Immediate Implant Loading: A Comparison of Trabecular Metal and Tapered Screw-Vent Dental Implants

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Abstract

Aims: The aim of the present study is to compare osteointegration and marginal bone loss of immediately loaded Trabecular Metal® and Tapered Screw-Vent® Dental Implants (Zimmer Dental Inc., Carlsbad, CA, USA).

Methods: Eighty-seven (87) patients were selected and randomly divided into Group A and Group B. Twenty-six (26) patients were enrolled in Group A, and were rehabilitated using Zimmer Trabecular Metal Dental Implants®. Sixty-one (61) patients were enrolled in Group B, and were rehabilitated using Zimmer Tapered Screw-Vent Dental Implants®.

Results: The mean value of marginal bone loss after one year was 0.44 ± 0.40 mm for Group A and 0.95 ± 0.62 mm for Group B ($p<.003$). Mean marginal bone loss after 18 months was 0.46 ± 0.42 mm for group A and 0.97 ± 0.65 mm for group B ($p<.003$). No TM implant was lost (Group A), whereas one TSV implant (Group B) was lost before osseointegration and was not included in the statistical analysis.

Conclusion: Both Trabecular Metal and Tapered Screw-Vent dental implants showed satisfying levels of osteointegration and marginal bone loss; however, statistical analysis revealed a value significantly lower of marginal bone loss for TM. Thus, it may be deduced that when implants are immediately loaded, the average loss of marginal bone around the TM implants is lower than that of the Tapered Screw-Vent implants.

Key words: Trabecular metal, Immediate dental implant loading, Bone loss, Dental implant

Introduction

Compared to all other dental disciplines, implant dentistry has rapidly evolved, with progressive innovations, mainly in terms of development of new implant systems and the introduction of new surgical techniques [1-4]. Formation of a direct bone to implant contact is the main success criteria in implant dentistry.

Porous surface coating should enhance integration, by allowing bone growth inside the pores [5-6]; however, the number and size of the pores that can be obtained on the surface of the implant determine the quality and quantity of the bone growth. Histological studies showed that while a pore size of ~ 100 µm is adequate for bone ingrowth [7], osteon formation inside a porous material needs ~ 150 µm pores [8], while pores greater than ~ 300 µm are required to support vascularized bone ingrowth [9].

Difficulties, however, were encountered in trying to get regular pores of predetermined dimensions. To overcome this obstacle, orthopedic researchers developed a highly porous tantalum trabecular material (PTTM) (Trabecular Metal Material, Zimmer TMT, Parsippany, NJ, USA) that simulated the trabecular structure [10–17] and more closely resembled the elastic modulus (2.5–3.9 GPa) of both cancellous (6.8 GPa) and cortical (13–17 GPa) bone than titanium (106– 115 GPa), cobalt chromium (210 GPa), or stainless steel (230 GPa) surgical metals used for orthopedic implants.[17–20]. PTTM showed a bone-like three dimensional architecture [17,21], interconnected porosity up to 80% [12,13,16,17,22,23] and osteoconductive properties [12,13,16,17,22].

Since 1997, PTTM has been used for hip, knee, and spine reconstruction [12-14,16-18]. In recent years, PTTM was applied to the midsection of root-form, threaded, titanium alloy dental implants to create a three-dimensional, peri-implant bone ingrowth scaffold [24]. The porosity of Trabecular Metal Material not only significantly increases the surface available for bone formation, but also allows angiogenesis and bone formation inside the pores [8,10,24,25]: the average pore size of Trabecular Metal Material is ~550 µm, adequate for blood vessel formation and osseoincorporation [24,26]. The term osseoincorporation indicates the combination of osseointegration/bone ongrowth (bone to implant contact, BIC) and bone ingrowth within the porous material.

In his initial studies on osseointegration, Branemark identified in titanium and tantalum the most suitable materials for implant manufacturing [27]. Tantalum demonstrated a high biocompatibility and resistance to corrosion [28-32]; however, the difficulty in working this material limited its use [33] and titanium was preferred.

In the 90's a process of deposition of vapor using tantalum overcame the manufacturing limits. Trabecular metal material is nowadays produced by coating a vitreous carbon skeleton (2% of TM) with tantalum (98% of TM) via a chemical vapor deposition process [10,11,13]: the result is a nanotextured, osteoconductive framework [20] of three dimensional, dodecahedron-shaped interconnected pores [10,11,13,14,19]. The pores are large enough to allow bone ingrowth and blood vessel formation.

