Reconstruction of Posterior Mandibular Alveolar Ridge Deficiencies With the Piezoelectric Hinge-Assisted Ridge Split Technique: A Retrospective Observational Report

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Background: Reconstruction of alveolar defects in the posterior edentulous mandible can be a difficult task. In addition to complicating anatomic features, such as the inferior alveolar nerve, mental foramen, oblique ridge, and lingual undercut of the mylohyoid ridge, edentulous ridges in the posterior mandible have thicker cortices and decreased volumes of vascular trabecular bone than their maxillary counterparts. Traditionally, these areas have been treated with autogenous block grafts. Significant resorption of these grafts, in combination with patient morbidity at secondary donor sites, has led clinicians to seek alternatives for augmenting the edentulous posterior mandible. The aim of this retrospective consecutive case series is to report on both the technique of the piezoelectric hinge-assisted ridge split procedure for augmenting these sites and the results that were achieved.

Methods: Thirteen patients with 17 horizontal alveolar ridge deficiencies of the posterior mandible were treated with the piezoelectric hinge-assisted ridge split procedure. After an average healing period of 14 weeks, dental implants were placed into the augmented sites. Intrasurgical alveolar ridge measurements taken at the initial surgery and subsequently at the time of implant placement documented the horizontal gains achieved by this procedure.

Results: Overall mean gain in horizontal width was 4.03 mm (± 0.67). For single implant-site augmentations, the mean gain was 3.38 mm (± 0.25). For multiple adjacent implant-site augmentations, mean gain was 4.25 mm (± 0.62). A total of 31 dental implants were successfully placed in all sites and none required additional augmentation procedures. There were no instances of adverse outcomes, such as neurosensory deficits or sequestration of mobilized buccal plates. After a minimum of 6 months of loading, all dental implants have been successful.

Conclusions: This retrospective observational report demonstrates that the piezoelectric hinge-assisted ridge split procedure can achieve substantial gains in horizontal ridge width of the edentulous posterior mandible without associated morbidity. Further prospective and larger observational studies are warranted to see if this is true over a larger patient population and to compare this technique to other more traditionally used approaches. J Periodontol 2010;81:1580-1586.

KEY WORDS
Alveolar ridge augmentation; bone regeneration; grafting, bone; mandible; partially edentulous jaw.

In some instances, edentulous spaces planned for dental implant treatment require reconstruction of alveolar ridge deficiencies before fixture placement. Recommendations for minimum dental implant alveolar housings range from 5 to 6 mm of residual bone width before implant placement1,2 or 1 to 1.5 mm of bone width around all lateral aspects of the implant after its delivery.3,4 To achieve such bony dimensions, a variety of augmentation techniques have been successfully used including guided bone regeneration with particulate graft;5 block grafts obtained from ramus,6 symphysis,7 iliac crest,8 or calvarial bone;9 distraction osteogenesis;10 ridge expansion osteotomy;11 and ridge...
splitting. Depending on the intraoral location of treatment, each procedure has inherent advantages and limitations.

The posterior mandible has been referred to as “the most difficult region for reconstruction and early implant placement in cases of severe alveolar resorption in the maxillomandibular complex.” In addition to complicating anatomic features, such as the inferior alveolar nerve, mental foramen, oblique ridge, and lingual undercut of the mylohyoid ridge, edentulous mandibular ridges have thicker cortices and decreased volumes of vascular trabecular bone than their maxillary counterparts. Traditionally, resorbed alveolar ridges of the most severe nature have been treated with autogenous block grafts. Although these grafts can provide substantial augmentation, use has been associated with patient morbidity at donor sites and, as such, alternative procedures yielding comparable gains to autogenous block grafts have been sought. The aim of this retrospective case series is to report on both the technique of the piezoelectric hinge-assisted ridge split (PHARS) procedure for augmenting posterior mandibular alveolar ridge deficiencies and the results that may be achieved.

