Radiographic Evaluation of Marginal Bone Levels Around Platform-Switched and Non–Platform-Switched Implants Used in an Immediate Loading Protocol

Roberto Crespi, MD, MS[1]/Paolo Capparè, MD[2]/Enrico Gherlone, MD, DDS, PhD[3]

Purpose: *The aim of this clinical study was to assess the marginal bone around two different types of implant-abutment junctions—a so-called platform-switched assembly and a conventional external-hexagon connection—after 24 months.* ***Materials and Methods****: Forty-five patients were included in this prospective study. All selected patients required the extraction of one or two hopeless teeth in maxillary and mandibular region monoradicular and second premolar teeth, and were randomly assigned to one of two groups. The first group received 34 implants with an external-hexagon junction with the abutment and the second group received 30 implants with platform-switched abutments. Implants were positioned immediately after tooth extraction and were loaded immediately.* ***Results:*** *After 24 months, a cumulative survival rate of 100% was reported for all implants. The platform-switching group showed a mean bone loss of 0.78 ± 0.49 mm and the external-hexagon group showed a mean bone loss of 0.73 ± 0.52 mm (no statistically significant difference between groups).* ***Conclusion:*** *The results of this study indicate that implants placed immediately in fresh extraction sockets and loaded immediately represent a predictable procedure, with no differences in bone level changes between "platform-switched" and conventional external-hexagon implants after 24 months.*
Int J Oral Maxillofac Implants 2009;24:920–926

Key words: *dental implants, immediate loading, implant-abutment junction, marginal bone loss, platform switching*

To preserve alveolar bone from resorption following healing of extraction sockets, different authors[1–4] have placed dental implants into fresh extraction sockets, obtaining high success rates. Covani et al[5] analyzed bone remodeling around 15 implants placed immediately after tooth removal. They observed the healing of coronal bone around immediate implants, which involved new bone apposition around the neck of the implants and, at the same time, bone resorption with a reduction in the horizontal width of the bone ridge.

Likewise, bone preservation and soft tissue management around implants represent important esthetic concerns for patients. To maintain an excellent esthetic profile of the soft tissues around implant-supported restorations, various authors[6–8] have provided immediate loading (occlusal load applied to provisional crowns placed on implants immediately after loading) of implants placed in fresh extraction sockets in anterior (premolar to premolar) regions. Survival rates of 100% and minimal bone crestal loss were reported.

The remodeling of crestal bone occurs in response to the stress that develops between the neck of an implant system and the cortical bone. Since cortical bone is 65% more susceptible to shear forces than compressive forces,[9] the bone loss may be explained by the lack of mechanical stress distribution between the coronal region of the implant and the surrounding bone.[10] Different studies[11–13] have reported a positive correlation between surface roughness parameters and interfacial shear strength, suggesting that retentive elements such as microthreads at the implant neck may counteract marginal bone resorption.

[1]Researcher, Department of Dentistry, Vita Salute University, San Raffaele Hospital, Milano, Italy.
[2]Clinician, Department of Dentistry, Vita Salute University, San Raffaele Hospital, Milano, Italy.
[3]Full Professor and Chairman, Department of Dentistry, Vita Salute University, San Raffaele Hospital, Milano, Italy.

Correspondence to: Dr Roberto Crespi, Department of Dentistry, Vita Salute University, San Raffaele Hospital, Via Olgettina N 48, 20123 Milano, Italy. Email: robcresp@libero.it

The loss of crestal bone may also be influenced by the relationship of the implant-abutment junction (IAJ) to the crestal bone. Several authors[14–16] have demonstrated that when the IAJ is positioned deeper within the bone, vertical crestal bone loss increases.

When an implant and an abutment of matching diameters are used, the inflammatory cell infiltrate is located at the outer edge of the IAJ near to the crestal bone; this close proximity may explain partially the biologic and radiographic observations of crestal bone loss around restored two-piece implants. On the other hand, if the horizontal relationship between the outer edge of the implant and a smaller-diameter component (ie, "platform switching") is altered, in addition to other favorable implant design conditions, there seems to be reduced crestal bone loss.[17]

Since few studies have focused on immediate loading of different types of implants placed in fresh extraction sockets, the aim of the present clinical study was to evaluate the marginal bone around two different types of IAJs after 24 months: a so-called platform-switched IAJ and a conventional external-hexagon IAJ.

