Case Series

# Equicrestal and Subcrestal Dental Implants: A Histologic and Histomorphometric Evaluation of Nine Retrieved Human Implants

Marco Degidi,* Vittoria Perrotti,† Jamil A. Shibli,‡ Arthur B. Novaes,§ Adriano Piattelli,† and Giovanna Iezzi†

**Background:** Stability of peri-implant crestal bone plays a relevant role relative to the presence or absence of interdental papilla. Several factors can contribute to the crestal bone resorption observed around two-piece implants, such as the presence of a microgap at the level of the implant–abutment junction, the type of connection between implant and prosthetic components, the implant positioning relative to the alveolar crest, and the interimplant distance. Subcrestal positioning of dental implants has been proposed to decrease the risk of exposure of the metal of the top of the implant or of the abutment margin, and to get enough space in a vertical dimension to create a harmoniously esthetic emergence profile.

**Methods:** The present retrospective histologic study was performed to evaluate dental implants retrieved from human jaws that had been inserted in an equicrestal or subcrestal position. A total of nine implants were evaluated: five of these had been inserted in an equicrestal position, whereas the other four had been positioned subcrestally (1 to 3 mm).

**Results:** In all subcrestally placed implants, preexisting and newly formed bone was found over the implant shoulder. In the equicrestal implants, crestal bone resorption (0.5 to 1.5 mm) was present around all implants.

**Conclusion:** The subcrestal position of the implants resulted in bone located above the implant shoulder. *J Periodontol 2011;82:708-715.*

**KEY WORDS**

**Bone remodeling; dental abutments; dental implants; histology; osseointegration.**

* Private Practice, Bologna, Italy.
† Dental School, University of Chieti-Pescara, Chieti, Italy.
‡ Department of Periodontology, Dental Research Division, Oral Implantology Clinic, Guarulhos University, Guarulhos, São Paulo, Brazil.
§ Department of Periodontology, School of Dentistry of Ribeirao Preto, University of São Paulo, São Paulo, Brazil.

Stability of peri-implant crestal bone plays a relevant role in the presence or absence of interdental papilla.[1-4] Loss of the interproximal papilla can lead to esthetic and phonetic problems and the possibility of lateral food impaction,[5] and crestal bone resorption can produce gingival margin recessions. Several factors can contribute to crestal bone resorption observed around two-piece implants, such as surgical trauma, overloading, peri-implantitis, the anatomy of the cervical region, the surface characteristics of the implants, the establishment of a biologic width, the presence of a microgap at the level of the implant–abutment junction (IAJ), the type of connection between implant and prosthetic components, the implant positioning relative to the alveolar crest, and the interimplant distance.[6-8] Subcrestal position of dental implants has been proposed to decrease the risk of exposure of the metal top of the implant or of the abutment margin, and to have sufficient space in a vertical dimension to create a harmoniously esthetic emergence profile.[5-7] In two-piece implants, however, the level of the crestal bone seemed to be related to the location of the microgap; if this microgap was located at or below the alveolar

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crest, bone resorption could occur.[9-12] A significant causal relationship has been found between the extent of peri-implant inflammation and the degree of crestal bone loss.[13] The position of the microgap plays a key role in the accumulation of inflammatory cells apical to the bone crest;[13] the deeper the microgap, the greater the degree of peri-implant inflammation.[13] Moreover, a more apical location of the bacteria may favor a more pathogenic composition of the microbial biofilm.[14] The clinical implications for such an implant location in two-piece implants could be gingival margin recession, an impaired esthetic result, and a more difficult maintenance.[14]