MATERIALS AND METHODS

Patients

This retrospective case series reports on consecutive patients who were treated in separate private practices in Texas, Washington DC, and Pennsylvania with the PHARS technique. Information was gained after exhaustive chart review. A total of 13 patients with 17 horizontal alveolar ridge deficiencies of the posterior mandible were found who had been referred for dental implant treatment between 2008 and 2009. Patients included seven males and six females with a mean age of 35.15 years (range, 22 to 43 years). Because this was a retrospective observational report, patients were treated as they presented, and there were no exclusionary parameters. All patients were either systemically healthy or had well-controlled medical conditions (i.e., hypertension, gastric esophageal reflux disease, asthma, and so forth). Written informed consent was obtained from each patient. Site-specific indications for the PHARS technique typically used by the authors are as follows: 1) ≥2 mm of horizontal bone thickness at crest; 2) ≥10 mm of vertical bone height to vital structures; 3) non-concave cross-sectional anatomy; 4) corticotomies must remain 1 mm away from adjacent teeth; and 5) single tooth sites difficult (only molars if single tooth).

Surgical Procedure

At all edentulous sites (Fig. 1), crestal incisions were placed after obtaining local or block anesthesia. Vertical incisions were used at the mesial and distal most aspects of the edentulous area and elevation of full-thickness flaps was performed (Fig. 2A). Piezoelectric surgical cutting tips were used to make corticotomy cuts in preparation for controlled fracture of the buccal cortical plate. The initial corticotomy was made at the mid-crest and terminated approximately 1 mm from any adjacent teeth. The precise cutting nature of the piezoelectric surgical units provided a margin of safety allowing for closer cuts to adjacent teeth compared to traditional cutting instruments. When a tooth was extracted adjacent to an edentulous space, the ridge splitting technique was slightly modified. The initial horizontal cut was initiated at the mid-crest of the edentulous ridge from the inner aspect of the extraction site. The initial crestal cut was then retraced and deepened up to a depth of 10 mm. Apical flaring of the residual alveolar bone typically negated the need to deepen the horizontal cut any further than this. At the terminus of the horizontal corticotomy, vertical cuts were made approximating the length and depth of the crestal horizontal cut. Vertical cuts completely transected the buccal cortical plate into the marrow space. In cases of severely resorbed ridges with little to no marrow space, the depth of the vertical cuts approximated one half of the total ridge width. Finally, apical “hinge cuts” connected the vertical corticotomies (Fig. 2B) to gain better control of greenstick fracturing and allow for more extensive lateral mobilization of the buccal plate. This cut required careful attention to detail and is the most difficult cut of the procedure. Complete transection of the buccal plate is to be avoided. Apical hinge cuts did not fully transect the cortical plate because their intent was to act as a “guide” for the fracture and a “hinge” for lateral positioning of the bony segment.

On completion of the corticotomies, ridge expansion chisels were sequentially used to widen the...
crestal horizontal cut anywhere from 3 to 5 mm depending on the dimensions of the original ridge defect (Fig. 2C). In cases where the buccal plate did not mobilize with the initial ridge expansion chisels, the apical hinge cut was retraced and deepened, taking care to maintain the hinge by not fully transecting the cortical bone. After sufficient lateralization of the buccal plate (Fig. 2D), particulated freeze-dried bone allograft# was condensed into the gap separating the cortical plates. Additional particulated bone was placed buccally to fill and diffusely cover the vertical corticotomies and apical hinge cut (Fig. 3A). The split ridge and particulated graft material were then covered with resorbable collagen membranes taking care to cover all graft material that exceeded the extent of the piezoelectric corticotomies (Fig. 3B). Periosteal releasing incisions were used for mucoperiosteal flap mobilization to obtain tension-free primary closure (Fig. 3C). Post-surgical management included suture removal at 10 to 14 days. Patients were placed on a systemically administered bactericidal agent, such as amoxicillin, for 7 to 10 days along with topical application of chlorhexidine mouthrinse twice daily for up to 3 weeks.

Surgical sites were reentered 3 to 4 months after initial surgery (Fig. 4A) and dental implants were placed (Fig. 4B) as a single-staged procedure. Dental implants were allowed to heal for an average of 2 to 3 months before final restoration.