Two preclinical studies on PTTM documented bone growth inside the porous tantalum structures [18,22,34]. In the first study, histologic analysis detected regions of contact between bone and implant increasing with time and evidence of Haversian remodelling within the pores at later stages. Mechanical tests at four weeks indicated a minimum shear fixation strength of 18.5 MPa, substantially higher than that obtained with other porous materials with a lower volumetric porosity [18,22].

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In the second study, 22 PTTM acetabular implants were studied in a canine model for a period of 6 months. Histology, radiography, and electron microscopy revealed stable bone-implant interfaces in all 22 implants. All histologic sections presented areas of bone ingrowth. The depth of bone ingrowth ranged from 0.2 mm to 2 mm. The mean bone ingrowth for all sections was 16.8%. In the peripheral regions, where bone-implant contact was most consistent, bone ingrowth averaged 25.1% [18,34].

The aim of the present study is to clinically and radiographically evaluate osteointegration and marginal bone loss of immediately loaded Trabecular Metal Dental Implants® (Zimmer Dental Inc., Carlsbad, CA, USA) 18 months after insertion in partially edentulous patients.

Materials and Methods

The study was conducted in the Head and Neck Department of "Sapienza" University of Rome, and was open to all patients who met specific inclusion and exclusion criteria *(Table 1)* and provided signed informed consent, according to the World Medical Association's Declaration of Helsinki.

Table 1. Patient Selection Criteria.

Table 1	Patient Selection Criteria
Inclusion	Male or female at least 18 years of age
	Benefit from the implant prosthesis
	Adequate bone volume to support an implant without additional augmentation
	Healed extraction site
	Insertion torque of >35 Ncm for immediate loading
	ISQ>70 at implant placement
Exclusion	Subjects with bruxism or clenching parafunctional habits
	Fresh extraction site
	Grafted sites with <6 months of healing by the implantation date
	Smokers
	Sites with a previously failed dental implant
	Uncontrolled systemic disease (e.g., uncontrolled diabetes)
	Severely compromised immune system
	Untreated oral pathologies
	Pregnancy
	Bleeding disorder or use of anticoagulants
	Use of bisphosphonates
	Other conditions the investigator may feel would inhibit the patient from being a good candidate for the study

The Authors selected eighty-seven (87) patients, aged from 24 to 72 years (mean age 51), and randomly divided them into Group A (study group) and Group B (control group). The randomization procedure consisted in flipping a coin to determine whether the participant had to go into the study or control group.

Twenty-seven (27) patients, aged from 24 to 68 years, with an average of 49 years old, were enrolled in Group A, and were rehabilitated using Zimmer Trabecular Metal Dental Implants. Each patient was treated with one implant. 15 implants were placed in the mandible and 11 in the maxilla. The sizes of the implants were the following: 4.7 x 11.5 mm (1 implants); 4.1 x 13 mm (1 implant); 4.1 x 11,5 mm (3 implants); 4.1 x 10 mm (9 implants); 3.7 x 11.5 mm (5 implants); 3.7 x 10 mm (7 implants) *(Tables 2-3)*.

Table 2. Treatment Sites Trabecular Metal Dental Implants.

Maxillary locations	Lateral Incisor	3
	Canine	4
	First premolar	2
	Second premolar	0
	First molar	1
	Second molar	1
Mandibular locations	Lateral Incisor	1
	Canine	4
	First premolar	2
	Second premolar	4
	First molar	1
	Second molar	3
Bone Density	Type I	2
	Type II Type III	12 8
	Type IV	4

Table 3. Dimensions and Surfaces of Trabecular Metal Dental Implants.

Lengths (mm)	Diameters (mm) ø 3.7 mm	4.1 mm	4.7 mm	Implants
10 mm	7	15	0	16
11.5 mm	5	5	1	9
13 mm	0	3	0	1
Surfaces	Cervical collar			0.5mm Ti machined
	Implant Body (Ti-6Al-4V)			MTX® Microtextured
	Implant Body (Trabecular Metal)			Nanotextured

Sixty-one (61) patients, aged from 26 to 72 (mean age 54) were enrolled in Group B, and were rehabilitated using Zimmer Tapered Screw-Vent Dental Implants. Each patient was treated with one implant. 37 implants were placed in the mandible and 24 in the maxilla. The sizes of the implants were the following: 4.7 x 11.5 mm (2 implants); 4.1 x 13 mm (3 implants); 4.1 x 11.5 mm (5 implants); 4.1 x 10 mm (15 implants); 3.7 x 11.5 mm (20 implants); 3.7 x 10 mm (21 implants) *(Tables 4-5)*.

