



Histological Analysis of Osseointegrated Zirconia Implant in Human: Case Report

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Abstract

Background: Zirconia implants have been considered a viable alternative to traditional titanium implants with the advantage of providing a more favorable esthetics result and less biofilm adhesion when compared with titanium. There are few studies in the literature showing histological analysis of zirconia implants in humans. The aim of this study is to present the biopsy of a zirconia implant that was placed, osseointegrated but had to be removed due to inadequate three-dimensional positioning.

Case report: A removal of a zirconia implant is presented, where the implant was malpositioned making it impossible to undergo a prosthetic rehabilitation. A trephine drill was used to remove the implant placed in the central incisor of the maxilla and to obtain a biopsy of the adjacent bone tissue. After the removal, the implant was immersed in 4% formaldehyde and the perforation was filled with deproteinized bovine mineral bone and covered with a collagen membrane. After the surgical procedure, a histological analysis was performed to assess the bone-implant contact and surrounding bone quality.

Conclusion: Zirconia implants are an excellent alternative to titanium implants but requires more experience from the operator, since malpositioned implants are more difficult or impossible to correct with prosthetic abutments.

Background

Zirconia (Zr) implants have been currently considered an alternative to titanium (Ti) implants [1], due to the ability of zirconia to withstand large masticatory loads [2,3], biocompatibility [4-6], low retention of biofilm [7-10], excellent aesthetics results [11] and also, elimination of risk of allergies and the formation of corrosive products in the oral cavity [12].

During the planning of the case, the professional should consider many factors to select the appropriate material of the implant. One of the factors is the gingival phenotype of the patient [13,14]. The dark coloring of the Ti implant may appear by translucency in the peri-implant tissue and compromises the aesthetic result of the clinical case, this situation may be avoided by using Zr implants which have opaque white coloring [11].



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Most Zr implants available in the market are one-piece design, this occurs due to the technical difficulty in developing a screw connection in zirconia components [15,16]. In these implants, the only prosthetic option is cement retained prosthesis [13]. This type of prosthesis has the advantage of elimination of the micro gap between the implant and the abutment [17-19], but adversely, may be difficult to rehabilitate implants with incorrect three-dimensional position [20]. In addition, the cementation, when not properly carried out can presents risks like the excess of cement which is harmful to peri-implant health and may be hard to detect initially, neither in the clinical exam nor in radiographic [21]. Regarding the success rates of Zi implants, some studies have presented survival rates ranging from 92% to 95.6% [12,22]. However, systematic reviews still demonstrate the need for more scientific evidence from longitudinal randomized clinical studies to confirm their success [13,22-25]. Several previous animal studies have been carried out using biopsies to analyze the contact between bone tissue and the implant [26-30]. However, the literature still lacks the histological analysis in humans. This study aims to present the histological analysis of an osseointegrated Zr implant, which was indicated to be removed due to its incorrect three-dimensional position.

Case report

A 20-year-old female patient sought treatment in the Implantology Clinic, in the School of Dentistry in Araraquara – São Paulo (UNESP). The patient was healthy and was not using any continuous medication. During clinical examination it was possible to observe that the patient had Zr implants (Pure Ceramic®, Straumann, Basel, Switzerland) placed in the region of the left upper lateral and central incisors that was supposed to be prosthetically rehabilitated.

After clinical (**Figure 1-2**) and tomographic analysis (**Figure 3**), it was found that rehabilitation of the central incisor implant would not be possible, due to the inadequate tridimensional positioning. Therefore, the implant removal surgery was planned.

Surgical procedure

The patient's extra and intra-oral asepsis were performed with 2% and 0.12% chlorhexidine digluconate, respectively. Anterior superior alveolar and nasopalatine nerves was anesthetized with Articaine 4% 1:100.000 - Nova DFL, Brazil.

