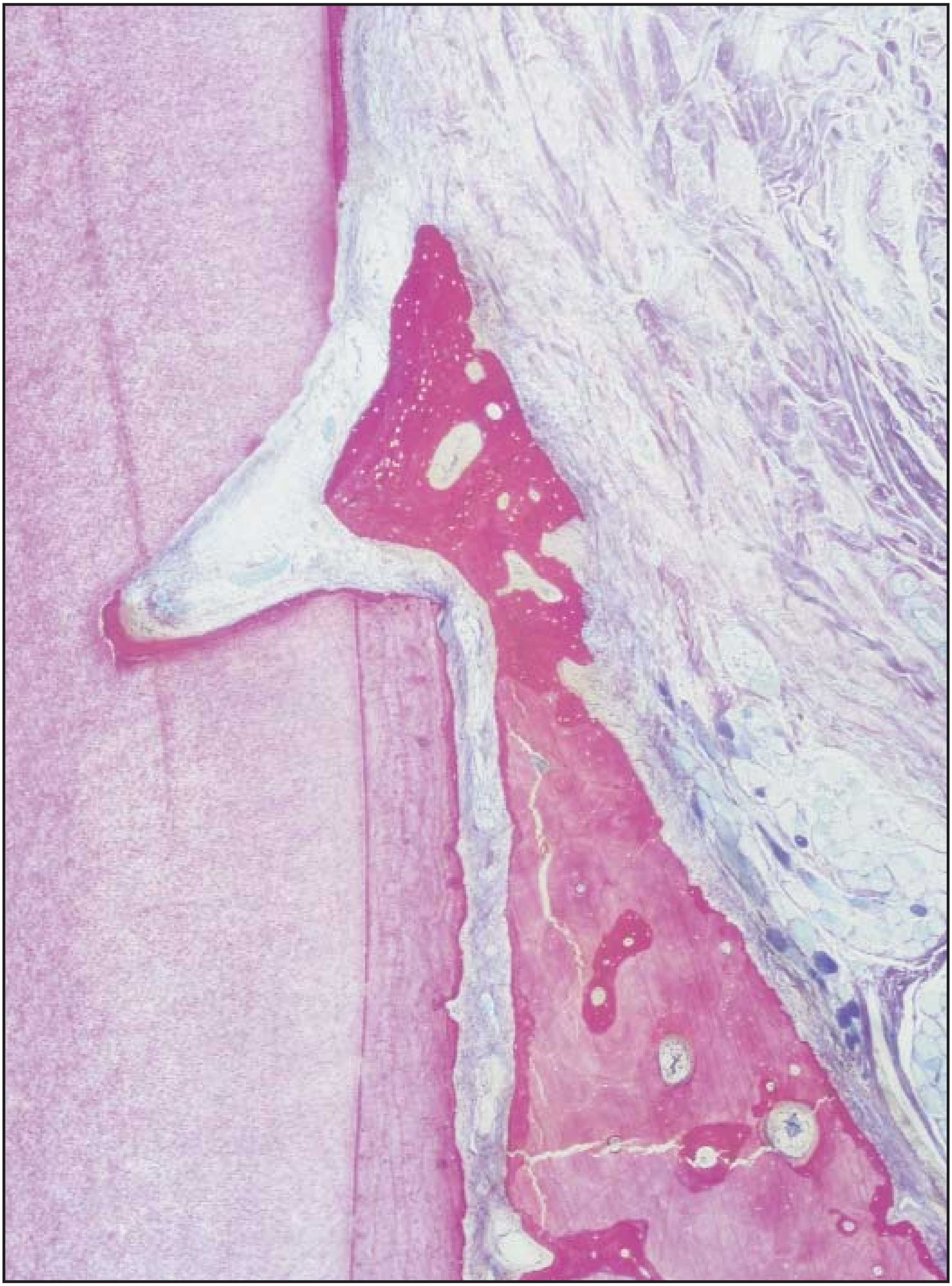

Osseous Response Following Resective Therapy with Piezosurgery

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A piezoelectric instrument vibrating in the ultrasonic frequency range was investigated for its potential use in periodontal resective therapy. The rate of postoperative wound healing (baseline and 14, 28, and 56 days after surgery) in a dog model following surgical ostectomy and osteoplasty was the marker used to compare the efficacy of this instrument (PS) with a commonly used carbide bur (CB) or a diamond bur (DB). The surgical sites treated by CB or DB lost bone, in comparison to baseline measurements, by the 14th day, while the surgical sites treated by PS revealed a gain in the bone level. By day 28, the surgical sites treated by all three instruments demonstrated an increased bone level and regeneration of cementum and periodontal ligament. However, by day 56, the surgical sites treated by CB or DB evidenced a loss of bone, versus a bone gain in the PS-treated sites. Thus, it appears that PS provided more favorable osseous repair and remodeling than CB or DB when surgical ostectomy and osteoplasty procedures were performed. Therefore, PS could be regarded as being efficacious for use in osseous surgery. (Int J Periodontics Restorative Dent 2005;25:543–549.)

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The wound healing response in the alveolar crest following ostectomy and osteoplasty has been the subject of many investigations.[1–11] Matherson[9] and Caffesse et al[6] reported minimal or insignificant crestal resorption, while Lobene and Glickman[2] reported up to 1.7 mm of alveolar bone loss following osseous surgery in animal studies. Wilderman et al[8] recorded minimal initial bone resorption ranging from 0.14 to 4.47 mm (average of 1.2 mm), followed by alveolar regrowth ranging from 0.14 to 1.15 mm (average of 0.8 mm) in a human histologic study that examined the reparative potential of tissue following mucogingival flap and osseous surgery. Initial bone thickness was an important determinant of the amount of postoperative bone loss. They found that thicker bone with marrow spaces exhibited less resorption and greater repair when compared with thin bone. Similar values were reported by Moghaddas and Stahl[12] in their study of alveolar bone following osseous surgery in humans. Crestal bone loss at interdental, radicular, and furcation sites was 0.23 mm, 0.55 mm, and 0.88 mm, respectively, at 6 months postsurgery.

