

# Immediate One-Stage Postextraction Implant: A Human Clinical and Histologic Case Report

Roberto Cornelini, MD, DDS<sup>1</sup>/Antonio Scarano, DDS<sup>2</sup>/Ugo Covani, MD, DDS<sup>3</sup>/  
Giovanna Petrone, DDS<sup>2</sup>/Adriano Piattelli, MD, DDS<sup>4</sup>

*The placement of an implant immediately after tooth extraction may have the following advantages: reduction in morbidity, treatment time, and treatment costs; preservation of the residual ridge width and height; optimal esthetic result; and easier definition of implant position. The aim of the present study was the presentation of a human clinical and histologic report involving a nonsubmerged implant placed in a mandibular postextraction site and removed because of persistent pain. At low-power magnification, it was possible to see that newly formed bone with wide osteocyte lacunae was present around the implant. A 1.5-mm sulcular epithelium was visible on one side of the implant, with a 0.5-mm epithelial attachment. The thickness of the supracrestal connective tissue was 3.2 mm. This connective tissue was dense, had few cells, was well vascularized, and showed no evidence of an inflammatory infiltrate. Under polarized light, it was possible to observe that the connective fibers were arranged perpendicular to the implant surface and that these fibers became parallel near the implant. These results show that human immediate postextraction implants can have a high percentage of bone-implant contact. (INT J ORAL MAXILLOFAC IMPLANTS 2000;15:432-437)*

**Key words:** connective tissue, endosseous dental implantation, epithelium

The healing of an extraction socket often produces bone resorption, which may compromise the site for implant placement.<sup>1</sup> A bone dimension of 4 mm in buccolingual width and 7 mm in height has been said to be the minimum quantity necessary for placement of an endosseous implant.<sup>2</sup> It has been shown that following tooth extraction, when conventional dentures are placed immediately, bone crest resorption is about 23% after a 6-month period, with a further 11% loss after another 2 years.<sup>3</sup> Other researchers<sup>4,5</sup> have reported an even greater amount of resorption. Resorption of the buccal wall of the extraction socket may produce a

buccal concavity in the alveolar process;<sup>6</sup> this fact usually determines that an implant be placed more lingually than the neighboring teeth, producing a compromised esthetic situation. However, placement of an implant immediately after tooth extraction may help to maintain the bone crest and may lead to ideal implant positioning from a prosthetic point of view.<sup>7,8</sup> The use of immediate implants has been proposed by several authors.<sup>9-14</sup> This technique can have the clinical advantages of reduction in morbidity, reduction in treatment time, preservation of residual ridge width and height, and an optimal esthetic result. With regard to implant utilization, there can be a reduction in treatment costs if graft and membrane use is not necessary, the implant placement may be guided by the bone socket, an easier definition of implant position can be provided, and better opportunities for osseointegration can exist because of the healing potential of the fresh extraction site.<sup>8,15-18</sup>

These benefits are usually accompanied by a minor drawback resulting from the lack of adaptation of the alveolar bone in the cervical region of the implant.<sup>6,17</sup> This space is similar to a circumferential vertical defect and can be occupied by soft tissues.<sup>17,19,20</sup> The replacement of an extracted tooth

<sup>1</sup>Visiting Professor, Dental School, University of Chieti, Chieti, Italy.

<sup>2</sup>Research Fellow, Dental School, University of Chieti, Chieti, Italy.

<sup>3</sup>Visiting Professor, Dental School, University of Pisa, Pisa, Italy.

<sup>4</sup>Professor of Oral Medicine and Pathology, Dental School, University of Chieti, Chieti, Italy; and Honorary Senior Lecturer, Eastman Dental Institute for Oral Health Care Sciences, London, United Kingdom.

