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Ti-Zr alloy (ROXOLID) will become a Paradigm Shift in Implant Material? -A Narrative Review

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ABSTRACT: Titanium and Zirconia are one of the most widely used biomaterials for dental implants. Titanium has an excellent osseointegration but has insufficient mechanical resistance and the zirconia implants are used in anterior regions. So, TiZr alloy(Roxolid) was introduced that increased mechanical resistance than titanium alloys with similar biocompatibility to bone tissues. In this narrative review, the authors discuss various properties of TiZr alloy and use of these as implant materials due to their superior properties.

Keywords: Titanium, Zirconia, TiZr alloy, Roxolid, Implant material.

INTRODUCTION:

Titanium is the most widely used biomaterial for dental implants. Titanium has admittedly excellent osteointegration ability, but its mechanical strength or corrosion resistance is insufficient in some cases, where reduced-dimension implants are required or the corrosive environment is severe, like those containing chlorides or fluorides and toxicity. To improve the properties of titanium implants, the binary titanium-zirconium alloy has emerged as a good candidate for implant use, particularly in these demanding conditions. [1] Titanium (Ti) alloy is the main material used for manufacturing dental implants due to its excellent mechanical properties and biocompatibility.[2,3]

Zirconia implants were developed for use especially in the anterior region; specifically, the anterior region has a thin gum and bone tissue, which may reveal the greyish colour of the titanium implant. [4] Since the smaller diameter titanium implants mainly have high failure rates in the posterior regions. [5] It was reported that Ti ions are the causative factor of peri-implant mucositis , which can further induce severe peri-implantitis with alveolar bone resorption [6,7] The TiZr alloy (Roxolid) originated from mixing an alloy of Ti with 13%– 15% of Zr. This alloy has increased mechanical resistance than titanium alloys, with similar biocompatibility in the bone tissue.[8] Because of

this feature, TiZr alloy is recommended when manufacturing small diameter implants, mainly in regions with high occlusal overload. [9,10]

Binary titanium-zirconium alloys have been studied as promising alternatives for Ti implants. The commercial Ti-15Zralloy (Roxolid, Straumann) has been the major subject of numerous binary Ti-Zr alloys-related studies and has gained wide recognition in laboratory studies and clinical practices.[11] The use of narrow Ti-Zr implants can allow for expanded prosthetic options while also reducing or eliminating the need for bone grafting. This will result in a reduction in patient morbidity, cost and treatment time making patients more accepting of implant therapy. [12]

PROPERTIES:

The tensile strength and fatigue endurance limit of Ti-15%Zr alloy were found to be higher than those of grade 4 titanium, without reducing the tensile elongation or the fracture toughness.[13] The main reason for the electrochemical superiority of the alloys was related to a thicker and denser passive film on the Ti-Zr alloy surfaces that were reinforced by the ZrO oxide [14] The TiZr alloy is biocompatible material, [15,16] [Sista S, Wen C, Hodgson PD, Pande G. The influence of surface energy of titanium–zirconium alloy on osteoblast cell functions in vitro. J Biomed Mater Res A. 2011;97:27–36.][Bernhard N, Berner S, de Wild M, Wieland M. The binary TiZr alloy—a newly developed Ti alloy for use in dental implants. Forum Implantol. 2009;5:30–39.] and it has a tensile strength 2.5 to 3 times greater than that of Ti alloy and also Zr. [5] Moreover, the presence of Zr in the implant increases its corrosion resistance in biological fluids, decreasing the release to the tissues. [17,18]

TiZr alloy has demonstrated significantly higher fatigue and tensile strengths than conventional titanium implants [5] The TiZr SLActive implant surface improved osseointegration compared to Ti implants with the SLActive surface. [19] A high elastic recovery capability, indicating a high strength and low modulus, is essential for many load-bearing implants and dental applications [20] Implant materials with lower elastic moduli (closer to that of human bone) can reduce the stress-shielding effect [21] Accordingly, Ti-Zr alloys with low moduli are preferable for implant materials. The main reason for the electrochemical superiority of the alloys was related to a thicker and denser passive film on the Ti-Zr alloy surfaces that were reinforced by the ZrO oxide. [22]

