Sinus Floor Augmentation at the Time of Maxillary Molar Extraction: Technique and Report of Preliminary Results

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A technique is described for accomplishing both localized sinus augmentation and guided bone regeneration at the time of maxillary molar extraction. One hundred nine sites were treated in 92 patients. Of these, 102 procedures (94.0%) were successful and 7 (6.0%) were partially successful. Success was defined as the ability to ideally position an implant at least 10 mm in length and 4.8 mm in width without perforating the floor of the sinus or generating an implant fenestration or dehiscence. Partially successful procedures required an additional osteotome sinus lift at the time of implant placement.
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Key words: guided bone regeneration, implants, osteotome, sinus augmentation

Reconstruction of the posterior maxilla using implant-supported fixed prostheses presents unique clinical challenges. Buccolingual and apico-occlusal resorption patterns following tooth loss, poorer quality bone often encountered in the posterior maxilla, pneumatization of the maxillary sinus, and final sinus position relative to remaining alveolar bone require diagnostic acumen and a comprehensive clinical approach if implant reconstruction is to be contemplated in this region.[1–5]

The advent of sinus augmentation and guided bone or block-graft ridge augmentation procedures have expanded the applicability of implant reconstructive therapy in the posterior maxilla. Numerous publications have demonstrated the efficacy of sinus augmentation procedures utilizing a variety of autogenous and nonautogenous grafting materials, which result in significantly increased apico-occlusal bone volume for placement of longer implants.[6–15] Block grafts and guided bone regeneration (GBR) procedures, incorporated either at the time of sinus augmentation[6,12,15,16] or in a separate procedure,[17–22] result in apico-occlusal and/or buccolingual hard tissue ridge augmentation, enhancing both implant positioning and the use of larger implants to theoretically better withstand functional forces over time. However, while such therapeutic modalities are highly predictable, they necessitate additional surgical entries, a more protracted course of therapy, and greater financial burden for the patient. As a result, increased attention is being paid to preservation and regeneration of bone at the time of tooth removal, and site preparation in anticipation of future implant placement.[2,23–27]

The phenomenon of alveolar modeling following tooth loss is understood and well documented.[28,29] Loss of alveolar height and width following tooth removal is significant, often accounting for up to 50% of the alveolar mass in the area. Such resorption often precludes implant placement, or forces placement of narrower, shorter implants than desired, often in less than ideal positions. The compromised final clinical result may have significant functional, hygienic, and esthetic ramifications.

A therapeutic modality that would afford a predictable means of both preserving and augmenting available bone buccolingually and apico-occlusally at the time of maxillary molar extraction would offer a number of clinical benefits.

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Materials and Methods

Patient Selection. Following a thorough review of medical histories, patients were deemed unsuitable to receive augmentation therapy based upon the following criteria:

1. The presence of uncontrolled diabetes, immune diseases, or other contraindicating systemic conditions.
2. Radiation therapy to the head and neck region in the 12 months prior to proposed therapy.
3. Chemotherapy in the 12-month period prior to proposed therapy.
4. Uncontrolled periodontal disease, or an unwillingness to undergo needed periodontal therapy, around remaining teeth.
5. An active sinus infection, or a history of persistent sinus infections.
6. A smoking habit of 1 package of cigarettes per day or greater.
7. A psychologic problem that in the opinion of the authors would have rendered the delivery of comprehensive therapy untenable, including depressive states and extreme nervousness or agitation that would preclude the patient undergoing numerous, lengthy treatment visits.
8. An unwillingness to commit to a long-term, post-therapy maintenance program.

A complete examination of oral hard and soft tissues was carried out for each patient, and an overall treatment plan was formulated in conjunction with the treating restorative dentists. Panoramic radiographs were taken of all patients by a certified dental assistant. Diagnostic casts, face-bow mountings on articulators, diagnostic wax-ups, and surgical templates were also utilized. Surgical templates were potentially useful at 2 stages of therapy: at the time of augmentation (as a guide to the desired final ridge dimension buccolingually and apico-occlusally), and at the time of implant placement.