An intra-sulcular incision was made surrounding the implant and the adjacent teeth. A mucous- periosteal flap was elevated and the implant was exposed. With the aid of a trephine drill (3i Implant Innovations, Florida, USA), a biopsy of the implant was obtained accompanied by the adjacent bone tissue, which was immediately immersed in 4% formaldehyde. The region of the removed implant was filled with deproteinized bovine mineral bone (Cerabone® - Botiss biomaterials, Zossen, Germany) and covered with a collagen membrane (Jason® - Botiss biomaterials, Zossen, Germany). Interrupted sutures were performed with Nylon 5-0 (Ethicon®, Johnson & Johnson, New Brunswick, Nova Jersey, EUA) and drug prescriptions included Amoxicillin 875mg + Potassium Clavulanate 125mg every 12 hours for 7 days; Nimesulide 100mg every 12 hours for 3 days; Sodium Dipyron 500mg every 6h for 3 days and mild mouthwash with 0.12% chlorhexidine digluconate twice a day for 15 days. After 15 days, suture was removed and, good healing and absence of inflammatory signs could be seen. At the moment, the patient

is waiting for a healing period of 8 months for the subsequent installation of a new implant in the region.

Histological analysis

The biopsy obtained was fixated in formaldehyde 4% (freshly derived from paraformaldehyde) for 48 hours and washed with running water for 6 hours for subsequent dehydration in an increasing series of ethanols (60-100 °GL).

The biopsy was infiltrated with a mixture of glycolmethacrylate (Technovit 7200 VLC, Kultzer Heraeus GmbH & CO, Werheim, Germany) and ethyl alcohol, following gradual variations, ending with two infiltrations of pure glycolmethacrylate, under constant agitation, then, polymerized. The block containing the implant and bone tissue was cut at a central point using a cut and micro-wear system (Exakt-Cutting System Apparatebau GmbH, Hamburg, Germany). The final sections (approximately 45 µm thick) were stained with Stevenel's Blue and analyzed under an image analysis system (DIASTAR - Leica Reichert & Jung prod-



Figure 1: Initial clinical image of the patient smile.

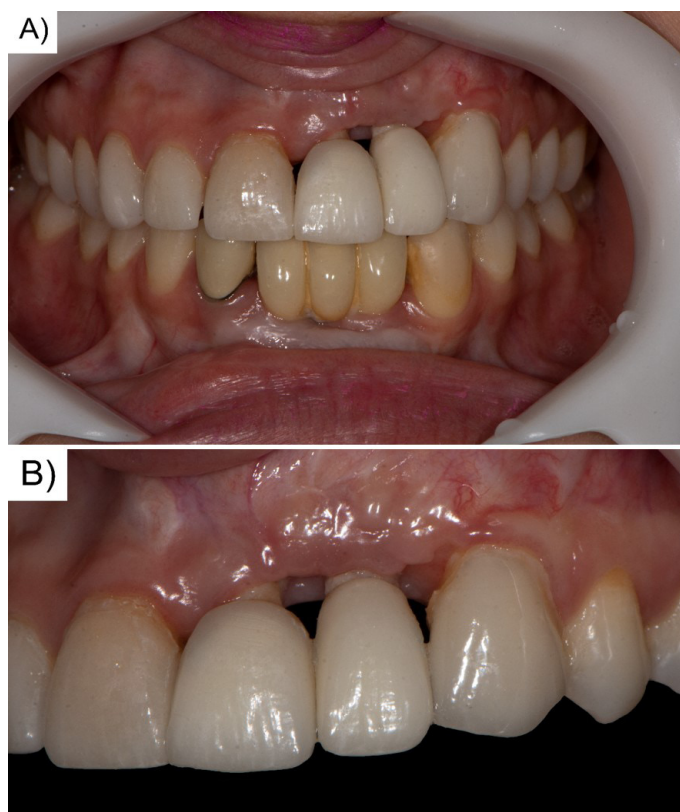


Figure 2A, B: Initial clinical condition with labial retractor indicating the incorrect tridimensional position of the implant and the absence of papillae.