Table 4. Treatment Sites Tapered-Screw Vent Dental Implants.

Maxillary locations	Lateral Incisor	3
	Canine	4
	First premolar	3
	Second premolar	6
	First molar	6
	Second molar	2
Mandibular locations	Lateral Incisor	3
	Canine	6
	First premolar	4
	Second premolar	5
	First molar	10
	Second molar	9
Bone Density	Type I	10
	Type II	15
	Type III	8
	Type IV	4

Table 5. Dimensions and Surfaces of Tapered Screw Vent Dental Implants.

Lengths (mm)	Diameters (mm) ø 3.7 mm	4.1 mm	4.7 mm	Implants
10 mm	21	9	0	30
11.5 mm	20	3	2	25
13 mm	0	1	0	1
Surfaces	Cervical collar			0.5mm Ti machined
	Implant Body (Ti-6Al-4V)			MTX ® Microtextured

One hour before surgery, patients were administered oral prophylactic antibiotics, either amoxicillin (2 g) or clindamycin (600 mg). All implants were inserted under local anesthesia and after flap incision and elevation. Implant insertion torque, measured in newton-centimeters (N/cm), and resonance frequency analysis (RFA) values, measured in implant stability quotient (ISQ) value were recorded at implant placement.

Within 48 hours of implant placement, an abutment was interlocked to the implant, and a temporary prosthesis was cemented to the abutment using provisional luting cement *(Figure 1)*. Occlusion of the restoration was adjusted so that crown did not come into contact with the opposing tooth in both intercuspal and lateral excursive movements. The provisional crown was left in place for about 7 to 14 days to allow soft tissues healing. Subsequently, if the implant appeared clinically stable, definitive ceramo-metal prosthesis was cemented onto the final abutment and the restoration was placed in occlusion *(Figure 2)*. Follow-up examinations were performed at 1, 3, 6, 12 and 18 months, for clinical monitoring and annual hygiene prophylaxis.

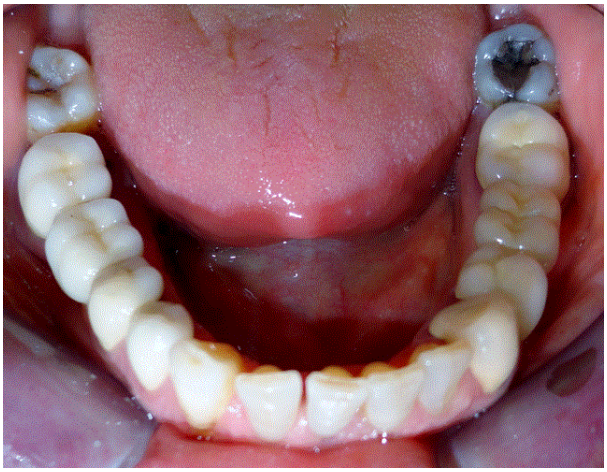

Figure 1. TM Dental Implant; provisional restoration.

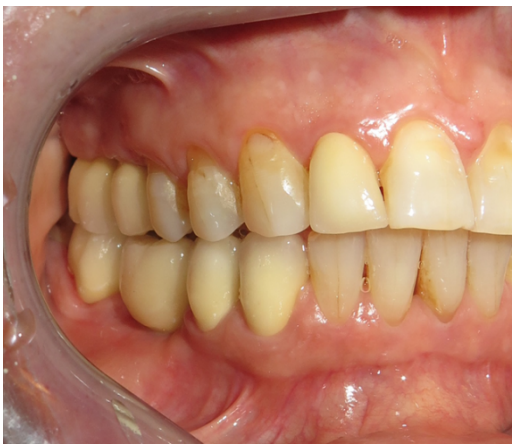

Figure 2. TM Dental Implant; final restoration.

Periapical radiographs were performed for each implant at provisionalization (baseline) *(Figure 3)* and after 6, 12 and 18 months of functioning *(Figure 4)*, perpendicular to the long axis of the implants using a Rinn's XCP (Extension Cone Paralleling) film holding system. All periapical radiographs were provided in JPEG format. Bone levels were measured by calculating the distance from the implant shoulder to the first bone-to-implant contact. Both mesial and distal measurements were made on each periapical radiograph. The known height of the implant was used as the standardized dimension for calibration. Changes in crestal bone levels were summarized by averaging distal and mesial measurements for each radiograph.