However, the internal displacement of the IAJ away from the external, outer edge of the implant and neighboring bone (platform switching or shifting) has been reported to decrease the effects of the abutment inflammatory connective tissue on the surrounding tissues.[15,16] Hürzeler et al.[17] found that 1 year after final restoration, the mean values of crestal bone loss were 0.22 ± 0.53 mm for implants with platform-switched abutments, whereas control implants showed a loss of 2.02 ± 0.49 mm. Similar results were reported by Vela-Nebot et al.,[18] who found in test implants a bone loss of 0.76 mm, whereas in control implants the bone loss was 2.53 mm. High stability of the peri-implant soft tissues has also been reported in an implant system with an inbuilt gap-free bacteria-proof tapered abutment connection with maximum mechanical stability and lack of any micromovement.[19-22] It has been suggested that the subcrestal positioning of the implants may have some positive influence in the maintenance or formation of a crestal bone peak in the interimplant region.[6] The presence of bone slightly over the top of the implant could play a beneficial outcome in the esthetic regions.[6] Several histologic reports have shown mineralized tissues at the interface in immediately loaded dental implants.[23-31]

Therefore, the aim of the present histologic study was to evaluate dental implants retrieved from human jaws which had been inserted in an equicrestal or subcrestal position.

## MATERIALS AND METHODS

The archives of the Implant Retrieval Center of the Dental School of the University of Chieti-Pescara, Chieti, Italy, were searched for human retrieved implants that had been inserted equicrestally (at the level of the alveolar crest) or subcrestally (at a deeper location, ≥1 mm apical to the alveolar crest). A total of nine implants were found:[‖] five of these had been inserted in an equicrestal position, whereas the other four had been positioned subcrestally (between 1 and 3 mm). All of these implants, except for one that was removed for reasons of psychologic distress, have already been reported in other studies.[20,32-34] All of these implants presented a shoulder with an acid-etched microtexturized surface. All of these studies were approved by the Ethical Committee of the University of Guarulhos, São Paulo, Brazil, and all the patients signed a written informed consent form. Seven of these implants were immediately loaded, whereas two were left submerged. All implants were retrieved after a healing period of 4 to 8 weeks. Before retrieval, all implants were clinically osseointegrated and were not mobile. All implants were retrieved with a trephine bur under abundant saline irrigation.

### *Processing of Specimens*

The implants and the surrounding tissues were stored immediately in 10% buffered formalin and processed to obtain thin ground sections with an automated system.[35¶] The specimens were dehydrated in an ascending series of alcohol rinses and embedded in a glycolmethacrylate resin.[#] After polymerization, the specimens were sectioned longitudinally along the major axis of the implants with a high-precision diamond disc at ≈150 μm and ground down to ≈30 μm. Three slides were obtained from each implant and then averaged for each group. The slides were stained with acid fuchsin and toluidine blue. A double staining with von Kossa and acid fuchsin was done to evaluate the degree of bone mineralization. One slide, after polishing, was immersed in $AgNO_3$ for 30 minutes, and exposed to sunlight. The slides were then washed under tap water, dried, immersed in basic fuchsin for 5 minutes, and then washed and mounted.

Histomorphometry of bone–implant contact percentage was carried out using a light microscope[**] (×20 to ×100 magnification) connected to a high-resolution video camera[††] and interfaced to a monitor and personal computer.[‡‡] This optical system was associated with a digitizing pad[§§] and a histometry software package with image-capturing capabilities.[‖‖] Bone–implant contact was defined as the amount of mineralized bone in direct contact with the implant surface. The measurements were made throughout the entire extent of the microimplant. A single calibrated examiner (GI) performed the histometric parameters. A total of 10 ground sections were used for the calibration exercise. The sections were analyzed twice with a 1-week interval between measurements. Paired *t* test statistics showed no significant differences ($P$ >0.05) in intraexaminer reproducibility. The standard error of the mean difference of histometric analysis was 4% for bone–implant contact.