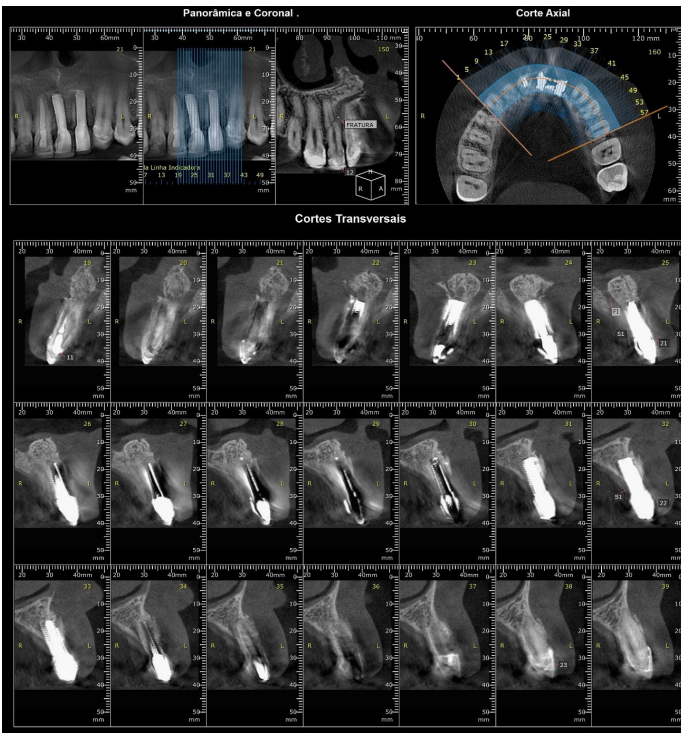


Figure 3: Cone beam computed tomography indicating the incorrect tridimensional position of the implant in the region of the tooth 21.



Figure 4: Micrography of the biopsy of the osseointegrated zirconia implant (Zr I) in a 2.5x magnification.

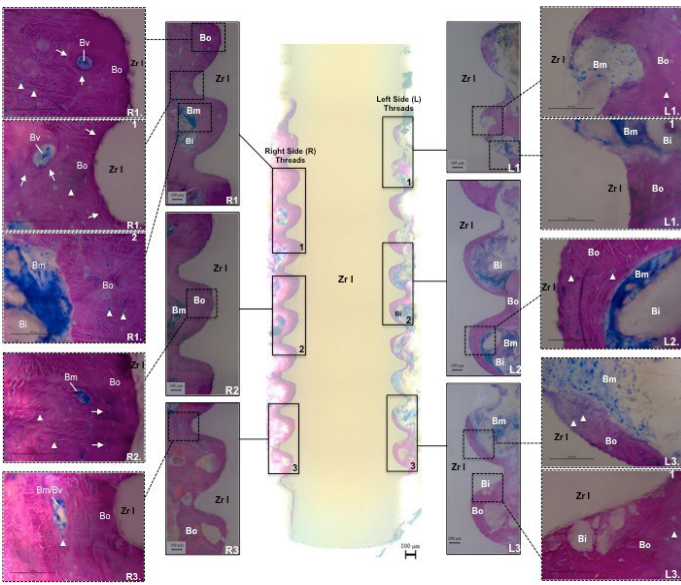


Figure 5: Light micrographs of sections from the biopsy of the osseointegrated zirconia implant (Zr I). At central part of the figure, the osseointegrated Zr I is observed in a lower magnification (2,5x). The insets are indicating regions of bone/implant contacts, present at the right (R) and left sides (L) sides of the Zr I in 40x magnification. The insets from right (R1, R2 and R3) and left (L1, L2 and L3) sides show that Zr I has it threads surrounded by bone (Bo) (pink colour), bone marrow (Bm) (blue colour) and/or biomaterial (Bi) (no colour). The dotted insets are indicating the highest magnifications of some right (R1.1, R1.2, R1.3, R2.1, R3.1) and left (L1.1, L1.2, L2.1, L3.1 and L3.2) regions. Besides the close contact between Bo or Bm and Zr I, micrographs are showing lamellar bone (arrowheads) surrounding Bm and/or blood vessels (Bv). Moreover, the lamellar bone showed viable osteocytes (arrows) inside bone lacunae. In some regions of the Bo and/or Bm, it was also found portions of Bi, inserted during the Zr I placement. The Bi also seems to be well integrated to adjacent tissues.

ucts, Wetzlar, Germany and a DXC-1107A/107AP video camera - Sony electronics Inc®, Minato, Tokyo, Japan).