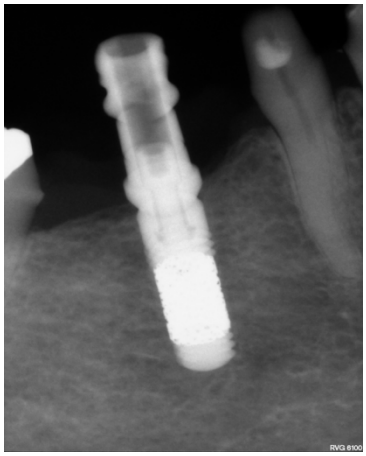

Figure 3. TM Dental Implant placed in the mandible (right first molar); periapical radiograph at baseline.

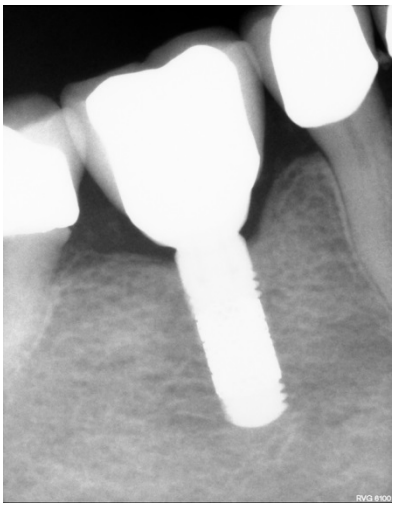

Figure 4. TM Dental Implant; periapical radiograph 18 months after placement.

Results and Discussion

The total number of implants inserted was 87; one Tapered Screw-Vent implant (Group B) was lost before osseointegration and was not included in the statistical analysis,whereas no implant was lost in the Group A (TM). Marginal bone loss was measured on the periapical radiographs [35] after 12 and 18 months. Data were analyzed by descriptive statistics and Student's t-test.

The mean value of marginal bone loss after one year was 0.44 + 0.40 mm for TM implants (Group A) and 0.95 ± 0.62 mm for Tapered Screw-Vent implants (Group B) ($p<0.003$). Mean marginal bone loss after 18 months was 0.46 ± 0.42 mm for Group A and 0.97 ± 0.65 mm for Group B ($p<0.003$) *(Table 6)*.

Hence, data proved to be statistically significant. Therefore, it may be deduced that when implants are immediately loaded, the average loss of marginal bone around the TM implants is lower than that of the Tapered Screw-Vent implants.

Table 6. Marginal bone loss in Group A and Group B.

	TM Implants (Group A)	Taperd Screw-Vent Implants (Group B)
Marginal bone loss at 12 months	0.44 ± 0.40 mm	0.95 ± 0.62 mm
Marginal bone loss at 18 months	0.46 ± 0.42 mm	0.97 ± 0.65mm

These findings are in accordance with previous studies on Zimmer TM and Tapered Screw-Vent implants [36].

The criteria for implant success include the following: (a) absence of persistent pain; (b) absence of peri-implant infection with suppuration; (c) absence of mobility; (d) absence of continuous periimplant radiolucency; (e) peri-implant bone resorption less than 1.5 mm in the first year of function and less than 0.2 mm in the subsequent years [37].

With the exception of the implant not osseointegrated, all implants met these characteristics, with no differences between study and control group.

Osseointegrated dental implants have traditionally been placed in accordance with a 2-stage protocol: implants were submerged and left to heal for a period of 3-4 months in the mandible and 6-8 months in the maxillae. Attempts to early load the implants were associated with increased failure rates [38]. This practice is based on the assumption that the implant micro-movements, caused by the functional forces exerted during wound healing, can induce the formation of fibrous tissue around the implant, rather than bone, leading to clinical failure [39]. Early or immediate implant loading is now a common procedure, particularly in mandibles with good bone quality [40]. A Cochrane systematic review of randomized controlled clinical trials, assessing timing for dental implant loading, suggested that immediately loaded implants, in selected cases, can be just as effective as those loaded after a conventional healing time [41].