‖ ANKYLOS plus, DENTSPLY-Friadent, Mannheim, Germany.
¶ Precise 1 Automated System, Assing, Rome, Italy.
# Technovit 7200 VLC, Kulzer, Wehrheim, Germany.
** Laborlux S, Leitz, Wetzlar, Germany.
†† 3CCD, JVC KY-F55B, JVC, Yokohama, Japan.
‡‡ Intel Pentium III 1200 MMX, Intel, Santa Clara, CA.
§§ Matrix Vision, Oppenweiler, Germany.
‖‖ Image-Pro Plus 4.5, Media Cybernetics, Immagini & Computer, Milan, Italy.

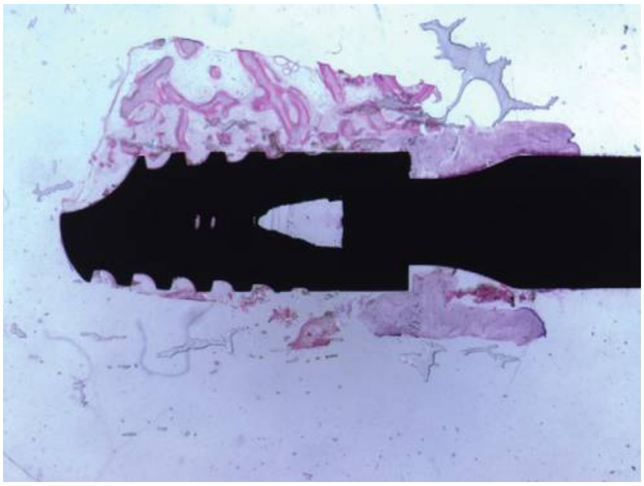

*Figure 1.*
*Equicrestal implant. The implant had been inserted flush with the alveolar crest bone. Note, on one side of the implant, the bone resorption of ≈1.2 mm starting from the implant shoulder (acid fuchsin–toluidine blue, original magnification ×12).*

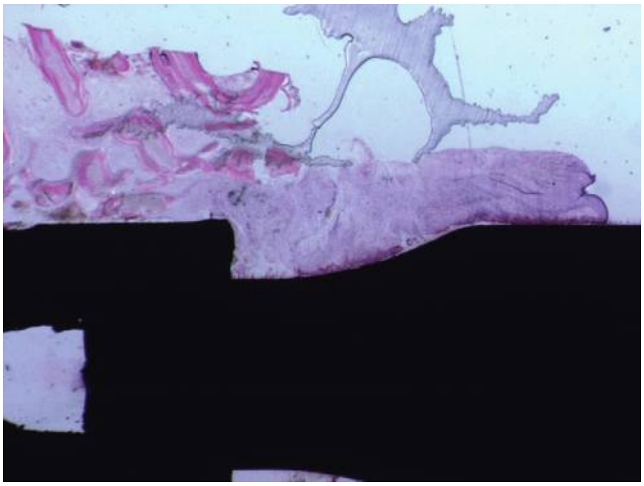

*Figure 2.*
*Equicrestal implant, higher magnification. The soft tissues are closely adapted to the abutment. Resorption of the peri-implant crestal bone is present (acid fuchsin–toluidine blue, original magnification ×40).*

## RESULTS

### Equicrestal Implants

At low-power magnification, lamellar bone was present around the implants (Fig. 1). Dense connective tissue, with only a few inflammatory cells, was observed at the level of the shoulder of the implant and of the peri-implant coronal portion (Fig. 2). Some newly formed bone trabeculae were present on the implant surface in the coronal area. Wide osteocyte lacunae were present in these trabeculae. No gaps or connective fibrous tissues were present at the interface. Many areas with bone remodeling units were present, with osteoblasts depositing osteoid matrix. Newly formed bone was found in the interthread spaces (Fig. 3); osteocytes were present near the implant surface. The peri-implant bone was very trabecular; many marrow spaces were present. The implant surface seemed to be lined by bone trabeculae with a thickness of ≈200 to 300 μm. In the coronal area bone remodeling was present with areas of new bone formation. A 0.5-mm pocket was present around some implants. Connective tissue, with few inflammatory cells, was present around one side of two implants, in the coronal portion. At the bottom of this pocket there was newly formed bone. Most of the perimeter of the implant was lined by bone. No inflammatory cell infiltrate was found around the implants. The mean of bone–implant contact was 64.67%. The bone loss was between 0.5 and 1.5 mm. Measurements from the top of the implant to the first bone–implant contact are reported in Table 1.

