Odontology
DOI 10.1007/s10266-012-0084-z

CASE REPORT

Peri-implant bone tissues around retrieved human implants after time periods longer than 5 years: a retrospective histologic and histomorphometric evaluation of 8 cases

Giovanna Iezzi · Adriano Piattelli · Carlo Mangano · Jamil A. Shibli · Giovanni Vantaggiato · Massimo Frosecchi · Claudio Di Chiara · Vittoria Perrotti

Received: 19 September 2011 / Accepted: 4 August 2012

Abstract Only rarely, it is possible to find in the literature histological reports of human retrieved implants, especially after several years of functional loading. These implants can help us in understanding the reactions of peri-implant bone. The aim of this study was to perform a histologic and histomorphometric analysis of the peri-implant tissues behavior and of the bone–titanium interface in titanium dental implants retrieved from patients after time periods longer than 5 years. The archives of the Implant Retrieval Center of the Dental School of the University of Chieti-Pescara, Italy were searched for human dental implants, retrieved after a loading period of more than 5 years. A total of 8 implants were found: 3 of these had been retrieved after 5 years, 1 after 6 years, one after 10 years, 1 after 14 years, 1 after 18 years, 1 after 22 years. Only the bone to implant contact in the three best threads was evaluated. Compact, mature, lamellar bone, with few and small marrow spaces, was present around the implants. Osteons with Haversian canals were present inside some threads, in close proximity to the interface, at both cortical and trabecular regions. Other osteons had a direction perpendicular to the direction of the long axis of the implants. Numerous reversal lines were present. At higher magnification, no gaps or fibrous, connective tissues were present at the interface. The BIC of the three best threads for all implants varied from 94 to 100 %.In conclusion, within the limitations of the present report histology showed that implants with different surfaces all presented the potential to maintain osseointegration over a long period, with a continuous remodeling at the interface, as indicated by the presence of reversal lines.

Keywords Bone remodeling · Human histology · Implant surfaces · Retrieved dental implants

G. Iezzi · A. Piattelli (✉) · V. Perrotti
Dental School, University of Chieti-Pescara, Via Dei Vestini 31, 66100 Chieti, Italy
e-mail: apiattelli@unich.it

G. Iezzi
e-mail: gio.iezzi@unich.it

C. Mangano
Private Practice, Gravedona (Como), Italy

J. A. Shibli
Department of Periodontology, Dental Research Division, Guarulhos University (UnG), Guarulhos, SP, Brazil

G. Vantaggiato
Private Practice, Lecce, Italy

M. Frosecchi
Private Practice, Florence, Italy

C. Di Chiara
Private Practice, Venice, Italy

Introduction

Retrieved implants are usually removed for failure [1]. Reasons for retrieval of osseointegrated and clinically stable implants are varied, i.e. fractures, psychological reasons, implants impossible to restore prosthetically, dysesthesia, or implants retrieved at autopsy [2–4]. In almost all of these cases, the retrieved implants have an excellent bone anchorage [2–4]. These implants can help us in understanding the reactions of peri-implant bone [2–4]. The evidence quality of in vitro and experimental animal studies, performed for the evaluation of different implant macrogeometries, surface topographies, loading conditions, implant insertion in different bone qualities and quantities, is relevant, but lower than in vivo studies on patients, and the results of such studies cannot always be transferred to a human situation [2–4]. The evaluation of retrieved human dental implants can be a useful information source.

The term "osseointegration" is clinical and is based for the most part on the stability of the implants. The precise value of bone to implant contact (BIC) necessary for an implant to be osseointegrated and stable is still unknown [2, 4]. Only the histological evaluation of human retrieved implants allows a complete analysis and understanding of the occurrences at the bone–implant interface [5, 6].

However, in the literature is it possible to find histological case reports of human retrieved implants after several years of functional loading [3, 9–14, 16, 18–20, 23–25], more rarely case series [2, 7, 8, 15, 17, 21, 22, 26] as well as long-term human data on a large sample size [1]. It could also, probably, be interesting and useful to study the healing events at the interface after different time periods [21]. A histological and histomorphometrical evaluation of a series of implants could help to give some answers [2, 4]. Studies reporting human retrieved implants, after in vivo loading periods ranging from months to years, have shown different degrees of BIC and structural organization of the peri-implant bone [2, 4, 8, 10, 11, 13, 14, 17, 19, 23]. The continuous observed bone remodeling could allow an evaluation of how bone responds to different loads, implant geometries and implant surfaces [27]. Macroretention offered by implant threads can reduce the risk of implant movements.

