

Four-year clinical and radiographic follow-up: ceramic vs titanium implant in the aesthetic area

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01
Panoramic image of the patient wearing orthodontic braces and the provisional resin-bonded crown in the position of tooth #21.

Abstract

This study reports a four-year clinical and radiographic follow-up of a single patient treated with screw-retained implant restorations in the aesthetic zone. Eleven years after receiving a titanium implant for the maxillary right central incisor, a two-piece ceramic implant replaced the left central incisor. Follow-up assessments (initial at six months, then yearly) from 2019 to 2023 demonstrated successful outcomes for both implants, with good peri-implant tissue stability. These findings suggest ceramic implants may be a viable long-term alternative for patients seeking restorations free of potential metal toxicity concerns.

Introduction

Since the advent of osseointegration, the rehabilitation of partially or totally edentulous spaces with the use of dental implants has been in constant advancement. Widely accepted concepts such as “osseointegration” are now being challenged. It has been recently suggested that rather than a bone repair process, osseointegration is in fact an osteo-immune defense reaction,¹ which would lead the body to form new bone to encapsulate and isolate the endosseous implant from the oral tissues. Within this scenario, titanium implants should be seen as osteoimmunomodulatory elements rather than a bioinert biomaterial, as previously thought.² Thus,



02
Initial periapical radiographic showing the missing tooth #21 and a resorbed alveolar ridge; the titanium implant in tooth #11.

marginal bone loss (MBL) may be understood as a result of osteo-immunological mechanisms that react to titanium ions and particles released into the oral tissue due to corrosion and wear, while bacterial challenge should be seen as a secondary condition.¹ Moreover, the accumulation of titanium ions and particles in the body may also result in tissue discoloration; toxic reactions and hypersensitiveness to metals.^{3,4}

Due to concerns being raised regarding the use of titanium implants, zirconia ceramic implants have emerged as an alternative, not only due to their aesthetic benefits, but also the biocompatibility and biomechanical properties,⁵ peri-implant soft-tissue response,⁶ bacterial adhesion,⁷ and plaque formation,⁸ which have been shown to be at least similar, if not better than titanium. Furthermore, differently from titanium implants, zirconia implants also seem to be bioinert for human tissues.⁹

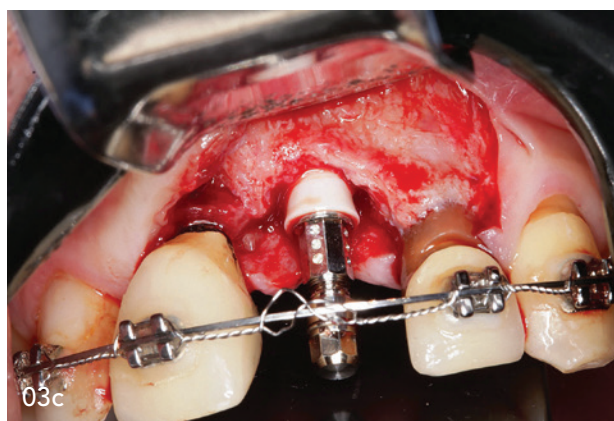
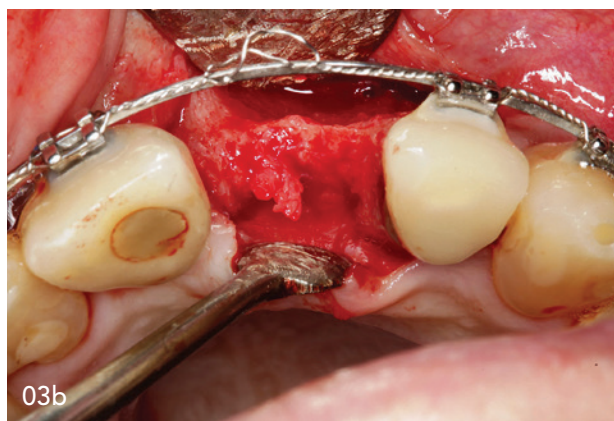
However, there is a lack of long-term data comparing ceramic implants with titanium implants, especially when placed in the same patient. Therefore, the aim of this article is to report on the results of a four-year clinical and radiographic follow-up of a patient rehabilitated with screw-retained single restorations supported by a ceramic and a titanium implant in the aesthetic area.