**Reprint requests:** Prof Adriano Piattelli, Via F. Sciucchi 63, 66100 Chieti, Italy. Fax: +39-0871-3554076. E-mail: apiattelli@unich.it

by an implant during the same procedure almost always implies resorting to osteopromotive techniques.<sup>17</sup> Only for small peri-implant defects are barrier membranes or bone grafts unnecessary as long as the sockets are intact, a favorable defect morphology is present, and an implant with an appropriate surface is used.<sup>15,19,20</sup> Contained circumferential defects at the coronal aspect of extraction sockets tend to fill with blood and bone.<sup>21</sup>

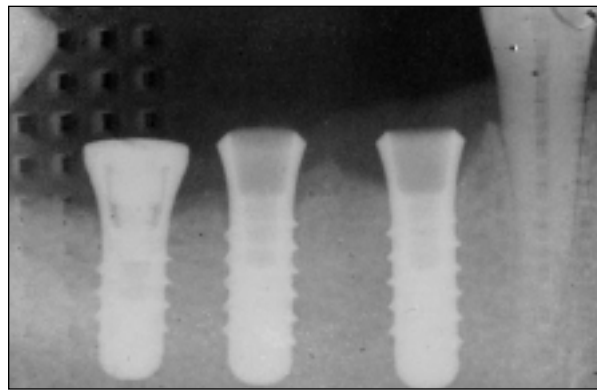
A high success rate with immediately placed implants, according to the criteria proposed by Albrektsson et al,<sup>22</sup> has been reported in the literature.<sup>14,23,24</sup> Becker et al<sup>21</sup> reported a cumulative success rate of 93.3%, Rosenquist and Grenthe<sup>23</sup> reached an average survival rate of 93% with immediately placed implants, and Grunder et al<sup>18</sup> achieved a cumulative survival rate of 92.4% for maxillae and 94.7% for mandibles after 3 years of loading.

Barzilay et al<sup>25,26</sup> reported no significant differences in bone-implant contact between conventional or immediate implant techniques in a monkey model. Becker et al<sup>27</sup> in dogs and Simion et al<sup>28</sup> in humans reported successful clinical results with implants placed into extraction sites. However, direct extrapolation cannot be made from an animal model to a human population.<sup>25,26</sup> To the authors' knowledge, only one human histologic study of retrieved implants placed in immediate extraction sites has been reported in the literature, and it was found that these implants achieved osseointegration, with direct bone-implant contact.<sup>15</sup> However, this did not occur when the space was greater than 1.5 mm, and the authors did not use membranes.<sup>15</sup>

The aim of the present study was to report the clinical and histologic results of a nonsubmerged implant placed into a postextraction site in a human female.

## CASE REPORT AND MATERIAL AND METHODS

A 45-year-old nonsmoking female with a non-contributory past medical history was referred for the replacement of a mandibular second premolar with an immediate implant and the placement of 2 additional implants in the molar region of the right mandible. Following local anesthesia, a mucoperiosteal flap was elevated and the premolar was extracted, avoiding fracture of the buccal and lingual bone walls. The remaining soft tissues were removed, and preparation of the bone socket was then performed for placement of a 13 × 4.1 mm Bonefit implant (Straumann, Waldenburg, Switzerland).

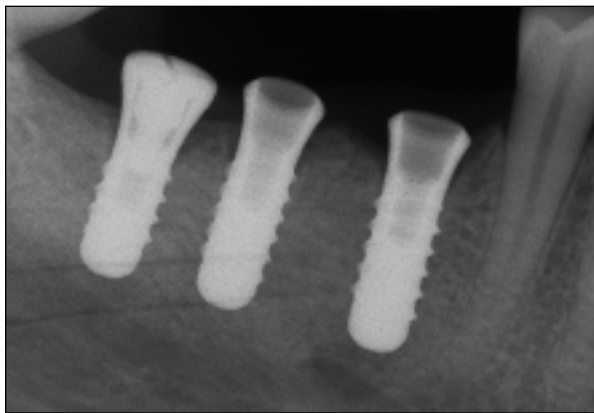


**Fig 1** Periapical radiograph taken immediately after implant placement.

The implant was placed (Fig 1) and primary stability was achieved; the implant shoulder was positioned at the level of the buccal/lingual bone crest; the apical part was very close to the mental foramen. The gap from the implant surface to the surrounding marginal bone walls was 1 mm mesially, 1 mm distally, 2 mm buccally, and 2 mm lingually, as measured with a graded periodontal probe. A resorbable membrane (Guidor AB, Huddinge, Sweden) was placed around the implant and fixed by a healing screw. The remaining pocket epithelium on the inside of the flap was removed by the use of a rotating diamond stone, and the flap was sutured around the healing screw with a teflon suture (Gore-Tex, W. L. Gore, Flagstaff, AZ).