Biometric Evaluation

Biometric data were obtained from a retrospective chart review. As is standard for all bone augmentation procedures, pre-and post-surgical alveolar ridge widths were recorded. After full-thickness mucoperiosteal flap reflection, the narrowest portion of each ridge was measured to the closest half millimeter with UNC-15 periodontal probes and recorded in the patient’s chart. Data from the chart review were then pooled and averaged for analysis.

RESULTS

All patients healed uneventfully with no instances of infection, sequestration of the mobilized buccal plate, or neurosensory deficits. Retrospective review data are presented in Table 1. Overall mean gains in horizontal width were 4.03 mm (±0.67). For single-implant site augmentations, mean gains were 3.38 mm (±0.25). For multiple adjacent implant site augmentations, mean gains were 4.25 mm (±0.62). A total of 31 dental implants with a mean diameter of 4.71 mm (±0.46) were successfully placed in all treated sites without need for additional augmentation. Anecdotal observations made of the ridge split surgical sites included regenerated bone being well vascularized and that bone density was consistently Type II and occasionally Type I bone. To date, all dental implants placed in hinge-assisted ridge split sites have healed uneventfully and achieved 100% survival at a minimum of 6 months post-restoration.

DISCUSSION

The alveolar ridge split augmentation procedure was introduced nearly 20 years ago¹² and has since undergone a variety of modifications. In their original description of the procedure, Simion et al.¹² noted that the aim of the ridge split technique was to create a “self-space making” defect that would allow for better graft containment and produce additional bony walls adjacent to the graft. Splitting of atrophic alveolar ridges essentially converts a one-wall defect to a four-wall defect. The benefit of additional defect walls was clearly demonstrated by Cortellini et al.²⁰

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who found that bone defect fill improved proportionally to the number of residual defect walls.

Multiple studies have documented that lateral gains up to 5 mm may be achieved with ridge-splitting procedures.\textsuperscript{12,21,22} Most of these studies, however, dealt with maxillary sites composed of softer bone densities than those of the mandible, making this procedure easier to perform.\textsuperscript{23} This was noted by Bravi et al.\textsuperscript{24} in a long-term multicenter retrospective clinical study of 1,715 implants placed with the edentulous ridge expansion technique.\textsuperscript{24} In this study, 44\% of implants placed in mandibular sites required two-stage delivery because of what the authors\textsuperscript{24} described as “inelastic bone.” The reason for this lack of elasticity relates to the mandibular posterior having thicker cortical bone measurements versus those in the posterior maxilla.\textsuperscript{15} One study evaluating ridge split procedures performed in the mandible noted that “greenstick fracture is not possible in this arch due to the high risk for complete fracture of the mobilized segment.”\textsuperscript{25} To avoid a “mal fracture” from occurring, the authors modified the original technique by placing apical hinge cuts (Fig. 2B). The intent of this modification is to guide the apical ridge split fracture and allow for additional horizontal mobilization of the buccal plate. Other ridge split articles involving the posterior mandible have found the need to use similar cuts or variations thereof.\textsuperscript{22,26,27} More extreme variations were described by Enislidis et al.\textsuperscript{28} and Basa et al.\textsuperscript{13} Mandibular ridge splitting in the Enislidis et al.\textsuperscript{28} study used a three-staged approach with apical scoring cuts performed during the first stage of the technique. In the Basa et al.\textsuperscript{13} study, the apical cuts fully transected the buccal plate.
Table 1.