MATERIALS AND METHODS

Patient Selection

Between February 2006 and March 2008, 45 patients (27 women and 18 men with a mean age of 48.73 years; range, 25 to 67 years) were included in this study. All selected patients required the extraction of one or two teeth because of root fractures, caries, endodontic lesions, or periodontal disease and were randomly assigned to one of the two groups. The first group received 34 implants with an external-hexagon abutment connection and the second group received 30 implants with so-called platform-switching, ie, the abutment diameter was less than the implant diameter. Implants were positioned immediately after tooth extraction and were loaded immediately. The patients included in this clinical study were treated by one oral surgeon and one prosthetic specialist in the Department of Dentistry, San Raffaele Hospital.

All patients were in good health, with no chronic systemic disease; implant sites needed to have all four bony walls of the alveolus and at least 4 mm of bone beyond the root apex. Exclusion criteria were: presence of dehiscence or fenestration of the residual bony walls, coagulation disorders, presence of signs of acute infection around alveolar bone at the surgical site, a heavy smoking habit (more than 10 cigarettes per day), alcohol or drug abuse, or bruxism.

The local ethical committee approved the study, and all patients signed an informed consent document for immediate implant loading.

Surgical Protocol

One hour prior to surgery, patients received 1 g amoxicillin; they continued to take 1 g amoxicillin twice a day for a week after surgery. Surgery was performed under local anesthesia (Optocaine 20 mg/mL with adrenalin 1:80,000, Molteni Dental).

Forty maxillary and 24 mandibular teeth in the incisor, canine, and premolar regions were extracted, with socket integrity carefully maintained. Buccal and palatal flaps were avoided, and a periodontal probe was used to verify the integrity of the four walls of the fresh sockets. All experimental sites showed no fenestrations or dehiscence of the bony walls and a residual gap between the implant surface and adjacent bone of no more than 2 mm. No regenerative procedures were performed.

The implant site was prepared with a standard drilling sequence following the palatal bony walls as a guide, and the apical portion of the implant was always placed at least 4 mm beyond the root apex; no countersinking was used. The quality of alveolar bone was determined during surgery at each site. Most sites were classified as quality 2 or 3 according to the Lekholm and Zarb classification.[18]

The group 1 implants had a machined neck for 0.8 mm, a rough titanium plasma-sprayed surface, a body with a progressive thread design, and an external-hexagon implant-abutment connection (Seven Sweden & Martina). Group 2 implants had a Morse cone connection (Ankylos Plus, Dentsply-Friadent) with a built-in "platform switch" and a rough-surface body with a progressive thread design. For both types of implants, the platform of the implants was inserted 1 mm below the level of the alveolar crest.

Immediately after the surgical procedure, provisional abutments were placed and provisional crowns were cemented. Immediate loading of the implants was performed with implant insertion torque of at least 35 Ncm. No flap was raised in any site. Patients rinsed with chlorhexidine mouthwash twice daily for the next 15 days.

Prosthetic Protocol

Immediately after the surgical procedure, provisional prefabricated acrylic resin crowns were performed, adapted with acrylic resin along the margins of the provisional abutment, and luted with provisional cement (Temp Bond, Kerr Manufacturing). All provisional crowns were in full contact in centric occlusion; the occlusal surfaces were flattened to avoid horizontal relations. All patients followed a soft diet for 2 months.

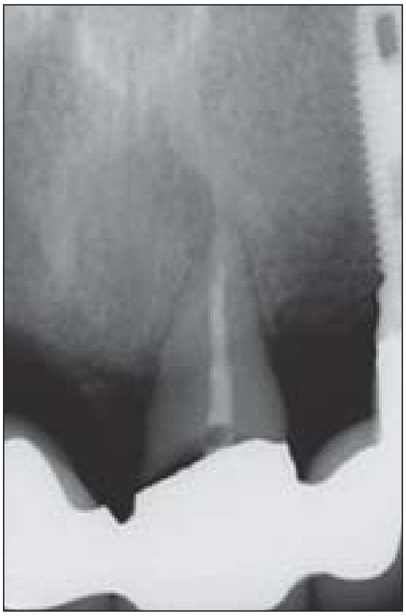

Fig 1a Preoperative radiograph of the maxillary left central incisor. Deep root decay was present.

Fig 1b Postoperative periapical radiograph showing a group 1 implant placed into the fresh extraction socket.

Fig 1c The same patient at the 2-year follow-up.

