IMMEDIATE POSTEXTRACTION IMPLANTS: A HISTOLOGIC AND HISTOMETRIC ANALYSIS IN MONKEYS

Antonio Scarano, DDS
Giovanna Iezzi, DDS
Giovanna Petrone, DDS
Vanessa C. Marinho, DDS, PhD
Massimo Corigliano, DDS
Adriano Piattelli, MD, DDS

KEY WORDS

Bone–implant interface
Histomorphometry
Monkeys
Osteointegration
Postextraction implants

Antonio Scarano, DDS, Giovanna Iezzi, DDS, and **Giovanna Petrone, DDS,** are research fellows at the Dental School, University of Chieti, Italy.
Vanessa C. Marinho, DDS, is in the PhD program, University of Southern California, School of Dentistry, Los Angeles, Calif., and is a CAPES of Brazil Scholarship-awarded fellow.
Massimo Corigliano, DDS, is in private practice, Mentana (Rome), Italy.
Adriano Piattelli, MD, DDS, is professor of oral pathology and medicine at the Dental School, University of Chieti, and an honorary senior lecturer at the Eastman Dental Institute for Oral Health Care Sciences, London, UK. Address all correspondence to Prof. A. Piattelli, Via F. Sciucchi 63, 66100 CHIETI, Italy.

The aim of this study was to evaluate the reaction of peri-implant tissues to immediately placed titanium plasma-sprayed implants into extraction sockets. Six *macaca fascicularis* monkeys were used in the study. A total of 36 titanium plasma-sprayed implants (PHI, Legnano, Italy) were inserted in both arches (18 in the posterior maxilla and 18 in the posterior mandible). The two premolars and the first molars of the maxilla and the mandible of all animals were extracted, and immediate postextraction implants were placed. After a releasing periosteal incision, the flap was coronally repositioned and sutured. No barrier membranes were used, and the only graft material used was autogenous bone chips. The implants were loaded after 2 months. Six months after implant loading, a block section was carried out, the remaining defects were filled with nonresorbable hydroxyapatite, and all 36 implants were retrieved. The implants were treated with the Precise System (Assing, Rome, Italy), to obtain thin ground sections. A total of three slides were cut for each implant and were examined under normal and polarized light. A histomorphometrical analysis was done. All implants were covered by compact, mature bone under examination in light microscopy. A very high bone-implant contact percentage (65–70%) was observed. No bone loss was present after the loading period. These results indicate that implants placed into fresh extraction sites grafted with autogenous bone chips will heal in a predictable way.

INTRODUCTION

An immediate implant is one that is placed into an extraction socket when a tooth is extracted.[1,2,3] Immediate postextraction implants have several advantages, such as fewer surgical procedures, preservation of bone volume, and shortening the time until the implants can be restored.[4] Additional advantages of the use of the immediate postextraction implants are the following:

1. Shortening of the edentulous time period,

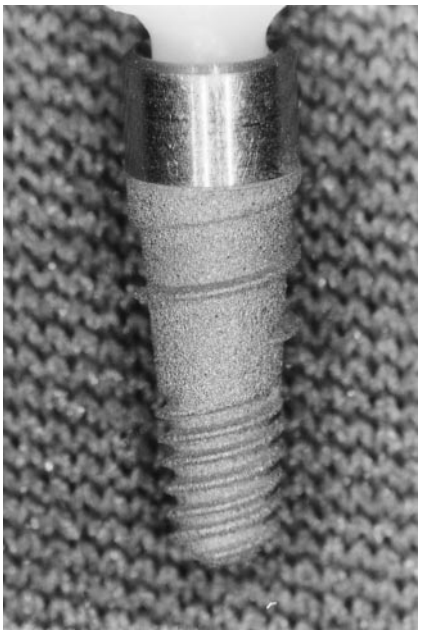


FIGURE 1. Macroscopic view of the PHI implant.

