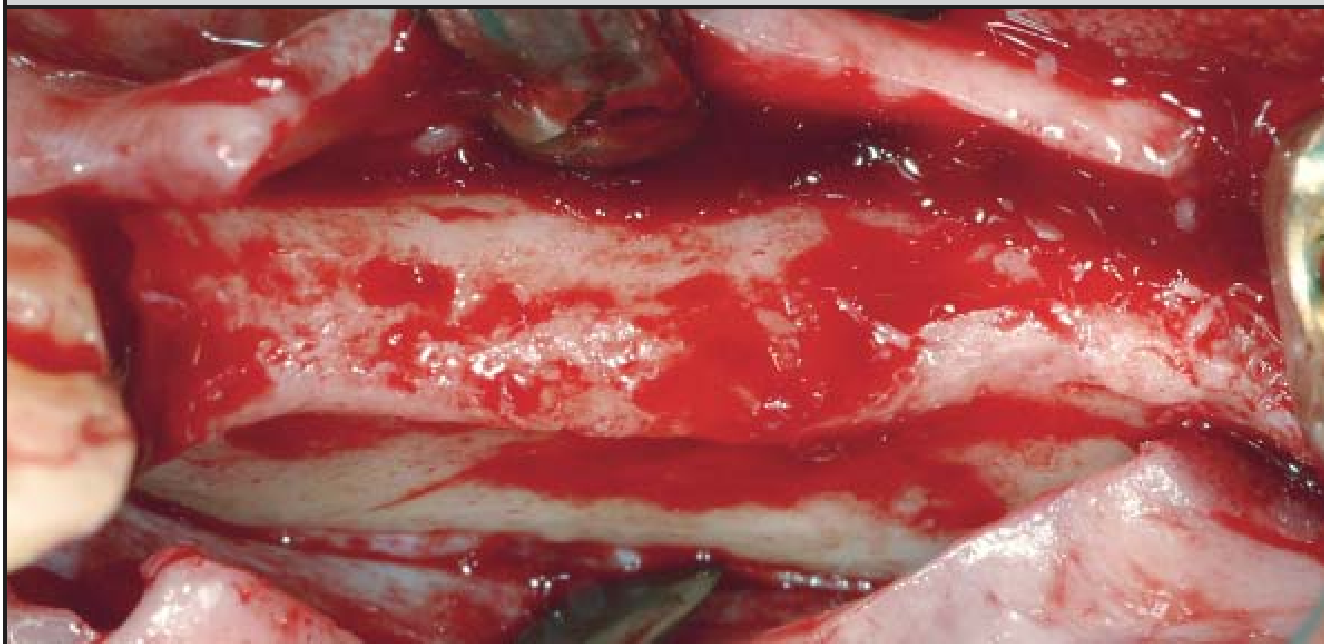

Prospective Evaluation of the Use of Motorized Ridge Expanders in Guided Bone Regeneration for Future Implant Sites

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The purposes of this prospective, randomized, controlled clinical investigation were to evaluate the performance of motorized ridge expanders (MREs) and to compare their results with those achieved using lateral ridge augmentation (LRA). Eight subjects with bilateral ridge deformities were selected. One technique was used on the right side and the other on the left. Implants were placed 6 months after bone augmentation procedures. All measurements were recorded at 2 and 5 mm from the most coronal aspect of the crest. The augmentation achieved with both techniques was statistically significant: 1.2 mm for LRA and 1.5 mm for MRE 2 mm from the crest and 1.5 mm for LRA and 1.6 mm for MRE at 5 mm from the crest. The differences between the two techniques were statistically insignificant. The amount of expansion achieved in the MRE sites appeared to be negatively correlated with the thickness of the cancellous bone (P < .05), and it was not affected by the thickness of the cortical plate. The MRE technique appears to be as effective as the LRA technique in augmenting the thickness of atrophic ridges. Defects treated with MREs showed less bone width contraction during the first 6 months of healing. (Int J Periodontics Restorative Dent 2011;31:547–554.)

