

Pilot Clinical and Histologic Evaluations of a Two-Piece Zirconia Implant



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An investigation was conducted to evaluate the clinical and histologic results of bone and soft tissue healing around a two-piece zirconia dental implant in a human model. A healthy female patient requiring tooth replacement with dental implants received a two-piece zirconia implant together with conventional titanium implants to be implemented in a prosthesis. Clinical and radiographic evaluations at 6 months revealed stable osseointegrated zirconia and titanium dental implants. Light microscopy and backscatter scanning electron microscopic analyses confirmed the biocompatibility and achievement of osseointegration, in addition to maintenance of the crestal bone level. The findings suggest that the bone-to-implant contact with a zirconia implant surface is sufficient to provide clinical and histologic evidence of osseointegration. The biopsied two-piece zirconia dental implant with platform switching demonstrated osseointegration occlusal to the implant-abutment junction, eliminating the significance of the microgap. (Int J Periodontics Restorative Dent 2011;31:157–163.)

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Treatment of partially and completely edentulous patients with dental implants has become a valuable and recommended treatment modality in contemporary dentistry. Continuous improvements in dental implant surface topography or the degree of surface roughness through various chemical and physical surface modifications are known to enhance bone healing and integration.¹

Titanium-based dental implants and abutments exhibit excellent biocompatibility and mechanical properties. The potential for compromised esthetic outcomes, such as “grayish” gingival emergence through a thin biotype mucosa, have been noted with the use of titanium dental implants and abutments.² Radiopaque zirconia implants are currently being investigated to overcome the esthetic problems associated with the titanium implant. Excellent biocompatibility and mechanical properties of zirconia have been demonstrated in both preclinical and clinical studies and are attributable to its inherent characteristics, such as high fracture toughness, high bending strength



Fig 1 A hot isostatic postcompaction (HIP) zirconium dioxide ceramic implant with a defined roughened surface (aluminum oxide-blasted).

and hardness, resistance to corrosion and wear, and low thermal conductivity.^{3–19} Zirconia-based dental materials have been accepted widely in dentistry, ranging from their use as substrates in conventional prosthetic restorations to implant restorations.

Human histologic evidence of successfully osseointegrated implants is extremely rare.^{20–24} Most available evidence features fractured implants that are controversial because of the microbial contamination and mechanical failure that could have altered the previous bone-to-implant interface.^{25–27} The retrieval of histologic samples from successfully osseointegrated implants is the only irrefutable confirmatory method to generate valuable knowledge.²⁵ Human histologic data are critical to validate and confirm preclinical results.

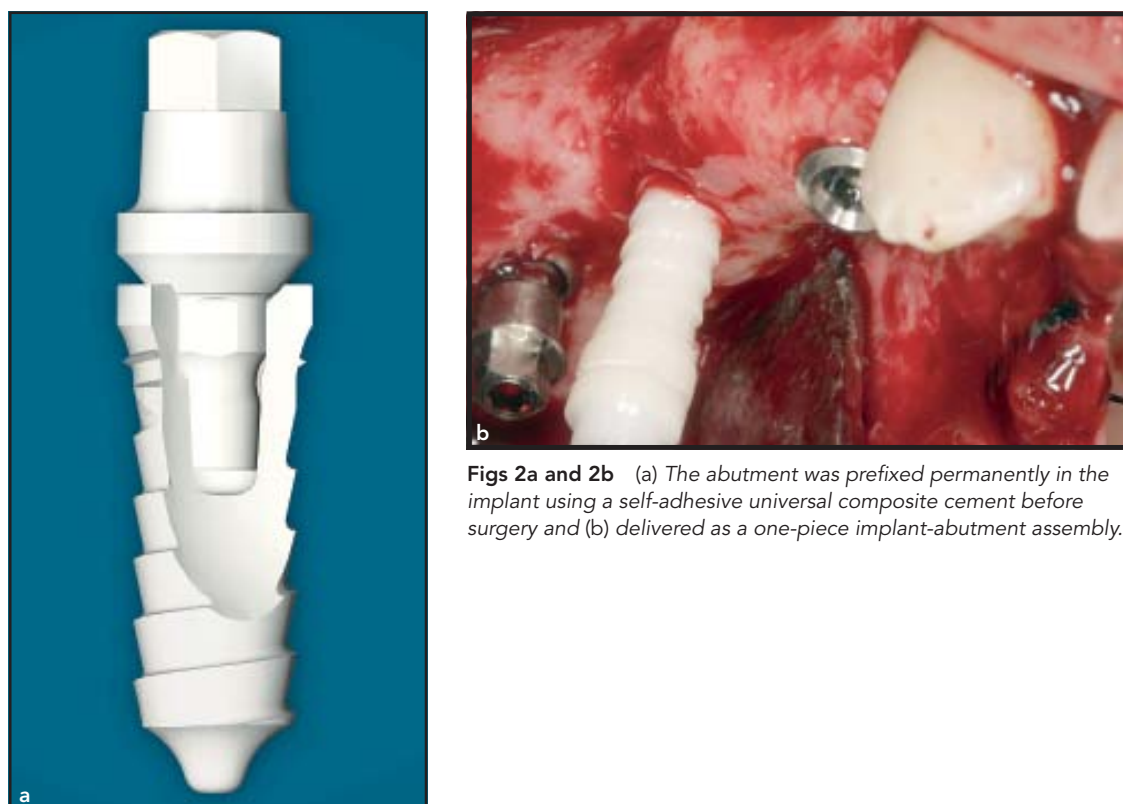
The objective of this study was to investigate the clinical and histologic results of osseointegration and soft tissue attachment of a two-piece zirconia dental implant (ziterion)