TABLE 1

Histomorphometric analyses

Mandible	Mean of % of the Three Sections	Maxilla	Mean of % of the Three Sections
1	80.1	1	67
2	72.5	2	59
3	66	3	61.3
4	59.5	4	69.3
5	73	5	52
6	68.8	6	65.5
7	62.5	7	71
8	63.5	8	59.5
9	74	9	73
10	76	10	65
11	72	11	71
12	83	12	71
13	72	13	72
14	65	14	65.5
15	72	15	60
16	82	16	75
17	78	17	63
18	80	18	55
Total	72.2	Total	65.3
SD	6.949418	SD	6.510105

2. Reduction in the costs of treatment,
3. Improving the psychological approach with the patient,
4. Reduction in morbidity,
5. Optimal aesthetic result, with an easier definition of the implant position.[5]

Several human clinical studies have demonstrated that with immediate postextraction implants it is possible to obtain very high (>90%) long-term success percentages.[4–10] Moreover, many experimental studies have confirmed that a high percentage of bone-implant contact can be achieved on a light microscopic level in animals when using immediate postextraction implants.[11–15] One major drawback in using immediately placed postextraction implants is the lack of adaptation of the alveolar bone in the cervical portion of the implant.[14,16] This space can be filled by soft tissues, creating problems in the osseointegration of the implant. When using immediate postextraction implants, it is almost always necessary to resort to osteopromoting techniques.[16–19] The use of graft materials and barrier membranes have been extensively used when placing immediate implants,[6,17,19–21,38] however, complications such as exposure of the membranes (especially of nonresorbable ones[9,22]) are often reported. The placement of implants into fresh extraction sites with autogeneous bone chips and without the use of barrier membranes has been advocated by some investigators,[23–26] even if other researchers found that the combination of barrier membranes with bone substitutes increased the mineralized bone-to-implant contact percentage.[27]

The aim of this study was to evaluate the peri-implant tissue reactions to immediately placed titanium plasma-sprayed implants with autogenous bone chips and without barrier membranes into fresh extraction sockets of *macaca fascicularis* monkeys.

MATERIALS AND METHODS

Implants

The plasma-sprayed titanium fixtures (PHI, Legnano, Italy) used in this study were screw-shaped, 4 mm in diameter and 10 mm in length. The plasma-spray covered 7.5 mm of the body of the screw, whereas the neck was made with a smooth titanium surface. The body of the implant consisted of three threads, each with a pitch of 1.5 mm (Fig 1).

Experimental animals

Six 6- to 8-year-old *macaca fascicularis* monkeys weighing 8–10 kg were used in the study.

Surgical procedure

The animals were anesthetized by intramuscular injections of ketamine hydrochloride (20 mg/kg), atropine sulfate (0.05 mg/kg), and chlorpromazine hydrochloride (1 mg/kg). The two premolars and the first molars of the maxilla and mandible of all the animals were extracted unilaterally, followed by immediate placement of the implants (Figs 2, 3). A total of 36 implants were inserted, 18 in the mandible (Fig 4) and 18 in the maxilla. The socket preparation and threading was done with a 4.0 mm custom-made instrument. The implants were carefully inserted by manual tapping. No barrier membranes were placed, and the only graft material used was autogenous bone chips. The size of the peri-implant defects ranged from 0 to 2.0 mm. Cover screws were immediately inserted on the implants, and a releasing periosteal incision was done and the flap was coron-

ally repositioned and sutured. Loading of the implants was done after 2 months of healing. After 6 months of loading, block sections of the six animals with the implants were obtained, and the remaining bone defects were treated with guided bone regeneration using resorbable membranes.

Processing of the specimens

The specimens were stored immediately in 10% buffered formalin and processed to obtain thin ground sections with the Precise 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 longitudinally along the long axis of the implant bucco-lingually with a high-precision diamond disc at about 150 μm and then ground down to about 30 μm. Three sections were obtained for each implant. Staining was done with acid fuchsin and toluidine blue. A double staining with von Kossa and basic fuchsin was done to evaluate the degree of bone mineralization. One slide per implant, after polishing, was immersed in $AgNO_3$ for 30 minutes and exposed to sunlight; the slides were then washed under tap water, dried out, immersed in basic fuchsin for 5 minutes, washed again, and then mounted. The histomorphometry was done under a Laborlux-S light microscope (Leitz, Wetzlar, Germany) using an Intel Pentium II 300 MMX, a video-acquired schedules Matrox, a video camera, and KS 100 software (Zeiss, Hallbergmoos, Germany). The images acquired have been analyzed using the described software system.

