Research article

Comparative evaluation between one-piece implants of zirconia or titanium placed in posterior mandible: 6 months follow-up

Ricardo R. Vecchiatti,[1] Andre L.O. Campos,[1] Welington F. Morais,[1] Jose A. Rodrigues,[2] Alessandra Cassoni,[1] and Jamil Awad Shibli.[1,*]

[1] Department of Periodontology and Oral Implantology, Dental Research Division, University of Guarulhos - UnG, São Paulo, Brazil
[2] Department of Restorative Dentistry, Dental Research Division, University of Guarulhos - UnG, São Paulo, Brazil

*Corresponding author: Jamil Awad Shibli, jashibli@yahoo.com

Submitted on July 10th, 2014; accepted after minor corrections on July 28th, 2014.

Abstract

Background and objectives. At present, only few studies with zirconia implants have been developed, but there are no conclusive results. This prospective study evaluated one-piece zirconia implants placed in posterior mandible assessing implant survival rate, implant success and marginal bone remodeling.

Materials and Methods. 43 one-piece implants were placed in 2 groups: zirconia implants (Zi, n=21 implants) and sandblasted acid-etched titanium surface (SAE, n=22 implants). These implants were inserted in partially edentulous mandible of 15 patients in a split-mouth design. At 6-months loading follow-up, clinical and radiographic parameters were assessed. Mann-Whitney statistical analysis was performed to compare groups (α=0.05). Success criteria included absence of pain, sensitivity, suppuration, implant mobility; absence of continuous peri-implant radiolucency; distance between the implant shoulder and the first visible bone contact (DIB) <1.5 mm.

Results. After a 6 months loading time, the overall implant survival rate was 94.59%, with 3 implant losses (2 Zi and 1 SAE). Among the surviving implants (34 out of 37), all fulfill the success criteria; therefore, the implant success was 94.59%. The mean distance between the implant shoulder and the first visible bone contact (DIB) for Zi and SAE implants were 0.34 ± 0.95 mm and 0.43 ± 0.85 mm, respectively (p>0.05).

Discussion and Conclusion. Within the limits of this study, one-piece implants made of Zi or SAE seem to represent a safe and successful procedure for implant-supported restoration, after 180 ± 60 days follow-up.

Keywords. Biomedical and dental materials, bone remodeling, ceramics, dental implants, zirconia.

1. Introduction

The implant-supported restorations have been used as an alternative to prosthesis **[1]**. The material of choice for dental implants is the commercially pure titanium. Due to its biocompatible, this material has been extensively used, showing high success rates during the years due to osseointegration **[2-4]**.

Osseointegration has been defined as a direct, functional linkage with the implant surface and the surrounding bone. With the intention to evaluate osseointegration of dental implants, many methods had been developed. An established method is the measurement of the Bone Implant Contact (BIC) by histomorphometric analysis, in animal studies, as a direct contact between bone and implant surface without any connective tissue interposition **[5]**.

The ceramic zirconia material was introduced as an option to metallic abutments implants **[6,7]** because of its white color. However, the peri-implant mucosa color and biotype also influences the implant esthetics **[8]**. The development of zirconia material as an option to implant abutments **[9,10]** had also represented an important goal to achieve esthetic result associated with function. Dental implants made with zirconia had been evaluated **[11]**. These implants present an excellent resistance to corrosion and wear, good biocompatibility, high bending strength and fracture toughness **[12]**, and low bacterial adhesion **[13]**.

Zirconia implants with modified surfaces have showed osseointegration similar to titanium implants **[14,15]**. Degidi et al. (2006) have stated that occurs a lower inflammatory infiltrate with much lower extension at zirconia healing caps than at titanium healing caps **[16]**. In addition, animal studies with histological observations have stated similar capacity of zirconia implants for osseointegration as titanium implants **[17-20]**.

One-piece implants have several clinical advantages. The surgery is minimally invasive, restorative procedures are simple, and abutment screw loosening cannot happen. Furthermore, the amount of crestal bone resorption may be minimized since there is no microgap or micromovement between an implant and an abutment **[21,22]**.

Reports of excellent implant stability, esthetics, and patient satisfaction in the short-term perspective have been published with regard to this specific implant, although some reports have demonstrated lower survival rates related to the implant design **[22,23]**.