One hundred nine sites in 92 patients were treated. Of these patients, 50 (60 sites) were female (55%) and 42 (49 sites) were male (45%). Patient age ranged from 27 to 60 years. All surgical therapy and preoperative and postoperative measurements were documented by the author.

Surgical Technique. A sulcular incision was made around the tooth or teeth to be removed. Mesial and distal releasing incisions extending well up into the buccal fold were placed at the mesial aspect of the mesial papilla and the distal aspect of the distal papilla, thus including the papillary tissue in the flap extent. The bases of the buccal releasing incisions were extended approximately 3 to 6 mm horizontally, as described in a previous publication.[30] The buccal mucoperiosteal flap was reflected in a full-thickness manner, with care taken to completely release the tissue beneath the horizontal releasing incision extensions, thus creating a freely moving buccal mucoperiosteal flap. Mesial and distal palatal releasing incisions were positioned to coincide with the buccal releasing incisions, and a full-thickness palatal mucoperiosteal flap was reflected.

Care was taken to extract the indicated maxillary molars in a manner so as to minimize trauma to the surrounding hard tissues, thus preserving the remaining interradicular bone. When mandated by root morphology or the lack of intact tooth structure on which to gain leverage for tooth removal, the tooth was trisected and the roots were gently removed individually. The extraction socket was thoroughly debrided.

A calibrated trephine bur (Ace Surgical Supply, Brockton, MA) was placed over the interradicular bone, which was of sufficient dimension to encompass both the interradicular septum and approximately 50% of the extraction sockets. Each trephine bur was approximately 1 mm thick. Utilizing preoperative radiographs, measurement of removed roots, and residual ridge morphology as guides, the clinician used the trephine to prepare a site to within approximately 1 to 2 mm of the sinus membrane at a cutting speed of 75,000 rpm (Figs 1a to 1d). Following removal of the trephine bur, if the bone core was found to be inside the trephine, it was gently removed and replaced in the alveolar bone preparation; however, this occurred only rarely.

An osteotome (Implant Innovations, West Palm Beach, FL) was selected to correspond to the diameter of the trephine preparation. The osteotome was utilized, under gentle malletting forces, to implode both the trephined interradicular bone and the underlying sinus membrane to a depth at least equal to the apico-occlusal dimension of the trephined bone core (Figs 1e and 1f).

The residual extraction socket was filled with nonautogenous particulate material (Bio-Oss, OsteoHealth, Shirley, NY), and a membrane was selected (nonresorbable, titanium-reinforced nonresorbable, or resorbable) (WL Gore, Flagstaff, AZ) in accordance with previously discussed membrane selection criteria.[22,31] The membrane was trimmed and secured with fixation tacks (Steri-Oss, Yorba Linda, CA). Flaps were sutured utilizing interrupted mattress Gore-Tex sutures (WL Gore) so as to achieve passive primary closure through the use of previously described mucoperiosteal flap modifications.[30,32]

Postoperative Management. Medications prescribed included Peridex rinses twice a day for 21 days, amoxicillin 500 × 40, 4 times daily (enteric-coated erythromycin 400 × 30, 3 times daily was utilized in penicillin-sensitive patients), ibuprofen 600 × 20, 4 times daily unless medically contraindicated, and pain medication (Tylenol with Codeine III or Percocet) as needed for pain.