### Subcrestal Implants

Preexisting and newly formed bone was found ≈0.5 to 3 mm over the implant shoulder (Table 2, Fig. 4). No

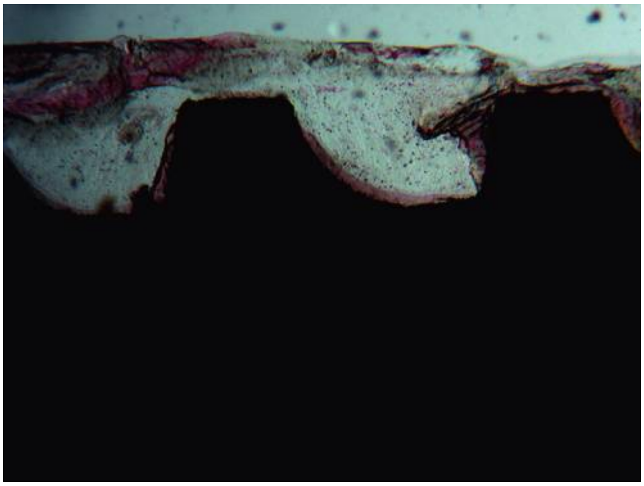

*Figure 3.*
*Equicrestal implant, higher magnification. Newly formed bone was found in the interthread spaces (acid fuchsin–toluidine blue, original magnification ×40).*

resorption of the coronal bone was present, and in this area no osteoclasts were present. No infrabony pockets were present. At higher magnification, it was possible to observe areas of new bone formation on both sides of the implants, over the implant shoulders (Fig. 5). This bone was in close contact with the titanium surface (Fig. 6). About 20 μm of osteoid matrix and 10 μm of woven, not yet mineralized bone was found around the metal surface. In other portions of the interface the width of the woven bone was slightly larger (≈40 μm). Many osteoblasts were present. No gaps or fibrous connective tissue was found at the bone–implant interface. No epithelial downgrowth

**Table 1.**

## Equicrestal Implants

| Implant–Abutment Junction | Bone Loss (mm) | Bone–Implant Contact (%) | Implants |
|---|---|---|---|
| 0 | 0.5 | 54.7 | Submerged 4 weeks |
| 0 | 0.5 | 65.5 | IL 4 weeks |
| 0 | 1.5 | 62.3 | Submerged 8 weeks |
| 0 | 1.0 | 76.2 | IL 8 weeks |
| 0 | 1.2 | 53.8 | IL 4 weeks |

IL = immediately loaded.

was present. The coronal bone appeared to be very compact with many haversian canals. In the coronal area, bone remodeling was present with areas of new bone formation. In some portions of the interface, bone appeared to be detached, but in all probability this fact was caused by the retrieval or processing artifact. Absence of infrabony pockets was observed. In one implant, it was possible to see a loose, richly vascularized, and with the presence of many small-sized vessels, connective tissue at the interface with the abutment. In another implant, it was possible to observe the formation of bone directly on the abutment surface. This tissue was in close contact with the metal surface and no gaps were present at the interface. At the level of the implant shoulder, areas of new bone formation were present in tight contact with the metal surface (Fig. 7), and in addition, osteoblasts were depositing osteoid matrix. Newly formed bone trabeculae had formed in an apico-coronal direction, and in some areas these trabeculae were present in the most coronal aspect of the abutment and contacted the lower part of the implant–prosthetic restoration. Only in the most coronal portion of the abutment did the connective tissue appear to be detached from the metal surface, most probably because of an artifact during the preparation of the specimen. No inflammatory cell infiltrate was found around the implant. Only a few, scattered inflammatory cells were present inside the connective tissue. The mean bone–implant contact was 56.57%. Measurements from the top of the implant to the first bone–implant contact are reported in Table 1.