This prospective study evaluated one-piece zirconia implants placed in posterior mandible assessing implant survival rate, implant success and marginal remodeling bone.

2. Materials and methods

The Ethics Committee for Human Clinical Trials at Guarulhos University approved the study protocol, which was explained to each subject, and all patients signed informed consent.

2.1. Selection of the subjects

Fifteen partially edentulous subjects (four males and eleven females, mean age of 40.58 ± 10.68 years) in posterior mandible were included in this study. These patients fulfilled the following inclusion criteria: patients had to meet pre-established inclusion parameters (i) at least 2 lower posterior mandibular teeth missing, (ii) reasonable to good oral and general health, (iii) not be pregnant or breath feeding; (iv) no history of irradiation on head and neck, (v) adequate amount of bone height for placement of implants with a minimum length of 8.5mm in a prosthetic optimal position, (vi) implant site free from acute infection.

Exclusion criteria included (i) previous bone augmentation in the implant site, (ii) moderate to severe chronic periodontitis (i.e., suppuration, bleeding on probing in more than 30% of the subgingival sites or any site with probing depth ≥ 5mm), (iii) not controlled diabetes or any systemic condition that could affect the bone healing.

ISSN 2307-5295, Published by the POSEIDO Organization & Foundation

2.2. Special manufactured of one-piece implants

One-piece screw-shaped implants (4.1 mm in diameter and 8.5 to 10 mm length; AS Technology Titanium-FIX, São José dos Campos, SP, Brazil) were especially manufactured with titanium (SAE) or yttrium-stabilized tetragonal zirconia polycrystal Y-TZP (Zi). The grade-4 titanium implants were additionally blasted with 100 μm Al_3O_2 particles. After sandblasting, the specimens were ultrasonically cleaned with an alkaline solution, washed in distilled water and pickled with HNO_3 **(Figure 1)**.

Figure 1. Lateral view of the one-piece titanium and zirconia implants.

The samples were first checked for chemical composition with XPS/ESCA (X-Ray Photoelectron Spectroscopy/Electron Spectroscopy for Chemical Analysis), and no significant pollution was detected **[24,25]**. The topographies at the microscale were then visualized using routine Scanning Electron Microscopy (SEM) control. At the nanoscale, the SEM confirmed that both surface types were nanosmooth, following the current definition. The sole difference between these 2 tested implant types was therefore the specific material (zirconia and titanium) as well as the microtopography **[26]**.

The implants were characterized by a Confocal White Light Microscope (Leica Scan DCM 3D - Leica Microsystems Ltd, Switzerland) with an objective magnification 50X, to measure one-piece dental implant surface topography.

Titanium and zirconia groups were evaluated and the surface roughness was calculated. Surface roughness (Ra) length of 254.64 μm (768 X 56 pixels) was recorded **(Figure 2)**.