Thus, it could be postulated that animal responses to osseous surgery showed ranges of alveolar bone remodeling similar to those obtained in humans. The degree in which the bony support of the teeth was modified without significant attachment loss following osseous surgery seemed to be dependent on the quality and quantity of the bone present following the osseous surgery.[10]

Although it has been almost 55 years since the concept of ostectomy and osteoplasty was applied in periodontal surgery to achieve desired physiologic osseous contour as well as pocket elimination, there has not been a significant improvement in the instrumentation used to achieve these goals.[13] The instruments available for osseous surgery include chisels, files, rongeurs, and rotating instruments such as carbide burs, diamond burs, and steel burs.

Recently, a piezoelectric knife (Mectron Piezosurgery System) was introduced to enhance periodontal surgical procedures. The micrometric cut of the scalpel allows for maximum intraoperative precision with minimal tissue damage, and the selective frequency of the scalpel minimizes the risk to adjacent soft tissues.

Thus, the purpose of this study was to evaluate histologically and histometrically the postoperative wound healing response following surgical ostectomy and osteoplasty with piezosurgery (PS) compared to a commonly used carbide bur (CB) or diamond bur (DB).

Method and materials

This study protocol for four adult female hounds was approved by the Institutional Animal Care and Use Committees (IACUC). All surgical procedures were performed under general anesthesia (nembutal, 25 mg/kg administered intravenously; Abbott Laboratories) after preadministration of acepromazine (10 mg/kg administered intramuscularly; Boehringer Ingelheim Vetmedica) and antibiotic (bicillin, 600,000 IU intramuscularly; Wyeth Laboratories).

