help avoid complications and mitigate the reduced flexural strength of ceramic implants when restored with novel, more elastic prosthetic materials.

Case presentation

A 28-year-old female patient, a non-smoker with no contributing medical history, presented to our practice with a complaint of pain in her right maxillary second premolar. According to her, the pain was intense and the worst when chewing or simply on occlusion. The clinical examination disclosed that there was a periapical

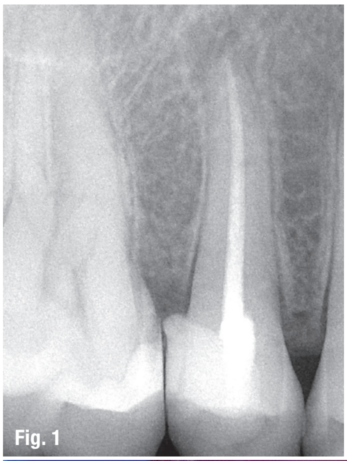


Fig. 1: Pre-op radiograph. **Fig. 2:** Pre-op clinical photograph. **Fig. 3:** Extracted tooth #15.

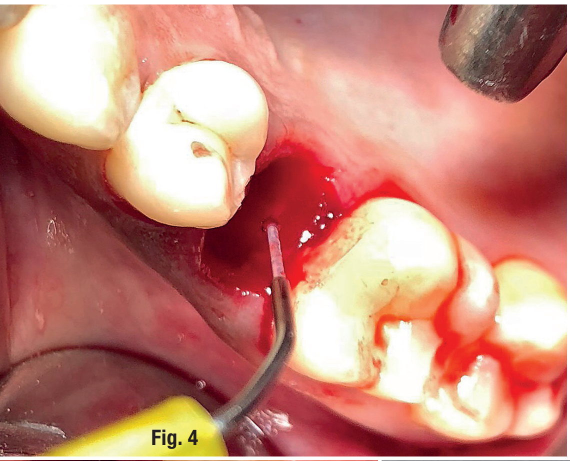
pathology above the endodontically failed tooth #15, which was confirmed through a radiographic examination showing a well-defined radiolucency bound by a thin radiopaque line (Figs. 1 & 2).

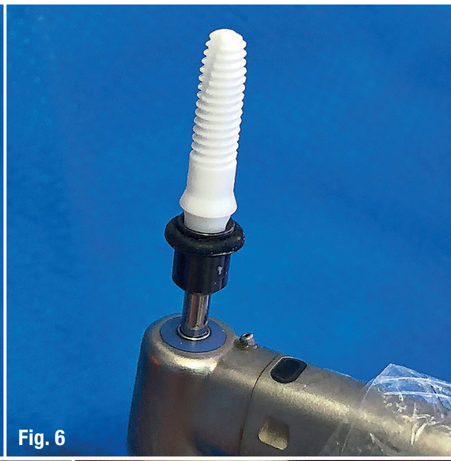
The patient insisted on the removal of the tooth and was apprehensive about metal implants and crowns, and thus requested an option other than a titanium implant. The extraction of tooth #15 followed by the immediate placement of a zirconia implant (ZiBone, COHO Biomedical) was recommended, along with a composite-bonded-to-PEEK restoration. PEEK-based restorations for dental implant prostheses have the ability to dampen occlusal forces, thus dissipating and cushioning occlusal forces transmitted to the implant and bone during function. The patient accepted the proposed treatment and signed the informed consent agreement.

Tooth extraction was performed as atraumatically as possible (Fig. 3). Curettage and in-depth debridement were also completed while preserving soft-tissue integrity around the extraction socket (Fig. 4). In the next step, the osteotomy was performed as indicated by the implant manufacturer and under profuse irrigation. A ZiBone implant of 4.1 mm in diameter and 13.0 mm in length was inserted into the prepared osteotomy at a speed of 700 rpm and a torque of 35 Ncm (Figs. 5–7).

Fifteen days postsurgery, radiographic and clinical evaluation disclosed the soft-tissue appearance was excellent, without signs of inflammation (Figs. 8 & 9). The patient reported no bleeding, absence of pain and minimal swelling at that time.