Several parameters, such as implant surface and design, implant diameter and length, bone quality and surgical procedures, influence the primary stability of dental implants [42-45]. The decision to immediately load the implant or not is largely based on its primary stability. Resonance frequency analysis technique is a viable means for accurately evaluating implant stability [46]. Furthermore, the possibility of repeating the measurements over time makes it possible to intercept any changes in implant stability during loading. Implants with loss of stability due to an overload can thus be detected before failure occurs.

The possibility of loading the implants immediately after their insertion is a major advantage for patients, because the treatment period may be significantly reduced, and the aesthetic result may be achieved forthwith.

An implant is considered successful when the marginal bone loss is less than 1.5 mm in the first year after loading and less than 0.2 mm/year in the following years [37]. The maintenance of bone tissue around implants is the most important factor in determining long-term implant success, and progressive bone loss dramatically reduces the chances of

survival of dental implants [47]. Among the causes that may lead to marginal bone loss surgical trauma, incongruous occlusal forces, bacterial colonization of the implant-abutment gap and an unsuitable implant design should be mentioned [48]. All these factors should be considered when planning implant rehabilitation.

Zimmer TM implants have rather parallel walls in their central area, because a conical shape would not allow incorporation of the tantalum body to the implant. This could be considered a serious disadvantage, as when a tapered implant is inserted into a straight, under-prepared osteotomy, the bone is compressed, with a consequent improvement in primary stability; this obviously cannot happen with a cylindrical implant. This could be a limitation especially in the rehabilitation of the upper jaw, where there is a lower bone density [49]. Nevertheless, in our study, the tantalum body was found to give the implant an optimal primary and secondary stability.

Conclusions

Immediate loading is a safe and efficacious procedure when measured in terms of implant survival. It reduces treatment time and patient discomfort, while ensuring a high predictability and good aesthetic results. Within the limitations of this study, it is possible to assert that immediate loading of Zimmer TM implants gives satisfying results in terms of success and marginal bone loss.

Conflict of Interest

Authors declare no conflict of interest.

References

1. Spector M. Historical review of porous-coated implants. *J Arthroplasty*. 1987; **2**: 163–177.

2. Brentel AS, Vasconcellos LMR, Oliveira MV, et al. Histomorphometric analysis of pure titanium implants with porous surface versus rough surface. *J Appl Oral Sci*. 2006; **14**: 213–218.

3. Pilliar RM. Porous surfaced endosseous dental implants: fixation by bone ingrowth. *Univ Tor Dent J*. 1988; **1**: 10–15.

4. Schroeder A, van der Zypen E, Stich H, Sutter F. The reactions of bone,connective tissue,and epithelium to endosteal implants with titanium-sprayed surfaces. *J Maxillofac Surg*. 1981; **9**: 15–25.

5. Liu X, Lim JY, Donahue HJ, Dhurgati R, Mastro AM, Vogler EA. Influence of substratum surface chemistry/ energy and topography on the human fetal osteoblastic cell line hFOB 1.19: phenotypic and genotypic responses observed in vitro. *Biomaterials*. 2007; **28**: 4535–4550.

6. Vandamme K, Naert I, Sloten JV, Puers R, Duyck J. Effect of implant surface roughness and loading on peri-implant bone formation. *J Periodontol*. 2008; **79**: 150–157.

7. Hulbert SF, Cooke FW, Klawitter JJ, et al. Attachment of prostheses to the musculoskeletal system by tissue ingrowth and mechanical interlocking. *J Biomed Mater Res*. 1973; **7**: 1–23.

8. Bobyn JD, Pilliar RM, Cameron HU, Weatherly GC. The optimum pore size for the fixation of porous-surfaced metal implants by the ingrowth of bone. *Clin Orthop Relat Res*. 1980; **150**: 263–270.

9. Karageorgiou V, Kaplan D. Porosity of 3D biomaterial scaffolds and osteogenesis. *Biomaterials*. 2005; **26**: 5474–5491.

10. Hacking SA, Bobyn JD, Toh KK, Tanzer M, Krygier JJ. Fibrous tissue ingrowth and attachment to porous tantalum. *J Biomed Mater Res*. 2000; **52**: 631–638.

11. Zardiackas LD, Parsell DE, Dillion LD, Mitchell DW, Nunnery LA, Poggie R. Structure, metallurgy, and mechani- cal properties of a porous tantalum foam. *J Biomed Mater Res*. 2001; **58**: 180–187.

12. Wigfield C,Robertson J,Gill S,Nelson R.Clinical experience with porous tantalum cervical interbody implants in a pro- spective randomized controlled trial. *Br J Neurosurg*. 2003; **17**: 418–425.