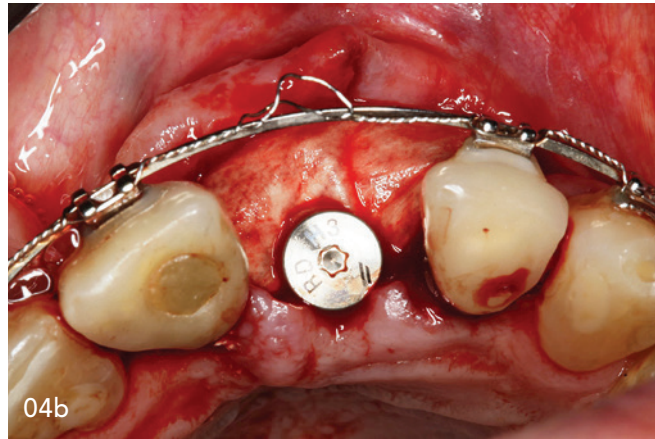
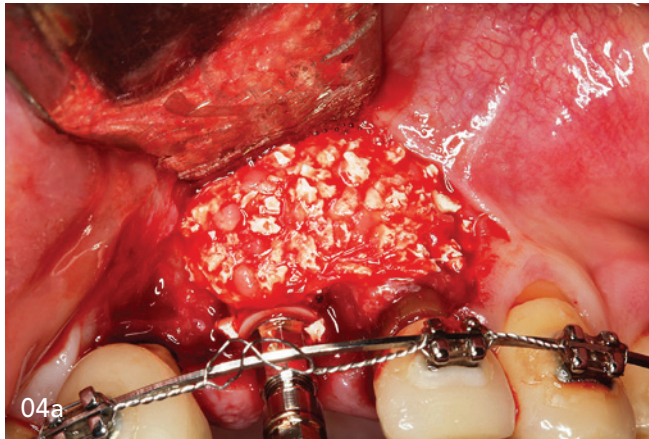
Clinical case

In the beginning of 2019, a systemically healthy 41-year-old, non-smoker, male patient was referred to a specialised private clinic in the city of Curitiba, Brazil for the replacement of a lost maxillary left central incisor (#21). Eleven years previously, at the age of 30, the patient reported being in an accident that resulted in the traumatising of his maxillary anterior teeth and the loss of his upper right central incisor (#11) and the breakage of his upper

03a–c

Occlusal view showing a resorbed alveolar bone (a); flap elevation (b); and ceramic implant manually installed in the alveolar ridge (c).





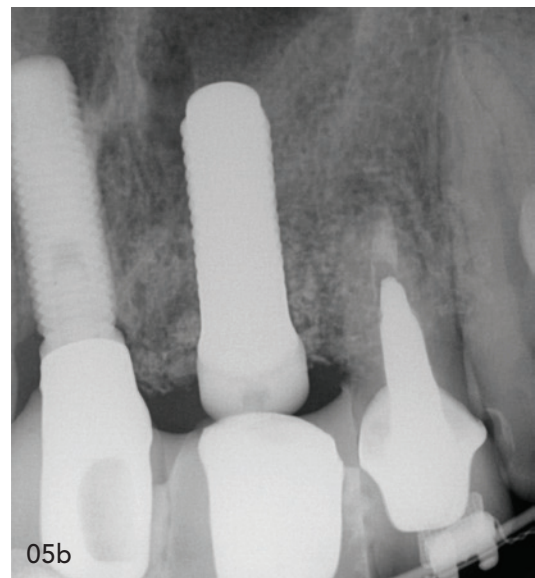
04a + b
Implant defect covered with xenogeneic bone substitute (a); and collagen membrane placed to cover all the graft material and around the healing cap (b).

left central (#21) and lateral incisor (#22; Fig. 1). Teeth #21 and #22 underwent endodontic treatment and were rehabilitated with individual conventional prostheses. Tooth #11 was rehabilitated with a screw-retained metal-ceramic crown connected to an external hexagon titanium implant. All the procedures were conducted by another clinician, which prevented access to treatment details.