ISSN 2307-5295, Published by the POSEIDO Organization & Foundation

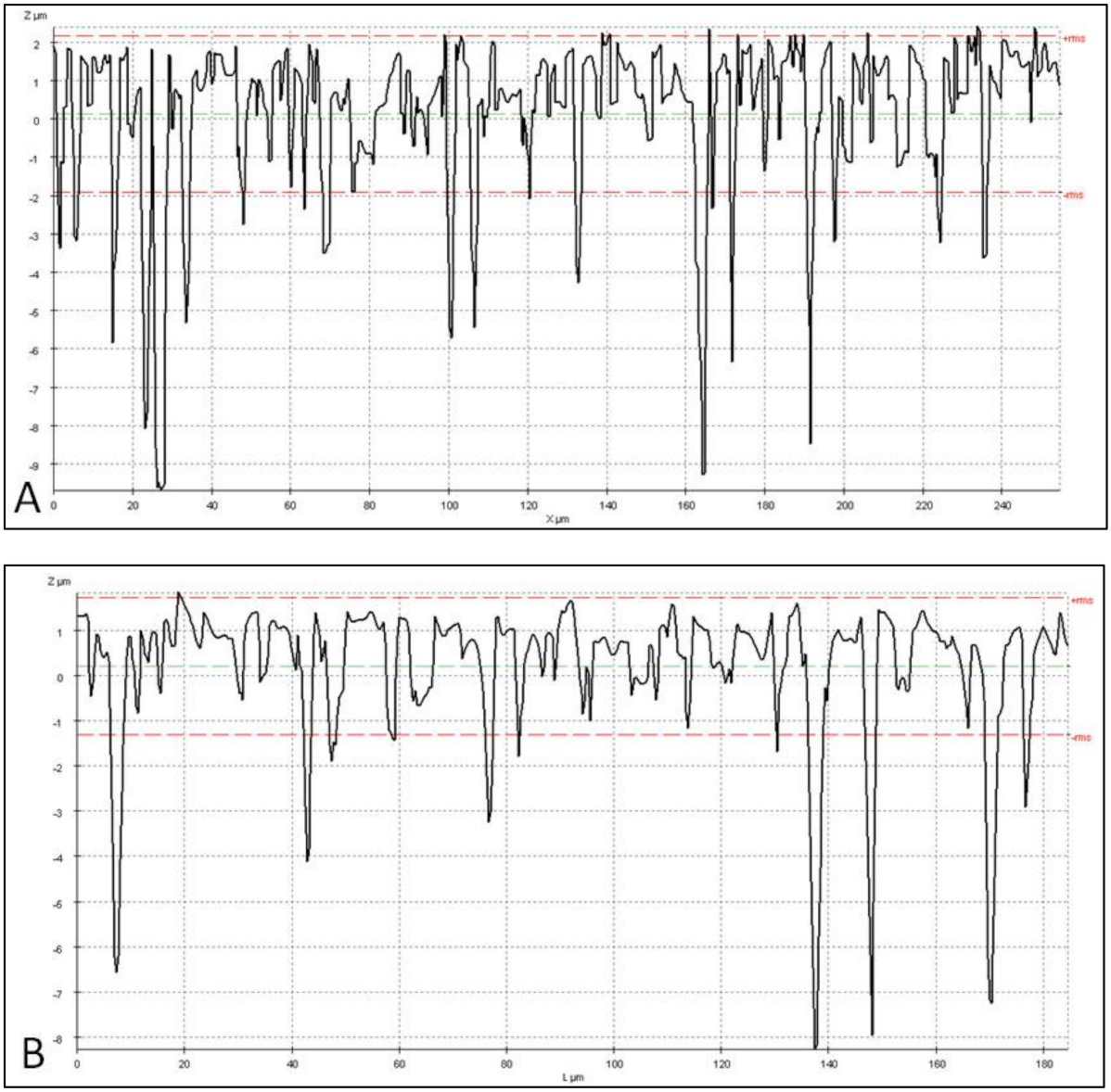

Figure 2. Representative profile of Surface Roughness for SAE titanium surface **(A)** and zirconia surface **(B)**.

2.3. Implant placement

One-piece screw-shaped implants for both groups were placed in posterior mandible **(Figure 3)**. The preparation of implant sites was carried out with twist drills of increasing diameter (2.0, 2.8, 3.15 and 3.35 mm) to place 4.1 mm diameter implants, under constant irrigation.

Care was taken to assess the position of the mental foramen. Implants sites were marked using a surgical template. The templates were based on the diagnostic waxing with perforations on the longitudinal axis, on the premolar and molar regions, according to ideal position of final implant supported restorations. Interrupted sutures to ensure a non-submerged healing procedure in dental implants were done.

ISSN 2307-5295, Published by the POSEIDO Organization & Foundation

Figure 3. Clinical view of titanium and zirconia implants being inserted in posterior mandible.

2.4. Post-operative treatment

All patients received oral antibiotics (Clindamicyn, 900mg each day) for 7 days Postoperative pain was controlled by administering 100 mg Nimesulide every 12 hours for 5 days. Detailed oral hygiene instructions were provided, with mouth-rinses with 0.12% chlorhexidine administered for 7 days. Suture removal was performed at 7 days. After surgery, the patients were instructed to avoid brushing and any trauma to surgical site. A cold and soft diet was recommended for the first day, and a soft diet for the first week.

2.5. Restorative procedure

Following four months of implant healing, an impression was taken utilizing a silicon putty polyvinylsiloxane (Contrast – VOCO) directly on the implants. Laboratory templates were made and a master cast was fabricated.