## DISCUSSION

In the last few years, some studies have been conducted on the alterations produced by the subcrestal positioning of the implants on crestal bone resorption. Implant placement at deeper crestal positions (1- to 3- mm subcrestal) for esthetic improvements would allow the use of healing caps with an emergence profile and the substitution of the prosthetic component in case of marginal tissue recession, and would contribute to the maintenance of the peri-implant mucosa texture and tonality and would provide the reestablishment of the marginal tissue architecture.[36] Different results, however, have been reported. Todescan et al.[37] found that crestal bone resorption around more deeply placed external hex-implants was higher and increased with time, whereas Pontes et al.[38] found that the level of internal hex-implant placement did not jeopardize the height of the peri-implant ridge. Novaes et al.,[5] in a clinical and radiographic study in dogs, where platform-switched implants had been positioned at the level of the crest and 1.5 mm below the crest, found that subcrestal implants showed better results compared to crestal implants. The subcrestal position of the

**Table 2.**

## Subcrestal Implants

| Implant–Abutment Junction (mm) | Bone Loss (mm) | Bone–Implant Contact (%) | Implants |
|---|---|---|---|
| −1 | 0.5 | 51.2 | IL 5 weeks |
| −1.5 | 0.5 | 55.1 | IL 5 weeks |
| −3 | 0.1 | 55.0 | IL 6 weeks |
| −2 | 0.0 | 65.0 | IL 4 weeks |

IL = immediately loaded.

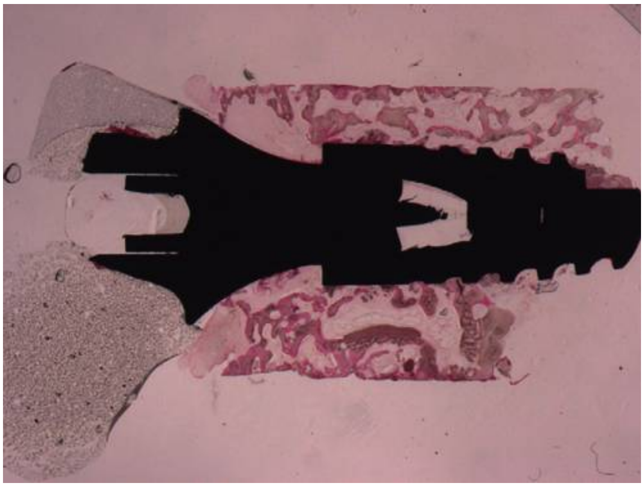

***Figure 4.***
*Subcrestal implant. The implant had been inserted 3 mm below the alveolar crest. A resorption of only 0.1 mm is present. On one side of the abutment it is possible to observe the presence of small islands of bone on the abutment surface. Bone is present over the level of the implant shoulder on both sides of the implant (acid fuchsin–toluidine blue, original magnification ×12).*

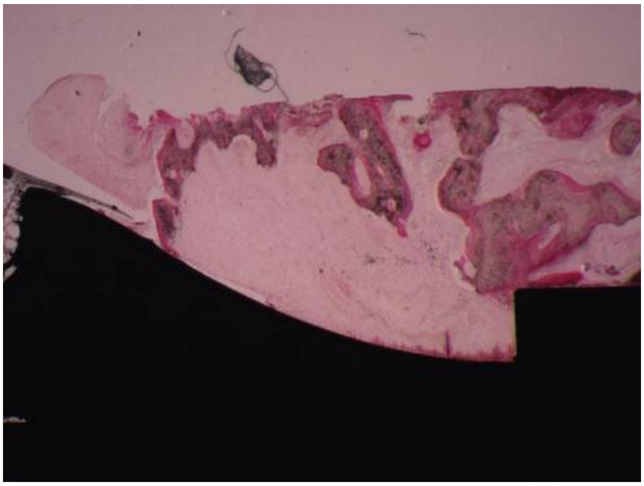

***Figure 5.***
*Subcrestal implant, higher magnification. It is possible to observe the close adaptation of the connective tissue to the implant shoulder (microtextured surface) and to the abutment. Bone is present over the level of the implant shoulder (acid fuchsin–toluidine blue, original magnification ×40).*

