Immediate Implant Surgery: Three-Year Retrospective Evaluation of 50 Consecutive Cases

David A. Gelb, DDS

Since August 1989, 35 consecutive patients were treated with immediate implants to replace 50 teeth requiring extractions as a result of root fractures, endodontic instability, nonrestorable carious lesions, or periodontal disease. Defects relative to the implant were morphologically grouped and were treated for bone regeneration with demineralized freeze-dried crushed cancellous bone (DFDBA), e-PTFE membrane, or both. Thread exposure initially ranged from 4 to 20 threads, while implant lengths varied from 8.5 to 18 mm. The mean implant length was 15 mm, with mean thread exposure of 11.34 threads, or 54% of the threaded length of the implant. Reentry confirmed 100% thread coverage in all but one implant in the no-wall group treated with DFDBA alone. Histologic evaluation of three cases confirmed viability of the regenerated bone. The patients were followed through April 1993, with 49 implants (98%) remaining osseointegrated and functional, supporting the predictability of immediate implant placement. The age of the patients ranged from 16 to 80 years, hence implant placement considerations relative to adolescents are also discussed. (INT J ORAL MAXILLOFAC IMPLANTS 1993;8:388—399.)

Key words: bone regeneration, immediate implant, retrospective study

Implant dentistry has provided treatment planning opportunities that have revolutionized dentistry. The ability to restore completely and partially edentulous patients to function and an esthetic appearance comparable to the dentate state has been demonstrated to be predictable.1-5

Because tooth retention in the dentulous patient is bone dependent, implant placement in the completely or partially edentulous patient is also bone dependent. The bone resorptive and remodeling process after tooth extraction can be either conducive or preclusive to subsequent implant placement. The natural tendency for crestal resorption and remodeling, resulting in an apical and lingual loss of ridge anatomy, may alter a site that was adequate for tooth retention to one that is inadequate dimensionally for implant replacement. Lingual remodeling of alveolar anatomy may complicate implant position relative to opposing occlusal landmarks. Furthermore, changes in soft tissue landmarks relative to those of adjacent teeth can add to a compromised esthetic outcome.

To fulfill both functional and esthetic requirements for implant placement in the lingually resorbed ridge, it may be necessary to plan implant placement in Concert...
with ridge expansion procedures,\textsuperscript{6-10} a ridge-lap prosthesis,\textsuperscript{11} or the use of angulated abutments.\textsuperscript{12,13} Esthetic appearance may still be compromised in the presence of less than ideal implant placement and soft tissue anatomy. Bone augmentation procedures at the time of tooth extraction contribute to preservation of ridge width, ridge height, and soft tissue dimensions.\textsuperscript{14,15} This approach requires an interim healing period with a secondary surgical procedure for implant placement.

Immediate implant placement has been reported in both experimental animals and humans.\textsuperscript{16-20} Animal studies in both monkeys and dogs have histologically demonstrated that osseointegration occurs after immediate placement of titanium implants in extraction sites.\textsuperscript{16,18,19}

The number of cases of immediate implant placement and documented follow-up has been limited. This paper reports on 50 consecutively placed immediate implants in humans over a 3-year period, evaluating initial defect morphology, treatment modality, regenerative results, predictability, and esthetic and functional attainment.

Materials and Methods
Since August 1989, 35 consecutive partially edentulous patients presented for immediate implant placement of 50 teeth (Fig 1) following extraction. The presenting clinical situations included horizontal or vertical root fractures (n = 16), teeth unresponsive to endodontic treatment (n = 3), teeth with nonrestorable carious lesions (n = 9), and periodontally compromised teeth (n = 22).

A comprehensive medical and dental history was obtained and all patients were identified as suitable implant candidates. Clinical and radiographic evaluation revealed a minimum of 4 mm of sound bone for implant stabilization beyond the socket apices, or in one case, 4 mm at the socket apex where the diameter narrowed to accept a 4-mm-diameter implant. Patients were informed of the risks and benefits of immediate implant surgery, in which regenerative therapy was essential for suitable implant outcome. Patients ranged from 16 to 80 years of age (Table 1). All patients signed informed consent agreements before treatment. Patients were scheduled for surgery shortly after examination, because the clinical situations with which they presented were not all conducive to bone preservation.