DISCUSSION:

The interaction strength between implant and bone surface for TiZr alloy was higher than Ti. [23,24] Mu¨ ller et al ., [25] conducted a 5-year follow-up study comparing 3.3-mm diameter TiZr implant with Ti grade IV in mandibular implant-based removable overdentures. The authors reported a success rate of 95.8% for TiZr alloy implants and 92.6% for Ti grade IV implants. For implants in the posterior regions, it may be desirable to choose TiZr alloy

implants since studies have shown a success rate greater than 95% and approximately 100% survival.[26,27] Small diameter implants made of Roxolid showed high survival (98.7 % after one year, 97.3 % in 3 years) and success rates. [28,29]

CONCLUSION: The Roxolid implant material showing superior properties than titanium and zirconium. Still long term clinical studies may require in the future. Existing literature assuring that, this combination of titanium (82%-85%) and zirconium (13%-15%) (Roxolid) may shift the paradigm in implant materials.

REFERENCES:

1.Cui WF, Shao CJ. The improved corrosion resistance and anti-wear performance of Zr-xTi alloys by thermal oxidation treatment. Surf Coat Technol 2015; 283:101-107.

2.Branemark PI. Osseointegration and its experimental background. J Prosthet Dent. 1983;50:399–410.

3.Le Gue´hennec L, Soueidan A, Layrolle P, Amouriq Y. Surface treatments of titanium dental implants for rapid osseointegration. Dent Mater. 2007;23:844–854.

4Andreiotelli M, Wenz HJ, Kohal RJ. Are ceramic implants a viable alternative to titanium implants? A systematic literature review. Clin Oral Implants Res. 2009;20(suppl 4):32–47.

5.Kobayashi E, Matsumoto S, Doi H, Yoneyama T, Hamanaka H.Mechanical properties of the binary titanium–zirconium alloys and their potential for biomedical materials. J Biomed Mater Res. 1995;29:943–950.

6.Wachi T, Shuto T, Shinohara Y, Matono Y, Makihira S. Release of titanium ions from an implant surface and their effect on cytokine production related to alveolar bone resorption. Toxicology 2015;327:1-9.

7. D. Mareci, G. Bolat, A. Cailean, J.J. Santana, J. Izquierdo, R.M. Souto. Effect of acidic fluoride solution on the corrosion resistance of ZrTi alloys for dental implant application. Corros Sci 2014; 87:334-343.

8. Ikarashi Y, Toyoda K, Kobayashi E, et al. Improved biocompatibility of titanium–zirconium (Ti-Zr) alloy: tissue reaction and sensitization to Ti-Zr alloy compared with pure Ti and Zr in rat implantation study. Mater Trans. 2005;46:2260–2267.

9.Veltri M, Ferrari M, Balleri P. One-year outcome of narrow diameter blasted implants for rehabilitation of maxillas with knife-edge resorption. Clin Oral Implants Res. 2008;19:1069–1073.

10.Altuna P, Lucas-Taule´ E, Gargallo-Albiol J, Figueras-A´ lvarez O, Herna´ndez-Alfaro F, Nart J. Clinical evidence on titanium–zirconium dental implants: a systematic review and meta-analysis. Int J Oral Maxillofac Surg.2016;45:842–850.

11.Zhao Q,Ueno T, Wakabayashi N.A review in titanium-zirconium binary alloy for use in dental implants: Is there an ideal Ti-Zr composing ratio?. Japanese Dent Sci Rev 2023;59:28-37.

12.Boynton T, Shafer DM, Onekhana J. Poster 16: New Treatment Options with 3.3 mm Diameter Titanium-Ziconium (Straumann Roxolid™) Implants. J Oral and Maxillofac Surg 2012;70(9):E49.

13.Medvedev AE, Molotnikov A, Lapovok R, Zeller R, Berner S, Habersetzer P et al. Microstructure and mechanical properties of Ti-15Zr alloy used as dental implant material.J Mech Behav Biomed Mater 2016 2016; 62:384-398.