Distally, 2 transmucosal implants were placed in the molar region. The patient was instructed to rinse twice daily for 2 minutes with a 0.1% chlorhexidine solution during the first 4 weeks following surgery. An antibiotic regimen was prescribed (amoxicillin, Augmentin 1 g, 2 tablets/day) for 10 days. Two weeks postsurgically, the sutures were removed. Soft tissue healing was uneventful and without membrane exposure. A transient partial paresthesia was present during the first 2 weeks; subsequently, the symptoms disappeared completely.

Six months later, a radiograph (Fig 2) demonstrated complete filling of the bony defect around the premolar implant. Clinical examination revealed a probing depth around the implant of 0 mm at the buccal and mesial sites, and 1 mm at the distal and lingual sites, without bleeding on probing. The abutments were connected after 4 weeks of soft tissue healing. After another month the patient presented with persistent pain in the region of the immediate implant. This pain was resistant to medical treatment, and for this reason it was decided to remove



**Fig 2** Periapical radiograph taken 6 months after implantation. The mesial implant is in close proximity to the mental foramen.

the implant. No clinical signs of inflammation of the peri-implant soft tissues were present during the healing period. The implant was retrieved with a trephine, taking care to not alter the peri-implant soft tissues.

The specimen was immediately fixed in 10% buffered formalin and processed to obtain thin ground sections with the Precise System (Assing, Rome, Italy).<sup>29</sup> Briefly, the specimen was dehydrated in an ascending series of alcohols and embedded in a glycolmethacrylate resin (Technovit 7200 VLC, Kulzer, Wehrheim, Germany). After polymerization, the specimen was sectioned with a high-precision diamond disk at a thickness of about 150  $\mu\text{m}$  and ground to approximately 30  $\mu\text{m}$ . After polishing, the slides were stained with acid fuchsin-toluidine blue and observed under normal light in a Leitz Laborlux microscope (Leitz, Wetzlar, Germany). Histochemical staining for alkaline (ALP) and acid phosphatase (ACP) was done according to a previously described technique.<sup>30</sup> The histomorphometry was done under a Laborlux-S light microscope (Leitz) using a personal computer, a video-acquired schedule Matrox, a video camera, and KS 100 Software (Zeiss, Hallbergmoos, Germany).

## RESULTS

Low-power magnification showed newly formed bone, with wide osteocyte lacunae, around the implant (Fig 3a). This bone was strongly stained with acid fuchsin and was very thin (about 300 to 400  $\mu\text{m}$ ). Histomorphometric analysis showed that the bone-implant contact percentage was 61.4% ( $\pm$  5.3%). In many fields a rim of ALP-positive osteoblasts were observed actively secreting osteoid

matrix (Fig 3b). Many wide marrow spaces were present around the implant perimeter; no inflammatory cells were present in these spaces. Areas of bone remodeling were also present, and in only some of these areas osteoclasts were present. Osteoclasts were also present at the level of the crestal bone. No cells positive to ACP were found. No gaps or fibrous tissue were present at the bone-implant interface.

A 1.5-mm sulcular epithelium was visible on one side of the implant, with a 0.5-mm epithelial attachment (Figs 4a and 4b). The thickness of the supracrestal connective tissue was 3.2 mm. This connective tissue was dense, with few cells, and well vascularized and showed no inflammatory infiltrate (Fig 4c). No migration of the epithelial cells in the underlying tissues was evident. Under polarized light, connective fibers were seen oriented perpendicular to the implant surface (Fig 4d); near the implant, these fibers were oriented parallel to the surface.