The aim of the present report was a histologic and histomorphometric analysis of the peri-implant tissues reactions and of the bone–titanium interface in titanium dental implants retrieved from human patients after time periods longer than 5 years.

Cases

The archives of the Implant Retrieval Center of the Dental School of the University of Chieti-Pescara, Italy were searched for human dental implants, retrieved after a loading period of more than 5 years. A total of 8 implants were found: 3 of these had been retrieved after 5 years, 1 after 6 years, 1 after 10 years, 1 after 14 years, 1 after 18 years, 1 after 22 years: the most important features of all these implants were reported in Table 1. Seven implants had been loaded, while 1 had been left unloaded for 18 years; none has been immediately loaded. In all the cases, but one (the 1 removed after 18 years, which was left unloaded because prosthetically unrestorable), the implants had supported partial fixed bridges. Implant #1 had been retrieved following a mandibular resection, implants #2, 7 and 8 for problems with the prosthetic superstructure, implant #3 for misalignment, implants #4 and 5 for fracture and implant #6 for psychological reasons. Two implants were located in the maxilla and 6 implants in the mandible. All these implants were stable before retrieval. All the implants had been retrieved with a 5 mm trephine bur.

Specimen processing. All the specimens were washed in saline solution and immediately fixed in 4 % paraformaldehyde and 0.1 % glutaraldehyde in 0.15 M cacodylate buffer al 4 °C and pH 7.4, to be processed for histology. The specimens were processed to obtain thin ground sections with the Precise 1 Automated System (Assing, Rome, Italy) [28]. The specimens were dehydrated in an ascending series of alcohol rinses and embedded in a glycolmethacrylate resin (Technovit 7200 VLC, Kulzer, Wehrheim, Germany). After polymerization, the specimens were sectioned, along their longitudinal axis, with a high-precision diamond disk at about 150 μm and ground down to about 30 μm with a specially designed grinding machine. A total of two slides were obtained for each specimen. The slides were stained with acid Fuchsin and toluidine blue. The slides were observed in normal transmitted light under a Leitz Laborlux microscope (Leitz, Wetzlar, Germany) and polarized-light microscopy (Leitz, Wetzlar, Germany).

Histomorphometry of bone–implant contact (BIC) percentages in the three best threads of all implants was

Table 1 Implant feature

Implant	Implant system	Specifics	Loading (years)	No. of implants	Area	BIC (%) Three best threads	Sex	Reason for retrieval
1	Branemark	Machined	22	1	Mandible	100	Male	Mandibular resection
2	Branemark	Machined	18	1	Maxilla	100	Male	Prosthetic
3	Leader	AE	5	1	Mandible	94	Male	Misalignment
4	Leader	AE	10	1	Mandible	–	Female	Fracture
5	Screw-vent		14	1	Mandible	100	Female	Fracture
6	De Bortoli	Sandblasted/AE	5	1	Mandible	100	Male	Psychological
7	De Bortoli	Sandblasted/AE	6	1	Mandible	100	Female	Prosthetic
8	De Bortoli	Sandblasted/AE	5	1	Mandible	100	Male	Prosthetic

AE acid-etched

carried out using a light microscope (Laborlux S, Leitz, Wetzlar, Germany) connected to a high-resolution video camera (3CCD, JVC KY-F55B, JVC®, Yokohama, Japan) and interfaced to a monitor and PC (Intel Pentium III 1200 MMX, Intel®, Santa Clara, CA, USA). This optical system was coupled to a digitizing pad (Matrix Vision GmbH, Oppenweiler, Germany) and a histometry software package with image capturing capabilities (Image-Pro Plus 4.5, Media Cybernetics Inc., Immagini & Computer Snc Milan, Italy).

The histomorphometrical analysis has not been undertaken on the entire length of the implants due to problems in the retrieval procedure, which lead to the presence of only fragments of tissue at the interface of some samples or to the absence of some implant threads.

