Alternative Bone Expansion Technique for Immediate Placement of Implants in the Edentulous Posterior Mandibular Ridge: A Clinical Report

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Purpose: *The aim of this study was to evaluate the effectiveness of a split-crest bone augmentation technique performed for immediate implant placement in thin edentulous posterior mandibular ridges.* ***Materials and Methods:*** *In the present study, 125 implants were placed in posterior mandibular ridges of 30 patients. The mandibular buccal walls were split, expanded, and grafted with a combination of platelet-rich plasma and Cerasorb. The split segments were held in place by cortical bone screws. Before loading, periodontal status was checked, implant stability was evaluated with the Periotest, and panoramic radiographs and computerized tomography scans were obtained. Second-stage surgery (cover screw removal and healing abutment placement) was performed after 3 to 4 months.* ***Results:*** *All implants osseointegrated successfully and underwent loading after 4 months. Optimal healing occurred 3 to 4 months earlier than the usual 6 to 9 months required, and no lip paresthesia was noted.* ***Discussion:*** *Although onlay-inlay grafts, sandwich osteotomies, guided bone regeneration, piezoelectricity, and alveolar distraction have been indicated for augmentation in the posterior mandibular region, each of these techniques involves risks and complications. The crest-splitting bone expansion technique enables single-stage immediate implant placement and lateral ridge augmentation in thin crests and may prevent neurosensorial deficiencies.* ***Conclusions:*** *The split-crest surgical technique is a valid reconstructive procedure for sharp posterior mandibular ridges. If performed using platelet-rich plasma and Cerasorb, it can shorten the osseointegration period.* INT J ORAL MAXILLOFAC IMPLANTS 2004;19:554–558

Key words: *β-tricalcium phosphate, platelet-rich plasma, split-crest technique*

Patients with long-standing edentulous arches may have narrow, knife-edged ridge crests with changing angulations that make endosseous implant placement difficult. These patients may benefit from augmentation procedures; however, it can be difficult to choose the most appropriate one. Alteration of normal anatomic properties causes intraoperative problems, faulty placement, and inadequate bone support on the lingual and buccal sides of an implant.

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Performing implantation surgery in the edentulous posterior mandibular area, where sharp, narrow ridge crests may be found, carries certain risks. Attachment of the mylohyoid muscles may disguise the concave depression below the mylohyoid line, so that lingual perforation can occur easily. The presence of the inferior alveolar neurovascular bundle also limits the length of the implant to be placed. The implant should terminate 2 mm above the superior aspect of the inferior alveolar canal to prevent paresthesia of the lower lip.

According to Atwood,[1] knife-edge crests may be managed by conventional bone grafting, guided bone augmentation procedures with the use of membranes, and various other techniques. The sharp ridges can also be expanded surgically using a split-crest technique to permit implant placement in these regions.

Although it may take a long time for osseointegration to occur in this region, surrounding the

Fig 1 The horizontal osteotomy was performed with a flexible diamond disk along the narrow ridge.

Fig 2 Finished preparation of the alveolar bony window; note the buccal depression narrowing the posterior ridge.

implants with a mixture of platelet-rich plasma (PRP) and β-tricalcium phosphate (β-TCP) allograft (Cerasorb; Curasan, Kleinostheim, Germany) can induce bone formation earlier. Autologous PRP, which can be derived from the patient's blood, may enhance bone formation because of its structural properties. It contains several growth factors and bone morphogenic proteins.[2]

In the present study, a split-crest technique was used: The mandibular buccal wall of the alveolus was split, expanded, and grafted with a combination of PRP and Cerasorb.[3]

MATERIALS AND METHODS

Thirty consecutive patients (21 women with a mean age of 48 years and 9 men with a mean age of 46 years) with thin, narrow posterior alveolar ridges were selected for ridge augmentation by a split-crest technique followed immediately by implant placement. The main inclusion criteria were sufficient depth of the inferior neurovascular bundle to allow implant placement, 3 to 4 mm of crestal width in the posterior alveolar ridge, and patterns of buccal cortex resorption (especially a concave buccal wall, the presence of which was determined by preoperative probing). All surgical work was performed at the Department of Oral and Maxillofacial Surgery, University of Marmara, Istanbul, Turkey.

Sixty tapered titanium plasma-sprayed Frialit implants (Friadent, Mannheim, Germany) and 65 Camlog implants (Altatec Biotechnologies, Wurmberg, Germany)—a total of 125 implants ranging from 4.3 to 5.5 mm in diameter and either 8, 11, or 13 mm in length—were used.

The PRP was prepared before the surgery. The PRP preparation set consisted of a Heraeus Labofuge 300 (SPX Corporation/Kendro Laboratory Products, Asheville, NC), a Vortex mixer (VWR International, West Chester, PA), a rack of monovettes (Sarstedt, Nümbrecht, Germany), a PRP kit, and materials to produce citrated blood.

Surgical Method

Before the surgical procedure was carried out, the patients were sedated using midazolam administered intravenously and 2 mL articain hydrochloride as a mandibular block anesthesia. A buccal incision was made along the edentulous posterior alveolar ridge. For optimal exposure, vertical releasing incisions were made on both sides, and the periosteum was dissected bluntly from both the lingual and buccal sides. Care was taken to avoid insulting the mental nerve during the vertical incision.