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Periodontal disease, tooth extraction, and traumatic injuries typically result in advanced alveolar bone loss that prevents the placement of implants in an optimal prosthetic position.[1] Common techniques of ridge augmentation include: block grafts, distraction osteogenesis, guided bone regeneration (GBR), split crest, and ridge expansion.[2–11]

The concept of GBR with the use of barrier membranes was introduced to correct bone deficiencies.[3,4,12–15] Since the late 1990s, the lateral ridge augmentation (LRA) technique has become a predictable surgical method to enhance horizontal bone formation.[4,10,12,16–18] Ridge expansion or ridge splitting is another technique used to correct horizontal ridge deficiencies.[9,11,19–24] This surgical technique involves the use of chisels or osteotomes to split the alveolar ridge longitudinally into two parts, provoking a greenstick fracture.[9,11,19,21–25] Some of these augmentation techniques have been used simultaneously with or without implant placement. Limiting factors for simultaneous implant placement are the implant's

Fig 1 *Sequence of the motorized ridge expander.*

incorrect three-dimensional prosthetic position, its angulation, and the lack of primary stability.[11,19,21,26]

The LRA and ridge expansion techniques have been described with the use of grafting materials.[13,16,27,28] Research on humans using demineralized freeze-dried bone allograft (DFDBA)[13] and deproteinized bovine bone mineral,[27] along with the use of resorbable membranes, has shown successful results in augmenting deficient ridges. The common histologic findings using these bone substitutes, after a 6-month healing period, show the presence of bone graft particles surrounded by woven bone.[29]

Although ridge expansion with both chisels and osteotomes can predictably expand alveolar ridges, patients who underwent these procedures often reported a high level of discomfort. A new device, the motorized ridge expander (MRE; Biotechnology Institute), has been designed to expand horizontally atrophic ridges without the need of a surgical mallet. MREs comprise a series of four sequential noncutting drills with increasing diameters (Fig 1).

The purposes of this clinical investigation were to evaluate the performance of MREs in expanding atrophic ridges and to compare the results with those achieved with the LRA technique.

Method and materials

Eight subjects (four men, four women) were selected from those who presented to the Department of Periodontology, Tufts University School of Dental Medicine, Boston, Massachusetts, and for whom implant placement was planned but had lacked sufficient bone width for the procedure. This was a 6-month prospective cohort study with a split-mouth design. Each subject required bilateral ridge augmentation. Subject inclusion criteria was as follows: a bone crest thickness between 3 and 5 mm, measured on an axial computed tomography (CT) scan at 2 mm (RW) from the most coronal part of the crest, and at least 10 mm of bone from the coronal part of the ridge to any vital structure, measured using the CT scan. Smokers, diabetics, or pregnant women were excluded from this research.

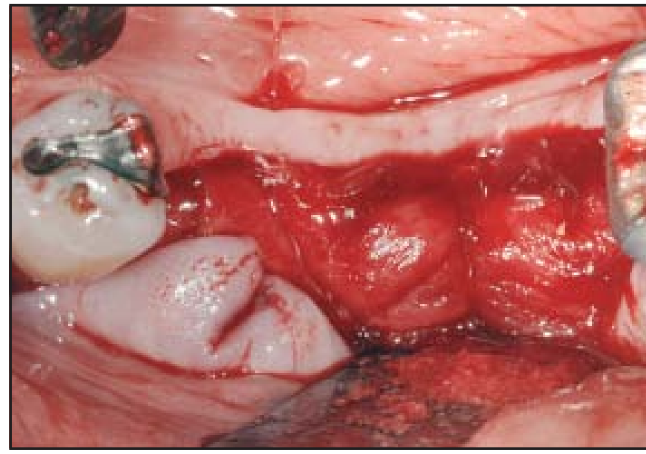

Fig 2 *Control site treated with LRA using a bioresorbable collagen membrane.*

Diagnosis and clinical procedures

This study was approved by the Institutional Research Board at Tufts Medical Center, Boston, Massachusetts. The study was presented to the subjects, and a written consent form was provided and accepted.