(Fig 1). Recent promising preclinical data demonstrating similar bone-to-implant contact for both titanium and zirconia implants with the same surface modifications and roughness present a need for further human analysis.¹⁴ This histologic study was conceived to be the first to evaluate the hard and soft tissue attachment to a zirconia dental implant in the human model.

Method and materials

One healthy female patient requiring tooth replacement with dental implants was recruited for this study. Oral and written explanations of the study, including the risks, benefits, and alternative therapies, were provided. The patient volunteered for the protocol and signed an informed consent form based on the Helsinki Declaration of 1975, as revised in 2000. Preoperative periapical radiographs and a computed tomography (CT) scan were taken prior to initiation of the study.

The implant surgical procedure was performed on an outpatient basis. The edentulous maxilla was anesthetized with local anesthesia (2% xylocaine with 1:100,000 epinephrine). Implant osteotomies were performed, and all implants were placed according to the manufacturer's guidelines (ziterion) at the alveolar crestal level. A total of four titanium and two zirconia implants were placed, with one two-piece implant scheduled for biopsy at 6 months. The two-piece zirconia implant was selected at the request of the manufacturer and delivered as a one-piece implant-abutment assembly, since it was prefixed permanently in the implant using a self-adhesive universal composite cement (RelyX Unicem, 3M ESPE) (Figs 2a and 2b). Appropriate antibiotics, analgesics, and mouthwash were prescribed. Sutures were removed 7 to 10 days postsurgery, and the patient was seen at regular intervals during the 6 months of healing.



Figs 2a and 2b (a) The abutment was prefixed permanently in the implant using a self-adhesive universal composite cement before surgery and (b) delivered as a one-piece implant-abutment assembly.

A postoperative CT scan and periapical radiographs were obtained 6 months after implant placement when the zirconia dental implant was biopsied. Harvesting of the implant was successful without adverse effects, and the biopsied implant was immediately immersed in a fixative solution. The harvested site was repaired with hard and soft tissue grafting.

Specimen preparation and analysis

The specimen was prepared for both light microscopy and backscatter scanning electron microscopy to evaluate osseointegration.

Light Microscopy

The fixed specimen was dehydrated in a graded series of ethanols with agitation and vacuum. The block was infiltrated with Kulzer Technovit 7200 VLC resin (Haraeus Kulzer) and placed into embedding molds. Polymerization was performed under ultraviolet light. The polymerized block was sectioned in the buccolingual direction parallel to the long axis of the implant. The slices were reduced and polished using an Exakt grinding unit to an even thickness of 30 to 40 μm . Sections were stained with toluidine blue/pyronin G and examined using both a Leica MZ16 stereomicroscope and a Leica 6000DRB light microscope (Leica Microsystems).

Backscatter scanning electron microscopy

Following the light microscopic evaluation, specimens were sputter-coated with a 6-nm-thick carbon layer (SCD 050 Sputter Unit, Bal-Tec) and examined in the backscatter modus (Supra 40VP scanning electron microscope, Zeiss).