With a flexible diamond disk, the horizontal osteotomy line was cut along the narrow crest under copious saline irrigation (Fig 1).The horizontal cut was deepened approximately 2 to 3 mm in the crestal cortical bone. Then the inferior cortical osteotomy cut was outlined across the outer buccal cortex at a 3-mm depth. The horizontal superior and inferior cortical osteotomy margins were united with bony cuts made from mesial and distal parts of the osteotomized bony window (Fig 2). Fine osteotomes were used for complete mobilization of the split window (Figs 1 and 2).

After cleaving the outer cortex, implants were placed in the 3 to 4 mm of available spongious bone, which was enough for primary stabilization. The implants were placed under saline irrigation, and care was taken to avoid penetration of the sublingual plate. The split crestal bone was adjusted

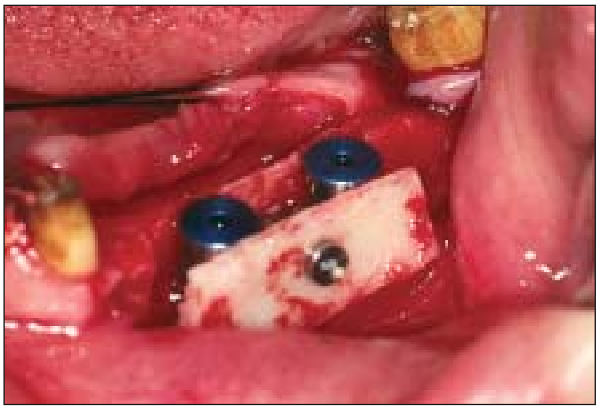

Fig 3a The crest was split, the implants were placed, and the resected bony window was set back lateral to the implants and stabilized by a cortical bone screw.

Fig 3b The intercortical space was filled with PRP and Cerasorb.

Fig 4 CT examination revealed ossification at the mesial margin of the osteotomy.

back to its previous position, on the lateral side of the implants, and the split crest was fixed with a cortical bone screw so that it extended bicortically amid the implants from the buccal cortex to the lingual plate (Fig 3a). In 22 patients, cortical bone screws were placed unilaterally; in the remaining 8 patients, cortical bone screws were screwed bilaterally. Each split area received 2 or 4 implants and a cortical bone screw.

The PRP prepared from autologous blood was added to a glass vessel containing Cerasorb. The mixture was allowed to rest for 10 minutes so that the fibrin gel could form. It was then used to coat implants and fill the residual space created after replacement of the split window (Fig 3b).

The flaps were sutured with resorbable 4/0 polyethylene sutures. All patients received antibiotics and nonsteroidal analgesics postoperatively. A soft diet and appropriate oral hygiene with 0.2% chlorhexidine mouthwash were prescribed for 2 weeks postoperatively.

After assessment of osseointegration, second-stage surgery was performed to remove the healing abutments and place the cover screws.

Evaluation and Data Collection

All patients were recalled for clinical and radiographic evaluations at 3 and 4 months. The clinical examination included assessment of implant mobility, both by manual percussion and with the Periotest (Periotest; Siemens, Bensheim, Germany), and assessment of lip and chin dysesthesia by soft stroking of the lower lip and chin with a cotton pellet and by pinching with tweezers.[4]

Second-stage surgery and implant loading were initiated if supported by the Periotest values, computerized tomography (CT) examinations, and osteotomy line ossification at the third and fourth months (Fig 4).

RESULTS

Postoperative results were assessed by panoramic and periapical radiographs and CT scans. None of the patients complained of lip paresthesia.[3] There was no meaningful difference in healing between the bilateral split crests. All implants osseointegrated, and second-stage surgery was performed after 3 to 4 months in all cases. Ossification of the osteotomy lines was evident and could be observed as sites with increasing radiopacity on CT scans taken approximately 4 months after first-stage surgery (Fig 4).

After the healing abutments were removed, implant mobility was assessed using the Periotest. The median Periotest value (PTV) was –4 (range –7 to +6). Five implants had a PTV of 2. The mean PTV for the Frialit implants was -3.4 ± 0.5; the mean PTV for the Camlog implants was -3.2 ± 0.7. The mean PTVs, radiographs, CT scans, and periodontal health were the critical parameters used to determine whether the implants could be loaded early (ie, at 3 or 4 months after implant placement instead of at 6 to 9 months postplacement, as is usually recommended for this region of the mandible).

One hundred twenty implants in 28 patients were loaded 4 months after placement (ie, following second-stage surgery and review of implant stability).[5] Implants were not loaded until osseointegration was complete. Five implants were not loaded until 6 months of healing were completed.