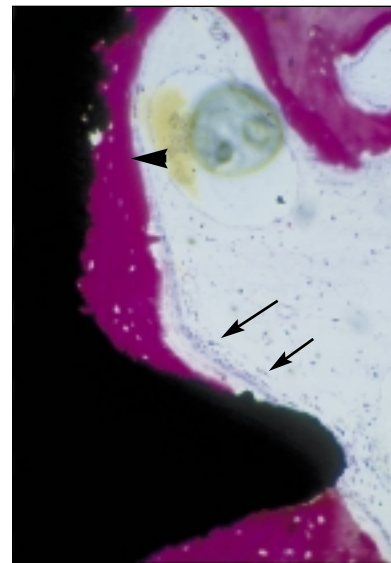
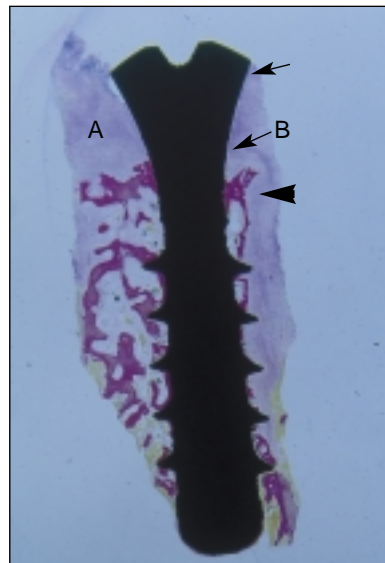
## DISCUSSION

It has been shown that non-submerged implants do not compromise hard and/or soft tissue integration or the long-term results of implant treatment.<sup>31-33</sup> Studies on immediate implants have also shown that there is bone fill in peri-implant defects and close contact between newly regenerated bone and implant surfaces.<sup>27,34,35</sup>

Both resorbable and non-resorbable membranes have been used for bone regeneration techniques in fresh sockets. When using non-resorbable membranes, there is an increased risk of membrane exposure during healing, accompanied by bacterial colonization of the membrane and a decreased level of bone regeneration.<sup>13</sup> This exposure seems to be common in situations involving immediate implant placement. Becker et al<sup>13</sup> removed 41% of e-PTFE membranes prematurely because of incomplete wound closure, inflammation, or infection. Jovanovic et al<sup>36</sup> reported that 16% of e-PTFE membranes became exposed. Some studies have reported the use of immediate 1-stage transmucosal implants in combination with non-resorbable barrier membranes.<sup>37,38</sup> The results from these studies indicate success rates similar to those following standard implant placement, ie, placement following healing of the extraction socket.<sup>39</sup>

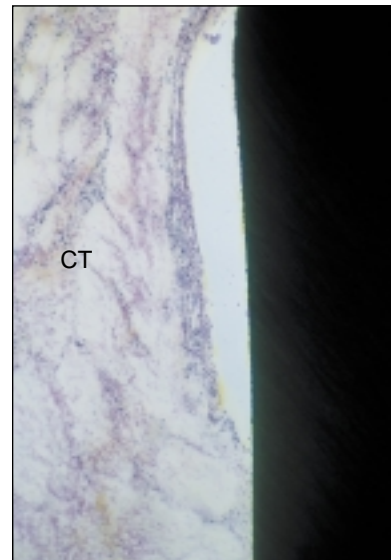
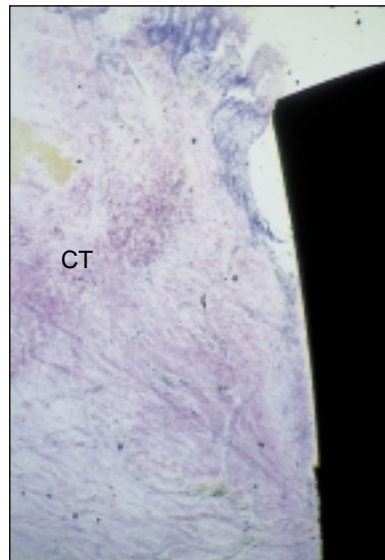
With the use of a resorbable membrane, non-submerged implant placement offers an advantage over submerged placement, because second-stage surgery for the removal of the membrane and for