Defect creation

The surgical sites were first disinfected with 10% povidone-iodine solution (Aplicare), which was followed by administration of local anesthesia (2% xylocaine with epinephrine 1:100,000; Dentsply Pharma) via infiltration at the respective buccal and lingual sites. Thorough plaque and calculus removal was performed for the mandibular posterior quadrants, including premolars (P1 to P4) and the first molars (M1). Sulcular incisions extended at least one tooth mesial and distal to the treatment sites, with vertical releasing incisions as required. Full-thickness mucoperiosteal flaps were elevated, and soft tissue degranulation was accomplished. The removal of 4 mm of bone by ostectomy and osteoplasty occurred around each tooth, with random assignment of treatment with PS, CB (Brasseler USA), or DB (Brasseler USA). This was done in conjunction with water coolant to simulate the instrument's actual use in clinical procedures. A notch was placed in the root surface at the postsurgical alveolar crest level. Mucoperiosteal flaps were approximated at the level of bone with interrupted 4-0 Vicryl sutures (Ethicon). The animals received a postoperative antibiotic regimen of bicillin for 5 days (600,000 IU twice a day) and an analgesic/anti-inflammatory medication (Voltaren, 50 mg twice a day for 3 days; Novartis Pharmaceuticals). Sutures were removed, and plaque control was performed by irrigating the oral cavity daily with 0.12% chlorhexidine gluconate (Peridex, Procter & Gamble) for 10 days postsurgery. After day 14, plaque accumulations were removed daily with a soft-bristle toothbrush and 0.2% chlorhexidine gel (Plak Out, Hawe-Neos). The animals received a soft diet during the entire healing period and treatment phase.

Histologic preparation and histometric analyses

Animals were sacrificed at baseline or at 14, 28, and 56 days after the surgery. The mandibular block sections containing the test teeth were surgically removed and placed in fixative for histologic preparation and evaluation. Each specimen was dissected into smaller buccolingual blocks that contained the complete tooth root and adherent mucoperiosteal tissue. The specimens were prepared for histology as described by Schenk et al.[14] Un-

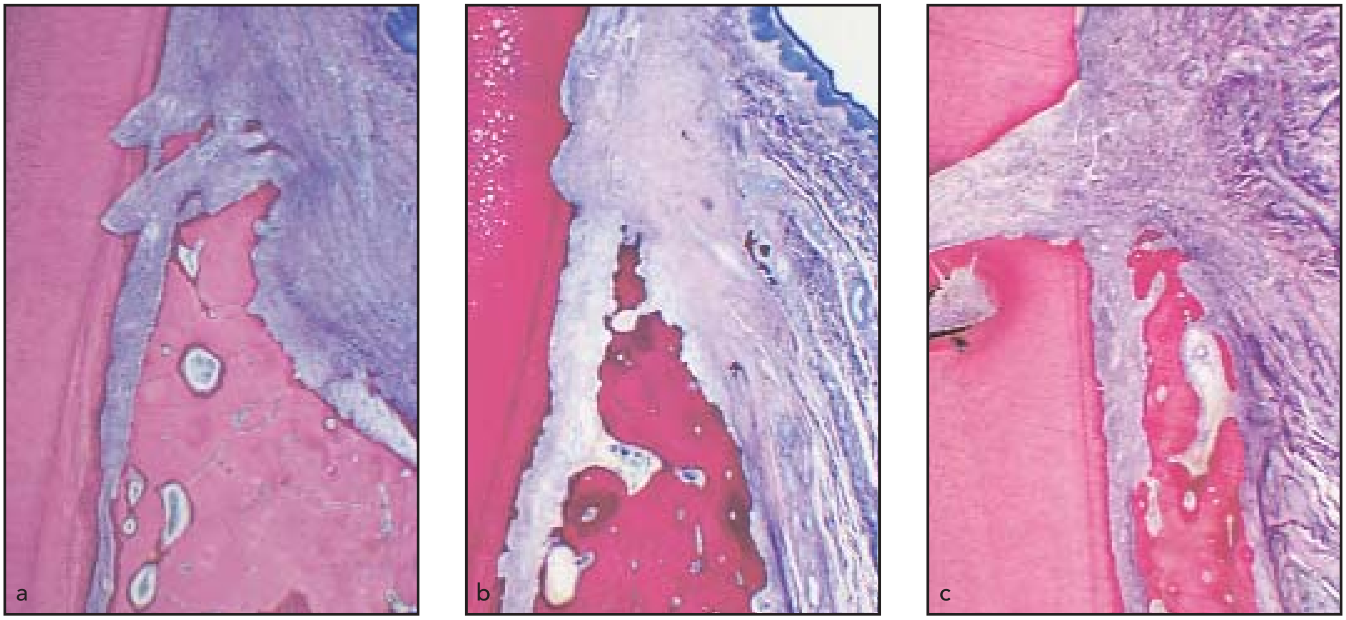

Fig 1 *Histologic sections of biopsies obtained 14 days after surgical procedures evidenced no discernable loss of bone apical to the notches. However, statistical analysis revealed a mean bone level loss of 0.21 mm for CB* (a) *and 0.03 mm for DB* (b) *and a gain of 0.03 mm for PS* (c) *(toluidine blue and basic fuchsin; original magnification ×25).*