Compact, mature, lamellar bone, with few and small marrow spaces, was present around the implants (Fig. 1). Many remodeling areas (arrows) were detected (Fig. 2). In all implants, bone with ongoing apposition and resorption phenomena was present inside the threads. This bone has a lamellar configuration, with the lamellae organized in different directions. Osteons with Haversian canals were present inside some threads, in close proximity to the interface, at both cortical and trabecular regions (Figs. 3, 4). Other osteons had a direction perpendicular to the direction of the long axis of the implants. Numerous reversal lines were present. At higher magnification, many osteocytes were observed in the peri-implant bone, close to the implant surface. No epithelial proliferation, no calculus or bacterial aggregates were present on any of the implants for their entire length. No inflammatory or multinucleated giant cells were present. At higher magnification, no gaps or fibrous, connective tissues were could be observed at the interface (Fig. 5). The BIC was evaluated in the three best threads because the interface of same samples was partially damaged. The values varied from 94 to 100 % (Figs. 6, 7).

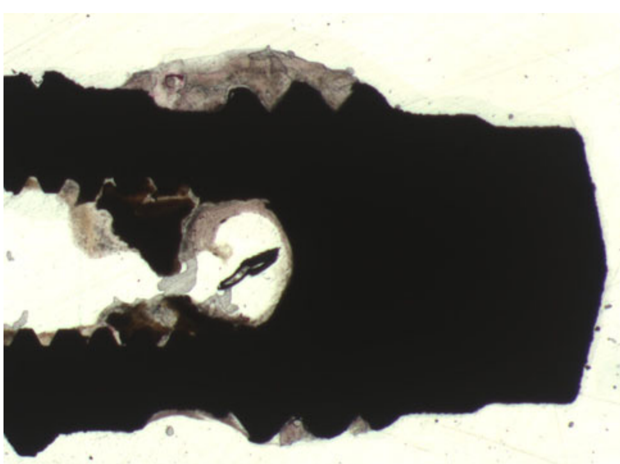

Fig. 1 Implant 2. Compact, mature bone was present around in the middle portion of the implant. The apical bone was lost due to the retrieval procedure. Acid Fuchsin–toluidine blue ×12

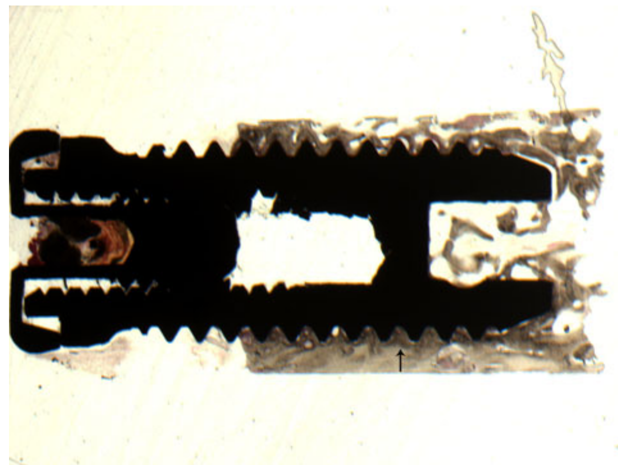

Fig. 2 Implant 1. Compact, mature bone, with many remodeling areas (*arrow*) was present around the middle and apical portion of the implant. Acid Fuchsin–toluidine blue ×8

Fig. 3 Implant 6. Osteons with Haversian canals were present inside some threads, in close proximity to the interface. The transversally oriented collagen fibers are indicated by an *arrow*. Acid Fuchsin–toluidine blue ×40

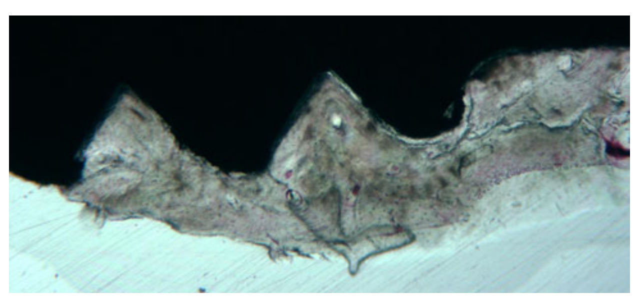

Fig. 4 Implant 2. Numerous reversal lines can be observed. Acid Fuchsin–toluidine blue ×40