The surgical protocol for osseointegration was adhered to\textsuperscript{26} as was the alteration of protocol to enhance esthetic and functional results of osseointegrated implants.\textsuperscript{15} Soft tissue management stage 1 surgery included preservation of keratinized tissue, atraumatic and adequate exposure of alveolar anatomy to provide accessibility for thorough debridement, and visualization of bone available for implant stabilization and primary closure where it did not alter vestibular depth. Primary closure was obtained in 36 cases; secondary closure included connective tissue grafts in 3, free gingival graft in 1, exposed e-PTFE membrane (Gore-Tex, WL Gore, Flagstaff, AZ) in 6, and exposed DFDBA (University of Miami School of Medicine demineralized
freeze dried crushed cancellous bone, 300 to 500 \( \mu \text{m} \) packed coronal to the implant within the soft tissue flap in 4 cases. Teeth were sectioned when necessary and atraumatically extracted to preserve socket anatomy.

Implant placement considerations included maximum use of bone apical to the extraction sockets as identified radiographically at the 2-mm drill stage with a Gelb Depth Gauge (Implant Innovations, West Palm Beach, FL). Implant placement prerequisites were: ideal implant alignment relative to the tooth to be restored for normal emergence profile and coronal-apical positioning of the head of the implant 3 mm apical to the cementoenamel junction (CEJ) of the adjacent teeth margins to allow for uniformity of CEJ margins and accommodation of abutment and porcelain subgingivally. Screw access chambers were aligned with the central fossa of posterior implant-supported prostheses. In the anterior region, implants were aligned with the cingulum of anterior implant-supported prostheses designed for screw retention, or the incisal edge of anterior implant-supported prostheses designed for cement retention (Figs 2 to 4) All implants were Bränemark (Nobelpharma AB, Gothenburg, Sweden) screw-type implants.

At the time of implant placement, the number of threads of the implant not contained in bone were counted, and the morphology of the bone defect relative to the exposed part of the implant was noted All clinical situations (Figs 5 and 6) were photographically documented and were reevaluated postsurgery with photographs to confirm observations made at the time of surgery.

Regenerative protocol was primarily selected according to bone defect morphology relative to the implant and then secondarily selected arbitrarily within each group to allow for comparison of treatment modality, defect morphology, and regenerative outcome (Fig 7)

Regenerative protocol included:

1. DFDBA packed tightly into the defects surrounding the implant (treatment protocol primarily in three-wall defects and circumferential defects)
2. DFDBA packed tightly into the defect surrounding the implant and covered with c-PTFE membrane. The membrane was contoured to overlap the defect margins by 2 mm onto sound bone (treatment protocol primarily in no-wall defects where ridge expansion was necessary)
3. e-PTFE membrane contoured to overlap the defect margins by 2 mm onto sound bone (treatment protocol primarily in three-wall defects and circumferential defects)

Postoperatively, patients were given 600 mg of ibuprofen (Advil), a prescription for an analgesic, and penicillin VK 500 mg QID for 10 days; or, if allergic to penicillin VK, erythromycin 333 mg TID for 10 days A 0.12% chlorhexidine solution (Peridex, Procter & Gamble, Cincinnati, OH), was prescribed for use
until suture removal. Where the e-PTFE membrane was exposed, chlorhexidine was used until membrane removal.

Radiographs were taken at the time of implant placement to confirm position as planned and to provide a baseline of bone morphology relative to the implant. Patients were scheduled 7 to 10 days after implant placement for suture removal and instruction in oral hygiene procedures. For those patients whose regenerative protocol included e-PTFE membrane, postoperative observations continued biweekly. Where the membranes were left exposed as part of the initial surgery, chlorhexidine rinse was continued BID until membrane removal. Membranes that became suppurative were scheduled for removal as soon as possible and the involved patients were placed on either penicillin VK 500 mg QID for 10 days or amoxicillin 250 mg TID and metronidazole 250 mg TID for 10 days.