Results

Clinical and radiographic observations

Both zirconia and titanium implants were placed in the posterior maxilla and achieved clinical osseointegration. There were no signs of implant

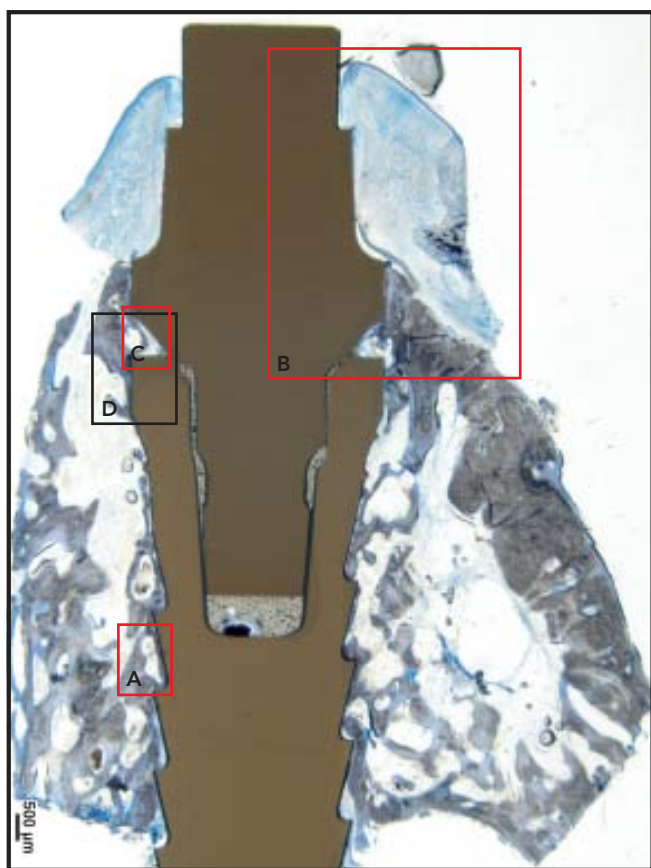


Fig 3 Light microscopy of the specimen revealed histologic evidence of osseointegration, demonstrating its potential as an implant material.

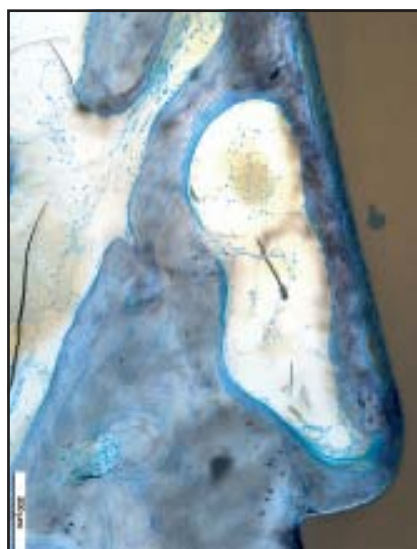


Fig 4 Light microscopy of the specimen demonstrating close bone apposition with the combination of newly formed and native bone (magnified view of highlighted area A).

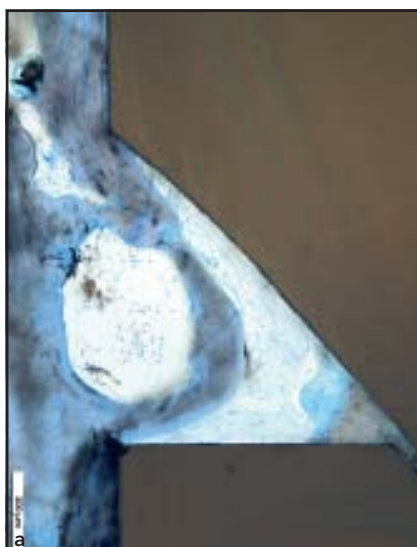
mobility throughout the observation period, and the soft tissues surrounding the implants were pink in color with no clinical signs of inflammation. An esthetic gingival architecture surrounded the zirconia implant without soft tissue recession. The composite cement used to prefix the abutment to the implant did not appear to have any negative effects on the clinical outcome. Radiographic observations (periapical radiograph and CT scan) demonstrated excellent vertical bone height.