Follow-up Evaluation

Follow-up visits were performed by a dental hygienist at 1, 3, 6, 12, and 24 months after implant insertion. The following clinical parameters were checked: plaque scores,[19] Bleeding Index registered at four surfaces on each implant,[20] pain, occlusion, and prosthesis mobility. Survival criteria for implants were: presence of implant stability, absence of radiolucency around the implants, no mucosal suppuration, and no pain.

Radiographic Assessments

Intraoral digital radiographic examinations (Schick CDR, Schick Technologies) were made at baseline and at 12 and 24 months after implant placement (Figs 1 and 2). The periapical radiographs were taken perpendicularly to the long axis of the implant with a long-cone parallel technique using an occlusal template to measure the marginal bone level. A blinded radiologist measured the changes in marginal bone height over time. The distance between the platform of the implant and the most coronal point of contact between the bone and the mesial and distal sites of implants was measured. Changes in bone level over time were measured by specific software (Schick CDR, Schick Technologies). Marginal bone loss was evaluated after 12 and 24 months of healing. Mesial, distal, and mean bone loss were calculated in the maxilla and mandible.

Statistics

Specific statistical software was used for all analyses (SPSS 11.5.0, SPSS). Data were presented as mean values and standard deviations. To compare the mean values for groups 1 and 2, a paired *t* test was performed (significant if $P < .05$), with the patient considered as the statistical unit.

RESULTS

Surgical and Prosthetic Outcomes

Group 1 consisted of 34 implants. Twenty-three implants had a diameter of 5 mm and 11 implants had a diameter of 3.80 mm; all were 13 mm long (Table 1). Group 2 consisted of 30 implants. Nineteen implants had a diameter of 5.5 mm and 11 implants had a diameter of 4.5 mm; all were 14 mm long (Table 2). After 24 months of follow-up, a survival rate of 100% was reported for all implants. There was acceptable wound healing around the provisional abutments, with good adaptation to the provisional crowns. Minor swelling of the gingival mucosa was present in the first days after the surgical procedures, but no mucositis or flap dehiscences with suppuration were observed. Three occlusal screws loosened in the provisional abutments of group 1 implants. The definitive ceramic-fused-to-metal restorations were cemented 6 months after implant placement.

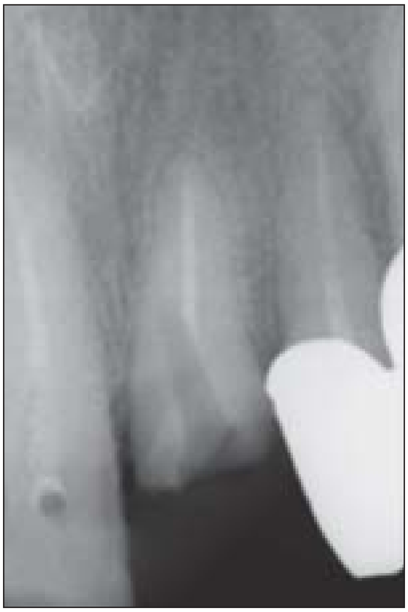

Fig 2a Preoperative radiograph of a maxillary left central incisor. Vertical radicular fracture was present.

Fig 2b Postoperative periapical radiograph showing a group 2 implant placed into the fresh extraction socket.

Fig 2c The same patient at the 2-year follow-up.

Table 1 Group 1 Implant Locations and Dimensions

Location	Implant size (mm) 5.0 × 13	3.80 × 13	Total
Maxilla	17	5	22
Mandible	6	6	12
Total	23	11	34

Table 2 Group 2 Implant Locations and Dimensions

Location	Implant size (mm) 5.5 × 14	4.5 × 14	Total
Maxilla	14	4	18
Mandible	5	7	12
Total	19	11	30

Table 3 Radiographic Findings (Means ± SDs)

Time	Mesial bone loss (mm)	Distal bone loss (mm)	Mean bone loss (mm)	Survival rate (%)
Group 1 implants				
Baseline	0.97 ± 0.35	1.02 ± 0.42	0.99 ± 0.38	100
12 mo	0.81 ± 0.37	0.84 ± 0.43	0.82 ± 0.40	100
24 mo	0.77 ± 0.40	0.80 ± 0.51	0.78 ± 0.45	100
Group 2 implants				
Baseline	0.96 ± 0.16	1.01 ± 0.53	0.98 ± 0.34	100
12 mo	0.73 ± 0.47	0.83 ± 0.51	0.78 ± 0.49	100
24 mo	0.68 ± 0.48	0.79 ± 0.57	0.73 ± 0.52	100

Clinical Parameters

Plaque accumulation at baseline was 2%, and it was 5% after 18 months. The Bleeding Index was 3% at baseline, and at 18 months a value of 5.3% was recorded. No pain or mobility of the definitive prosthesis was registered.