Radiographic and surgical stents with extended wings over the areas to be treated were made according to the prosthetic wax-up. CT scans were taken of every subject to ensure inclusion criteria compatibility. CT scan radiographic measurements to gauge cortical bone thickness were recorded at 5 and 10 mm from the most coronal portion of the crest. Cancellous bone thickness was recorded at 3 mm from the most coronal part of the crest.

Local anesthesia (0.5% bupivacaine with 1:200,000 epinephrine) was provided in test and control sites using local infiltration or a mandibular block.

A crestal incision with a mesial vertical releasing incision was performed to gain access to the bone both at control (LBA) and test (MRE) sites.

In control sites, a full-thickness flap was raised, and the deficient alveolar ridge was exposed. Intramarrow perforations were performed. A combination of deproteinized bovine bone mineral (D BBM; Bio-Oss, Geistlich) and DFDBA at a 1:1 ratio was applied on the exposed bone and covered with a collagen membrane (Bio-Gide, Geistlich) (Fig 2). In test sites, a full-thickness flap was raised, and the deficient alveolar ridge was exposed. The MRE technique was used in accordance with the manufacturer's protocol (Fig 3). The defect produced between the buccal and lingual/palatal cortical plates was filled with the DBBM (Bio-Oss) and DFDBA combination at a 1:1 ratio, and a collagen membrane (Bio-Gide) was used to cover the area.

Both control and test sites were sutured with a horizontal mattress and a continuous interlocking technique using a 5.0 polyglactin 910 suture (Vicryl, Ethicon).

Ridge (hard tissue) thickness was recorded using a caliper (Ridge Mapping Instrument, Hartzell & Son) prior to and post–ridge expansion at 2 and 5 mm from the most coronal part of the alveolar crest. Notches were made on the stent accordingly for future reference.