decalcified specimens were embedded in methylmethacrylate and stained with toluidine blue and basic fuchsin. Consecutive orofacial step sections with a thickness of approximately 80 µm, spaced at intervals of about 1 mm, were obtained for histologic and histometric analyses.

Each specimen was evaluated histometrically for changes in bone levels, with the notch as a reference point, by using a computer-based image analysis software program (NIH Image version 1.61, National Institutes of Health). Each image of the undecalcified specimens was digitized as a 540 × 720 array of 16-bit density values and transferred to a microcomputer for analysis.

Statistical analysis

Group means were calculated for each measured parameter (0, 14, 28, and 56 days) to compare the bone level for all instrument groups. The Kruskal-Wallis test was performed for each measured parameter. The Scheffe procedure was used to determine whether the means were statistically different from the Kruskal-Wallis test. The Mann-Whitney *U* test was also used to compare the difference in bone levels between each instrument group. A P value of $< .01$ indicated statistical significance.

Results

The surgical and postoperative phases were uneventful. All of the instruments were effective in removing bone with ease and precision.

All surgical sites were included in the histometric analysis. The osseous crest at day 0 was located at the base of the notch for all treatment groups. At day 14, the surgical sites treated by CB and DB lost bone (0.21 and 0.03 mm of mean bone loss, respectively), while the surgical sites treated by PS revealed a minimal mean bone level gain (0.03 mm) (Fig 1). By day 28, the surgical sites treated with all three instruments demonstrated an increased