**Fig 3a** (Left) Newly formed bone with wide marrow spaces (*arrowhead*) is present around the implant. Arrows indicate the polished collar. This bone is strongly stained with acid fuchsin, which is typical of immature, newly formed bone tissue. Bone defects and zones with resorption are not seen in the coronal portion (acid fuchsin-toluidine blue; magnification  $\times 12$ ). A = distal portion; B = mesial portion.



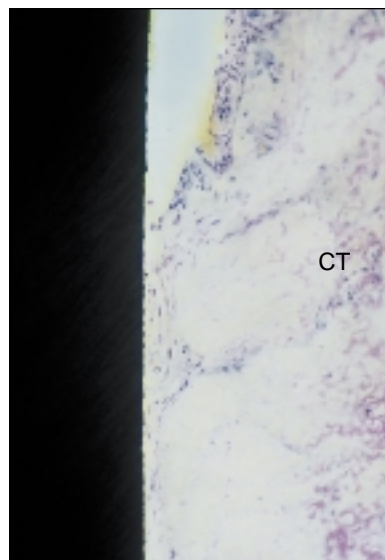
**Fig 3b** (Right) Higher-power magnification of the same specimen. Small bone trabeculae (*arrowhead*) are in direct contact with the titanium surface. Many osteoblasts (*arrows*) are depositing osteoid matrix on the implant surface (acid fuchsin-toluidine blue; magnification  $\times 50$ ).

**Fig 4a** (Left) Higher-power magnification of zone A from Fig 3a. A gingival sulcus of 0.5 mm is present; no inflammatory cells are observed in the connective tissue (CT) (acid fuchsin-toluidine blue; magnification  $\times 50$ ).

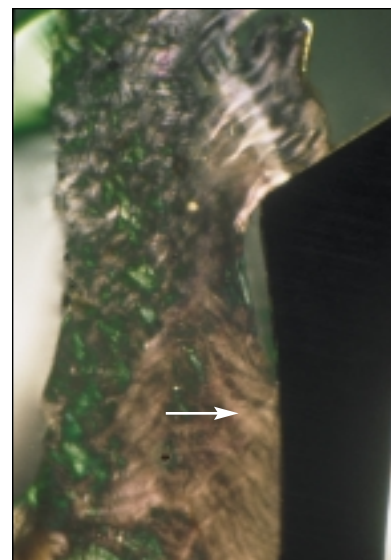


**Fig 4b** (Right) High-power magnification of the epithelial attachment zone. No gaps between the connective tissue (CT) and the implant surface are present; inflammatory cells are absent (acid fuchsin-toluidine blue; magnification  $\times 100$ ).

**Fig 4c** (Left) Higher-power magnification of zone B from Fig 3a. Connective tissue fibers (CT) are attached to the cervical surface of the implant (acid fuchsin-toluidine blue; magnification  $\times 50$ ).



**Fig 4d** (Right) Observation under polarized light of the area shown in Fig 4a. Connective tissue fibers (*arrow*) run perpendicularly toward the implant surface, forming an interconnecting network as they approach the titanium surface (acid fuchsin-toluidine blue; magnification  $\times 100$ ).



abutment connection to the implant is not necessary. Reports have been found in the literature on the use of resorbable membranes for bone regeneration in humans<sup>39,40</sup> but to the authors' knowledge no studies have been done on the use of resorbable membranes in conjunction with immediate placement of 1-stage transmucosal implants.