The implant-supported restoration made with ceramic (IPS D'Sign - Ivoclar Vivadent) was placed direct on the implant. These restorations were fixed with a resin cement (Variolink II - Ivoclar Vivadent). All centric and lateral contacts were assessed by an articulating paper and adjusted if necessary.

2.6. Clinical and radiographic evaluation

For each implant, the following clinical parameters **[27]** were investigated, after 6 months of functional loading, as the presence or absence of: 1.) pain/sensitivity, 2.) suppuration/exudation and 3.) implant mobility. The number 3 was tested manually using the handles of two dental mirrors.

ISSN 2307-5295, Published by the POSEIDO Organization & Foundation

Moreover, intraoral periapical radiographs were taken for each implant, at the baseline (immediately after implant insertion) and at the 6 months of occlusal loading. Radiographs were taken using a Rinn alignment system with a rigid film-object-X-ray source coupled to a beam-aiming device in order to achieve reproducible exposure geometry. The distance between the first angle of the implant body and the first visible bone contact, was measured in mm by an appropriate software (ImageTool - Texas University).

Crestal bone level changes at 6 months were registered as modifications in the distance from the implant shoulder to the bone level on the mesial and distal implant side. To correct dimensional distortion, the apparent dimension of each implant was measured on the radiograph and then compared with the actual implant length.

2.7. Implant Survival and Implant Success criteria

The evaluation of implant survival and implant success was performed according to the following clinical and radiographic parameters **[28]**. Implants were basically divided into two categories: "survived" and "failed" implants. An implant was classified as a "survived implant" when it was still in function at the end of the study, after 6 months of functional loading. To achieve implant success, the following clinical and radiographic success criteria should be fulfilled as absence of: pain or sensitivity upon function, suppuration or exudation, clinically detectable implant mobility, continuous peri-implant radiolucency, and DIB < 1.5 mm after 6 months of functional loading. Implant losses were categorized as failures; implants presenting pain upon function, suppuration or clinical mobility were removed, and were all failure categories. The conditions for which implant removal could be indicated included failure of osseointegration or infection, recurrent peri-implantitis, or implant loss due to mechanical overload.

3. Results

At the time of evaluation, of the 15 patients, 13 had only returned. After a 6 months loading time, the overall implant survival rate was 95% (titanium implants) and 89.47% (zirconia implants), with 3 out of 39 implant losses by mobility without infection (2 Zi and 1 SAE). Among the surviving implants (34 out of 37), all fulfill the success criteria; therefore, the implant success was 94.59%. Two zirconia abutments at single-tooth implant-supported restoration fractured at final insertion, showing no influence on the osseointegration.

The mean distance between the first angle of the implant body and the first visible bone contact (Distance Implant Bone-DIB) for Zi and SAE implants were 0.34 ± 0.95 mm and 0.43 ± 0.85 mm respectively ($p>0.05$)**(Figure 4)**.

ISSN 2307-5295, Published by the POSEIDO Organization & Foundation

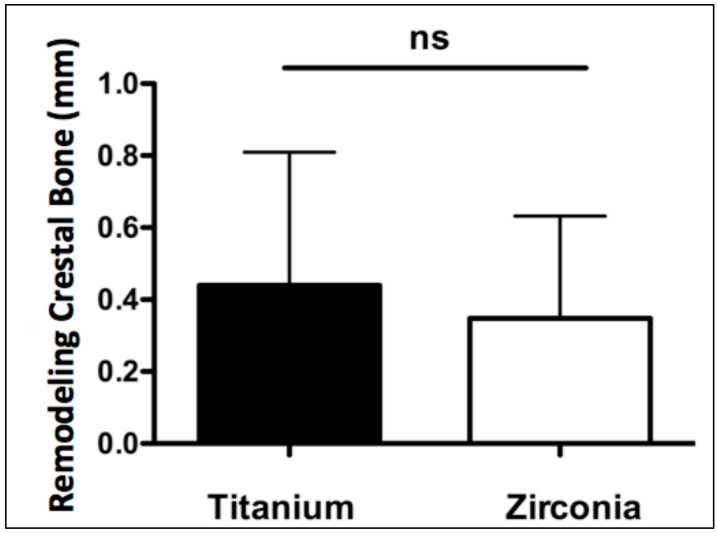

Figure 4. Mean and standard deviation (mm) of remodeling crestal bone of evaluated group.