Patients were not allowed to use any removable prosthesis until after the sutures were removed 10 to 12 days postoperatively. At that time, removable prostheses were adjusted, relined, and placed for

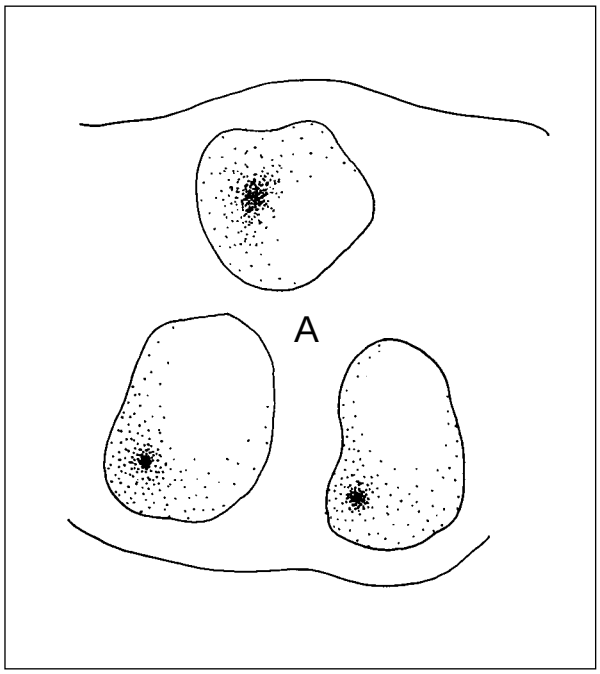

Fig 1a Schematic view of the extraction socket following removal of a maxillary molar. A = interradicular bone.

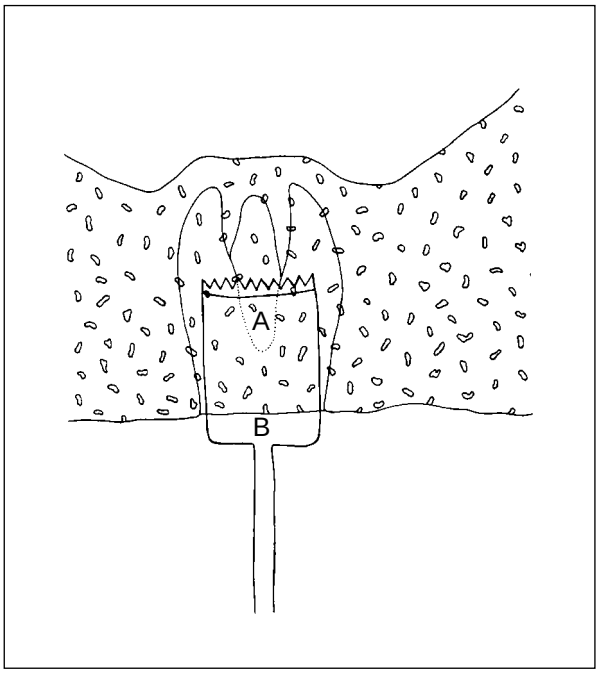

Fig 1b Trephine bur of sufficient diameter to encompass the residual interradicular alveolar septum is placed into the extraction socket. A = interradicular bone; B = trephine bur.

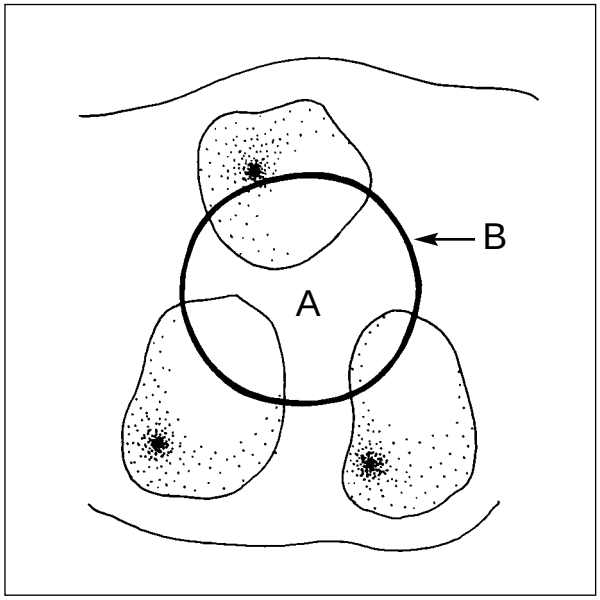

Fig 1c Occlusal representation of the diameter and positioning of the trephine bur. A = interradicular bone; B = trephine bur cut.