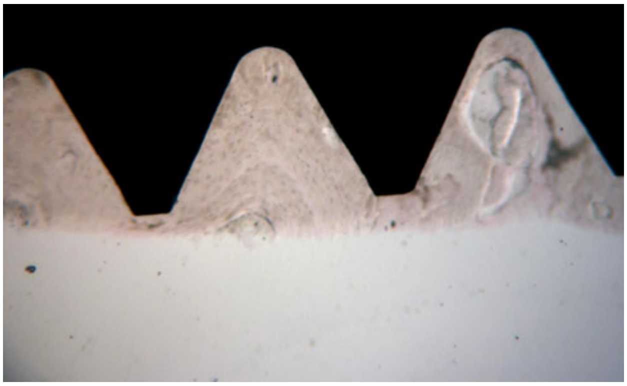

Fig. 5 Implant 5. Compact bone with small marrow spaces can be observed in tight contact with the implant surface with no gaps at the interface. Acid Fuchsin–toluidine blue ×40

Fig. 6 Implant 4. Compact, mature bone is present along the implant perimeter. No connective tissue can be observed. Acid Fuchsin–toluidine blue ×8

Discussion

One of the most important questions to be answered is the compatibility and long-term success of the most common implant surfaces [4]. The quality of the submitted material of retrieved human specimens may vary and it can happen that, due to problems in the fixation or to the difficulties during the retrieval procedure, sometimes only fragments of tissue can be present at the interface [4].

In some cases, bone is completely lost, and some of the threads can be cut, or even there could be a lack of the whole section of the implant and thus a complete analysis of bone–implant interface is not possible. Unfortunately, due to the above limitations regarding the small sample size and the difficulties in the retrieval procedure in the present report, the interface was partially damaged, and therefore it has been decided to evaluate the BIC only around the three best threads of all these implants rather than to the entire perimeter [29–32]. Indeed the BIC of the implants evaluated in the present study vary between 35 and 88 %; the lowest values have been detected in the implants that were subjected to problems during the retrieval procedure.

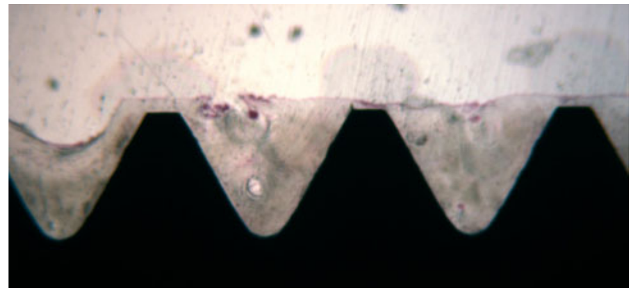

Fig. 7 Implant 7. Bone is present inside the concavities and the convexities of the implant threads. Inside some threads osteons can be observed. Acid Fuchsin–toluidine blue ×40

Implant surface features represent the factors that affect the peri-implant bone response and the mechanical quality of the interface [33]. In the present specimens, different surfaces were evaluated: machined, acid-etched, and finally sandblasted and acid-etched surfaces. In all cases, the BIC of the three best threads was very high, with no important variations between the different surfaces; it could be hypothesized that this was due to the long-term healing period. Indeed, surface characteristics may be crucial in the early healing phases, but their influence ease over time [33].

Traini et al. [12, 14] showed a strong correlation between compressive stresses and collagen fibers orientation, and, in fact, in the dental implant removed after 5 years of functional loading, it was possible to observe a change in the microstructure of the bone, with an increase in the transversally oriented collagen fibers. The orientation of the collagen fibers was strictly dependent on the shape of the implant. Bone remodeling areas were frequently observed in the peri-implant bone of these implants. It has been shown that remodeling cycles are necessary to obtain a high level of the organization of the peri-implant bone that shows good mechanical properties [27, 34]. The present results indicated that after many years of functional loading, all these retrieved implants were well integrated and presented high BIC, with no trace of fibrous connective tissue at the bone-implant interface or the presence of a downgrowth of the epithelium. This fact is very important because the efficacy of any given implant is related to a large part on the stability and integration between implant and bone [5]. The peri-implant bone had undergone remodeling as indicated by the presence of Haversian systems near the implant bone interface.

The long-term maintenance of osseointegration seems to be closely related to a continuous and adequate remodeling around the implants, with bone restructuring having an important role in the anchoring of the implant [5, 25, 34–36]. Functional loads produce strains in the bone that play an important role in the adaptation of bone, and, when microstrains are limited to a certain amount, they may produce a better mineralization of the bone at the interface with the implant [34–36]. In all the present specimens, no untoward effects were present at the interface after several years as far as the three best threads.

In conclusion, the present histological results confirmed that implants with different surfaces all presented the potential to maintain osseointegration over a long period, with a continuous remodeling at the interface.