Radiographic Findings

Radiographic results were reported at 12 and 24 months after implant placement (Table 3). In group 1, at 12 months, a mean mesial bone loss of 0.81 ± 0.37 mm and a mean distal bone loss of 0.84 ± 0.43 mm (mean overall bone loss = 0.82 ± 0.40 mm) were reported. At 24 months, a mean mesial bone loss of 0.77 ± 0.40 mm and a mean distal bone loss of 0.80 ± 0.51 mm (mean overall bone loss = 0.78 ± 0.45 mm) were measured. In group 2, at 12 months, a mean mesial bone loss of 0.73 ± 0.47 mm and a mean distal bone loss of 0.83 ± 0.51 mm (mean overall bone loss = 0.78 ± 0.49 mm) were reported. At 24 months, a mean mesial bone loss of 0.68 ± 0.48 mm and a mean distal bone loss of 0.79 ± 0.57 mm (mean overall bone loss = 0.73 ± 0.52 mm) were measured. No statistically significant differences were found between groups 1 and 2 for values obtained at 12 and 24 months after implant placement ($P > .05$).

DISCUSSION

The present study, which reported a survival rate of 100% after 24 months of follow-up in both groups, showed that immediate restorations of implants placed in fresh extraction sockets may provide successful treatment. The success of immediate loading of implants was histologically documented in a case report.[21] Two dental implants were placed immediately into fresh extraction sockets; one (control) was connected to a healing abutment, whereas the other implant was loaded immediately (test). After 6 months, both implants were removed, along with the surrounding peri-implant bone. Histomorphometric analysis showed bone-to-implant contact percentages for the control and test implants of 58% ± 4.0% and 52% ± 3.2%, respectively. Around the loaded implant, a more compact, mature, well-organized peri-implant bone was found, with many areas of remodeling and some osteons, whereas the bone tissue surrounding the unloaded implant consisted of only thin bone trabeculae.[22]

The screw-type implants with an external-hexagon connection used in the present study showed a minimum marginal bone level change of 0.83 ± 0.52 mm. This is similar to the result obtained in a clinical study by Degidi et al,[23] in which 52 parallel-screw, grit-blasted, and acid-etched implants with internal-hexagon connections were positioned in anterior regions and restored immediately. Implants were placed in 37 postextraction sites and 15 healed sites. The distance between the IAJ and the highest coronal point of the supporting bone showed average bone loss of 0.73 mm at 6 months, 0.92 mm at 12 months, and 1.41 mm at 72 months.

Barone et al[7] inserted single implants into fresh extraction sockets and immediately restored them with provisional abutments and crowns. They reported a complete healing process, with success at the 12-month follow-up. Kan et al,[24] in a prospective study, evaluated 35 threaded hydroxyapatite-coated implants that were placed and provisionalized immediately after each failing tooth had been removed. After 12 months, all implants remained osseointegrated, although marginal bone and gingival levels were statistically significantly different versus pretreatment levels. In a similar study, Cornelini et al[6] reported no implant failures, radiographic mean bone resorption of 0.5 mm, and a mean variation in gingival levels, compared to the neighboring teeth, of –0.75 mm at 1 year after treatment.

The present study found no statistically significant differences in crestal bone loss between the groups. At 24 months after implant placement, the platform-switched implants showed a mean bone loss of 0.78 ± 0.49 mm and the external-hexagon implants showed a mean bone loss of 0.73 ± 0.52 mm. Although a slight difference in favor of the platform-switching group was reported, statistical evaluation showed that this difference was not significant.

The data explained in the present study are in accordance with those reported by Canullo and Rasperini,[25] who placed 10 consecutive immediately loaded implants in extraction sockets in maxillae without compromised bone tissue. This type of implant had threads with a reverse buttress, a smooth neck of 1.7 mm in height, and a platform of 6 mm. The edge of the implant platform was placed at the level of the labial bony wall. In each situation, adequate primary implant stability was achieved with an initial torque of 32 to 45 Ncm. After 22 months of follow-up, postoperative radiographs demonstrated an average bone loss of 0.57 mm on mesial surfaces and 1.01 mm on distal surfaces; overall mean bone loss was 0.78 ± 0.36 mm.