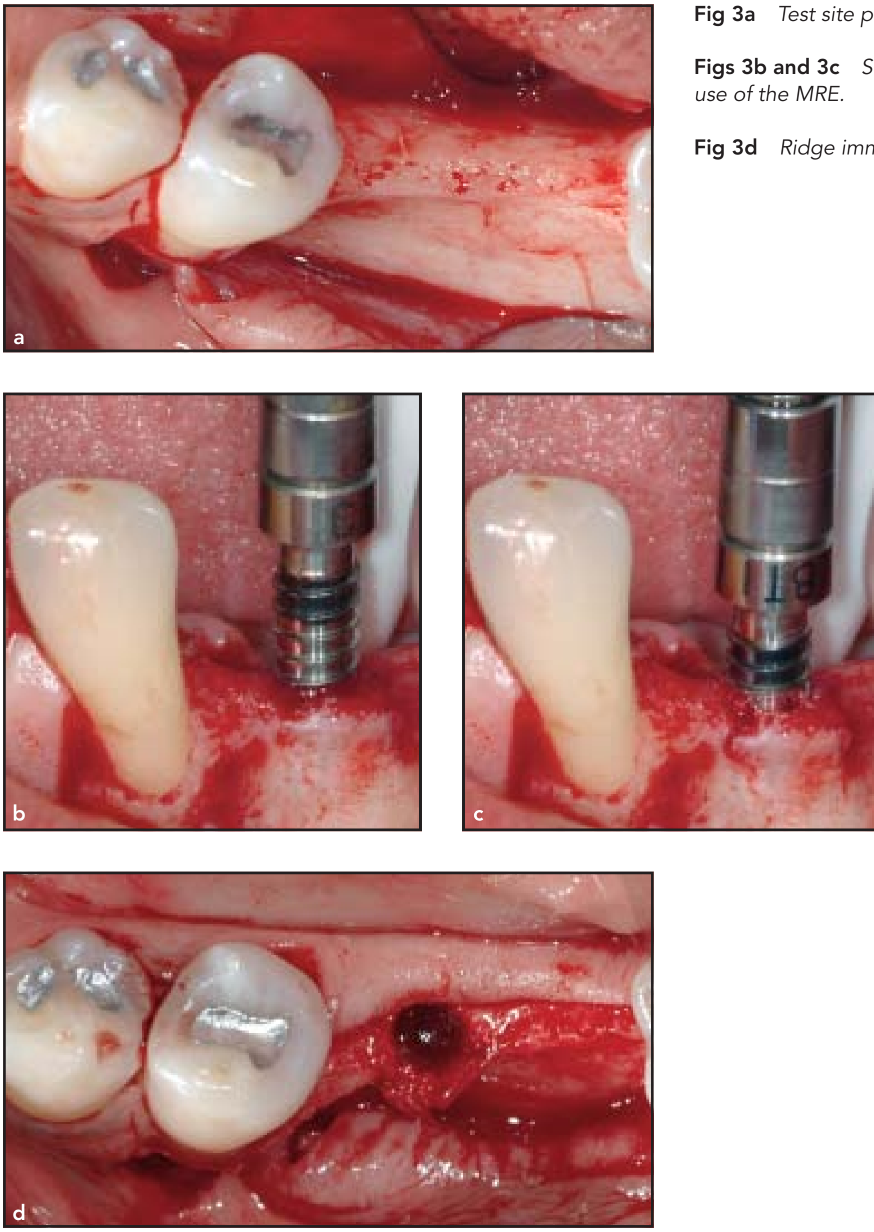

Fig 3a *Test site prior to the use of the MRE.*

Figs 3b and 3c *Sequence of the treatment in the test site with the use of the MRE.*

Fig 3d *Ridge immediately after expansion.*

Following surgery, subjects were placed on antibiotic coverage (500 mg amoxicillin three times daily for 10 days) and received nonsteroidal anti-inflammatory medication. Rinses with 0.12% chlorhexidine digluconate (Peridex) were also prescribed twice daily for 2 weeks.

Postoperative observations were conducted at 14, 30, and 90 days postsurgery. At 180 days of healing after the bone augmentation procedure, at the moment of implant placement (Fig 4), the ridge thickness was measured again with the caliper using the notches previously created on the stent.

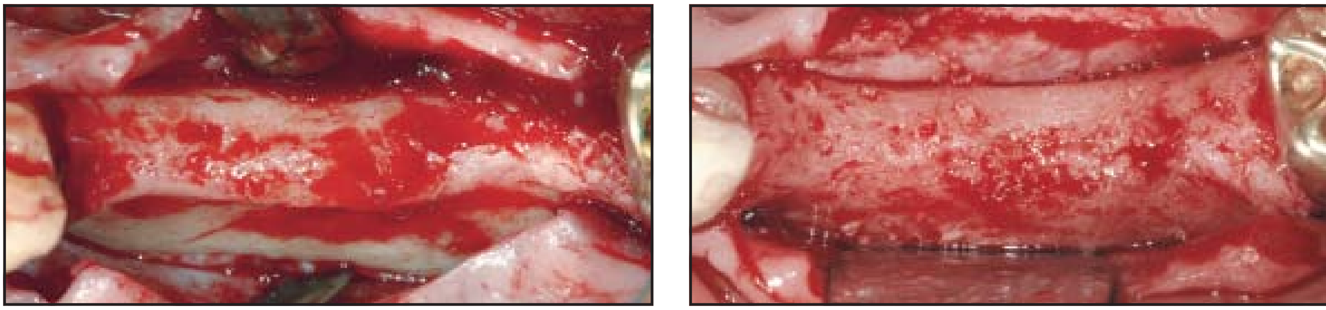

Fig 4 *Test site. Ridge* (left) *before expansion and* (right) *after the 6-month healing period.*

Statistical analysis

Measurements of the treated sites were compared using the paired Student *t* test. Any correlation between the anatomical characteristics of the treated test site and the amount of expansion were investigated using Pearson correlation. All analyses were performed using SPSS version 14.0 (IBM).

Results

Eight patients with a mean age of 47 years and with bilateral Seibert class I ridge deformities were treated with the LRA technique (control) on one side and the ridge expansion technique (test) on the other. The number of sites was represented by the number of implants placed in each area. A total of 23 sites were treated, including 10 control and 13 test sites. Randomization between sites was done by flipping a coin, and the distribution of treated sites was similar between the two groups.