4. Discussion

The present study showed a 94.59% success rate for all implants placed in the posterior mandible. Specifically, zirconia implants presented an 89.47% success rate while one-piece titanium implants showed 95% under the same loading conditions. These data agree with previous studies that evaluated the success rate of zirconia implants placed in human jaws **[29]**. In that study, the authors achieved a success rate of 92.7% in zirconia implants without surface topography preparation, in the same condition as performed in our study. In a later study, Oliva et. al., (2007) reported a higher success rate ranged around 98%, however, this zirconia surface was previously coated, data that range very close to the titanium implants evaluated in our study **[30]**. These data could suggest that the implant surface topography should increase the bone healing around the peri-implant environment, and consequently increase the success rate.

When comparing the results with animals, Akagawa et. al. (1998) evaluating seven monkeys and twenty-eight non-treated zirconia implants, reported success index ranged between 54% and 71% after twelve months of follow-up **[31]**.

Several studies have demonstrated bone integration of threaded zirconia implants under both unloaded and loaded conditions **[32]**. Akagawa et al. (1998) showed, in monkeys, the long-term stability of partially stabilized zirconia implants placed with different loading designs in a one-stage procedure **[31]**. Direct bone apposition to the implant was generally seen. Fractures of the implants did not appear, confirming the favorable mechanical properties of zirconia.

A review of the literature indicates that sensitivity to titanium is rare, two reports showed possible hypersensitive reactions to titanium. Oliva et al. (2010) describes a full-mouth oral rehabilitation of a titanium allergic patient with zirconia implants **[33]** hence, the zirconia implants provide the possibility of a metal-free treatment option to patients who request this **[34-36]**.

ISSN 2307-5295, Published by the POSEIDO Organization & Foundation

Kohal et al. (1997) compared custom-made titanium and zirconia implants used to support metal crowns in the superior jaw of six monkeys **[37]**. The two types of implants were sandblasted, and the titanium was also acid- etched. All implants maintained stability and no mechanical problems were reported. Histologic examinations confirmed no differences in the bone tissue response to the titanium and zirconia implants.

In a systematic review, Wenz et al. (2008) have related that the osseointegration of yttria–tetragonal zirconia polycrystal implants (Y-TZP) were similar to titanium implants; modifications of their surfaces have the potential to improve initial bone healing and resistance to removal torque; low temperature degradation might affect the behavior of Y-TZP **[38]**. That suggested the higher adhesion capacity developed by cells on zirconia could be related to the earlier and abundant production of the adhesion protein fibronectin than titanium. Although, the more precocious and high production of organized structure for adhesion observed on zirconia, associated with the low toxicity exerted by this material, concur to explain the higher growth rate of cells incubated on it when compared with fibroblasts growing in contact with FE ceramic **[12]**.

Newly formed bone was observed in close contact with zirconia ceramic surfaces in a rabbit study that reported a bone-to-implant contact of 68.4% **[39]**. Kohal et al. (2004) compared airborne-particle-abraded zirconia implants with acid-etched titanium implants in monkeys; after 9 months of healing and 5 months of loading, no significant difference in bone-to-implant contact between the two groups could be found **[32]**.

Kohal et al. (2009) reported that the mean mineralized bone-to-implant contact for the Ti machined group was 39.4%, 46.6% for the ZrO_2 machined group, 55.2% for the TiUnite group and 59.4% for the ZrO_2 modified group **[15]**. That investigation supports those findings that the surface modifications for the titanium, and also for the zirconia implants resulted in higher BIC compared with the machined surfaces. Because there was no significant difference between the TiUnite surface and the modified zirconia surface, it can be concluded that zirconia surface is as biocompatible and osteoconductive as the modified titanium surface **[15]**.

Sennerby et al. (2005) reported a strong bone tissue response to surface-modified zirconia implants after 6 weeks of healing in rabbit bone **[20]**. The modified zirconia implants showed a resistance to torque forces 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.