The present results support those of Wilson et al<sup>15</sup> that osseointegration in humans can be achieved on a light microscopic level following implant placement in immediate extraction sites. Those authors found that for the implants placed in sites with a horizontal defect dimension of 1.5 mm or less, the mean bone-implant contact percentage was 50%, while the lowest percentage was found in sites where the horizontal defect was larger than 4 mm. A control implant placed in mature bone had a bone-implant contact percentage of 72.14%.<sup>15</sup> It was concluded from this study that the horizontal component of defects was most critical in determining the final amount of bone-implant contact, and that a membrane was not necessary in sites with peri-implant bone defects of 1.5 mm or less in the horizontal dimension.

The high level of bone-implant contact percentage observed in the implant under consideration could be the result of alveolar socket walls remaining intact, a favorable defect morphology, and, probably, an appropriate implant surface (titanium plasma-spray).<sup>15</sup> It must also be recognized that osseointegration is enhanced by using guided bone regeneration techniques when implants are placed immediately after extraction.<sup>17</sup> No presence of inflammatory infiltrate in the supracrestal connective tissues was found in this patient. This could be related to the fact that with non-submerged implants there is only one microgap located above or slightly below the gingival margin.<sup>41</sup>

The present results showed that in the authors' case connective tissue fibers were oriented perpendicularly to the implant surface. Similar results have been reported by Schroeder et al<sup>42</sup> and Piattelli et al.<sup>43</sup> Moreover, a wide extension of the supracrestal connective tissue (3.2 mm) was found along with an epithelial attachment of only 0.5 mm. Because of that, bone did not cover the entire surface of the implant. These results were similar to those reported by Weber et al in a canine model.<sup>44</sup> In a human autopsy report, supracrestal connective tissues were found to have a width of 1.9 mm.<sup>43</sup>

## ACKNOWLEDGMENTS

This work was partially supported by the National Research Council (C.N.R.), Finalized Project "Materials Tailored for Advanced Technologies" PF MSTA II, Rome, Italy; and by the Ministry of University, Research, Science and Technology (M.U.R.S.T.), Rome, Italy.

## REFERENCES

1. Kohal RJ, Mellas P, Hurzeler MB, Trejo PM, Morrison E, Caffesse RG. The effects of guided bone regeneration and grafting on implants placed into immediate extraction sockets. An experimental study in dogs. *J Periodontol* 1998; 69:927-937.
2. Lekholm U, Zarb GA. Patient selection and preparation. In: Brånemark P, Zarb GA, Albrektsson T (eds). *Tissue-Integrated Prostheses: Osseointegration in Clinical Dentistry*. Chicago: Quintessence, 1985:199-210.
3. Carlsson GE, Persson G. Morphologic changes of the mandible after extraction and wearing of dentures. *Odontol Rev* 1967;18:27-54.
4. Atwood D. Postextraction changes in the adult mandible as illustrated by microradiographs of midsagittal section and serial cephalometric roentgenograms. *J Prosthet Dent* 1963;13:810-816.
5. Ulm C, Solar T, Blahout R, Matejka M, Gruber H. Reduction of the compact and cancellous bone substances of the edentulous mandible caused by resorption. *Oral Surg Oral Med Oral Pathol* 1992;74:131-136.
6. Zitzmann NU, Naef R, Schupbach P, Schärer P. Immediate or delayed immediate implantation versus late implantation when using the principles of guided bone regeneration. *Acta Med Dent Helv* 1996;1:221-227.
7. Shanaman R. The use of guided tissue regeneration to facilitate ideal prosthetic placement of implants. *Int J Periodontics Restorative Dent* 1992;12:257-265.
8. Watzek G, Haider R, Mensdorf-Pouilly N, Haas R. Immediate and delayed implantation for complete restoration of the jaw following extraction of all residual teeth: A retrospective study comparing different types of serial immediate implantation. *Int J Oral Maxillofac Implants* 1995;10: 561-567.
9. Becker W, Becker B, Handelsman M, Ochsenein C, Albrektsson T. Guided tissue regeneration for implants placed into extraction sockets: A study in dogs. *J Periodontol* 1991;62:703-709.
10. Krump JL, Barnett BG. The immediate implant: A treatment alternative. *Int J Oral Maxillofac Implants* 1991;6: 19-23.
11. Lazzara RJ. Immediate implant placement into extraction sites: Surgical and restorative advantages. *Int J Periodontics Restorative Dent* 1989;9:333-343.
12. 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.
13. Becker W, Dahlin C, Becker B, Lekholm U, van Steenberghe D, Higuchi K, Kultje C. 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.