At test sites, the mean crest width before expansion (TBA) at 2 and 5 mm was 3.88 and 5.88 mm, respectively. Immediately after crest expansion (TAA), the mean width at 2 and 5 mm became 5.96 and 7.23 mm, respectively. After the 6-month healing period, the mean thickness of the ridge was 5.38 mm at 2 mm (TIP2) and 7.11 mm at 5 mm (TIP5). At control sites, the mean ridge width was 3.7 mm at 2 mm and 5.6 mm at 5 mm. Immediately after the surgical procedure, the mean ridge width was 6.3 mm at 2 mm (TAA2) and 7.5 mm at 5 mm (TAA5). At the time of implant placement, the mean thickness of the ridge was 4.9 mm at 2 mm (TIP2) and 7.1 mm at 5 mm (TIP5).

The augmentation achieved with both techniques was statistically significant. At 2 mm from the crest, the provisional augmentation mean (TAA–TBA) was 2.1 ± 0.95 mm for test and 2.6 ± 0.95 mm for control sites. The total augmentation mean (TIP–TBA) was 1.5 ± 1.06 mm for test and 1.2 ± 1.31 mm for control sites, and the graft stability mean (TIP–TAA) was 0.6 ± 1.17 mm for test and 1.4 ± 0.83 mm for control sites. At 5 mm from the crest, the provisional augmentation mean was 1.6 ± 0.57 mm for test and 1.9 ± 0.75 mm for control sites. The total augmentation mean was 1.6 ± 0.77 mm for test and 1.5 ± 1.19 mm for control sites, and the graft stability mean was 0.2 ± 1.10 mm for test and 0.4 ± 0.96 mm for control sites. The results of the test and control sites were compared, and no statistical differences were detected when both the provisional and total augmentations were compared. In contrast, statistical differences were detected when the graft contraction (TAA–TBA) in the two treatment modalities was measured at 2 mm from the crest, showing less contraction in test sites (0.6 mm) when compared with control (1.4 mm) (P = .05). No differences were detected in the stability of the graft at 5 mm from the crest (P = .625). The presence of any correlation among the anatomical characteristics of the sites (cancellous bone thickness, cortical plate thickness at 2 and 5 mm from the crest) and the amount of augmentation achieved was investigated. The only statistically significant finding was the negative correlation between the thickness of the cancellous bone and the amount of expansion achieved with the use of MREs. The thinner the cancellous bone, the greater the amount of augmentation achieved.

Discussion

Based on clinical observation, reported pain was mild to moderate, and no significant differences were observed between the two treatment groups. Moreover, the MRE did not lead to any unpleasant sensations. Considering the lack of controlled clinical trials and cross-sectional studies on the use of MREs, it was difficult to compare the results of the present research with those obtained in other studies.[21–23] Previous research on MREs focused on implant placement success after using the instrument to prepare the osteotomy.[24] Therefore, the authors can only compare it with the use of osteotomes[19,26] or the split crest technique[9,11,23] to expand atrophic ridges. Unfortunately, in those studies, limited data are available regarding the amount of ridge width gain achieved with the procedure; the main parameter analyzed was implant survival.[19,24,30]