13. Nasser S, Poggie RA. Revision and salvage patellar arthroplasty using a porous tantalum implant. *J Arthroplasty*. 2004; **19**: 562–572.

14. Bobyn JD, Poggie RA, Krygier JJ, et al. Clinical validation of a structural porous tantalum biomaterial for adult reconstruction. *J Bone Joint Surg Am*. 2004; **86**-A(Suppl 2): 123–129.

15. Shimko DA, Shimko VF, Sander EA, Dickson KF, Nauman EA. Effect of porosity on the fluid flow characteristics and mechanical properties of tantalum scaffolds. *J Biomed Mater Res B Appl Biomater*. 2005; **73**: 315–325.

16. Tsao AK, Roberson JR, Christie MJ, et al. Biomechanical and clinical evaluations of a porous tantalum implant for the treatment of early-stage osteonecrosis. *J Bone Joint Surg Am*. 2005; **87**: 22–27.

17. Unger AS, Lewis RJ, Gruen T. Evaluation of a porous tantalum uncemented acetabular cup in revision total hip arthroplasty. Clinical and radiological results of 60 hips. *J Arthroplasty*. 2005; **20**: 1002–1009.

18. Levine B, Della Valle DJ, Jacobs JJ. Applications of porous tantalum in total hip arthroplasty. *J Am Acad Orthop Surg*. 2006; **14**: 646–655.

19. Macheras GA, Papagelopoulos PJ, Kateros K, Kostakos AT, Baltas D, Karachalios TS. Radiological evaluation of the metal-bone interface of a porous tantalum monoblock acetabular component. *J Bone Joint Surg*. 2006; **88-B**: 304– 309.

20. Levine BR, Sporer S, Poggie RA, Della Valle CJ, Jacobs JJ. Experimental and clinical performance of porous tantalum in orthopedic surgery. *Biomaterials*. 2006; **27**: 4671– 4681.

21. Cohen RA. A porous tantalum trabecular metal: basic science. *Am J Orthop*. 2002; **31**: 216–217.

22. Bobyn JD, Stackpool GJ, Hacking SA, Tanzer M, Krygier J. Characteristics of bone ingrowth and interface mechanics of a new porous tantalum biomaterial. *J Bone Joint Surg Br*. 1999; **81**: 907–914.

23. Bobyn JD. Fixation and bearing surfaces for the next millennium. *Orthop*. 1999; **22**: 810-812.

24. Bencharit S, Byrd WC, Altarawneh S, Hosseini B, Leong A, Reside G, Morelli T, Offenbacher S. Development and Applications of Porous Tantalum Trabecular Metal-Enhanced Titanium Dental Implants. *Clin Implant Dent Relat Res*. 2013 Mar 25. [Epub ahead of print].

25. Miyazaki T, Kim HM, Kokubo T, Miyaji F, Kato H, Nakamura T. Effect of thermal treatment on apatite-forming ability of NaOH-treated tantalum metal. *J Mater Sci Mater Med*. 2001 Aug; **12**: 683-7.

26. Den Hartog L, Meijer HJ, Stegenga B, Tymstra N, Vissink A, Raghoebar GM. Single implants with different neck designs in the aesthetic zone: a randomized clinical trial. *Clin Oral Implants Res*. 2011; **22**: 1289-97.

27. Brånemark P-I. Introduction to osseointegration. In Brånemark PI, Zarb GA, and Albrektsson T (Eds.) Tissue-Integrated Prostheses. Osseointegration in Clinical Dentistry. Chicago, IL: Quintessence Publishing Co, Inc, 1985: 11-76.

28. Black J. Biological Performance of Tantalum. *Clin Mater*. 1994; **16**: 167-173.

29. Bellinger DH. Preliminary Report on the Use of Tantalum in Maxillofacial and Oral Surgery. *J Oral Surg*. 1947; **5**: 108-122.

30. Burke GL. The corrosion of metals in tissues; and an introduction to tantalum. *Can Med Ass J*. 1940; **43**: 125.

31. Matsuno H, Yokoyama A, Watari F, Uo M, Kawasaki T. Biocompatibility and osteogenesis of refractory metal implants,

titanium, hafnium, niobium, tantalum, and rhenium. *Biomaterials*. 2001; **22**: 1253-1262.