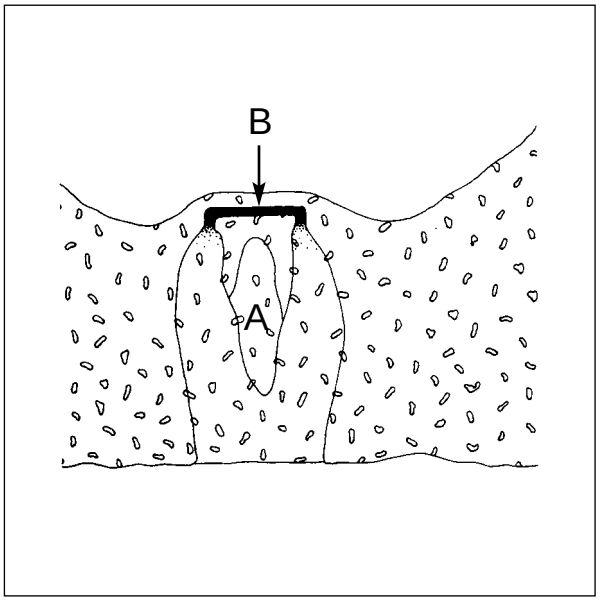

Fig 1d Trephine bur penetrates to within 1 to 2 mm of the sinus membrane. A = interradicular bone; B = trephine bur cut.

cosmetic purposes only. Patients were not allowed to function with these restorations throughout the regenerative phase. Patients undergoing concomitant buccolingual or apico-occlusal ridge augmentation procedures were never allowed to use removable prostheses over operated sites until regeneration had been deemed complete through radiographic and clinical examination. Peridex rinses continued for the total course of membrane retention when membrane exposure occurred. Gore-Tex membrane exposure occurred in 3 of the 109 sites treated. However, no membrane exposure was considered extensive enough to necessitate premature removal of the membrane.

Healing Time. Nonresorbable membranes were removed 16 weeks after placement over intact sockets that had not required buccolingual or apico-occlusal augmentation beyond the boundaries of the remaining alveolar walls and 24 to 32 weeks after placement in defects that required buccolingual or apico-occlusal augmentation beyond the confines of the residual alveolar bone, depending upon the initial defect morphology and regenerative endpoints desired. Implant placement was performed at the time of membrane removal, unless inadequate maturity of the regenerated tissues or patient constraints prevented such therapy. Either 4.1- or 4.8-mm-wide ITI implants of varying lengths (Straumann, Waltham, MA), or 5.0- or 6.0-mm-wide hex-headed implants of varying lengths (Implant Innovations) were placed as indicated by alveolar morphology, space limitations, occlusal considerations, and restorative treatment plan. No implant with an intraosseous body shorter than 10 mm was placed. Implants were uncovered 5 months after placement and restored according to various manufacturer protocols.

Assessment of Success. The augmentation procedure was deemed a success if an implant at least 10 mm in length could be placed in an ideal position without perforating the floor of the sinus or creating a dehiscence and/or fenestration defect around the implant. If an additional localized sinus procedure to place an implant of at least 10 mm in length by means of the osteotome technique was necessary at the time of implant placement, the original augmentation procedure was deemed a partial success.