Stage 2 surgery was scheduled 4 months after implant placement for mandibular implants and 6 months after implant placement for maxillary implants. Soft tissue management objectives for stage 2 surgery were followed. The degree of regeneration and implant thread coverage was evaluated at the time of membrane removal (Fig 8) in those cases where the bone was adequately mineralized at this time, or at stage 2 surgery. At stage 2 surgery, provisional healing abutments or provisional restorations were placed. Final abutment placement occurred 3 to 6 weeks later, with subsequent impressions and completion of the prosthesis. In one case, the keratinized tissue had sloughed, with exposure of the e-PTFE membrane (regular Gor-Tex membrane was used before the availability of the augmentation material). This situation was corrected with a subepithelial connective tissue graft at stage 2 surgery.

Photographs, radiographs, and clinical evaluations documented satisfactory completion of the final prosthesis. Periodic recalls at 6- to 12-month intervals were scheduled for maintenance care and ongoing evaluation.

Results
In all cases the surgical procedures were completed as planned with absolute stabilization of the implants in the available bone. Implant sizes ranged from 8.5 to 18.0 mm (see Fig 6). No untoward effects such as paresthesia or postoperative complications were sustained, except in isolated instances of tissue intolerance to the membrane. Clinically, pathognomonic of this tissue intolerance was swelling, suppuration, and if protracted, membrane exposure of previously covered membranes. All patients, including those whose membranes became exposed, tolerated the combined extraction, implant placement, and regenerative procedures well.

The implant defect morphology as evaluated in the 50 cases could be categorized into three groups: no-wall, three-wall, and circumferential defects (Figs 9a to 9c).
No-Wall Defects. Thirteen defects were described as no-wall defects, having no labial plate (Fig 9a). These defects were of two or three surfaces with the implants in contact on the lingual surface and in such cases the mesial or distal surfaces as well. Adequate bone apical to the anatomic void was necessary to stabilize these implants.

Regenerative procedures (Fig 10) included DFDBA in one case with a 76% thread coverage (13/17 threads; 13-mm implant) at reentry. This case was re-treated at stage 2 surgery with DFDBA and e-PTFE membrane and resulted in 100% thread coverage. The other 12 defects were treated with DFDBA as a volume maintainer and e-PTFE membrane to promote guided tissue regeneration (see Figs 2f to 2h). In these 12 cases, 100% thread coverage was obtained. (see Figs 2i and 4c). The e-PTFE membrane was removed in these cases between 5 and 24 weeks (see Fig 8) depending on tissue tolerance to the membrane. In general, the more fibrotic, keratinized, and thicker the tissue, the better it was able to tolerate the e-PTFE membrane.

In two of the no-wall defects there had been an exuberant labial regeneration of bone where no bone and thread exposure had existed previously. Labial bone was removed with a chisel at the time of membrane removal for histologic evaluation. Bone of 3-month and 6 month maturity, respectively, was evaluated histologically at the University of Connecticut School of Dental Medicine Oral Pathology Laboratory. Histologic evaluation revealed clear areas of new bone, individual trabeculae with well-formed osteoid at the periphery, viable and recognizable osteocytes within bone lacunae, areas of mild remodeling, and a conspicuous lack of inflammatory response (Figs 11a and 11b).

Three-Wall Defects. The second defect morphologic group involved three-wall defects (see Fig 9b). This group consisted of four cases with both buccal and lingual three-wall defects relative to the implant. This defect resulted from immediate placement into maxillary premolar extraction socket with interfurcal bone. Four three-wall defects were buccal, lingual, or mesial, and one defect existed both mesial and distal to the implant. Because all defects responded similarly to regenerative procedures, they were grouped together as 9 three-wall defects. Treatment distribution (see Fig 7) included DFDBA and e-PTFE membrane in two cases, DFDBA alone in four cases, and e-PTFE membrane alone in three cases.

For those cases receiving membranes, removal of the membrane occurred between 6 and 10 weeks (see Fig 8) depending on tissue tolerance and patient and surgical convenience. Two of these cases were completed with exposed e-PTFE membranes at stage 1 surgery, and membrane removal was scheduled at 9 and 10 weeks, respectively. In all cases (see Fig 10), 100% thread coverage was observed at reentry (see Fig 3b).

Circumferential Defects. The third category included implants that circumferentially had no bone at their coronal aspect (see Fig 9c). Fixture
stabilization was dependent on sound bone apical to the defects. Regenerative protocol (Fig 10) included one case of ePTFE membrane and DFDBA, 22 cases of DFDBA, and five cases of e-PTFE membrane alone. For those cases receiving membranes, removal occurred between 3 and 9 weeks (see Fig 8). At reentry in all circumferential defects, 100% thread coverage was observed.