Acknowledgments This work was partially supported by the Ministry of Education, University, Research (M.I.U.R.), Rome, Italy.

Conflict of interest The authors declare that they have no conflict of interest.

References

1. Proussaefs P, Olivier HS, Lozada J. Histologic evaluation of a 12-year-old threaded hydroxyapatite-coated implant placed in conjunction with subantral augmentation procedure: a clinical report. J Prosthet Dent. 2004;92:17–22.
2. Coelho PG, Marin C, Granato R, Suzuki M. Histomorphologic analysis of 30 plateau root form implants retrieved after 8 to 13 years in function. A human retrieval study. J Biomed Mater Res Appl Biomater. 2009;91B:975–79.
3. Sakakura LE, Nociti FH Jr, Mello GP, de Mello ED, de Rezende ML. Histomorphometric evaluation of a threaded, sandblasted, acid-etched implant retrieved from a lower human jaw: a case report. Implant Dent. 2005;14:289–93.
4. Bolind PK, Johansson CB, Becker W, Langer L, Sevetz EB Jr, Albrektsson TO. A descriptive study of retrieved non-threaded and threaded implant designs. Clin Oral Implants Res. 2005;16:447–55.
5. Testori T, Szmukler-Moncler S, Francetti L, Del Fabbro M, Scarano A, Piattelli A, Weinstein RL. Immediate loading of Osseotite implants: a case report and histologic analysis after 4 months of occlusal loading. Int J Periodontics Restorative Dent. 2001;21:451–9.
6. Testori T, Szmukler-Moncler S, Francetti L, Del Fabbro M, Trisi P, Weinstein RL. Healing of Osseotite implants under submerged and immediate loading conditions in a single patient: a case report and interface analysis after 2 months. Int J Periodontics Restorative Dent. 2002;22:345–53.
7. Uehara T, Takaoka K, Ito K. Histological evidence of osseointegration in human retrieved fractured hydroxyapatite-coated screw-type implants: a case report. Clin Oral Implant Res. 2004;15:540–5.
8. Trisi P, Emanuelli M, Quaranta M, Piattelli A. A light microscopy, scanning electron microscopy and laser scanning microscopy analysis of retrieved blade implants after 7 to 20 years of clinical function. J Periodontol. 1993;64:374–8.
9. Piattelli A, Trisi P, Romasco N, Emanuelli M. Histological analysis of a screw implant retrieved from man: influence of early loading and primary stability. J Oral Implantol. 1993;19:303–6.
10. Piattelli A, Scarano A, Paolantonio M. Immediately loaded screw implant removed for fracture after a 15-year loading period: histological and histochemical analysis. J Oral Implantol. 1997;23:75–9.
11. Degidi M, Scarano A, Iezzi G, Piattelli A. Histologic and histomorphometric analysis of an immediately loaded implant retrieved from man after 14 months of loading. J Long Term Effects Med Implant. 2005;15:489–98.
12. Traini T, De Paoli S, Caputi S, Iezzi G, Piattelli A. Collagen fibers orientation near a fractured dental implant after a 5 years loading period: a case report. Implant Dent. 2006;15:70–6.
13. Di Stefano D, Iezzi G, Scarano A, Perrotti V, Piattelli A. Immediately loaded blade implant retrieved from man after a 20 years loading period: a histological and histomorphometrical case report. J Oral Implantol. 2006;32:171–6.
14. Traini T, Iezzi G, Pecora G, Piattelli A. Preferred collagen fiber orientation in the human peri-implant bone after short and long-term loading periods: a case report. J Oral Implantol. 2006;32:177–81.
15. Iezzi G, Scarano A, Petrone G, Piattelli A. Two human hydroxyapatite-coated dental implants retrieved after a 14 years loading period. A histologic and histomorphometric case report. J Periodontol. 2007;78:940–7.
16. Iezzi G, Scarano A, Mangano C, Cirotti PA. Histologic results in a human implant retrieved for fracture 5 years after insertion in a sinus augmented with anorganic bovine bone: a case report. J Periodontol. 2008;79:192–8.
17. Vantaggiato G, Iezzi G, Fiera E, Perrotti V, Piattelli A. A histological and histomorphometrical case report of 3 immediately loaded screw implants retrieved from man after a 3 years loading period. Implant Dent. 2008;19:192–9.
18. Iezzi G, Orlandi S, Pecora G, Piattelli A. Histologic and histomorphometric evaluation of the bone response around an hydroxyapatite-coated implant retrieved after 15 years. Int J Periodont Restorative Dent. 2009;29:99–105.
19. Iezzi G, Pecora G, Scarano A, Perrotti V, Piattelli A. Immediately loaded screw implant retrieved from man after a 12 years loading period: a histological and histomorphometrical case report. J Osseointegrat. 2009;2:54–9.
20. Rohrer MD, Sobczack RR, Prasad HS, Morris HF. Postmortem histologic evaluation of mandibular titanium and maxillary hydroxyapatite-coated implants from 1 patient. Int J Oral Maxillofac Implants. 1999;14:579–86.
21. Proussaefs P, Lozada J, Ojano M. Histologic evaluation of threaded HA-coated root-form implants after 3.5 to 11 years of function: a report of three cases. Int J Periodont Restorative Dent. 2001;21:21–9.
22. Proussaefs PT, Tatakis DN, Lozada J, Caplanis N, Rohrer MD. Histologic evaluation of hydroxyapatite-coated root-form implants retrieved after 7 years in function: a case report. Int J Oral Maxillofac Implants. 2000;15:438–43.
23. Proussaefs P. Histologic evaluation of an immediately loaded titanium provisional implant retrieved after functioning for 18 months: a clinical report. J Prosthet Dent. 2003;89:331–4.
24. Block MS, Finger IM, Misiek DJ. Histologic examination of a hydroxyapatite-coated implant nine years after placement. J Oral Maxillofac Surg. 1996;54:1023–6.
25. Stellino G, Landi L. A 6-year unloaded hydroxyapatite-coated dental implant placed into an extraction socket in conjunction with non resorbable hydroxyapatite grafting material: histologic evaluation. Int J Periodont Restorative Dent. 2002;22:575–81.
26. Ledermann PD, Schenk RK, Buser D. Long-lasting osseointegration of immediately loaded bar-connected TPS screws after 12 years of function: a histologic case report of a 95-year-old patient. Int J Periodontics Restorative Dent. 1998;18:553–63.