Results

One hundred nine augmentation procedures were performed at the time of maxillary molar extraction in 92 patients; 97 maxillary first molars and 12 maxillary second molars were removed and the sites were augmented. Of these, 93 first molar sites and 9 second molar sites were treated, for a total of 102 sites. This resulted in the regeneration of adequate hard tissue for placement of implants at least 10 mm in length, as determined by panoramic radiographs. Seven augmentation procedures (4 molar and 3 second molar sites)

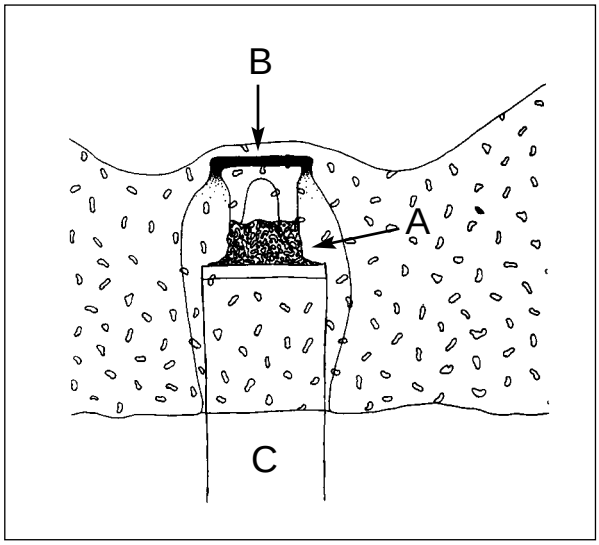

Fig 1e An osteotome is utilized with mallet force to compress and implode the interradicular septum. A = compressed interradicular bone; B = trephine bur cut; C = osteotome.

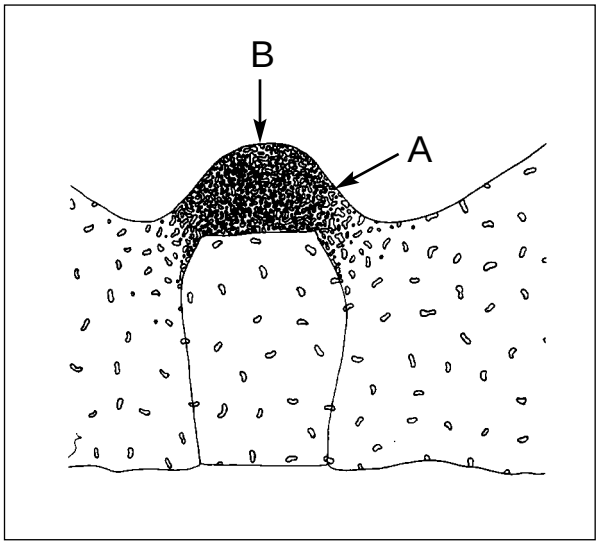

Fig 1f Following osteotome use, the interradicular bone has been compressed and displaced apically, and the sinus membrane has been lifted significantly. A = compressed interradicular bone; B = raised floor of the sinus.

resulted in adequate regenerated hard tissue, as determined by panoramic radiographs, for placement of an implant at least 10 mm in length. If a concomitant localized sinus augmentation was performed through the use of osteotomes, the results were deemed partially successful. In all but 13 sites (3 that exhibited early membrane exposure, 2 sites in which the regenerating hard tissue was considered to have inadequate maturity to achieve primary stability of an implant in an ideal position, and 8 sites in which mature tissue of adequate dimension for implant placement had been demonstrated but the patient declined implant placement), implants were placed at the time of membrane removal. Of these the 5 sites in which the patients agreed to implant placement had the implants placed 4 to 6 weeks after membrane removal. A total of 101 implants were placed.

At the time of statistical compilation, 84 of the 101 implants had been uncovered, and 74 of these 84 had been restored. Single-crown restorations were placed on 80 of the implants, and 4 implants were restored with 2 free-standing, 2-unit, cemented fixed prostheses. All implants were deemed stable and osseointegrated at the time of uncovering, and all restored implants were successful when evaluated by the criteria of Albrektsson et al.[33]

Discussion

While numerous surgical and prosthetic design solutions have been proposed for meeting the unique challenge of implant reconstruction of the posterior maxilla, multiple surgical interventions, a protracted course of therapy, and a significant financial burden to the patient are involved. In addition, non-ideally positioned implants, whose placement is dictated by the anatomy of the remaining bone, often represent compromises in function, force distribution, patient maintenance, and esthetics.