14.Cordeiro JM, Beline T, Ribeiro AR, Rangel EC, da Cruz NC, Landers R et al. Development of binary and ternary titanium alloys for dental implants. Dent Mater 2017;33(11):1244-257.

15.Sista S, Wen C, Hodgson PD, Pande G. The influence of surface energy of titanium–zirconium alloy on osteoblast cell functions in vitro. J Biomed Mater Res A. 2011;97:27–36.

16.Bernhard N, Berner S, de Wild M, Wieland M. The binary TiZr alloy—a newly developed Ti alloy for use in dental implants. Forum Implantol. 2009;5:30–39.

17.Albrektsson T, Hansson HA, Ivarsson B. Interface analysis of titanium and zirconium bone implants. Biomaterials. 1985;6:97–101.

18.Correa DR, Vicente FB, Donato TA, Arana-Chavez VE, Buzalaf MA, Grandini CR. The effect of the solute on the structure, selected mechanical properties, and biocompatibility of Ti-Zr system alloys for dental applications. Mater Sci Eng C Mater Biol Appl. 2014;34:354–359.

19.Gottlow J, Dard M, Kjellson F, Obrecht M, Sennerby I. Evaluation of a new titanium-zirconium implant: A biomechanical and histological comparative study in minipigs. Academy of Osseointegration 23rd Annual Meeting, Boston, MA, USA. 28 February–1 March 2008; abs OS-5.

20.Correa DRN, Vicente FB, Donato TAG, Arana-Chavez VE, Buzalaf MAR, Grandini CR. The effect of the solute on the structure, selected mechanical properties, and biocompatibility of Ti–Zr system alloys for dental applications. Materials Science and Engineering 2014;34:354-59.

21.Wang B, Ruan W , Liu J, Zhang T , Yang H, Ruan J. Microstructure, mechanical properties, and preliminary biocompatibility evaluation of binary Ti-Zr alloys for dental application. J Biomater Appl 2019;33(6):766-775.

22.Cordeiro JM, Beline T, Ribeiro AR, Rangel EC, da Cruz NC, Landers R et al. Development of binary and ternary titanium alloys for dental implants. Dent Mater 2017;33(11):1244-257.

23.Davidson JA, Daigle KP, Kovacs P. Wear-resistant, hemocompatible Ti-Nb-Zr and Zr-Nb alloys to improve blood pump design and performance. Artif Organs. 1996;20:513–522.

24.Goodman SB, Davidson JA, Fornasier VL. Histological reaction to titanium alloy and hydroxyapatite particles in the rabbit tibia. Biomaterials. 1993;14:723–728.

25.Muller F, Al-Nawas B, Storelli S, et al; Roxolid Study Group. Small diameter titanium grade IV and titanium–zirconium implants in edentulous mandibles: five-year results from a double-blind, randomized controlled trial. BMC Oral Health. 2015;15:123-43.

26.Barter S, Stone P, Bra¨gger U. A pilot study to evaluate the success and survival rate of titanium–zirconium implants in partially edentulous patients: results after 24 months of follow-up. Clin Oral Implants Res. 2012; 23:873–881.

27.Chiapasco M, Casentini P, Zaniboni M, Corsi E, Anello T. Titaniumzirconium alloy narrow-diameter implants (Straumann Roxolid) for the rehabilitation of horizontally deficient edentulous ridges: prospective study on 18 consecutive patients. Clin Oral Implants Res. 2012;23:1136–1141.

28.Storelli S, A Randomized, Controlled, Double Blind, Clinical Trial Comparing Two Different Implant Alloys (TiGrIV vs. TiZr): Year Report. SIO 2013 Milan; Poster 81Clinical Research.

29. Marc Quirynen , Bilal Al-Nawas , Henny J A Meijer , Amir Razavi , Torsten E Reichert , Martin Schimmel et al.Small-diameter titanium Grade IV & titanium-zirconium implants in edentulous mandibles: 3-year results from a double-blind, randomized controlled trial. Clin Oral Implants Res 2015;26(7):831-40.