Results

Mandible

In the most coronal portion of the implants, it was possible to observe the presence of a 3–4 mm compact, cortical bone with few marrow spaces (Fig 5). A few secreting osteoblasts were present only in the most coronal portion of the alveolar crest, whereas in other areas, they were present inside few marrow spaces (Fig 6). In the apical portion of all of the implants, on the other hand, only thin, small bone trabeculae covered the metal surface. The epithelium was lost during the retrieval of the specimens. The connective tissue was dense with few cells and no inflammatory infiltrate. It was possible to see a 3-mm infrabony defect around only one implant. No gaps were present between bone and metal. No connective or fibrous tissues were present around any portion of the implants. Bone resorption was not present in any area of the histological sections. Histomorphometric evaluation showed that the bone-implant contact percentage was 75.2% (±5%).

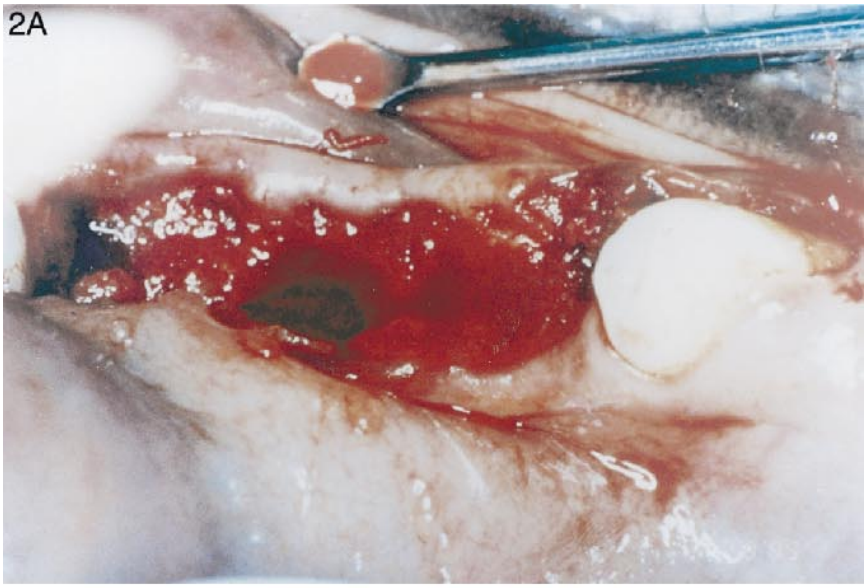
Maxilla

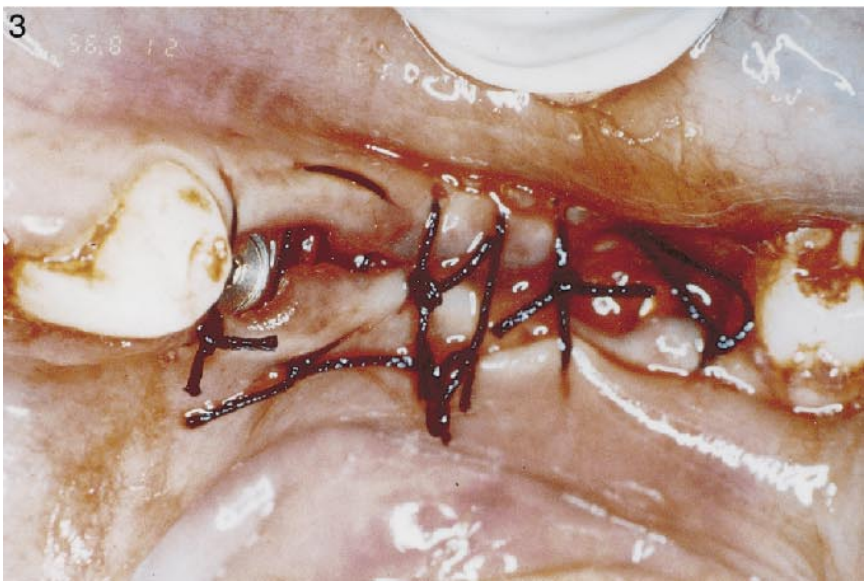
Mature, compact lamellar bone covered the implant surface in all of the implants analyzed (Fig 7). In some portions of the interface, this bone was composed only by small, thin bone trabeculae. In some areas, it was not possible to observe an osteoblastic rim. A direct contact was present between bone and implant, and no gaps or connective fibrous tissue were present at the interface; some osteoblasts were also secreting osteoid matrix toward the implant surface (Fig 8). In the most coronal portion, it was possible to detect the presence of a cortical bone with few marrow spaces. No inflammatory cells were present at the interface or in the peri-implant tissues. Also, at higher magnification no gaps could be seen at the interface. The compact, lamellar bone was especially thickened around the threads. With the Von Kossa–stained slides, the bone lining the implants appeared to be highly mineralized. With the double staining, no osteoid tissue was present in the peri-implant location. At the coronal portion, the newly formed bone was composed mainly by woven bone with wide osteocyte lacunae in all specimens. Infrabony defects were absent. The histomorphometrical analysis showed that the bone-implant contact percentage was 65.3% (±5%; Table 1).