27. Degidi M, Scarano A, Piattelli M, Perrotti V, Piattelli A. Bone remodeling in immediately loaded and unloaded titanium implants: a histologic and histomorphometric study in man. J Oral Implantol. 2005;31:18–24.
28. Piattelli A, Scarano A, Quaranta M. High-precision, cost-effective cutting system for producing thin sections of oral tissues containing dental implants. Biomaterials. 1997;18:577–9.
29. Jemt T, Lekholm U, Johansson CB. Bone response to implant-supported frameworks with differing degrees of misfit preload: in vivo study in rabbits. Clin Implant Dent Relat Res. 2000;2:129–37.
30. Johnsson AA, Sawaii T, Jacobsson M, Granström G, Turesson I. A histomorphometric and biomechanical study of the effect of delayed titanium implant placement in irradiated rabbit bone. Clin Implant Dent Relat Res. 2000;2:42–9.
31. Wennerberg A, Hallgren C, Johansson C, Danelli S. A histomorphometric evaluation of screw-shaped implants each prepared with two surface roughnesses. Clin Oral Implants Res. 1998;9:11–9.
32. Stenport VF, Olsson B, Morberg P, Törnell J, Johansson CB. Systemically administered human growth hormone improves initial implant stability: an experimental study in the rabbit. Clin Implant Dent Relat Res. 2001;3:135–41.
33. Junker R, Dimakis A, Thoneick M, Jansen JA. Effects of implant surface coatings and composition on bone integration: a systematic review. Clin Oral Implant Res. 2009;20(Suppl 4):185–206.
34. Jayme SJ, Ramos de Oliveira R, Muglia VA, Novaes AB, Ribeiro RF. The effect of different loading times on the bone response around dental implants: a histomorphometric study in dogs. Int J Oral Maxillofac Implants. 2010;25:473–81.
35. Misch CE, Bidez MW, Sharawy M. Bioengineered implant for a predetermined bone cellular response to loading forces. A literature review and case reports. J Periodontol. 2001;72:1276–86.
36. Garetto LP, Chen J, Parr AJ, Roberts WE. Remodeling dynamics of bone supporting rigidly fixed titanium implants: a histomorphometric comparison in four species including humans. Implant Dent. 1995;4:235–43.