Site-Specific Results After Augmentation With PHARS Technique

<table>
<thead>
<tr>
<th></th>
<th>Preoperative Width (mm)</th>
<th>Postoperative Width (mm)</th>
<th>Change (mm)</th>
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<tbody>
<tr>
<td>Single implant sites</td>
<td>3.13 (± 0.85)</td>
<td>6.51 (± 1.08)</td>
<td>3.38 (± 0.25)</td>
</tr>
<tr>
<td>Multiple implant sites</td>
<td>3.79 (± 0.78)</td>
<td>8.04 (± 0.91)</td>
<td>4.25 (± 0.62)</td>
</tr>
<tr>
<td>Overall</td>
<td>3.63 (± 0.82)</td>
<td>7.66 (± 1.15)</td>
<td>4.03 (± 0.67)</td>
</tr>
</tbody>
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resulting in a completely detached bone segment, which required subsequent screw fixation. The apical hinge cuts used in this report did not fully transect the buccal plate, which allowed for mobilization of the buccal segment without the need for fixation.

Fixation is one of the many variations that have been associated with ridge split procedures. Other studies have stressed the importance of stabilizing the mobilized buccal plate through the use of metallic ligatures,29 resorbable ligatures,30 screws,13 or titanium mesh to avoid its sequestration.21 Absolutely no attempt was made to stabilize or fixate the mobilized buccal plates in this report, and there were no complications during healing.

A second variation in ridge-splitting studies has related to managing the created four-wall defect. There is no consensus on whether to graft this surgically created defect, to use an exclusionary barrier, or to use a combination approach of graft and membrane. Resorbable membranes were used in all cases of this retrospective report, whereas other studies used titanium mesh,21 non-resorbable membranes,12 or nothing.13,19,31

Likewise, all surgically created ridge split defects in the current study were grafted with freeze-dried bone allograft, whereas other studies used particulated autograft,21 xenograft,22 alloplast,13 or nothing.12 A third variation in many ridge split studies has been the method by which cortical cuts were made. The technique documented in this report used piezoelectric surgery units to create corticotomies, whereas others used scalp blades,24 sharp chisels,12 flexible diamond disks,13 carbide burs,31 or microsaws.26 Studies comparing wound healing of piezoelectric bone cuts to those created with alternative methods have demonstrated reduced trauma and faster healing with the former and increased inflammation with the latter.32,33 Furthermore, a study comparing implant success rates in alveolar ridges split with piezoelectric surgical units to those where implants were placed into wide intact ridges found no difference in overall outcomes, although more failures did occur in the non-piezoelectric unsplit group.34

Although most other ridge split studies allowed 5 to 6 months of healing before initiating second-stage implant surgery,27-31,34-36 patients in this retrospective case series proceeded to implant placement after 3 to 4 months. Dental implants were usually placed in a single-staged fashion, eliminating the need for abutment placement at a later surgery. On average, dental implants were allowed to heal for 3 months before delivery of the final restoration. So, total treatment time and the number of interventions with the current case series were similar to prior studies where implants were placed at the time of ridge splitting. Because of the significant lateral mobilization of the buccal plates and lack of stabilization procedures, the authors believed a two-stage approach to implant delivery was most appropriate. Other studies confirm this, noting that nearly half of all implants placed in mandibular ridge split sites over a 10-year period required a two-stage approach.24 Additionally, Elian et al.37 noted that a two-stage approach for ridge splitting procedures allows for “reevaluation of the surgical site before implant placement and better control over implant position, angulation, and ultimately a more esthetic restoration.”

The horizontal gains documented in this retrospective case series report compare favorably to those where autogenous symphysis and ramus block grafts were used.38-40 Unlike autogenous block grafts, however, ridge splits are not commonly associated with secondary patient morbidity. Morbidities that have been reported at the symphyseal donor site have included neurosensory deficits, block fracture, excessive bleeding, potential damage to adjacent teeth, lip incompetence, and chin ptosis.1,17,41-43 Those associated with ramus graft harvest have included neurosensory deficits, block fracture, mandible fracture, excessive bleeding, and trismus.17,39,44 Additionally, block grafting requires the use of fixation screws, which adds extra time and expense to the procedure.

CONCLUSIONS

This retrospective observational report demonstrates that the PHARS procedure can achieve substantial gains in horizontal ridge width of the edentulous posterior mandible without associated morbidity. Both further prospective and larger observational studies are warranted to see if this is true over a larger patient population and to compare this technique to other more traditionally used approaches.
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REFERENCES


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