Four months postoperatively, no adjustments were made to the implant abutment (Fig. 10). Contouring of the soft tissue and exposure of the restorative margins were performed using a diode laser especially suitable for soft tissue (Epic, BIOLASE). A temporary acrylic crown was installed for a period of two weeks to achieve a proper emergence profile and soft-tissue anatomy (Figs. 11 & 12). The final impression was made using a polyether material (Impregum, 3M ESPE) after placement of retraction cords of size #00 (Ultrapak, Ultradent Products). The final restoration was then produced with the use of a PEEK coping and bonded composite overlay





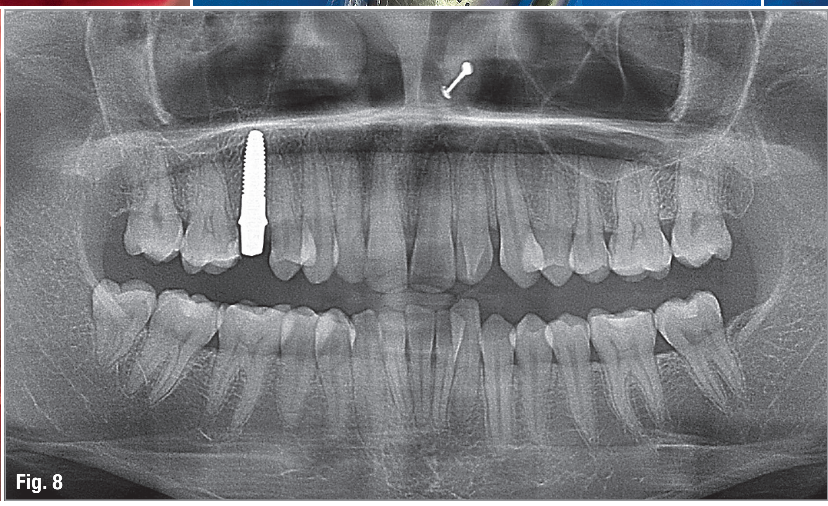
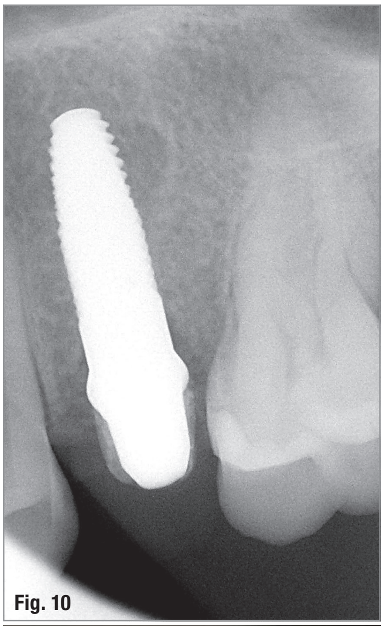


Fig. 4: Curettage performed with laser. **Fig. 5:** ZiBone drilling bur. **Fig. 6:** ZiBone implant before placement. **Fig. 7:** ZiBone implant *in situ*. **Fig. 8:** Dental panoramic tomogram after implant placement. **Fig. 9:** Post-op situation after two weeks.



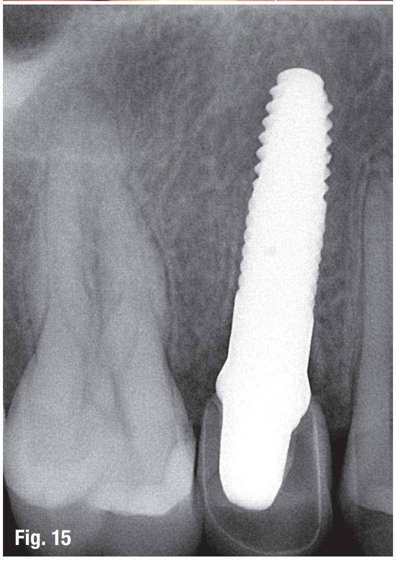


Fig. 10: Four-month post-op radiograph. **Fig. 11:** Temporary acrylic crown *in situ*. **Fig. 12:** Emergence profile. **Fig. 13:** PEEK-based crown with composite veneering. **Fig. 14:** Placement of final crown. **Fig. 15:** Post-op radiograph taken at the one-year follow-up. **Fig. 16:** Clinical situation one year post-op.

(Figs. 13 & 14). A resin-modified glass ionomer cement was used for bonding the crown to the implant.