Histological analysis of the biopsy indicated close bone-implant contact, confirming the success of Zr implants in ensuring osseointegration. The images were analyzed in 2,5x and 40x magnification. Although the close contact between the bone and Zr, the micrographs showed lamellar bone surrounding bone marrow and or blood vessels. The lamellar bone showed viable osteocytes inside bone lacunae. Besides that, it was also found portions of biomaterial in the regions of bone and or bone marrow, inserted during the Zr implant placement. The biomaterial also seems to be well integrated to adjacent tissues (Figure 4,5).

Discussion

Histological analysis of the implant biopsy indicated adequate bone-implant contact in all threads of the implant. This finding is consistent with the results of systematic reviews [30-32] and animal studies [33,34] that assessed the osseointegration of Zr implants through analyzes of bone-implant contact and implant removal torque, comparing them with those of Ti implants. In these studies, Zr implants could present adequate osseointegration, with similar results with Ti implants.

Regarding the interaction of Zr with soft tissues, the studies have also shown favorable results. A study in adult pigs compared the sealing of the mucosa around titanium and zirconia implants with machined necks and found similarity in the orientation of connective tissue fibers [35] in both types of implants.

Robert Cionca et al., 2015 [36], believe that due to the Zr implant having a greater long junctional epithelium and a higher density of collagen fibers, they are also related to greater soft tissue sealing and reduction of inflammatory infiltrate. However, *Atsuta et al.*, 2019 [37], in a study in rats, comparing the effectiveness of epithelial sealing in Zr and Ti implants, using horseradish peroxidase introduced with PBS (phosphate buffered saline) around the gingival margin of the implants, were able to identify histologically, the reaction with the horseradish had a greater apical extension around Zr implants than in Ti implants. In addition, immunohistochemical analyzes of the same study, against Ln-332, Plectin, IN- β 4 and β -actin proteins, indicated more significant values of cell adhesion for Ti implants and more significant in relation to cell migration to Zr implants.

Evaluating the size of the biological width around the implants, there is no consensus in the literature but the results found are similar. *Ralf J Kohal et al.*, 2004 [33] in a study in monkeys showed values of 4,5mm for biological width in Zr implants and 5,2 mm in Ti implants. *Liñares et al.*, 2016, in another study also on animals, were found dimensions of the biological width of 2.8 mm in Zr implants and 2.3 mm in Ti implants. *Roehling et al.*, 2019, in turn, in a systematic review, indicated mean values of 2.7-5.1mm for Zr implants and 2.8-5.2mm for Ti implants.

Randomized clinical studies evaluating the effectiveness of Zr implants [15,38,39], demonstrate excellent results, considering Zr implants as a safe substitute for Ti implants, as confirmed by histological analysis, which showed osseointegration, with mature/lamellar bone in close contact with the Zr implant. However, Zr implants with an one-piece design still offer disadvantages related to less prosthetic versatility, risk of excess cement and adverse indication for clinical cases of immediate loading [15,40]. Thus, this study reports a clinical case of Zr

implant with inadequate three-dimensional positioning that had its removal indicated to enable future prosthetic resolution. It is important to emphasize that one-piece Zr implants should be performed with greater precision and that commercial companies should continue to work on new technologies to expand the prosthetic options of Zr implants, as performed in Zr implants with a two-piece design.

Conclusion

Despite the study's limitation in presenting only one clinical case, it is possible to conclude that Zr implants are an excellent alternative to Ti implants but requires more experience from the operator, since, malpositioned implants are more difficult or impossible to correct with prosthetic abutments, leading to its removal.

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Conflict of Interest

The authors declare no conflict of interest.

Declaration about informed consent

The patient signed a term of consent and authorization of image use for teaching and research purposes, including scientific publication.

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