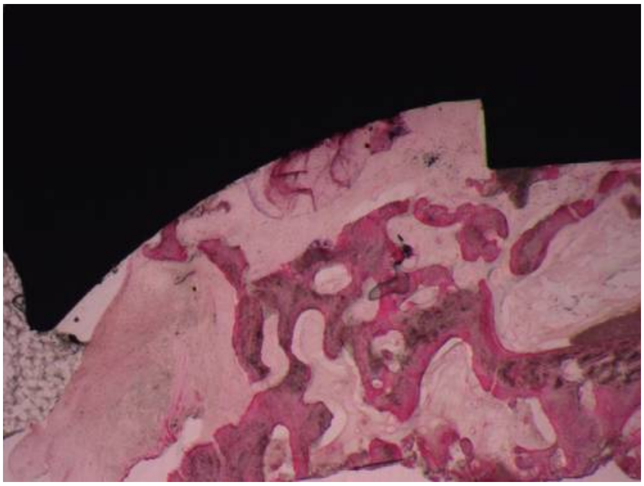

***Figure 6.***
*Subcrestal implant. It is possible to see that bone is present in direct contact with the surface of the abutment (acid fuchsin–toluidine blue, original magnification ×40).*

implants resulted in bone located above the implant shoulder. In addition, Barros et al.,[7] in a histologic study in dogs, found that vertical bone resorption was decreased in the subcrestal groups compared to the equicrestal groups, but the difference was not statistically significant. However, a peak of crestal bone was frequently observed between the implants placed subcrestally, whereas a flattened aspect of the crestal bone was observed in the equicrestal implants.[7]

Weng et al.[39] and Welander et al.,[40] in two different experiments in dogs, found that healing of implants placed in a subcrestal position could result in osseointegration to the abutment region of the implant (i.e., coronal to the IAJ). Weng et al.[39] observed that loss of peri-implant bone height was found when the implants were placed equicrestally. These results are very similar to those found in the present report. Another cause of peri-implant bone resorption could be the presence of excessive stresses transmitted to the implant–bone interface at the level of the alveolar crest with an overload and eventual microfracture of the bone structure.[8] Using platform switching, or shifting, displacement of stresses away from the dense cortical bone and toward the trabecular bone could occur because the trabecular bone is more resilient, less dense, more flexible, and better adsorbs the functional stresses.[6,21]

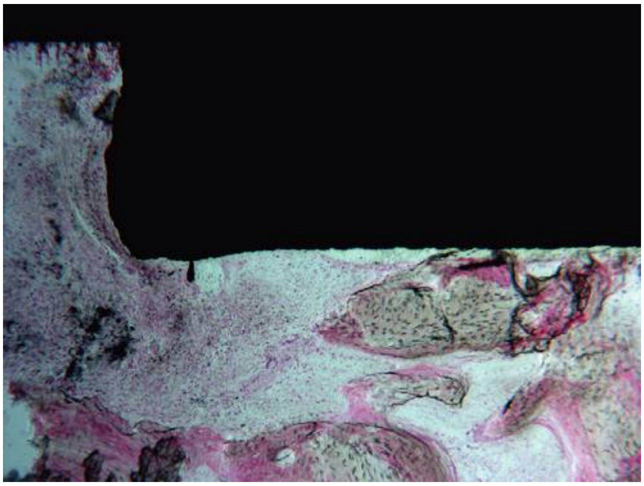

***Figure 7.***
*Subcrestal implant. Just below the implant shoulder areas, bone was found in tight contact with the metal surface (acid fuchsin–toluidine blue, original magnification ×40).*