A radiographic and clinical review were done one year after the first surgery, disclosing a successful procedure based on Albrektsson et al.'s criteria[6], as well as a natural characteristic of the soft tissue surrounding the restoration performed (Figs. 15 & 16).

Discussion

Intraoral factors such as salivary pH, plaque microbiota, diet and fluoride combine to create a harsh environment that poses challenges to metal implants. This is manifested by corrosive attack, which also contributes to metal ion release into the peri-implant tissue and peripheral organs.[7,8]

In recent years, numerous implant manufacturers and investigators have evaluated soft- and hard-tissue behaviour around zirconia implants. Their biocompatibility characteristics, along with their osseointegration being comparable to that of conventional implants, make zirconia implants a better option for dental clinical use.[9–12]

Numerous studies have found that zirconia-based implants present the same healing pattern as titanium-based implants, regarding both the stability of marginal bone and the healing time.[12,13] A recent University of California, Los Angeles, study showed also that osseointegration of the nano-surfaced zirconia-based implants used was higher compared with that of titanium-based products.[14] Other significant factors for consideration include implant–abutment–crown assembly, the restorative material composition and occlusal load transmission by antagonist teeth.[13]

When it comes to the load cushioning capacity of prosthetic elements, using PEEK as prosthetic construction on the implants has improved this recently.[15] PEEK is a thermoplastic high-density polymer with an aromatic linear semi-crystalline construction that has excellent chemical and physical properties regarding elasticity, toughness and hardness. Further, it has a low molecular weight and contains no metal, which makes it an excellent material for biocompatible prostheses. PEEK also has a low Young's modulus of 4 GPa in comparison to other conventional components like titanium with a modulus of 110 GPa or zirconium dioxide with 210 GPa.[16, 17]

Additionally, the bending resistance of metal–ceramic restorations lies between 400 and 600 MPa, in distinction to other composite coatings with a Vickers hardness of around 400 MPa and a 314 MPa bending capacity.[18, 19] Equally, zirconia proves to be three times harder (1,200 HV) and it has a bending resistance of 1,400 MPa. All together, these features prove that using high-rigidity materials results in the direct transmission of masticatory forces to zirconia implants. This probable overload could lead to resorption of bone surrounding the implants, which is referred to as the stress shielding effect and occasionally results in potential implant fracture. There are claims that this connection only exists in cases accompanied by a preceding inflammatory situation of infectious source, wherein bone loss would accelerate.

To prevent going beyond the bone's adaptive limits and to maintain proper mechanical stress stimulation, PEEK components appear to be a workable substitute for gaining a Young's modulus similar to that of cortical bone. This way, bone may be adequately stimulated to allow remodelling instead of resorption. It would focus the load through absorption and distribution. Its load absorption capacity has resulted in its recommendation for people suffering from severe bruxism.[18, 19]

Restricted element study suggests that contact pressure of a maximum level at the titanium implant edge can be expressively reduced with the use of a PEEK-based crown instead of an all-ceramic crown.[20–27] Additionally regarding PEEK, new composite materials or PMMA-based coatings, which integrate ceramic fillings, have been developed, and because of their molecular structure, these new materials have exceptional homogeneity and density. The integrated micro-filling in a polymer matrix increases abrasion resistance while providing optimal elasticity resembling the natural tooth structure.[25, 26] Though these restorations display good colour and shade stability, brightness and texture, they differ considerably from the ceramic coatings, which in contrast have exceptional optical properties, enabling them to accomplish better long-term aesthetics.[27, 28]

Conclusion

Using a PEEK-based restoration on a zirconia implant was found to be a good substitute for an all-ceramic crown. This restoration delivers exceptional elasticity and resembles the natural appearance of tooth structure. The biocompatibility and biostability make PEEK a promising material for tooth replacement. PEEK-based restorations are an effective alternative approach when zirconia implants are to be used because of the Young's modulus and cushioning effect, absorbing occlusal forces and wearing like natural teeth, which in turn could improve and eventually maintain osseointegration.

The clinical case thus suggests that PEEK-based restorations are a restorative option for zirconia implants when there is concern regarding excessive forces being applied and transmitted to the implant and the peri-implant hard tissue. Within the limitations of this clinical evaluation, we endorse the use of zirconia implants restored with a combination of a PMMA coating and PEEK coping. However, further and large-scale investigations are necessary to firmly establish this technique as a reliable and predictable option for restoration of ceramic implants.

Literature

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