Sinus and ridge augmentation procedures utilizing various approaches and materials are highly successful in providing adequate bone for the placement of wider, longer implants in more desirable positions.[1–21] However, such an approach is invasive and significantly increases cost and length of treatment. The surgical phase of therapy may take 6 months to 2 years to complete, depending upon the individual situation and the treatment approach used.

Less invasive localized management of the sinus floor (utilizing osteotomes to implode remaining bone and thus gain needed apico-occlusal dimension for implant placement), followed by immediate or second-stage implant placement has proven successful if extensive apico-occlusal and/or buccolingual augmentation is not required.[34,35] However, in the face of clinically non-salvageable maxillary molars, such therapy is not ideal. Following removal of the non-salvageable tooth, a number of variables must be managed to maximize both the functional and esthetic endpoints of therapy. An attempt to implode the remaining interradicular bone with osteotomes is difficult because of its variable morphology and often significant apico-occlusal extent. Such manipulation often results in loss of the crestal 30% to 50% of the interradicular bone and thus lessens the effect of therapy. In addition, should simultaneous placement of an implant 4.8 to 6.0 mm wide be contemplated, as is often preferred in a maxillary molar area, site preparation may well obliterate the remaining interradicular bone because of its limited diameter.

Finally, the question of treatment of the residual extraction socket must be addressed. If a regenerative procedure is not performed to rebuild the alveolus, significant 3-dimensional alveolar resorption may occur,[28,29,36] which will either compromise the final result or necessitate a significant ridge augmentation procedure at the time of conventional or osteotome sinus augmentation.[1] A course of therapy characterized by tooth extraction, healing, and expected postextraction resorption, and eventual sinus augmentation potentially complicates the treatment protocol and presents the possibility of a less than ideal result.

The combination of simultaneous tooth extraction, sinus augmentation using a trephine and osteotome, and the application of membrane-GBR addresses these concerns. The success of osteotome management of the sinus floor, modified here through the use of a trephine bur following tooth extraction, is documented. While it is dependent upon the proper management of a number of clinical concerns, GBR therapy has demonstrated a high degree of predictability and success.[17–24,31,36,37] While none of the implants placed in the augmented sites have been in function for more than 2 years, the success of implants placed in regenerated bone in a variety of clinical situations is well documented.[38,39]

The use of these therapies in combination, at the time of tooth removal, results in adequate bone for the placement of implants of desired widths and lengths for the replacement of missing maxillary molars. Although 7 augmented sites required additional sinus augmentation at the time of implant placement, each of these sites presented with less

than 3 mm of bone between the apices of the extraction socket and the floor of the sinus at the time of the initial augmentation procedure. Therefore, the need for an additional augmentation procedure was believed to be a function of a limitation of the technique (the amount of bone that could be imploded to lift the sinus floor), rather than a failure of the procedure to result in regeneration. Another potential limitation to success is the ability of the clinician to maintain primary soft tissue closure throughout the course of regeneration.

The question of the selection of appropriate particulate material is not addressed in this article. While it is generally accepted that autogenous bone is the "gold standard" of particulate grafting materials, procurement of such material often involves a second surgical site, increasing both procedural complexity and patient morbidity. Guided bone regeneration and sinus augmentation therapies have been shown to be highly successful when nonautogenous particulate materials are utilized.[13–15,21,22,31,37] In addition, much of the center of the regenerated hard tissue in areas where particulate materials have been placed will be removed during eventual site preparation and implant placement. The bone apical to the implant will essentially be made up of autogenous previously imploded hard tissues, thus potentially obviating the need for an in-depth discussion of material selection.

Conclusion

Through the combination of a localized sinus augmentation procedure utilizing a trephine and osteotome approach and GBR therapy at the time of maxillary molar extraction, adequate bone may be regenerated both buccolingually and apicoocclusally for ideal positioning of implants 10 mm long or longer and 4.8 mm wide or wider in the posterior region of the maxilla.