In addition, immediate loading protocols can reduce the treatment period because the soft tissues heal simultaneously with the hard tissues according to the contours of the provisional restoration. Immediate loading has esthetic, psychologic, and functional advantages in eliminating second-stage surgery, in reducing patient discomfort, and in the additional costs of the procedure. To the best of our knowledge, there are no studies in the literature that investigate the effect of loading on the osseointegration of implants placed equicrestally or subcrestally. It cannot be excluded that in the present investigation different loading conditions could have affected the results; indeed, the beneficial role of relative micromovement in stimulating bone formation in peri-implant location is well known.[24,33]

It has been reported that when an implant–abutment interface is located at the level of the alveolar crestal bone, a significant inflammatory cell infiltrate with resorption of the alveolar bone around the crest occurs.[13,18] Furthermore, the deeper the location of the interface, the greater the degree of inflammation at the level of the IAJ.[13] This fact could have relevant implications for the daily clinic because an implant placement in a more apical position could be required for esthetic reasons.[13] The resorption of the peri-implant bone could cause a recession with an esthetic failure.[13] The location of the implant shoulder subcrestally avoids the metal exposure and allows an adequate vertical dimension with an esthetic emergence profile.[18] Contrary to what happens with other implant systems, the insertion of implants with a Morse cone connection deeper in the bone does not seem to produce complications of the soft and hard tissues that have been reported in the literature.[22]

The results of the present retrospective study seem to show that a smaller dimension of the abutment compared to the diameter of the implant (platform switching or shifting) can create an area around the circumference of the implant that helps to minimize the invasion of the biologic width. This fact could, in part, explain the reduced rate of bone resorption reported for this type of implant connection. The bacteria-proof seal, the lack of micromovements caused by the friction grip, and the minimally invasive second-stage surgery can also be important factors in preventing cervical bone loss.[20,21] Similar results, using the same implant, were reported recently in a clinical and radiographic study, where mineralized hard tissue was found on the implant shoulder in about 70% of the implants, and there was a significant correlation between the subcrestal placement of implants and the presence of hard tissues on the implant shoulder.[41] Furthermore, from a hypothetical point of view, the subcrestal placement of the implant could produce a large space in which the blood clot can form and in sequence, woven bone can develop.[42-44] When healing chambers are produced because of the interplay between implant design and drilling dimensions, the formation of an intramembranous woven bone in large voids, previously occupied by the blood clot immediately after implantation, occurred.[42-44] Finally, a very interesting review and meta-analysis showed that platform switching may preserve interimplant bone height and soft tissue levels. It also concluded that the degree of marginal bone resorption is inversely related to the extent of the implant–abutment mismatch.[45] Therefore, it could be considered that the "platform switch" design had a positive effect on the results of the present study.

Berglundh et al.,[46] Buser et al.,[47] and Germanier et al.[48] have provided histologic evidence of prominent woven bone formation and maturation within experimental wound chambers cut into the surface of implants.

## CONCLUSIONS

The present results showed that a high percentage of bone contact can be obtained even in immediately loaded implants and even after very short healing periods (4 to 8 weeks). Immediate loading did not interfere with bone formation and did not have adverse effects on osseointegration.

Within the limits of this retrospective histology study, it could be suggested that in all subcrestally placed implants, preexisting and newly formed bone was found over the implant shoulder and in one case, where the implant had been inserted at a depth of 3 mm, no bone resorption was observed at all and the newly formed bone, coronal to the IAJ, contacted the abutment surface. These results should be considered with caution, and further prospective studies are needed with a larger sample of patients with implants placed equicrestally or subcrestally.

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Correspondence: Professor Adriano Piattelli, Via F. Sciucchi 63, 66100 Chieti, Italy. Fax: 011-39-0871-3554076; e-mail: apiattelli@unich.it.

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