During the initial clinical-radiographic examination, the patient, who had initiated orthodontic treatment three months before, was presented with tooth #21 restored with a resin-bonded restoration (Fig. 1). According to the patient, tooth #21 was highly mobile and extracted by the orthodontist. The periapical radiograph showed a resorbed marginal alveolar bone, indicating that no ridge preservation procedures had been conducted at the time of extraction (Fig. 2). A CBCT scan was requested to better assess the area and assist in treatment planning.

Based on the CBCT scan, a treatment plan was defined, and the patient was presented with the possibility to be restored with another conventional titanium implant or with a new ceramic implant. After considering the benefits and possible drawbacks of each treatment alternative, the patient opted for the ceramic implant. Due to the implantation position required, a two-piece Ø4.1 mm x 11 mm ceramic implant (PURE Ceramic®, Straumann) was chosen. After the bonded restoration was removed (Fig. 3a), a periosteal flap was elevated to grant access to the alveolar ridge (Fig. 3b). The ceramic implant was manually installed in a completely healed ridge by an experienced clinician (JL) to an initial insertion torque of 35 Ncm, as recommended by the implant manufacturer (Fig. 3c). The remaining buccal wall defect was completely covered by a xenogeneic bone substitute (Cerabone, botiss biomaterials; Fig. 4a), and then covered by a collagen membrane (Jason® membrane, botiss biomaterials). A healing cap was placed over

05a + b
Clinical view showing the non-resorbable sutures and the provisional resin-bonded crown in position, fixed to the orthodontic braces (a); and periapical radiographic, showing the ceramic implant with the healing cap (b).



Year	BOP*		Mob*		Sup*		PPD (mm)	
	TP 11	TP 21	TP 11	TP 21	TP 11	TP 21	TP 11	TP 21
2019	1	0.75	0	0	0	0	2.25	1.75
2020	1	0.75	0	0	0	0	2	1.75
2021	0.75	0.75	0	0	0	0	2	1.5
2022	0.5	0.75	0	0	0	0	2	1.5
2023	0	0	0	0	0	0	2	1.5

TP: tooth position; BOP: Bleeding on Probing; Mob: Mobility;
Sup: Suppuration; PPD: Peri-implant Pocket Depth.
* Mean of findings (0 absent; and 1 present) at four peri-implant sites (mesial, proximal, buccal and palatal).

Table 01
Mean values for the clinical variables measured around the ceramic implant (tooth #21) and the titanium implant (tooth #11) during the follow-up visits.

the implant (Fig. 4b), which allowed for a semi-submerged implant healing (Fig. 5a), while a provisional resin-bonded crown was placed over the implant (Fig. 5b).

After three months of healing, the clinical (Fig. 6a) and radiographic examination (Fig. 6b) showed the presence of a well-healed soft tissue and alveolar bone all around the implant. The implant was then loaded with a provisional screwed-retained crown that was kept in place until the completion of the orthodontic treatment. Three years after implant placement, the definitive ceramic crowns for both teeth #11 and #21 were delivered. All the prosthetic procedures were performed following the analogue flux.

The patient was included in a regular maintenance programme. The first clinical-radiographic examination was conducted six months after provisional crown loading in 2019, and yearly, from then on until 2023. At each visit, both implant #11 and #21 were clinically assessed with a manual periodontal probe (PUNC, Hu-Friedy) at four sites around each implant (mesial, distal, buccal, and palatal). The following parameters were recorded at each visit: Bleeding on Probing (BOP) and Peri-implant Pocket Depth (PPD), presented in mm as a mean of the four measured sites. Suppuration (Sup) and Mobility (Mob) as present (1) or absent (0); Sup as a mean of the four measured sites and Mob for each fixture. All the clinical data was collected at every visit by the same experienced clinician (FS). Periapical radiographs were also taken at each visit to check the integrity of the alveolar bone and for the presence of marginal bone loss.