Discussion

According to the original treatment protocol, patients who presented with failing or terminal dentition would be rendered edentulous and required to heal for a period before any attempt to place implants could be made.[29] However, after tooth extraction the resorption and remodeling of the alveolar socket can result in a site that will be inadequate, from a dimensional point of view, for the implant placement. When an implant is placed into an extraction socket, osteogenic and osteoresorptive responses are already initiated following extraction, and the tissue may enhance the capacity for healing. An immediate implant placed into an extraction socket has less cortical-type bone for support. The immediate placement presents three important advantages: (1) treatment time is significantly reduced, (2) ridge contour can be preserved, and (3) it is possible to place a fixture in a more ideal axial position, thus enhancing fabrication, aesthetics, and biomechanics of the future restoration.[29] On the other hand, it is very important that in immediate placement, periodontal pathology[30] must be taken into consideration as a possible cause of tooth loss and should best be treated mechanically and antimicrobially.

The use of guided bone regeneration can have an important role in the placement of implants into fresh extraction sites. Previous animal studies have demonstrated histologically that osseointegration occurs around immediately placed titanium implants in extraction sockets.[11–13,15,19,27,32–36] This technique has also been documented in humans,[5,17,18,37,38] with the use of barrier membranes alone[24,30] or in combination with alloplast materials,[30] alloplast materials alone,[29] and autogenous grafts without barrier membranes.[9,25,26,37,39] However, some complications were





present when using membranes: premature exposure[23] and the consequent contamination of the site, which jeopardizes the healing process,[22] and the unpleasant necessity to undergo another surgical procedure.

Therefore, if the remaining bone defects left by the socket's wall around the fixture could be filled with autogeneous bone chips and bone formation could be obtained after healing, it would be another advantage to the im-

←

FIGURE 2. (A) Surgical aspect of the extraction site and alveolar curettage. (B) The teeth after extraction.
FIGURE 3. Surgical aspect of the surgical closure.