In 1992, Simion et al[9] reported an expansion between 2 and 4 mm using osteotomes and simultaneous implant placement. In 2000, Vercellotti[31] described the use of Piezosurgery to perform a split crest technique, thereby achieving an increased width of the atrophic ridge varying from 2 to 3 mm. Vercellotti, like Simion and colleagues, placed the implants simultaneously. The gain in thickness reported by these two authors is slightly superior to the results achieved in this study. One difference to explain these results is that in the current study, implants were not placed simultaneously with the bone expansion, thus partially reducing the possibility of maintaining the gain in width achieved after the expansion. In fact, considering plastic bone properties, once the expander is removed, the space between the lingual and buccal cortical plates may not hold, and the plates tend to collapse into the space created by the MREs. It is interesting to note the lack of correlation found between the thickness of the cortical plate and the amount of expansion achieved at test sites. However, the negative correlation between the thickness of the cancellous bone at 3 mm from the crest and the total amount of augmentation is a significant finding. This specific correlation was surprising since, in the literature,[24,32] the use of MREs has been recommended in sites with a thin cortical plate and thick cancellous bone. It appears that a limited amount of cancellous bone might increase the amount of expansion, hence reducing the amount of possible bone condensation. Indeed, cancellous bone is rich in marrow spaces and quite trabecular in nature. These characteristics of cancellous bone probably absorbed part of the centripetal pressure that the expander generated, reducing the effectiveness of the expander. In this case, it appears that the expander works not only for its intended purpose, but also as a condenser of the trabecular bone. Comparing the results of test and control sites, no significant differences were detected. Given the study's small power, it would be incorrect to affirm that the two techniques work exactly the same. Perhaps the researchers failed to detect small differences that may have been present between the two groups as a possible result of the small sample size.

The data regarding the dimensional changes of the graft during the healing period appear interesting. In fact, while the MRE sites showed limited shrinkage, the LRA sites doubled that value. These data are unremarkable because in 2000, Simon et al[18] observed a loss of augmented alveolar ridge height and width during healing using DBBM of up to more than 50% of the total volume of the grafted material when measured 3 mm from the most coronal part of the crest. The data from this investigation is encouraging in that the use of the expander significantly limits the amount of width loss of augmented alveolar ridges during the healing period.

Conclusions

Within the limitations of this study, the authors conclude that:

- Ridge expansion using MREs is as effective as the LRA technique in augmenting the thickness of atrophic ridges.
- Defects treated with the MREs showed less bone width contraction during the first 6 months of healing.
- No correlation was found between the thickness of the cortical plate at 5 and 10 mm from the crest and the amount of expansion.
- A negative correlation between the thickness of the cancellous bone and the amount of expansion was found, suggesting that the thinner the cancellous bone, the greater the total amount of expansion.

References

1. Rose L, Mealey B, Genco R, Cohen D. Periodontics: Medicine, Surgery, and Implants. St Louis: CV Mosby, 2004.
2. Seibert JS. Reconstruction of deformed, partially edentulous ridges, using full thickness onlay grafts. Part II. Prosthetic/periodontal interrelationships. Compend Contin Educ Dent 1983;4:549–562.
3. Buser D, Brägger U, Lang NP, Nyman S. Regeneration and enlargement of jaw bone using guided tissue regeneration. Clin Oral Implants Res 1990;1:22–32.
4. Nyman S, Lang NP, 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.
5. Seibert J, Nyman S. Localized ridge augmentation in dogs: A pilot study using membranes and hydroxyapatite. J Periodontol 1990;61:157–165.
6. Jensen J, Sindet-Pedersen S. Autogenous mandibular bone grafts and osseointegrated implants for reconstruction of the severely atrophied maxilla: A preliminary report. J Oral Maxillofac Surg 1991;49:1277–1287.
7. Isaksson S, Alberius P. Maxillary alveolar ridge augmentation with onlay bonegrafts and immediate endosseous implants. J Craniomaxillofac Surg 1992; 20:2–7.
8. Keller EE, Tolman DE. Mandibular ridge augmentation with simultaneous onlay iliac bone graft and endosseous implants: A preliminary report. Int J Oral Maxillofac Implants 1992;7:176–184.
9. Simion M, Baldoni M, Zaffe D. Jawbone enlargement using immediate implant placement associated with a split-crest technique and guided tissue regeneration. Int J Periodontics Restorative Dent 1992;12:462–473.