In a histologic study, three implants with Morse cone connections[26] were inserted in the right posterior mandible of a 29-year-old partially edentulous patient. The platform of the implant was inserted 2 mm below the level of the alveolar crest. After a 1-month loading period, the most distal mandibular implant was retrieved with a trephine bur for histologic analysis. Bone was present 2 mm above the level of the implant shoulder. No resorption of the coronal bone was present. At the level of the shoulder of the implant, dense connective tissue was seen, with only a few scattered inflammatory cells. Newly formed bone was in direct contact with the implant surface. The bone-implant contact percentage was 65.3% ± 4.8%. The authors concluded that the use of abutments that were smaller than the diameter of the implant body (ie, platform switching), in combination with an absence of micromovement and a microgap, may protect the peri-implant soft and mineralized tissues, explaining the observed absence of bone resorption.

The very minimal changes in marginal bone level between platform-switched and non–platform-switched implants placed in fresh extraction sockets may be explained by the use of a minimally invasive surgical procedure. An animal study was conducted to evaluate the rate of osseointegration at apical, middle, and coronal levels of oral implants immediately placed into fresh extraction sockets.[27] In this study, the mandibular premolars of eight male adult mini-pigs were extracted via elevation of a partial-thickness gingival flap, and implants were immediately inserted. The gap between bone and implants ranged between 3 and 6 mm circumferentially. Bone specimens were obtained at 7, 15, 30, and 60 days after surgery for histologic and histomorphometric studies. Bone-to-implant contact (BIC), bone volume, trabecular thickness, trabecular number, and trabecular separation were recorded. BIC at the coronal level was close to 0% at day 7 and increased up to 60% at day 60 after surgery, on average. BIC increased from 11.7% to 47.38% at the middle level and from 53.4% to 67.38% at the apical level from day 7 to day 60. With respect to bone maturation, in the earlier stages of healing, many thin trabeculae were observed, which, particularly at the coronal level, became significantly fewer and thicker in more advanced stages. At day 60, the features of the bone were similar to those seen at baseline. The epithelium never migrated more than 1.8 mm apically to the top of the alveolar bone level.

When implants are placed immediately into fresh extraction sockets in mini-pig models, osseointegration also occurs without initial bone contact. These data are in contrast with those reported in animal studies,[28,29] in which the bone-to-implant contact that was established during the early phase of socket healing following implant placement and elevation of a full-thickness gingival flap was partially lost when the buccal bone wall underwent continued resorption. The integrity of the tissue architecture of a fresh socket, with the periosteum and gingival tissues maintained, may provide improved tissue healing around implant surfaces, with no differences in bone level maintenance between platform-switched and non–platform-switched implants. However, further clinical and histologic studies are needed to achieve a better understanding of this implant therapy protocol.