Over the follow-up period, both implant-rehabilitated crowns presented similar behaviour and characteristics (Table 1). BOP was present around both implants at all initial measurements but absent at the final assessment after the completion of the dental rehabilitation treatment. Mob and Sup were absent at all visits (Table 1). In 2023, an occlusal view of the implant sites permitted us to observe a dark shadow in the mucosa around the titanium implant, but not around the ceramic implant (Fig. 7c). Radiographically, the marginal bone level around both implants were stable over the follow-up period (Fig. 7c). At the completion of the treatment, the patient presented a pleasant aesthetic result in the anterior area of the mouth.



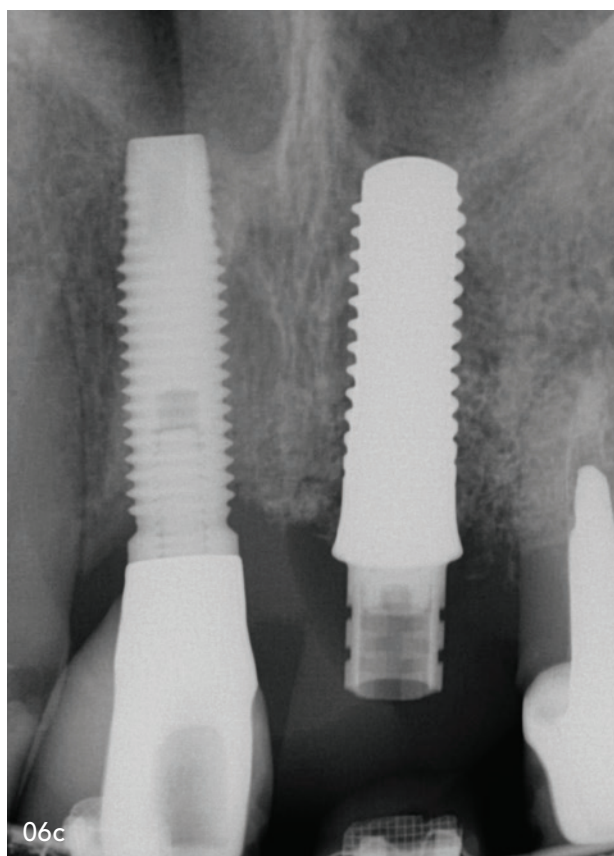
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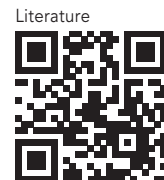
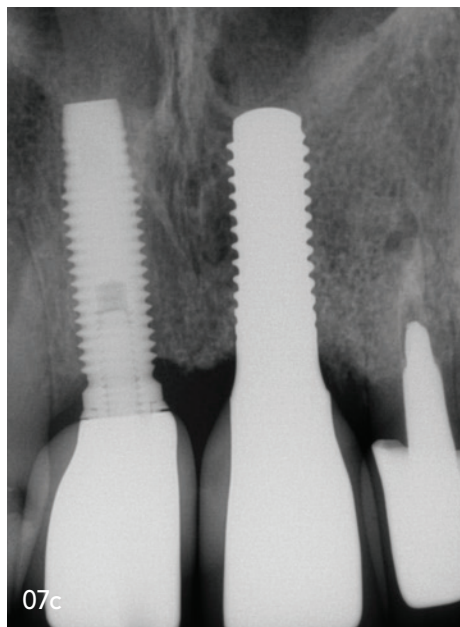
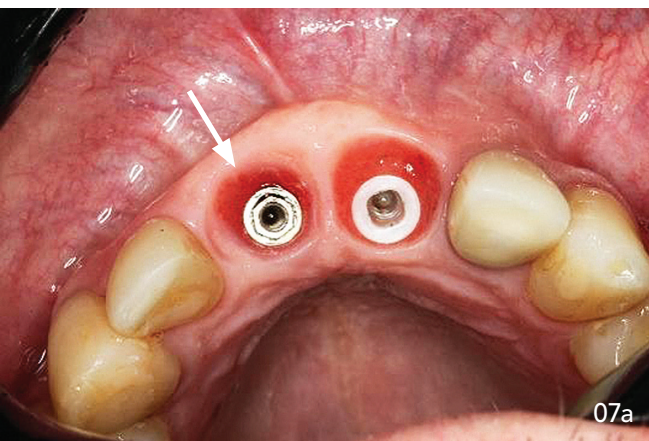