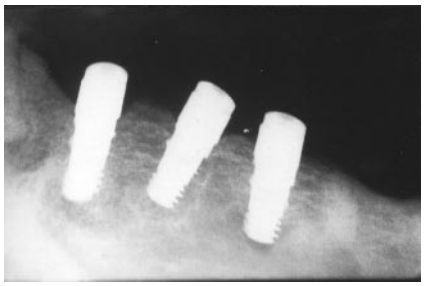
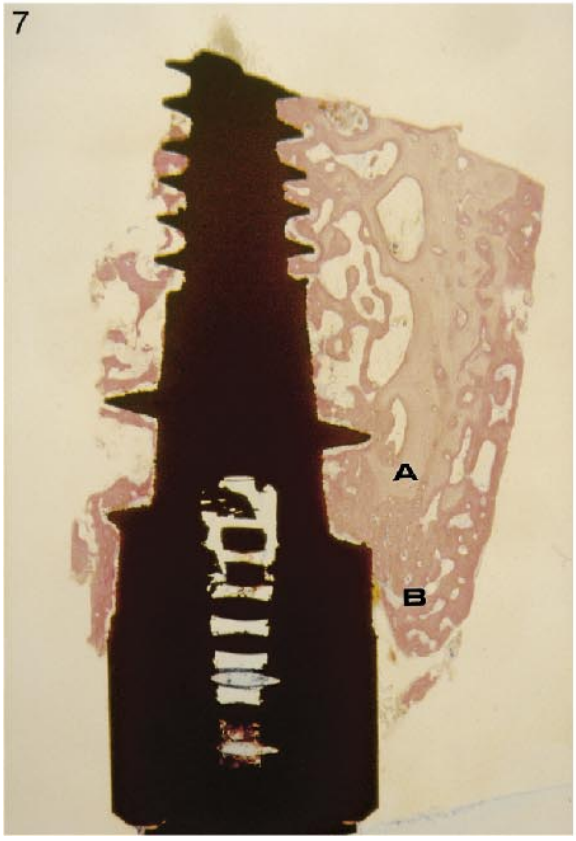
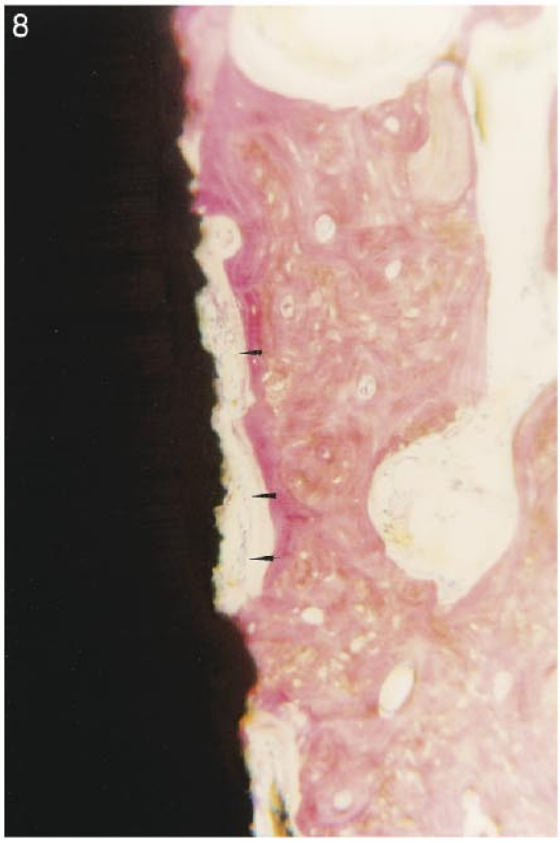


FIGURE 4. Periapical radiograph after placement of the postextraction implants in the mandible.

→

FIGURE 5. At low-power magnification in the mandibular section it is possible to observe mature compact bone surrounding the implant. In the most coronal part, newly regenerated bone (A) over the pre-existing cortical bone (B) is present (toluidine blue and acid fuchsin ×12).
FIGURE 6. Higher magnification of the apical part of the previous slide. Actively secreting osteoblasts are present (see arrows). No gaps between the bone-implant interface or presence of epithelial and soft tissues can be observed (toluidine blue and acid fuchsin ×200).
FIGURE 7. In the maxilla it is possible to observe newly regenerated bone (B) present over the pre-existing alveolar crest (A). This bone is strongly stained with acid fuchsin (toluidine blue and acid fuchsin ×12).
FIGURE 8. At higher magnification, many osteoblasts actively secreting osteoid matrix are present (see arrows). No osteoclasts can be observed. No apical migration of the epithelium or soft tissues is present (toluidine blue and acid fuchsin ×200).





mediate placement procedure. Following this line of thought, we evaluated the peri-implant tissue reactions to immediately placed titanium plasma-sprayed implants without the use of barrier membranes into fresh extraction sockets of *macaca fascicularis* monkeys. Our results indicated that implants placed into fresh extraction sites grafted with autogenous bone chips will heal in a predictable way. The use of bone chips without the use of barrier membranes also resulted in low complication levels. Interestingly, bone growth was present over the previous crestal bone (Fig 8). Results of the present study indicate that in terms of integration levels of bone there are few differences between the anatomic zones.