The research of Koch et al. (2010) showed that all implants (titanium and zirconia) had areas of tight BIC **[11]**. The trabecular architecture of bone around the zirconia, coated zirconia and titanium implants was classified as lamellar bone due to the circular apposition of bone lamellae around canals of Havers. All zirconia and titanium implants showed few signs of natural bone remodeling, apposition of osteoid and osteoblasts or lacunae of osteoclasts. Osteoblasts surrounding the bone trabeculae showed functional and mature bone architecture nearby the zirconia and titanium implants. Morphologically, the zirconia as well as the titanium implants were tightly osseointegrated. They showed that zirconia implants are capable of establishing BIC rates similar to what is known from the osseointegration behavior of roughened titanium implants with the same surface modification and roughness.

Despite many positive experiences, the use of zirconia implants remains debated and quite scarce in daily practice. There are still many uncertainties on the kind of zirconia to use and in which configuration, in order to have the best biomechanical behavior and long-term clinical results. The posterior mandible remains one of the most delicate area to rehabilitate

ISSN 2307-5295, Published by the POSEIDO Organization & Foundation

with such implant, as the biomechanical conditions are in theory the most unfavorable. This first study brings therefore a very interesting highlight on the opportunities and threats of this therapeutic option.

5. Conclusion

Within the limits of this study, one-piece implants made of Zi or SAE seem to represent a safe and successful procedure for implant-supported restoration in the posterior mandible, after 180 ± 60 days follow-up. A long-term follow-up of these patients (and of a larger group of patients) is needed to give a better feedback on the biomechanical and clinical potential of these implants in the posterior mandible, and to bring further this preliminary research.

Disclosure of interests

The authors have no conflict of interest to report.

Acknowledgements

The authors would like to thank Titanium Fix, São José dos Campos, Brazil for supplying the zirconia and titanium implants.

Author Contributions

JAS was in charge of the elaboration of the study proposal and the financial support of the study, and he participated to the elaboration of the manuscript and the treatment planning of each case. JAR and AC were in charge of the statistical analysis, the implant surface characterization and the financial support for the study. RRV, ALOC and WFM were in charge of the treatment planning of each case, the implant placement surgery and they participated to the elaboration of the manuscript. JAR and AC also participated to the elaboration of the study design and proposal.

References

[1] Al-Nawas B, Kammerer PW, Morbach T, Ladwein C, Wegener J, Wagner W. *Ten-year retrospective follow-up study of the TiOblast dental implant*. **Clin Implant Dent Relat Res**. 2012;14(1):127-34.

[2] Branemark PI, Hansson BO, Adell R, Breine U, Lindstrom J, Hallen O, Ohman A. *Osseointegrated implants in the treatment of the edentulous jaw. Experience from a 10-year period*. **Scand J Plast Reconstr Surg Suppl**. 1977;16:1-132.

[3] Adell R, Eriksson B, Lekholm U, Branemark PI, Jemt T. *Long-term follow-up study of osseointegrated implants in the treatment of totally edentulous jaws*. **Int J Oral Maxillofac Implants**. 1990;5(4):347-59.

[4] Orsini E, Giavaresi G, Trire A, Ottani V, Salgarello S. *Dental implant thread pitch and its influence on the osseointegration process: an in vivo comparison study*. **Int J Oral Maxillofac Implants**. 2012;27(2):383-92.

[5] Albrektsson T, Branemark PI, Hansson HA, Lindstrom J. *Osseointegrated titanium implants. Requirements for ensuring a long-lasting, direct bone-to-implant anchorage in man*. **Acta Orthop Scand**. 1981;52(2):155-70.

[6] Bressan E, Paniz G, Lops D, Corazza B, Romeo E, Favero G. *Influence of abutment material on the gingival color of implant-supported all-ceramic restorations: a prospective multicenter study*. **Clin Oral Implants Res**. 2011;22(6):631-7.

[7] van Brakel R, Noordmans HJ, Frenken J, de Roode R, de Wit GC, Cune MS. *The effect of zirconia and titanium implant abutments on light reflection of the supporting soft tissues*. **Clin Oral Implants Res**. 2011;22(10):1172-8.

[8] Jung RE, Sailer I, Hammerle CH, Attin T, Schmidlin P. *In vitro color changes of soft tissues caused by restorative materials*. **Int J Periodontics Restorative Dent**. 2007;27(3):251-7.