References

1. Bahat O, Fontnesi RV, Preston J. Reconstruction of the hard and soft tissues for optimal placement of osseous integrated implants. Int J Periodontics Restorative Dent 1993; 13:255–275.
2. Enquist B, Bergendal T, Linden U. A retrospective multicenter evaluation of osseous integrated supporting overdentures. Int J Oral Maxillofac Implants 1988;3:129–134.
3. Jaffin RA, Berman CL. The excessive loss of Brånemark fixtures in type IV bone: A five year analysis. J Periodontol 1991;62:2–4.
4. Johns RB, Jemt T, Health MR, Hutton JE, McKenna S, McNamara DC, et al. A multicenter study of overdentures supported by Brånemark implants. Int J Oral Maxillofac Implants 1992;7:513–522.
5. Fugazzotto PA. Success and failure rates of implants in type IV bone. J Periodontol 1993;64:1085–1087.
6. Breine U, Brånemark P-I. Reconstruction of the alveolar jaw bone. An experimental and clinical study of immediate and pre-formed autologous bone grafts in combination with osseointegrated implants. Scand J Plastic Reconstr Surg 1980;14:23–48.
7. Kahnberg KE, Nystrom E, Bartholdsson L. Combined use of bone grafts and Brånemark fixtures in the treatment of severely resorbed maxillae. Int J Oral Maxillofac Implants 1989;4:297–304.
8. Adell R, Lekholm U, Gröndahl K, Brånemark P-I, Lindström J, Jacobsson M. Reconstruction of severely resorbed edentulous maxillae using fixtures in immediate autogenous bone grafts. Int J Oral Maxillofac Implants 1990;3: 233–246.
9. Tatum H. Maxillary and sinus implant reconstructions. Dent Clin North Am 1986;30:207–229.
10. Wheeler SL, Holmes RE, Calhoun CJ. Six-year clinical and histologic study of sinus lift grafts. Int J Oral Maxillofac Implants 1996;11:26–34.
11. Williamson RA. Rehabilitation of the resorbed maxilla and mandible using autogenous bone grafts and osseointegrated implants. Int J Oral Maxillofac Implants 1996;11: 476–488.
12. Frost DE, Fonseca RJ, Burkes EJ. Healing of interpositional allogeneic lyophilized bone grafts following total maxillary osteotomy. J Oral Maxillofac Surg 1982;40: 776–786.
13. Fugazzotto PA. Maxillary sinus grafting with and without simultaneous implant placement: Technical considerations and clinical reports. Int J Periodontics Restorative Dent 1994;14:545–551.
14. Hurzeler MB, Kirsch A, Ackermann KL, Quinones CR. Reconstruction of the severely resorbed maxilla with dental implants in the augmented maxillary sinus: A five-year clinical examination. Int J Oral Maxillofac Implants 1996; 11:466–475.
15. Fugazzotto PA, Vlassis J. Long-term success of sinus augmentation using various surgical approaches and grafting materials. Int J Oral Maxillofac Implants 1998;13:52–58.
16. Keller EE, Eckert SE, Tolman DE. Maxillary antral and nasal 1 stage inlay composite bone grafts: Preliminary report of 30 recipient sites. J Oral Maxillofac Surg 1994; 52:438–447.
17. Buser D, Dula K, Belser U, Hirt H-P, Berthold H. Localized ridge augmentation using guided bone regeneration. I. Surgical procedure in the maxilla. Int J Periodontics Restorative Dent 1993;13:29–45.
18. Nevins M, Mellonig JT. Enhancement of the damaged edentulous ridge to receive dental implants: A combination of allograft and the Gore-Tex membrane. Int J Periodontics Restorative Dent 1992;12:97–111.
19. Buser D, Dula K, Hirt H-P, Schenk RK. Lateral ridge augmentation using autografts and barrier membranes: A clinical study with 40 partially edentulous patients. J Oral Maxillofac Surg 1996;54:420–422.
20. Nevins M, Mellonig JT. The advantages of localized ridge augmentation prior to implant placement: A staged event. Int J Periodontics Restorative Dent 1994;14:97–111.
21. Doblin JM, Slakin M, Melledo JR, Freedman AL, Stein MB. A histological evaluation of localized ridge augmentation utilizing DFDBA in combination with E-PTFE membranes and stainless steel bone pins in humans. Int J Periodontics Restorative Dent 1996;16:121–129.