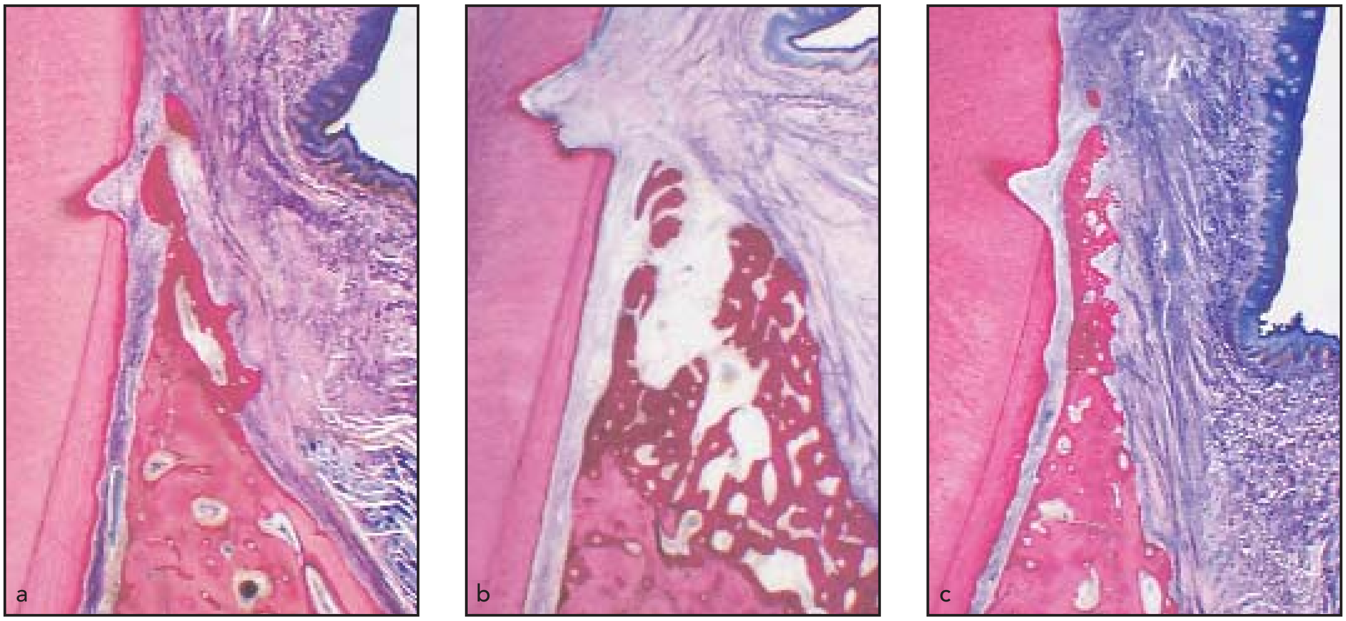

Fig 2 *Histologic sections of biopsies at 28 days after treatment with CB* (a), *DB* (b), *and PS* (c) *evidenced bone gain occlusal to the notches. This gain in bone was accompanied by regenerated cementum on the tooth surface that is connected to the bone by the regenerated periodontal ligament (toluidine blue and basic fuchsin; original magnification ×25).*

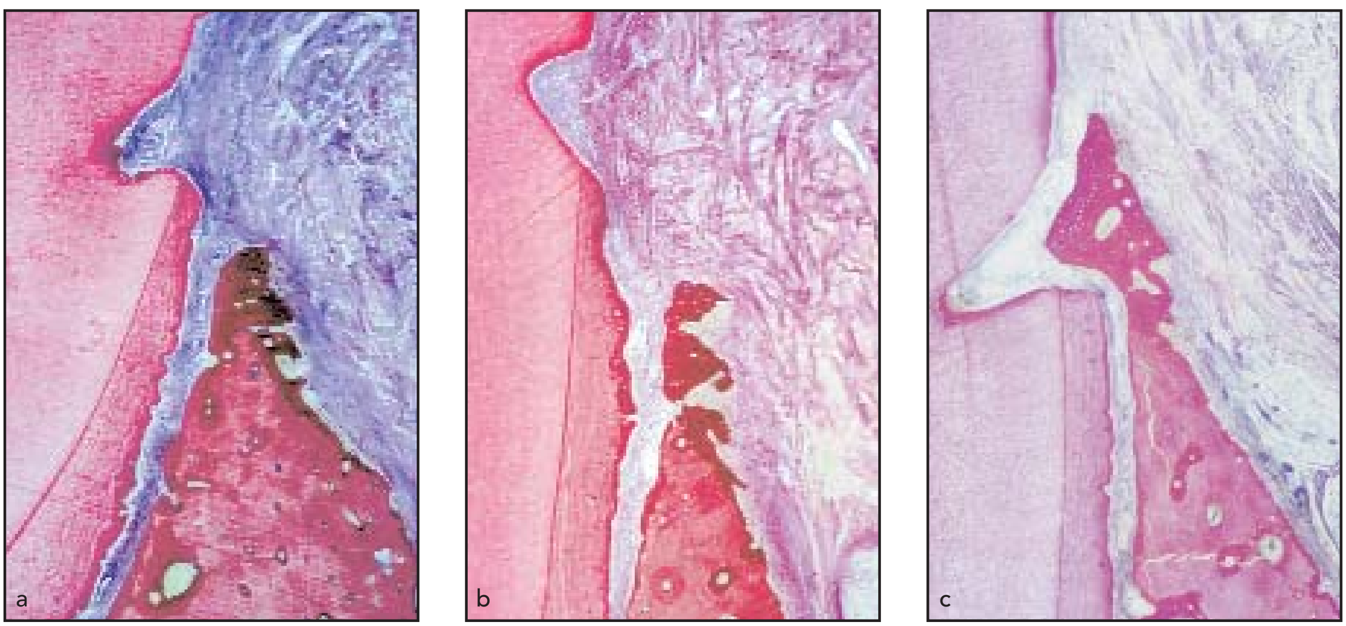

Fig 3 *Histologic sections of biopsies at 56 days following surgical procedures evidenced no bone loss apical to the notches, but the section treated by PS* (c) *demonstrated more coronal growth of bone than the sections treated by CB* (a) *or DB* (b) *(toluidine blue and basic fuchsin; original magnification ×25).*

mean bone level, with regeneration of cementum and periodontal ligament (Fig 2). By day 56, the surgical sites treated by CB and DB had lost minimal bone (0.37 and 0.83 mm of mean bone loss, respectively), compared to a minimal gain in bone level in the PS-treated sites (0.45 mm) (Fig 3). The mean bone level gain in PS versus DB at day 56 was statistically significant ($P < .01$) (Table 1).