CONCLUSION

The use of bone chips without the use of barrier membranes resulted in low levels of complications and in bone regeneration on the previously existing defects. The results indicate that implants placed into fresh extraction sites grafted with autogenous bone chips will heal in a predictable way. The results of this study did not indicate any harmful side effects from placing autogeneous bone grafts into small defects adjacent to the dental implants.

ACKNOWLEDGMENTS

This work was partially supported by the National Research Council (CNR) Finalized Project, ''Materials Tailored for Advanced Technologies,'' PF MSTA II, Rome, Italy, and by the Ministry of University, Research, Science, and Technology (MURST), Rome Italy.

REFERENCES

1. Barzilay I, Graser GN, Caton J, Shenkle G. Immediate implantation of pure titanium threaded implants into extraction sockets. *J Dent Res.* 1988;67: 234.

2. Barzilay I, Graser GN, Iranpour B, Natiella JR. Immediate implantation of a pure titanium implant into an extraction socket: report of a pilot procedure. *Int J Oral Maxillofac Implants.* 1991;6: 277-284.

3. Barzilay I, Graser GN, Iranpour B, Proskin H. 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.

4. Grunder U, Polizzi G, Goene R *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.

5. Gelb DA. Immediate implant surgery: 3-year retrospective evaluation of 50 consecutive cases. *Int J Oral Maxillofac Implants.* 1993;8:388–399.

6. Lazzara RJ. Immediate implant placement into extraction sites: surgical and restorative advantages. *Int J Periodontics Restorative Dent.* 1989;9:332–343.

7. Nyman S, Lang N, Buser D, Bragger U. Bone regeneration adjacent to titanium dental implants using guided tissue regeneration: a report of two cases. *Int J Oral Maxillofac Implants.* 1990; 5:9–14.

8. Rosenquist B, Grenthe B. Immediate placement of implants into extraction sockets: implant survival. *Int J Oral Maxillofac Implants.* 1996;11:205–209.

9. Schwartz-Arad D, Chaushu G. Placement of implants into fresh extraction sites: 4 to 7 years retrospective evaluation of 95 immediate implants. *J Periodontol.* 1997;68:110–116.

10. Wong K. Immediate implantation of endosseous dental implants in the posterior maxilla and anatomic advantages for this region: a case report. *Int J Oral Maxillofac Implants.* 1996;11: 529–533.

11. Barzilay I, Graser G, Iranpour B, Natiella J, Proskin H. Immediate implantation of pure titanium implants into extraction sockets of *macaca fascicularis.* Part II: histologic observations. *Int J Oral Maxillofac Implants.* 1996;11: 489–497.

12. Becker W, Becker BE, 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.

13. Becker W, Lynch SE, Lekholm U, Becker BE, Caffesse R, Donath K, Sanchez R. A comparison of ePTFE membranes alone or in combination with platelet-derived growth factors and insulin-like growth factor-I or demineralized freeze-dried bone in promoting bone formation around immediate extraction socket implants. *J Periodontol.* 1992;63:929–940.

14. Brunel G, Benque E, Elharar F, Sansac C, Duffort JF, Barthet P, Baysse E, Miller N. Guided bone regeneration for immediate nonsubmerged implant placement using bioabsorbable materials in beagle dogs. *Clin Oral Implants Res.* 1998;9:303–312.

15. Parr G, Steflik D, Sisk A. Histomorphometric and histologic observations of bone healing around immediate implants in dogs. *Int J Oral Maxillofac Implants.* 1993;8:534–540.

16. Zitzmann NU, Naef R, Scharer P. Resorbable versus nonresorbable membranes in combination with Bio-Oss for guided bone regeneration. *Int J Oral Maxillofac Implants.* 1997;12:844–852.

17. Becker W, Dahlin C, Becker BE, *et al.* The use of barrier membranes for bone promotion around titanium implant placed into extraction sockets: a prospective multicenter study. *Int J Oral Maxillofac Implants.* 1994;9:31–40.