[9] Sailer I, Zembic A, Jung RE, Siegenthaler D, Holderegger C, Hammerle CH. *Randomized controlled clinical trial of customized zirconia and titanium implant abutments for canine and posterior single-tooth implant reconstructions: preliminary results at 1 year of function*. **Clin Oral Implants Res**. 2009;20(3):219-25.
[10] Zembic A, Sailer I, Jung RE, Hammerle CH. *Randomized-controlled clinical trial of customized zirconia and titanium implant abutments for single-tooth implants in canine and posterior regions: 3-year results*. **Clin Oral Implants Res**. 2009;20(8):802-8.
[11] Koch FP, Weng D, Kramer S, Biesterfeld S, Jahn-Eimermacher A, Wagner W. *Osseointegration of one-piece zirconia implants compared with a titanium implant of identical design: a histomorphometric study in the dog*. **Clin Oral Implants Res**. 2010;21(3):350-6.
[12] Rocchietta I, Fontana F, Addis A, Schupbach P, Simion M. *Surface-modified zirconia implants: tissue response in rabbits*. **Clin Oral Implants Res**. 2009;20(8):844-50.
[13] Scarano A, Piattelli M, Caputi S, Favero GA, Piattelli A. *Bacterial adhesion on commercially pure titanium and zirconium oxide disks: an in vivo human study*. **J Periodontol**. 2004;75(2):292-6.
[14] Depprich R, Zipprich H, Ommerborn M, Naujoks C, Wiesmann HP, Kiattavorncharoen S, Lauer HC, Meyer U, Kubler NR, Handschel J. *Osseointegration of zirconia implants compared with titanium: an in vivo study*. **Head Face Med**. 2008;4:30.
[15] Kohal RJ, Wolkewitz M, Hinze M, Han JS, Bachle M, Butz F. *Biomechanical and histological behavior of zirconia implants: an experiment in the rat*. **Clin Oral Implants Res**. 2009;20(4):333-9.
[16] Degidi M, Artese L, Scarano A, Perrotti V, Gehrke P, Piattelli A. *Inflammatory infiltrate, microvessel density, nitric oxide synthase expression, vascular endothelial growth factor expression, and proliferative activity in peri-implant soft tissues around titanium and zirconium oxide healing caps*. **J Periodontol**. 2006;77(1):73-80.
[17] Josset Y, Oum'Hamed Z, Zarrinpour A, Lorenzato M, Adnet JJ, Laurent-Maquin D. *In vitro reactions of human osteoblasts in culture with zirconia and alumina ceramics*. **J Biomed Mater Res**. 1999;47(4):481-93.
[18] Hoffmann O, Angelov N, Gallez F, Jung RE, Weber FE. *The zirconia implant-bone interface: a preliminary histologic evaluation in rabbits*. **Int J Oral Maxillofac Implants**. 2008;23(4):691-5.
[19] Schultze-Mosgau S, Schliephake H, Radespiel-Troger M, Neukam FW. *Osseointegration of endodontic endosseous cones: zirconium oxide vs titanium*. **Oral Surg Oral Med Oral Pathol Oral Radiol Endod**. 2000;89(1):91-8.
[20] Sennerby L, Dasmah A, Larsson B, Iverhed M. *Bone tissue responses to surface-modified zirconia implants: A histomorphometric and removal torque study in the rabbit*. **Clin Implant Dent Relat Res**. 2005;7 Suppl 1:S13-20.
[21] Oh TJ, Yoon J, Misch CE, Wang HL. *The causes of early implant bone loss: myth or science?* **J Periodontol**. 2002;73(3):322-33.
[22] Ostman PO, Hellman M, Albrektsson T, Sennerby L. *Direct loading of Nobel Direct and Nobel Perfect one-piece implants: a 1-year prospective clinical and radiographic study*. **Clin Oral Implants Res**. 2007;18(4):409-18.
[23] Swart LC, van Niekerk DJ. *Simplifying the implant treatment for an unrestorable premolar with a one-piece implant: a clinical report*. **J Prosthet Dent**. 2008;100(2):81-5.
[24] Dohan Ehrenfest DM, Kang BS, Sammartino G, Shibli JA, Wang HL, Zou DR, Bernard JP. *Guidelines for the publication of articles related to implant surfaces and design from the POSEIDO: a standard for surface characterization*. **POSEIDO**. 2013;1(1):7-15.
[25] Dohan Ehrenfest DM, Del Corso M, Kang BS, Leclercq P, Mazor Z, Horowitz RA, Russe P, Oh HK, Zou DR, Shibli JA, Wang HL, Bernard JP, Sammartino G. *Identification card and codification of the chemical and morphological characteristics of 62 dental implant surfaces. Part 1: description of the Implant Surface Identification Standard (ISIS) codification system*. **POSEIDO**. 2014;2(1):7-22.
[26] Miranda PV, Rodrigues JA, Blay A, Shibli JA, Cassoni A. *Surface alterations of zirconia and titanium substrates after Er,Cr:YSGG irradiation*. **Lasers Med Sci**. 2015;30(1):43-8.
[27] Mangano F, Mangano C, Ricci M, Sammons RL, Shibli JA, Piattelli A. *Single-tooth Morse taper connection implants placed in fresh extraction sockets of the anterior maxilla: an aesthetic evaluation*. **Clin Oral Implants Res**. 2012;23(11):1302-7.
[28] Albrektsson T, Zarb GA. *Determinants of correct clinical reporting*. **Int J Prosthodont**. 1998;11(5):517-21.
[29] Oliva J, Oliva X, Oliva JD. *Five-year success rate of 831 consecutively placed Zirconia dental implants in humans: a comparison of three different rough surfaces*. **Int J Oral Maxillofac Implants**. 2010;25(2):336-44.
[30] Oliva J, Oliva X, Oliva JD. *One-year follow-up of first consecutive 100 zirconia dental implants in humans: a comparison of 2 different rough surfaces*. **Int J Oral Maxillofac Implants**. 2007;22(3):430-5.