10. Lang NP, Hämmerle CH, Brägger U, Lehmann B, Nyman SR. Guided tissue regeneration in jawbone defects prior to implant placement. Clin Oral Implants Res 1994;5:92–97.
11. Scipioni A, Bruschi GB, Calesini G. The edentulous ridge expansion technique: A five-year study. Int J Periodontics Restorative Dent 1994;14:451–459.
12. Buser D, Dula K, Hirt HP, Schenk RK. Lateral ridge augmentation using autografts and barrier membranes: A clinical study with 40 partially edentulous patients. J Oral Maxillofac Surg 1996;54:420–432.
13. Simion M, Trisi P, Piattelli A. GBR with an e-PTFE membrane associated with DFDBA: Histologic and histochemical analysis in a human implant retrieved after 4 years of loading. Int J Periodontics Restorative Dent 1996;16:338–347.
14. Lundgren D, Sennerby L, Falk H, Friberg B, Nyman S. The use of a new bioresorbable barrier for guided bone regeneration in connection with implant installation. Case reports. Clin Oral Implants Res 1994;5:177–184.
15. Hürzeler MB, Quiñones CR, Schüpbach P. Guided bone regeneration around dental implants in the atrophic alveolar ridge using a bioresorbable barrier. An experimental study in the monkey. Clin Oral Implants Res 1997;8:323–331.
16. Caffesse RG. Regeneration: Where are we? Pract Periodontics Aesthet Dent 1997;9:223–224, 226.
17. Ito K, Nanba K, Murai S. Effects of bioabsorbable and non-resorbable barrier membranes on bone augmentation in rabbit calvaria. J Periodontol 1998;69: 1229–1237.
18. Simon BI, Von Hagen S, Deasy MJ, Faldu M, Resnansky D. Changes in alveolar bone height and width following ridge augmentation using bone graft and membranes. J Periodontol 2000;71: 1774–1791.
19. Summers RB. The osteotome technique: Part 2—The ridge expansion osteotomy (REO) procedure. Compendium 1994; 15:422, 424, 426.
20. Chong WL, Chu SA, Dam JG, Ong KS. Oral rehabilitation using dental implants and guided bone regeneration. Ann Acad Med Singapore 1999;28:697–703.
21. Sethi A, Kaus T. Maxillary ridge expansion with simultaneous implant placement: 5-year results of an ongoing clinical study. Int J Oral Maxillofac Implants 2000;15:491–499.
22. Shimoyama T, Kaneko T, Shimizu S, Kasai D, Tojo T, Horie N. Ridge widening and immediate implant placement: A case report. Implant Dent 2001;10:108–112.
23. Palti A. Ridge splitting and implant techniques for the anterior maxilla. [Interview]. Dent Implantol Update 2003;14:25–32.
24. Lee EA, Anitua E. Atraumatic ridge expansion and implant site preparation with motorized bone expanders. Pract Proced Aesthet Dent 2006;18:17–22.
25. Scipioni A, Bruschi GB, Calesini G, Bruschi E, De Martino C. Bone regeneration in the edentulous ridge expansion technique: Histologic and ultrastructural study of 20 clinical cases. Int J Periodontics Restorative Dent 1999;19:269–277.
26. Duncan JM, Westwood RM. Ridge widening for the thin maxilla: A clinical report. Int J Oral Maxillofac Implants 1997; 12:224–227.
27. Zitzmann NU, Naef R, Schärer P. Resorbable versus nonresorbable membranes in combination with Bio-Oss for guided bone regeneration. Int J Oral Maxillofac Implants 1997;12:844–852.
28. Fugazzotto PA. GBR using bovine bone matrix and resorbable and nonresorbable membranes. Part 2: Clinical results. Int J Periodontics Restorative Dent 2003;23:599–605.
29. Becker W, Clokie C, Sennerby L, Urist MR, Becker BE. Histologic findings after implantation and evaluation of different grafting materials and titanium micro screws into extraction sockets: Case reports. J Periodontol 1998;69:414–421.
30. Summers RB. A new concept in maxillary implant surgery: The osteotome technique. Compendium 1994;15:152, 154–156.
31. Vercellotti T. Piezoelectric surgery in implantology: A case report—A new piezoelectric ridge expansion technique. Int J Periodontics Restorative Dent 2000;20: 358–365.
32. Anitua E. Ridge expansion with motorized expander drills. Dent Dialogue 2004; 2:3–13.