14. Henry PJ, Tan AES, Leavy J, Johnsson CB, Albrektsson T. Tissue regeneration in bony defects adjacent to immediately loaded titanium implants placed into extraction sockets: A study in dogs. *Int J Oral Maxillofac Implants* 1997;12:758-766.
15. Wilson TG, Schenk R, Buser D, Cochran D. Implants placed in immediate extraction sites: A report of histologic and histometric analysis of human biopsies. *Int J Oral Maxillofac Implants* 1998;13:333-341.
16. Becker W, Clokie C, Sennerby L, Urist M, Becker BE. Histologic findings after implantation and evaluation of different grafting materials and titanium microscrews into extraction sockets: Case reports. *J Periodontol* 1998;69:414-421.
17. Brunel G, Benqué E, Elharar F, Sansac C, Duffort JF, Barthet P, et al. Guided bone regeneration for immediate non-submerged implant placement using bioabsorbable materials in beagle dogs. *Clin Oral Implants Res* 1998;9:303-312.
18. Grunder U, Polizzi G, Goené R, Hatano N, Henry P, Jackson WJ, et al. A 3-year prospective multicenter follow-up report on the immediate and delayed-immediate placement of implants. *Int J Oral Maxillofac Implants* 1999;14:210-216.
19. Knox R, Caudill R, Meffert R. Histologic evaluation of dental endosseous implants placed in surgically created extraction defects. *Int J Periodontics Restorative Dent* 1991;11:365-375.
20. Carlsson L, Rostlund T, Albrektsson B, Albrektsson T. Implant fixation improved by close fit. Cylindrical implant-bone interface studies in rabbits. *Acta Orthop Scand* 1988;59:272-275.
21. Becker BE, Becker W, Ricci A, Geurs N. A prospective clinical trial of endosseous screw-shaped implants placed at the time of tooth extraction without augmentation. *J Periodontol* 1998;69:920-926.
22. Albrektsson T, Zarb GA, Erksson A. The long-term efficacy of currently used dental implants: A review and proposed criteria. *Int J Oral Maxillofac Implants* 1986;1:11-25.
23. Rosenquist B, Grenthe B. Immediate placement of implants into extraction sockets: Implant survival. *Int J Oral Maxillofac Implants* 1996;11:205-209.
24. Gelb D. Immediate implant surgery: Three-year retrospective evaluation of 50 consecutive cases. *Int J Oral Maxillofac Implants* 1993;8:388-399.
25. Barzilay I, Graser GN, Iranpour B, Proskin HM. Immediate implantation of pure titanium implants into extraction sockets of *Macaca fascicularis*. Part I: Clinical and radiographic assessment. *Int J Oral Maxillofac Implants* 1996;11:299-310.
26. Barzilay I, Graser GN, Iranpour B, Proskin HM. Immediate implantation of pure titanium implants into extraction sockets of *Macaca fascicularis*. Part II: Histologic observation. *Int J Oral Maxillofac Implants* 1996;11:489-497.
27. Becker W, Schenk R, Higuchi K, Lekholm U, Becker B. Variation in bone regeneration adjacent to implants augmented with barrier membranes alone or with demineralized freeze-dried bone or autologous graft: A study of dogs. *Int J Oral Maxillofac Implants* 1995;10:143-154.
28. Simion M, Dahlin C, Trisi P, Piattelli A. Qualitative and quantitative comparative study on different filling materials used in bone tissue regeneration. A controlled clinical study. *Int J Periodontics Restorative Dent* 1994;14:199-215.
29. Piattelli A, Scarano A, Quaranta M. High-precision, cost-effective system for producing thin sections of oral tissues containing dental implants. *Biomaterials* 1997;18:577-579.