32. Welldon KJ, Atkins GJ, Howie DW, Findlay DM. Primary human osteoblasts grow into porous tantalum and maintain an osteoblastic phenotype. *J Biomed Mater Res A*. 2008; **84**: 691-701.

33. Venable CS, Stuck WG. A general consideration of metals for buried appliances in surgery. Int Abst Surg. 1943; **66**: 297-304

34. Bobyn JD, Toh KK,Hacking SA, Tanzer M, Krygier JJ. Tissue response to porous tantalum acetabular cups: a canine model. *J Arthroplasty*. 1999; **14**: 347–354.

35. Mamoun JS. Assembly and clinical use of the XCP dental x-ray film holder and orientation devices in dentistry. *Dent Assist*. 2011; **80**: 8,10, 12-4 passim.

36. Schlee M1, van der Schoor WP, van der Schoor AR. Immediate Loading of Trabecular Metal-Enhanced Titanium Dental Implants: Interim Results from an International Proof-of-Principle Study. *Clin Implant Dent Relat Res*. 2013 Jul 30. doi: 10.1111/cid. 12127. [Epub ahead of print]

37. Albrektsson T, Zarb G, Worthington P, Eriksson AR. The long-term efficacy of currently used dental implants: a review and proposed criteria of success. *Int J Oral Maxillofac Implants*. 1986; **1**: 11-25.

38. Branemark PI, Hansson BO, Adell R, et al. Osseointegrated implants in the treatment of the edentulous jaw. Experience from a 10 year period. *Scand J Plast Reconstr Surg Suppl*. 1977; 16: 1e132.

39. Adell R, Lekholm U, Rockler B, Branemark PI. A 15 year study of osseointegrated implants in treatment of edentulous jaw. *Int J of Oral Surg*. 1981; **10**: 387e416.

40. Branemark PI, Engstrand P, Ohrnell LO, et al. Branemark Novum: a new treatment concept for rehabilitation of the edentulous mandible. Preliminary results from a prospective clinical follow up study. *Clin Implant Dent Relat Res*. 1999; **1**: 2e16.

41. Esposito M, Grusovin MG, Willings M, Coulthard P, Worthington HV. Interventions for replacing missing teeth: different times for loading dental implants. *Cochrane Database Syst Rev*. 2007; **18**: CD003878.

42. Monje A1, Suarez F, Garaicoa CA, Monje F, Galindo-Moreno P, García-Nogales A, Wang HL Effect of location on primary stability and healing of dental implants. *Implant Dent*. 2014; **23**: 69-73.

43. Cassetta M, Pranno N, Pompa V, Barchetti F, Pompa G. High resolution 3-T MR imaging in the evaluation of the trigeminal nerve course. *Eur Rev Med Pharmacol Sci*. 2014;**18**: 257-64.

44. Brauner E, Valentini V, Jamshir S, Battisti A, Guarino G, Cassoni A, Gaimari G, Fadda MT, Di Carlo S, Pompa G. Two clinical cases of prosthetical rehabilitation after a tumor of the upper maxilla. *Eur Rev Med Pharmacol Sci*. 2012; **16**: 1882-90.

45. Cassetta M, Di Carlo S, Pranno N, Stagnitti A, Pompa V, Pompa G. The use of high resolution magnetic resonance on 3.0-T system in the diagnosis and surgical planning of intraosseous lesions of the jaws: preliminary results of a retrospective study. *Eur Rev Med Pharmacol Sci.* 2012; **16**: 2021-8.

46. Sul YT, Johansson CB, Jeong Y, Wennerberg A, Albrektsson T. Resonance frequency and removal torque analysis of implants with turned and anodized surface oxides. *Clin Oral Implants Res.* 2002; **13**: 252-9.

47. Horowitz R. Current Implant Designs to Maintain Crestal Bone and Gingiva. *Functional Esthetics & Restorative Dentistry*. 2008; **1**: 88-90.

48. Bignozzi, I., Ciobanu, G., Quaranta, A., Pompa, G. Dental implant sites in healthy versus diabetic subjects: A two-year clinical and bacteriological assessment. *Eur J Inflam*. 2013; **11**: 813-23.

49. Rokn AR, Rasouli Ghahroudi AAR., Mesgarzadeh A., Miremadi AA.,. Yaghoobi S. Evaluation of Stability Changes in Tapered and Parallel Wall Implants: A Human Clinical Trial. *Journal of Dentistry of Tehran University of Medical Sciences* 2011; **8**: 37-42.