DISCUSSION

Conventional onlay/inlay grafts, interpositional sandwich osteotomies, guided bone regeneration with semipermeable membranes, piezoelectric stimulation, and alveolar distraction osteogenesis procedures can be used for alveolar ridge augmentation in the posterior mandibular region.[3,5–12] However, the split-crest bone expansion technique may be indicated for sharp mandibular and maxillary ridges in patients whose bone quantity is inadequate for primary stabilization. Slight separation of a maxillary ridge crest is performed as a hinge-like separation of the buccal cortex. It is difficult to achieve the same hinge-like separation in the posterior mandible because of the compact outer cortex and external oblique line.[13]

The posterior mandible is the most difficult region for reconstruction and early implant placement in cases of severe alveolar resorption in the maxillomandibular complex. Onlay grafting with biodegradable membranes and autografts is the most frequently used technique; however, this technique involves a long ossification period, and the tendency of the graft material to resorb can easily decrease bone quality and quantity.[8,9,14]

Moreover, primary stabilization of the implants is usually impossible to achieve simultaneous with grafting in severely atrophied posterior ridges. Thus implant placement is delayed until the second stage of surgery. Time lost and donor-side morbidity are the main disadvantages of this reconstructive approach. The split-crest technique should be delineated as a bone expansion procedure that potentially eliminates the overall disadvantages of onlay grafting in terms of esthetic and functional demands.

The split-crest technique used in this clinical investigation was more aggressive than that typically found in the literature.[15,16] The osteotomized bony window was separated completely and should be considered an autogenous cortical graft. The fine marginal cuts enabled the precise repositioning of the bone over the immediately placed implants. Primary stabilization of the implants was achieved using cortical bone screws and the remaining 3 to 4 mm of apical bone. The procedure's success depended on the bicortical placement of cortical bone screws and the tight adaptation of a split window, which ensured favorable pressure on the implants and thus stabilization of the graft material and implants.

Osseointegrated implants were assessed by the Periotest, routine radiographs obtained during the healing period, and CT scans. The ossification of the β-TCP particles was examined with CT scans. The integration of β-TCP particles with each other throughout the grafted region could only be demonstrated by a CT scan; patients who were able to afford a CT examination were requested to have one.

Simion and coworkers[17] treated narrow ridges with a split-crest technique combined with guided tissue regeneration. They recommended the technique as an alternative immediate reconstructive procedure for implant placement. They stated that the split-crest technique created a self–space-making structure that allowed bone regeneration from the surface where osteogenic cells are recruited.

Shimoyama and associates[18] used tapered implants with a split-crest technique in severely atrophic maxillae and covered them with barrier membranes. The authors recommended that augmentation method for use with immediate implant placement. However, they maintained that regenerative guiding membranes tend to defend the split-crest area from submucosal structures' penetration, inhibiting osteogenesis.

In a 5-year follow-up study, Scipioni and colleagues[19] reported expanding edentulous ridges without filling bone gaps. They emphasized the importance of periosteal and endosteal matrices in regenerative processes and described the intercortical bony gap as an extraction site that should be left at rest without any grafting. They placed root-form implants in consideration of the shape of the hinge-like expansion of the split crest, which was wider at the crest and narrower at the apical region.

The osteogenic properties of bone marrow and PRP encourage new bone formation between the intercortical spaces that were filled with resorbable β-TCP particles. Filling the interparticle gaps with PRP and shattered platelets diminishes fibroblast cell ingrowth. PRP stimulates bone formation via the acceleration of osteoid matrix synthesis by osteoblasts.

PRP, which includes high levels of peptide growth factors, accelerates bone regeneration and improves the quality of the regenerated bone.[2,6] In addition to growth factors, PRP possesses unique adhesive features that can hold biomaterials and bony segments together. The combination of PRP and β-TCP enhanced regenerative procedures at the healing area by increasing the rate of bone formation and thereby shortened the osseointegration period.[15,16]

Lin and associates[16] reported that human transforming growth factor-β1 (TGF-β1) adsorbed onto TCP-coated implants could improve mechanical fixation and bone ingrowth. TGF-β1 is an element of PRP. Lin and associates stated that TGF-β1 adsorbed onto TCP- and ceramic-coated implants accelerated repair activity in newly formed bone adjacent to the implants.

If a bone regeneration product had not been used, the osseointegration period would have been prolonged and implant loading delayed. Even though the bicortical matrices carry the biologic coding of bone formation, the application of PRP can shorten the osseointegration period. TCP supplies ions necessary for PRP activation and gel formation.

Optimum osseointegration can take 6 to 9 months when modified with various bone substitutes and healing promoters. The use of PRP may reduce that period to 3 to 6 months. Another advantage of this technique is the avoidance of invasive grafting procedures. Furthermore, alveolar crests are expanded from the same surgical site, obviating donor site morbidity.

CONCLUSION

Mandibular ridge expansion using a split-crest technique that included grafting the implant sites with a combination of PRP and Cerasorb was a viable therapeutic alternative for implant placement in this patient population. The split-crest technique should be considered a safe ridge expansion procedure in cases of crestal augmentation.

Routine protocols emphasize that implants in the posterior mandibular regions should not be loaded until 6 to 9 months after initial implant placement. In this investigation, most likely because PRP contributed to the rapid organization of cells and ossification, implants became capable of supporting functional loads between 3 and 6 months after implant placement, and bone regeneration and enhancement occurred at the peri-implant bone. However, the follow-up period for outcome evaluation in this series was limited.

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