06a–c
Six months
postoperative:
occlusal view
showing the ceramic
implant healing cap
surrounded by a
healthy mucosa (**a**);
provisional crown
installed over the
ceramic implant (**b**);
and periapical
radiographic
showing the ceramic
implant in healed
bone (**c**).

Discussion

To the best of our knowledge, this is the first case report to follow-up the behaviour of a conventional titanium implant in comparison with a ceramic implant installed next to each other in the anterior maxilla in the same patient. That was possible because the titanium implant was inserted 11 years before the ceramic implant. The clinical and radiographic data collected over the four-year period is quite unequivocal concerning the success of both implants. These findings were expected as previous studies have already indicated that ceramic implants can perform as successfully when compared to published findings on titanium implants.¹⁰ Even when we considered the metallic implant prosthetic connection installed so many years before the metal free implant.

Differences found for BOP over the follow-up period may be attributed to the presence of more plaque accumulation around the titanium implants than on ceramic implants. Animal models^{8,11,12} have already shown that the amount and thickness of dental plaque around zirconia specimens was reduced when compared with titanium specimens. Furthermore, the sulcular epithelium around zirconia implants appeared to be shorter, in some ways closer to dental sulcular epithelium dimensions.¹¹ A review study on different abutment connections also indicated that, similar to titanium, hemidesmosomes bind to zirconia, although epithelial adhesion seems to be improved around zirconia components.⁹ That might explain the lower PPD levels observed around the ceramic implant despite similar bone levels. The higher BOP scores observed at both implants in the first visits can be explained by the fact that the patient was under orthodontic treatment, which impeded proper access to oral hygiene and using provisional crown over the implants. Nonetheless, the combination of regular maintenance and a thick soft-tissue biotype ensured the stability of the peri-implant tissues. It's noteworthy, however, that the fact the dark shadow observed in the mucosa around the titanium implant, but not around the ceramic implant, may



07a–c
Three years post-operative: occlusal view showing the peri-implant mucosa around a metallic implant. Note the difference in colour (arrow) of the mucosa around the titanium implant (left) and the ceramic implant (right) (a); note the aspect of the definitive ceramic crowns over the implants (b); and periapical radiograph showing both implants and crowns (c).

be indicative of the dissolution of titanium ions and particles into the soft tissue. While that might not be sufficient to activate the osteoimmunological mechanisms to initiate MBL, metal toxicity has become a concern among many patients.^{3,4}

Mob and Sup were completely absent over the follow-up period for both the ceramic and titanium implants, indicating hard-tissue stability, as observed in another case series presented previously.¹⁴ That can be observed in the radiographic follow-up, which showed no significant bone changes. The hot-isostatic pressed tetragonal zirconia polycrystal used in the implant selected in this case received a surface treatment to improve hard-tissue adhesion.⁹ Moreover, a preclinical pilot study showed that in the presence of a stable peri-implant soft tissue in association with an adequate initial implant–bone contact, no statistically significant differences in MBL were observed between metallic and ceramic implants.¹¹

Conclusion

The findings of this case report have suggested that both titanium and ceramic implants have similar behaviour in the long term and can be successfully used for treating edentulous spaces. However, ceramic implants can be an important alternative for patients who do not feel comfortable with installing metal implants for fear of toxicity accumulation over time.



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