For all implants, initial thread exposure ranged from 4 to 20 threads (see Fig 5). Implant lengths ranged from 8.5 to 18 mm (see Fig 6). Mean implant length was 15 mm, with mean implant exposure 54% of the implant length covered by threads. At reentry all cases exhibited 100% thread coverage (see Fig 10), with many cases exhibiting bone growth over the cover screw, except for one implant in the no-wall defect group. Because these were generally large-volume defects, esthetic buccal alveolar contours were maintained with minimal buccolingual remodeling; in no cases was crestoapical remodeling observable. For one case in the no-wall defect group, reentry revealed that 4 threads, or 24% of the length of the fixture covered by threads, was exposed. Retreatment at stage 2 surgery corrected this to create 100% thread coverage.

Prostheses were completed with metal ceramic or allceramic restorations. No gradual loading, other than with provisional restorations, was used while the normal prosthetic treatment sequence continued. Forty-nine implants were integrated and free of symptoms associated with nonintegration. One 18-mm implant in the circumferential group, which had appeared to be integrated and was loaded with a provisional restoration at stage 2 surgery while the final prosthesis was being fabricated, was identified as nonintegrated 2 months later and removed. At stage 2 surgery reentry, there appeared to be full bone growth over the exposed threads of this implant.

In all cases, the esthetic protocol included ideal implant alignment, ideal soft tissue contours, optimal abutment selection, and subgingivally placed porcelain. An attempt was made to replicate the esthetic objectives of conventional fixed partial prostheses. Patient satisfaction with the esthetic results was universal. Ridge collapse secondary to extraction (see Figs 2c, 2i, 4a, and 4c) was avoided. Preservation of bone and soft tissue dimensions was predictable, as was preservation of dentofacial esthetics.

The dentofacial esthetics for individual teeth compared favorably to that of noninvolved contralateral teeth. Implant follow-up ranged from 8 to 44 months, with a mean implant follow-up of 17 months. Forty-nine implants (98%) remained osseointegrated and functional throughout the observation period.

**Discussion**

Implant dentistry must fulfill both functional and esthetic requirements to be considered a primary treatment modality. Root fractures, endodontic involvement, subgingival decay, and periodontal disease compromise not only continuation of
function but also dentofacial esthetics. The immediate implant procedure provides for implant placement and regeneration of dentoalveolar structure undermined by pathology. In this way, functional replacement and esthetic maintenance or enhancement are accomplished in one procedure.

As demonstrated in this study, both osseointegration and regeneration can be predictably obtained. Soft tissue preservation; atraumatic extraction; thorough debridement; precise implant placement; implant stabilization; space maintenance for regeneration with bone, membrane, or both; antibiotics; follow-up observation; esthetic soft tissue management at stage 2 surgery; and prosthetic design all are sequentially important for satisfactory results.

Implants were positioned 3 mm apical to the CEJ of adjacent teeth or 3 mm apical to the gingival margin of adjacent teeth where horizontal bone loss had occurred. Thus, the final prosthesis was confluent with the adjacent natural or restored dentition. Lazzara and Wilson suggested that an implant be positioned 2 mm apical to the coronal aspect of the socket, whereas Werbitt and Goldberg suggested positioning the implant 3 mm apical to socket walls. In this study, implants were positioned where necessary for ideal esthetics and for minimal postprosthetic transgingival height. Bone was regenerated to accommodate the implant position relative to the defects (see Figs 2e, 2i, 3a, 3b, 4b, and 4c).

In no-wall defects, the use of DFDBA and e-PTFE membrane gave predictable thread coverage. Further studies are necessary to explore the possibility that properly tented membrane or DFDBA alone would provide the same predictability of thread coverage. Knox et al. in a study involving surgically created extraction sockets in dogs, suggested that in sites with a large bone-to-fixture gap, as existed in our no-wall defects, bone graft and GTR may both be necessary for regeneration and osseointegration. In the large-volume defects, the membrane apparently helped contain the DFDBA.