Table 1 Mean bone level gain from the baseline (mm)

	Instrument		
Healing time (d)	CB	DB	PS
0	0.00	0.00	0.00
14	–0.21	–0.03	0.03
28	0.24	0.09	0.21
56	–0.37	–0.83*	0.45*

*DB versus PS: $P < .01$.
CB = carbide bur; DB = diamond bur; PS = piezosurgery.

Discussion

Periodontal disease associated with crestal bone resorption alters the morphology of the alveolar process and at times produces reverse osseous architecture, which significantly hinders removal of bacterial plaque.[12,13] Therefore, osseous surgery has the primary objectives of removing osseous deformities and creating a physiologic parabolic contour.[15]

The results of a histologic comparison of the effect of a standard ultrasonic insert to a rotary bur and a surgical chisel were published in 1975.[16] The ultrasonic insert, like the surgical chisel, was found to cut and not burnish bone. While the rotary bur was observed to produce the smoothest surface of bone, the rate of bone healing proceeded best when bone was removed by surgical chisel or ultrasonic insert. In a follow-up study[17] of clinical and histologic observations using ultrasonic instruments in the surgical removal of teeth and osseous surgery, ultrasonic inserts were found to remove bone with ease and preciseness. There was no evidence of detrimental histologic changes.[17] In addition, patient discomfort appeared to be reduced, resulting in higher acceptance.

Documentation exists to indicate that the piezoelectric knife used in our current study is effective in removing mineralized tissues. Vercellotti[18] reported its use for ridge expansion to place dental implants, and in a later publication, Vercellotti et al[19] used piezosurgery to perform sinus lifts in 15 patients. There was only one perforation in the 21 sinus lifts performed, resulting in a 95% success rate. The advantage of this new technique was its ability to cut the bony window with simplicity and precision, thereby avoiding the risk of perforating the membrane as a result of the shape of the bone scalpels working with ultrasonic modulating vibrations. Subsequent use of the piezoelectric elevators lifted the membrane without heightened risk of perforation, even in anatomically complex situations.[19]

In the current study, a modulated-frequency piezoelectric knife was investigated as a means of performing ostectomy and osteoplasty. The rate of postoperative level of bone change was used to compare the effectiveness of this instrument with a standard carbide bur and a standard diamond bur. Our results indicate that piezosurgery provided a more favorable osseous response than traditional carbide and diamond burs when surgical ostectomy and osteoplasty procedures were performed. As indicated for other surgical procedures, there seemed to be several advantages in the use of piezosurgery for periodontal surgeries.

For example, surgical control for the piezosurgery was effortless, because the force necessary to obtain a cut by the operator was much less compared to a rotational bur. In fact, the micromotor action of the rotational burs required a supplemental force (increase in hand pressure on the device) to oppose the rotation of the instrument. As a result, when a bur met structures of varying mineralization or soft tissues, there was a decrease in surgical sensitivity and an increase in hand pressure on the device. Secondly, because the piezosurgery insert vibrated within a width of 60 to 200 mm at a modulated ultrasonic frequency, an increase in temperature was avoided, which eliminated bone damage. In addition, the vibration frequency of piezosurgery was optimal for mineralized tissue and did not cut into the adjacent soft tissue, minimizing the risk of harming adjacent tissue. Finally, piezosurgery was already used in various disciplines such as in endodontic and maxillofacial surgeries that required delicate and detailed surgical techniques, indicating that it is safe to use in surgical periodontal procedures.

The limitation of the present study was a small sample size, but the results were consistent.

Patients perceive greater comfort when this instrument is substituted for conventional instruments for osseous surgery. First, it can be used for root planing, eliminating the noise in manual instrumentation while producing a smooth surface. The second advantage is elimination of the noise of the high-speed handpiece. Thus, patient response is significantly improved versus the traditional instrumentation.