REFERENCES

1. Becker W, Becker B, Handelsman M, Ochsenbein C, Albrektsson T. Guided tissue regeneration for implants placed into extraction sockets: A study in dogs. J Periodontol 1991;62:703–709.
2. Tolman D, Keller E. Endosseous implant placement immediately following dental extraction and alveoloplasty: Preliminary report with 6-year follow-up. Int J Oral Maxillofac Implants 1991;6:24–28.
3. Becker W, Dahlin C, Becker B, et al. The use of e-PTFE barrier membranes for bone promotion around titanium implants placed into extraction sockets: A prospective multicenter study. Int J Oral Maxillofac Implants 1994;9:31–40.
4. Wilson TG, Schenk R, Buser D., Cochran D. Implants placed in immediate extraction sites: A report of histologic and histometric analyses of human biopsies. Int J Oral Maxillofac Implants 1998;13:333–341.
5. Covani U, Cornelini R, Barone A. Bucco-lingual bone remodeling around implants placed into immediate extraction sockets: A case series. J Periodontol 2003;74:268–273.
6. Cornelini R, Cangini F, Covani U, Wilson T. Immediate restoration of implants placed into fresh extraction sockets for single-tooth replacement: A prospective clinical study. Int J Periodontics Restorative Dent 2005;25:439–447.
7. Barone A, Rispoli L, Vozza I, Quaranta A, Covani U. Immediate restoration of single implants placed immediately after tooth extraction. J Periodontol 2006;77:1914–1920.
8. Crespi R, Capparè P, Gherlone E, Romanos GE. Immediate occlusal loading of implants placed in fresh sockets after tooth extraction. Int J Oral Maxillofac Implants 2007;22:955–962.
9. Guo E. Mechanical properties of cortical bone and cancellous bone tissue. In: Cowin SC (ed). Bone Mechanics Handbook, ed 2. Boca Raton, FL: CRC Press, 2001:1–23.
10. Tolman D, Keller E. Endosseous implant placement immediately following dental extraction and alveoloplasty: Preliminary report with 6-year follow-up. Int J Oral Maxillofac Implants 1991;6:24–28.
11. Hansson S. The implant neck: Smooth or provided with retention elements. A biomechanical approach. Clin Oral Implants Res 1999;10:394–405.
12. Zechner W, Trinkl N, Watzek G, et al. Radiologic follow-up of peri-implant bone loss around machine-surfaced and rough-surfaced interforaminal implants in the mandible functionally loaded for 3 to 7 years. Int J Oral Maxillofac Implants 2004; 19:216–221.
13. Norton MR. Marginal bone levels at single tooth implant with a conical fixture design. The influence of surface macro and microstructure. Clin Oral Implants Res 1998;9:91–99.
14. Chou CT, Morris HF, Ochi S, Walker L, DesRosiers D. AICRG, Part II: Crestal bone loss associated with the Ankylos implant: Loading to 36 months. J Oral Implantol 2004;30:134–143.
15. Hermann JS, Schofield JD, Schenk RK, Buser D, Cochran DL. Influence of the size of the microgap on crestal bone changes around titanium implants. A histometric evaluation of unloaded non-submerged implants in the canine mandible. J Periodontol 2001;72:1372–1383.
16. Piattelli A, Vrespa G, Petrone G, Iezzi G, Annibali S, Scarano A. Role of the microgap between implant and abutment: A retrospective histologic evaluation in monkeys. J Periodontol 2003;74:346–352.
17. Abboud M, Koeck B, Stark H, Wahl G, Paillon R. Immediate loading of single-tooth implants in the posterior region. Int J Oral Maxillofac Implants 2005;20:61–68.
18. Lekholm U, Zarb GA. Patient selection and preparation. In: Brånemark P-I, Zarb GA, Albrektsson T (eds). Tissue-Integrated Prostheses: Osseointegration in Clinical Dentistry. Chicago: Quintessence, 1985:201–209.
19. Mombelli A, Lang NP. Clinical parameters for the evaluation of dental implants. Periodontol 2000 1994;4:81–88.
20. Schropp L, Wenzel A, Kostopoulos L, Karring T. Bone healing and soft tissue contour changes following single-tooth extraction: A clinical and radiographic 12-month prospective study. Int J Periodontics Restorative Dent 2003;23:313–323.
21. Guida L, Iezzi G, Annunziata M, et al. Immediate placement and loading of dental implants: A human histologic case report. J Periodontol 2008;79:575–581.
22. Romanos GE, Johansson CB. Immediate loading with complete implant-supported restorations in an edentulous heavy smoker: Histologic and histomorphometric analyses. Int J Oral Maxillofac Implants 2005;20:282–290.
23. Degidi M, Nardi D, Piattelli A. Peri-implant tissue and radiographic bone levels in the immediately restored single-tooth implant: A retrospective analysis. J Periodontol 2008;79:252–259.
24. Kan JYK, Rungcharassaeng K, Lozada J. Immediate placement and provisionalization of maxillary anterior single implants: 1-year prospective study. Int J Oral Maxillofac Implants 2003;18:31–39.

25. Canullo L, Rasperini G. Preservation of peri-implant soft and hard tissues using platform switching of implants placed in immediate extraction sockets: A proof-of-concept study with 12- to 36-month follow-up. Int J Oral Maxillofac Implants 2007;22:995–1000.
26. Degidi M, Iezzi G, Scarano A, Piattelli A. Immediately loaded titanium implant with a tissue stabilizing/maintaining design ('beyond platform switch') retrieved from man after 4 weeks: A histological and histomorphometrical evaluation. A case report. Clin Oral Implants Res 2008;19:276–282.
27. Rimondini L, Bruschi GB, Scipioni A, et al. Tissue healing in implants immediately placed into postextraction sockets: A pilot study in a mini-pig model. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2005;100:E43–E50.
28. Araújo MG, Sukekava F, Wennström JL, Lindhe J. Tissue modeling following implant placement in fresh extraction sockets. Clin Oral Implants Res 2006;17:615–624.
29. Araújo MG, Wennström JL, Lindhe J. Modeling of the buccal and lingual bone walls of fresh extraction sites following implant installation. Clin Oral Implants Res 2006;17:606–614.