In three-wall defects, all three regenerative approaches produced similar results. Subsequently, the therapeutic choice would be either DFDBA, autogenous bone, or e-PTFE membrane alone. While regeneration of bone was predictable in thread coverage, and crestoapical remodeling was not observed, buccolingual remodeling with narrowing of buccolingual width was frequently observed even in grafted defects (see Figs 3a and 3b). Nevertheless, at no time did this create inadequate buccolingual dimensions for thread coverage.

In circumferential defects, all three regenerative approaches produced similar results. DFDBA produced the most expeditious results in that no secondary procedure for membrane removal was necessary. Some patients refused the use of DFDBA for fear of transmission of disease and some did not have suitable sites for the atraumatic procurement of autogenous bone. The results suggest that in three-wall and circumferential defects, e-PTFE membrane provides predictable
regeneration of bone and thread coverage.

In those situations where at stage 1 surgery membranes had been placed and primary closure achieved, membrane removal was scheduled when the membranes were no longer tolerated, or at stage 2 surgery. Membrane removal at stage 2 surgery was at times difficult. In some cases the membrane was well attached to the soft tissue flap, requiring sharp dissection for removal. In other cases, the membrane was firmly adherent to the bone. Early membrane removal was easier to accomplish and resulted in continued maturation of the tissue over the implant and good soft tissue thickness for esthetic soft tissue management at stage 2 surgery. In this study, no problems were encountered with early membrane removal. All cases of early membrane removal resulted in full mineralized thread coverage at stage 2 surgery. Membranes were retained under the mucoperiosteal flap in close approximation to the bone. No cover screws were used to secure the membranes because a poorly tolerated membrane will more readily sequester through the soft tissue and will be removed earlier, thus the newly maturing bone precursor will not be irritated.

The defects in this study were generally of large volume. Thread exposure ranged from 4 to 20 threads. The mean number of threads exposed was 11.34. Nevertheless, regenerative results were consistent regardless of the volume of the initial defect or the pathology relative to the tooth to be replaced, as long as initial implant stability was accomplished and appropriate surgical protocol was followed. This regenerative consistency may be a consequence of the treatment of more acute clinical situations where marrow spaces were exposed. Bleeding and migration of cells to nourish the graft and promote osseous regeneration or organization of a clot apical to the membrane may be heightened in more acute situations. In addition, most defects treated were maxillary defects, in which the anatomy is more trabecular and well vascularized. As discussed in reports of fenestration defects by Dahlin et al, lack of rapid revascularization and of availability of osteogenic cells may reduce regenerative response in cortical areas. The mandibular defects responded equally as well as the maxillary defects, perhaps a result of the acute nature of the mandibular defects, which exposed more osteogenic and vascular areas of the mandible.

As had also been reported by Dahlin et al., membrane tolerance in patients unable to take penicillin VK and placed on erythromycin was not as good as occurred in patients able to tolerate penicillin VK. Antibiotics were initiated when membranes became suppurative and continued until the membranes were removed. Continued monitoring of patients receiving membranes is important so that tissue intolerance to membranes can be diagnosed early and treated appropriately.

Questions relative to immediate implant surgery include the following: Is immediate implant surgery predictable? This report supports the predictability of immediate implant surgery. Is regrowth of bone in the implant defects possible? The histology included herein adds to that previously reported in both animals and humans, confirming that the new tissue is bone. Is this bone osseointegrated to the
fixtures? The present report does not evaluate this phenomenon. Previous reports in animal models have confirmed this histologically.\textsuperscript{16,18,19} Are these immediate implants functionally stable? The follow-up in this report supports the functional stability of these implants, regardless of the number of threads initially exposed and the volume of bone regenerated. Dahlin et al\textsuperscript{8} observed that in fenestration defects, the new bone was able to withstand the stress and tensile forces when loaded, as was also observed in this study.

The population group in this study ranged from 16 to 80 years of age, which included five patients between 16 to 20 years of age. In this younger age group, passive eruption had not been completed and bone levels were found at the CEJ. It was important to adequately countersink these implants. In this way, as passive eruption progressed and bone levels remodeled apically, metal abutment margins would not be exposed. Equally important was the restorative need to design restorations subgingivally to mimic root morphology and establish crown contour subgingivally for continued esthetics as soft tissue passive eruption progressed.