18. Becker W, Becker BE, Polizzi G, Bergström C. Autogenous bone grafting of bone defects adjacent to implants placed into immediate extraction sockets in patients: a prospective study. *Int J Oral Maxillofac Implants.* 1994;9:389–396.

19. Wilson TG Jr. Guided tissue regeneration around dental implants in immediate and recent extraction sites: initial observations. *Int J Periodontics Restorative Dent.* 1992;12:185–193.

20. Gher ME, Quintero G, Assad D, Monaco E, Richardson AC. Bone grafting and guided bone regeneration for

immediate dental implants in humans. *J Periodontol.* 1994;65:881–891.

21. Lang NP, Brägger U, Hämmerle CHF, Sutter F. Immediate transmucosal implants using the principle of guided tissue regeneration. *Clin Oral Implants Res.* 1994;5:154–163.

22. Nowzari H, Slots J. Microbiologic and clinical study of polytetrafluoroethylene membranes for guided bone regeneration around implants. *Int J Oral Maxillofac Implants.* 1995;10:67–73.

23. Simion M, Baldoni M, Rossi P, Zaffe D. Comparative study of the effectiveness of GTAM membranes with and without early exposure during the healing period. *Int J Periodontics Restorative Dent.* 1993;14:167–180.

24. Gher ME, Quintero G, Sandifer JB, Tabacco M, Richardson AC. Combined dental implant and guided tissue regeneration therapy in humans. *Int J Periodontics Restorative Dent.* 1994; 14:332–347.

25. Isaksson S, Alberius P. Maxillary alveolar ridge augmentation with only bone grafts and immediate endosseous implants. *J Craniomaxillofac Surg.* 1992; 20:2–7.

26. Schwartz-Arad D, Chaushu G. Immediate implant placement: a procedure without incisions. *J Periodontol.* 1981;69:743–750.

27. 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.

28. 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.

29. Branemark P-I, Zarb GA, Albrektson T. Tissue Integrated Prostheses: Osseointegration in Clinical Dentistry. Chicago: Quintessence Pub Co; 1985.

30. Werbitt MJ, Goldberg PV. The immediate implant: bone preservation and bone regeneration. *Int J Periodontics Restorative Dent.* 1992;12:206–217.

31. Novaes A Jr, Novaes A. Immediate implants placed into infected sites: a clinical report. *Int J Oral Maxillofac Implants.* 1995;10:609–613.

32. Celletti R, Davarpanah M, Etienne D, Pecora G, Tecucianu JF, Djukanovic D, Donath K. Guided tissue regeneration around dental implants in immediate extraction sockets: comparison of e-PTFE and a new titanium membrane. *Int J Periodontics Restorative Dent.* 1994;14:242–253.

33. Dahlin C, Sennerby L, Lekholm U, Linde A, Nyman S. Generation of new bone around titanium implants using a membrane technique: an experimental study in rabbits. *Int J Oral Maxillofac Implants.* 1989;81:672–676.

34. Knox R, Caudill R, Meffert R. Histologic evaluation of dental endosseous implants placed in surgically created extraction defects. *Int J Periodontics Restorative Dent.* 1991;11:365–376.

35. Lundgren D, Rylander H, Andersson M, Johansson C, Albrektsson T. Healing of root analogue titanium implants placed in extraction sockets: an experimental study in the beagle dog. *Clin Oral Implants Res.* 1992;3:136–143.

36. Warrer K, Gottfredsen K, Hjorting-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.

37. Caudill RF, Meffert RM. Histologic analysis of the osseointegration of endosseous implants in simulated extraction sockets with and without e-PTFE barriers. Part I: preliminary findings. *Int J Periodontics Restorative Dent.* 1991;11:207–215.

38. Becker W, Becker B. Guided tissue regeneration for implants placed into extraction sockets and for implant dehiscences: surgical techniques and case reports. *Int J Periodontics Restorative Dent.* 1990;10:376–391.

39. Tong DC, Rioux K, Drangsholt M, Beirne OR. A review of survival rates for implants placed in grafted maxillary sinuses using meta-analysis. *Int J Oral Maxillofac Implants.* 1998;13: 141.