30. Piattelli A, Scarano A, Piattelli M. Detection of alkaline and acid phosphatases around titanium implants: A light microscopical and histochemical study in rabbits. *Biomaterials* 1995;16:1333-1338.
31. Ericsson I, Nilner K, Klinge B, Glantz P-O. Radiographical and histological characteristics of submerged and nonsubmerged titanium implants. An experimental study in the Labrador dog. *Clin Oral Implants Res* 1996;7:20-26.
32. Gotfredsen K, Rostrup E, Hjørtting-Hansen E, Stoltze K, Budtz-Jørgensen E. Histological and histomorphometrical evaluation of tissue reactions adjacent to endosteal implants in monkeys. *Clin Oral Implants Res* 1991;2:30-37.
33. Weber HP, Buser D, Donath K, Fiorellini JP, Doppalapudi V, Paquette DW, Williams RC. Comparison of healed tissues adjacent to submerged and nonsubmerged unloaded titanium implants. A histometric study in beagle dogs. *Clin Oral Implants Res* 1996;7:11-19.
34. Buser D, Ruskin J, Higginbottom H, Hardwick R, Dahlin C, Schenk R. Osseointegration of titanium implants in bone regenerated in membrane-protected defects: A histologic study in the canine mandible. *Int J Oral Maxillofac Implants* 1995;10:666-681.
35. Warrar K, Gotfredsen K, Hjørtting-Hansen E, Karring T. Guided tissue regeneration ensures osseointegration of dental implants placed into extraction sockets: An experimental study in monkeys. *Clin Oral Implants Res* 1991;2:166-171.
36. Jovanovic S, Spiekermann H, Richter E. Bone regeneration around titanium dental implants in dehiscence defect sites: A clinical study. *Int J Oral Maxillofac Implants* 1992;7:233-245.
37. Cochran DL, Douglas HB. Augmentation of osseous tissue around nonsubmerged endosseous dental implants. *Int J Periodontics Restorative Dent* 1993;13:506-519.
38. Brägger U, Hammerle CHF, Lang NP. Immediate transmucosal implants using the principle of guided tissue regeneration (II). A cross-sectional study comparing the clinical outcome 1 year after immediate and standard implant placement. *Clin Oral Implants Res* 1996;7:268-276.
39. Buser D, Mericske-Stern R, Bernard JP, Behneke N, Hirt HP, Belser UC, Lang NP. Long-term evaluation of non-submerged ITI implants. Part 1: 8-year life table analysis of a prospective multicenter study with 2359 implants. *Clin Oral Implants Res* 1997;8:161-172.
40. Mayfield L, Nobreus N, Attstrom R, Lindhe A. Guided bone regeneration in dental implant treatment using a bioabsorbable membrane. *Clin Oral Implants Res* 1997;8:10-17.
41. Hermann JS, Cochran DL, Nummikoski PV, Buser D. Crestal bone changes around titanium implants. A radiographic evaluation of unloaded nonsubmerged and submerged implants in the canine mandible. *J Periodontol* 1997;68:1117-1130.
42. Schroeder A, Van der Zypen E, Stich H, Sutter F. The reaction of bone, connective tissue and epithelium to endosteal implants with sprayed titanium surface. *J Maxillofac Surg* 1981;9:15-25.
43. Piattelli A, Scarano A, Piattelli M, Bertolai G, Panzoni E. Histologic aspects of the bone surrounding three titanium non-submerged plasma-sprayed implants retrieved at autopsy: A case report. *J Periodontol* 1997;68:694-700.
44. Weber HP, Buser D, Donath K, Fiorellini JP, Doppalapudi V, Paquette DW, Williams RC. Comparison of healed tissues adjacent to submerged and non-submerged unloaded titanium dental implants. A histometric study in beagle dogs. *Clin Oral Implants Res* 1996;7:11-19.