Histologic observations

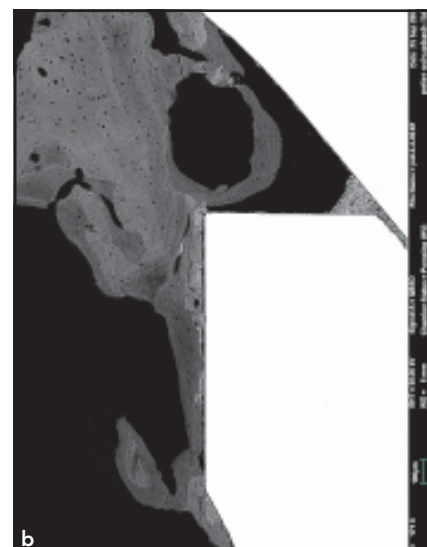
Light microscopy revealed close bone apposition with the combination of newly formed and native bone (Fig 3). There were areas where mineralized bone contacted the implant surface, as well as areas where bone marrow spaces were adjacent to the surface (Fig 4). These findings were confirmed by backscatter scanning electron microscopy images.



Fig 5 The vertical bone level was located coronal to the implant-abutment junction. The soft tissue demonstrated minimal inflammatory cellular infiltration, an indication that the material is biocompatible (magnified view of highlighted area B).



Figs 6a and 6b (a) Light microscopic and (b) backscatter scanning electron microscopy images demonstrated bone healing at and coronal to the microgap of the implant-abutment junction (Fig 6a is a magnified view of highlighted area C; Fig 6b is a magnified view of highlighted area D).



The vertical bone level was located coronal to the implant-abutment junction (Figs 5 and 6). The bone-to-implant contact was sufficient to provide a clinically stable implant, but not as strong as expected.

Discussion

The clinical success of dental implants is measured by the hard and soft tissue relationship to the implant surface. Maintenance of

the crestal bone level is influenced by factors such as surgical trauma, biologic width, microgap, peri-implantitis, occlusal overload, and stability of the abutment-implant interface.²⁸ The implant surface and design have been the subject of many innovations in an effort to preserve the crestal bone level.

Zirconia-based dental materials are of interest because of their inherent mechanical properties and esthetic appearance. There have been a limited number of clinical

investigations using zirconia dental implants.^{15–18} A reduction of the inflammatory infiltrate and bacterial adhesion/colonization in soft tissue has been reported for zirconia when compared to titanium, demonstrating favorable interaction between zirconia and the soft tissues.^{29–31} There is a paucity of clinical data comparing zirconia and titanium dental implants, but a recent systematic review reported that zirconia abutments could maintain an equivalent bone level when compared to titanium, gold, and aluminum oxides.³²

The zirconia implant tested was composed of hot isostatic post-compaction (HIP) zirconium dioxide ceramic (yttrium-tetragonal zirconia polycrystals or Y-TZP) with a defined roughened surface (aluminum oxide-blasted). The biopsied two-piece zirconia implant demonstrated clinical and radiographic evidence of osseointegration similar to the adjacent titanium dental implants. Light microscopy and backscatter scanning electron microscopy analyses revealed close bone apposition and marrow spaces to the zirconia surface. Kohal et al² raised a question regarding the durability of the zirconia implants to withstand long-term loads under physiologic conditions. The biopsied implant was not functionally loaded and did not address concerns related to function. The stability of the crestal bone level was excellent, and it was located coronal to the implant-abutment junction, thus completely eliminating the negative sequelae of the implant-abutment junction microgap. This

was probably anticipated, however, because the implant diameter was greater than the abutment diameter.

The preclinical study by Kohal et al¹² demonstrated that surface modifications of zirconia and titanium implants have led to a higher bone-to-implant contact and a higher push-in test value when compared to machined zirconia or titanium dental implants. Long-term clinical success regarding the feasibility and longevity of zirconia dental implants under functional loading is needed at this time. To the best of the authors' knowledge, this is the first human histologic report of a two-piece zirconia dental implant that investigated the soft and hard tissue attachments. Further large cohort clinical studies are needed to understand the clinical utility for a zirconia two-piece implant.

Conclusion

The findings of the human biopsied two-piece zirconia implant demonstrated maintenance of the crestal bone level and provided clinical and histologic evidence of osseointegration. The results support the hypothesis that zirconia is a biocompatible material for dental implants. Zirconia dental implants provided appropriate conditions for soft and hard tissue healing.

Acknowledgments

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