ISSN 2307-5295, Published by the POSEIDO Organization & Foundation

[31] Akagawa Y, Hosokawa R, Sato Y, Kamayama K. *Comparison between freestanding and tooth-connected partially stabilized zirconia implants after two years' function in monkeys: a clinical and histologic study*. **J Prosthet Dent**. 1998;80(5):551-8.
[32] Kohal RJ, Weng D, Bachle M, Strub JR. *Loaded custom-made zirconia and titanium implants show similar osseointegration: an animal experiment*. **J Periodontol**. 2004;75(9):1262-8.
[33] Oliva X, Oliva J, Oliva JD. *Full-mouth oral rehabilitation in a titanium allergy patient using zirconium oxide dental implants and zirconium oxide restorations. A case report from an ongoing clinical study*. **Eur J Esthet Dent**. 2010;5(2):190-203.
[34] Peters MS, Schroeter AL, van Hale HM, Broadbent JC. *Pacemaker contact sensitivity*. **Contact Dermatitis**. 1984;11(4):214-8.
[35] Lalor PA, Revell PA, Gray AB, Wright S, Railton GT, Freeman MA. *Sensitivity to titanium. A cause of implant failure?* **J Bone Joint Surg Br**. 1991;73(1):25-8.
[36] Sicilia A, Cuesta S, Coma G, Arregui I, Guisasola C, Ruiz E, Maestro A. *Titanium allergy in dental implant patients: a clinical study on 1500 consecutive patients*. **Clin Oral Implants Res**. 2008;19(8):823-35.
[37] Kohal RJ, Hurzeler MB, Mota LF, Klaus G, Caffesse RG, Strub JR. *Custom-made root analogue titanium implants placed into extraction sockets. An experimental study in monkeys*. **Clin Oral Implants Res**. 1997;8(5):386-92.
[38] Wenz HJ, Bartsch J, Wolfart S, Kern M. *Osseointegration and clinical success of zirconia dental implants: a systematic review*. **Int J Prosthodont**. 2008;21(1):27-36.
[39] Scarano A, Di Carlo F, Quaranta M, Piattelli A. *Bone response to zirconia ceramic implants: an experimental study in rabbits*. **J Oral Implantol**. 2003;29(1):8-12.

This article can be cited as:
Vecchiatti RR, Campos ALO, Welington F. Morais WF, Rodrigues JA, Cassoni A, Shibli JA. *Comparative evaluation between one-piece implants of zirconia or titanium placed in posterior mandible: 6 months follow-up.* **POSEIDO**. 2014;2(4):241-51.