Loss of anterior teeth is an emotional ordeal, particularly when the cause of tooth loss is acute, as in atraumatic root fracture or endodontic complication. The ability to offer such patients an immediate predictable solution that restores comparable function and reestablishes comparable esthetics is therapeutically important, particularly in light of the fact that in some of these cases, delaying implant placement could result in unfavorable dimension. Clinical and radiographic evaluation of treated cases through the observation period were consistent with the guidelines of success as reported by Albrektsson et al.\textsuperscript{2} Monitoring of this population group will continue for maintenance of treatment results as presently reported.

**Summary**

Immediate implant surgery offers a predictable immediate solution to tooth loss. The procedure preserves bone and soft tissue dimensions necessary for implant placement that may have been lost with extraction alone. The treatment sequence is accelerated, with an esthetic and functional outcome predictably obtained that is comparable to that obtained in implant placement in intact edentulous areas. The enhanced dentofacial esthetics in anterior tooth replacement is a significant additional treatment benefit.

**Acknowledgments**

The author wishes to acknowledge the critical review of Drs Barry D. Wagenberg, Burton Langer, William Becker, and Stephen Stein; histologic evaluation courtesy of Dr David J. Krutchkoff; and compilation of data and manuscript preparation by Ms Julie I. Sass, Ms Jeannie Cossette, and Ms Dawn C. Lowe.


<table>
<thead>
<tr>
<th>Age range (y)</th>
<th>10 - 20</th>
<th>20 - 30</th>
<th>30 - 40</th>
<th>40 - 50</th>
<th>50 - 60</th>
<th>60 - 70</th>
<th>70 - 80</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>9</td>
<td>7</td>
<td>6</td>
<td>3</td>
</tr>
</tbody>
</table>
Fig. 1 Immediate implant placement locations.

Fig. 2a Fistula of maxillary right central incisor (tooth 8) of 2-year duration after root canal therapy.

Fig. 2b Periapical pathology observed clinically.
Fig. 2c Extraction socket anatomy of tooth 8. Note the minimal buccolingual dimension, which would have led to dentofacial defect and an inadequate site for subsequent implant placement.

Fig. 2d Gelb depth gauge is used to evaluate length and alignment of implant.
Fig. 2e Implant placement: 3.75 x 18.0 with 18 of 25 threads exposed (now all three-surface defect).

Fig. 2f DFDBA packed.
**Fig. 2g** e-PTFE membrane in place.

**Fig. 2h** Closure is obtained with the connective tissue graft.
Reentry and membrane removal at 5 months with bone regeneration.

Cera-One abutment; good soft tissue integrity is apparent.
Fig. 2k Radiograph revealing normal bone anatomy relative to fixture.

Fig. 2l Final prosthesis (courtesy of Dr Bruce Abel).
Immediate implant placement into a three-wall defect, maxillary left first premolar location.

Re-entry no. 12—full regeneration
Fig. 3c Final restoration

(courtesy of Dr Rusty Camp).

Fig. 4a Narrow alveolus with minimal buccolingual dimension for implant placement, which would have led to a deficient site with postextraction remodeling.
Fig. 4b Immediate implant placement; e-PTFE membrane and DFDBA.

Fig. 4c Reentry shows full regeneration.
at implant placement.

**Fig. 5** Number of threads exposed

**Fig. 6** Thread exposure relative to implant site.
Fig. 7 Treatment distribution relative to defect.

Fig. 8 Membrane (e-PTFE) removal (between 3 and 24 weeks).
Fig. 9a No-wall defect.

Fig. 9b Three-wall defect.

Fig. 9c Circumferential defect.
Fig. 10 Thread coverage relative to defect and treatment modality.

Fig. 11a (Left) Histologic specimen from area treated with DFDBA and ePTFE membrane; note viable bone trabeculum containing numerous osteocytes within lacunae (arrows). Areas of remodeling are present, and there is a conspicuous lack of inflammatory reactions. (Hematoxylin-eosin stain, original magnification x64.)
Fig. 11b (Right) Histologic specimen from area treated with DFDBA and ePTFE membrane. Features are similar to those in Fig 11a; note osteoblastic rimming (arrow). (Mallory-trichrome stain; original magnification x64.)