22. Fugazzotto PA. Report of 302 consecutive ridge augmentation procedures: Technical considerations and clinical results. Int J Oral Maxillofac Implants 1998;13:258–268.
23. Fugazzoto PA. Guided bone regeneration for enhanced esthetics: Defining the therapeutic possibilities. J Esthet Dent 1993;5:252–257.
24. Becker W, Becker B, Caffesse RG. A comparison of demineralized freeze-dried bone and autologous bone to induce bone formation in human extraction sockets. J Periodontol 1994;65:1128–1133.
25. Lekovic V, Kenney EB, Weinlaender M, Han T, Klokkevold P, Nedic M, Orsini M. A bone regenerative approach to alveolar ridge maintenance following tooth extraction. Report of 10 cases. J Periodontol 1997;68:563–570.
26. O'Brien TP, Hinrichs JE, Schaffer EM. The prevention of localized ridge deformities using guided tissue regeneration. J Periodontol 1984;65:17–24.
27. Nemcovsky CE, Serfaty V. Alveolar ridge preservation following tooth extraction of maxillary anterior teeth. Report of 23 consecutive cases. J Periodontol 1996;67:390–395.
28. Claflin RS. Healing of disturbed and undisturbed extraction wounds. J Am Dent Assoc 1936;6:945–959.
29. Carlsson GE, Bergman B, Hedegard B. Changes in contour of the maxillary alveolar process under immediate dentures. Acta Odontol Scand 1967;25:45–75.
30. Fugazzotto PA. Maintenance of primary closure following guided bone regeneration: Report of 723 consecutive cases. J Periodontol (in press).
31. Fugazzotto PA, Shanaman R, Manos T, Shectman R. Guided bone regeneration around titanium implants: Report of the treatment of 1503 sites with clinical reentries. Int J Periodontics Restorative Dent 1997;17: 293–299.
32. Fugazzotto PA, De Paoli S, Parma-Benfenati S. Flap design considerations in the placement of single maxillary anterior implants: A clinical report. Implant Dent 1993;2:93–96.
33. Albrektsson T, Zarb G, Worthington P, Eriksson RA. The long-term efficacy of currently used dental implants: A review and proposed criteria of success. Int J Oral Maxillofac Implants 1986;1:11–25.
34. Scipioni A, Bruschi GB, Calesini G. The edentulous ridge expansion technique: A five year study. Int J Periodontics Restorative Dent 1994;14:451–459.
35. Bruschi GB, Scipioni A, Bruschi E. Localized management of sinus floor with simultaneous implant placement: A clinical report. Int J Oral Maxillofac Implants 1998;13: 219–226.
36. Anler MH, Johnson PL, Salmon I. Histological and histochemical investigation of human alveolar socket healing in undisturbed extraction wounds. J Am Dent Assoc 1960;92: 32–34.
37. Shanaman RH. A retrospective study of 237 sites treated consecutively with guided tissue regeneration. Int J Periodontics Restorative Dent 1994;14:293–301.
38. Fugazzotto PA. Success and failure rates of 626 osseointegrated implants function in regenerated bone for 6-51 months: A preliminary report. Int J Oral Maxillofac Implants 1996;12:17–24.
39. Nevins M, Mellonig JT, Clem DS, Reiser GM, Buser DA. Implants in regenerated bone: Long term survival. Int J Periodontics Restorative Dent 1998;18:35–46.