Overall, piezosurgery resulted in more favorable osseous repair and remodeling in comparison with carbide and diamond burs, and its use in ostectomy and osteoplasty procedures may prove a promising addition to the clinician's armamentarium.

Conclusion

A piezoelectric knife was compared with traditionally used diamond and carbide burs for the purpose of ostectomy and osteoplasty. The histologic conclusion of this study in a dog model was favorable when relating the level of the bone to a surgically produced notch at the most occlusal extent of the alveolar process at the time of surgery. The perceived benefits for the patient are magnified by the elimination of the need for noisy hand instrumentation to accomplish root planing and the noise of a high-speed handpiece. Patient comfort is achieved by familiarity with the ultrasonic instrumentation routinely used for the removal of accretions.

References

1. Wilderman MN, Wentz FM, Orban BJ. Histogenesis of repair after mucogingival surgery. J Periodontol 1960;31:283–299.
2. Lobene R, Glickman I. The response of alveolar bone to grinding with rotary diamond stones. J Periodontol 1963;34:105–119.
3. Friedman N, Levine HL. Mucogingival surgery: Current status. J Periodontol 1964;35:5–21.
4. Pennel BM, King KO, Wilderman MN, Barron JM. Repair of the alveolar process following osseous surgery. J Periodontol 1967;38:426–431.
5. Hiatt WH, Stallard RE, Butler ED, Badgett B. Repair following mucoperiosteal flap surgery with full gingival retention. J Periodontol 1968;39:11–16.
6. Caffesse RG, Ramfjord SP, Nasjleti CE. Reverse bevel periodontal flaps in monkeys. J Periodontol 1968;39:219–235.
7. Donnenfeld OW, Hoag PM, Weissman DP. A clinical study on the effects of osteoplasty. J Periodontol 1970;41:131–141.
8. Wilderman MN, Pennel BM, King K, Barron JM. Histogenesis of repair following osseous surgery. J Periodontol 1970;41:551–565.
9. Matherson DG. An evaluation of healing following periodontal osseous surgery in monkeys. Int J Periodontics Restorative Dent 1988;8:8–39.
10. Mills MP, McDonnell HT. Osseous surgery: The resective approach. In: Nevins M, Mellonig JT (eds). Periodontal Therapy: Clinical Approaches and Evidence of Success. Chicago: Quintessence, 1998:173–185.
11. Oakley E, Rhyu IC, Karatzas S, Gandini-Santiago L, Nevins M, Caton J. Formation of the biologic width following crown lengthening in nonhuman primates. Int J Periodontics Restorative Dent 1999;19:529–541.
12. Moghaddas H, Stahl SS. Alveolar bone remodeling following osseous surgery. A clinical study. J Periodontol 1980;51:376–381.
13. Schluger S. Osseous resection: A basic principle in periodontal surgery. Oral Surg 1949;2:316–325.
14. Schenk RK, Olah AJ, Hermann W. Preparation of calcified tissue for light microscopy. In: Dickson GR (ed). Methods of Calcified Tissue Preparation, ed 1. Amsterdam: Elsevier Science, 1984:1–56.
15. Cohen ES. Resective osseous surgery. In: Cohen ES (ed). Atlas of Cosmetic and Reconstructive Periodontal Surgery, ed 2. Philadelphia: Lea & Febiger, 1994:259–283.
16. Horton JE, Tarpley TM Jr, Wood LD. The healing of surgical defects in alveolar bone produced with ultrasonic instrumentation, chisel, and rotary bur. Oral Surg Oral Med Oral Pathol 1975;39:536–546.
17. Horton JE, Tarpley TM Jr, Jacoway JR. Clinical applications of ultrasonic instrumentation in the surgical removal of bone. Oral Surg Oral Med Oral Pathol 1981;51:236–242.
18. Vercellotti T. Piezoelectric surgery in implantology: A case report—A new piezoelectric ridge expansion technique. Int J Periodontics Restorative Dent 2000;20:359–365.
19. Vercellotti T, De Paoli S, Nevins M. The piezoelectric bony window osteotomy and sinus membrane elevation: Introduction of a new technique for simplification of the sinus augmentation procedure. Int J Periodontics Restorative Dent 2001;21:561–567.