Piezoelectric Vertical Bone Augmentation Using the Sandwich Technique in an Atrophic Mandible and Histomorphometric Analysis of Mineral Allografts: A Case Report Series

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The aim of this report is to investigate the efficacy of the sandwich technique for vertical bone augmentation in the atrophic posterior mandible of three patients through clinical and histologic studies. A complete osteotomy was conducted using a piezoelectric device to create segmented bone in the atrophic edentulous area and the segmented bone was elevated 6 mm vertically. Interpositional mineral allograft materials were inserted in the space between the basal bone and the segmented bone. After a mean 5-month healing period, bone biopsies were taken in the grafted areas and implants were placed. Six millimeters of vertical bone gain was achieved in all patients by using the sandwich technique. Histomorphometric analysis of the biopsy specimens showed favorable new bone formation without inflammation. (Int J Periodontics Restorative Dent 2010;30: 383–391.)

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The atrophic mandible is a challenging site to place dental implants. Many surgical methods, such as guided bone regeneration, alveolar distraction osteogenesis, pedicle or interposition alveolar bone graft, onlay block grafting, and iliac corticocancellous augmentation, have been used to overcome the bone deficiency seen at this site.[1–5] Among those procedures, the "sandwich" technique, along with interpositional bone grafting, is a vertical bone augmentation procedure that uses vertically elevated segmented bone created from basal bone and maintains the lingual periosteum that is attached to the mobile segment. The bone graft is placed in the space between the mobile segment and the basal bone. This procedure reduces morbidity of the donor site and is an easier procedure than the block bone graft procedure. Six millimeters or more of bone gain and minimal resorption of the transpositioned bone can be achieved with this procedure.[6] In addition, piezoelectric bone surgery can be used to perform a complete osteotomy to create the mobile segment. Piezoelectric bone surgery works only in hard tissues, not

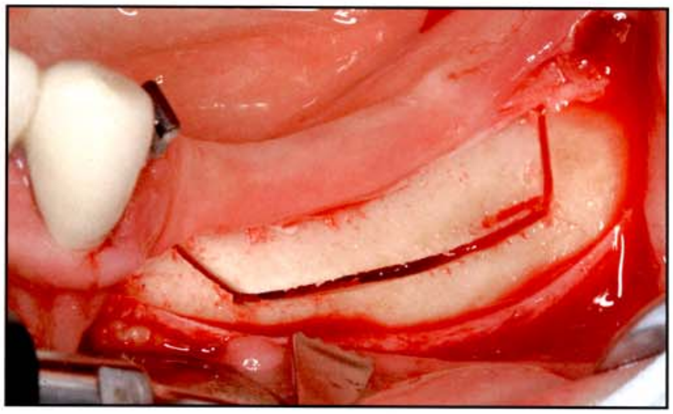


Fig 1a *Complete vertical and horizontal osteotomies were performed using a piezoelectric device.*

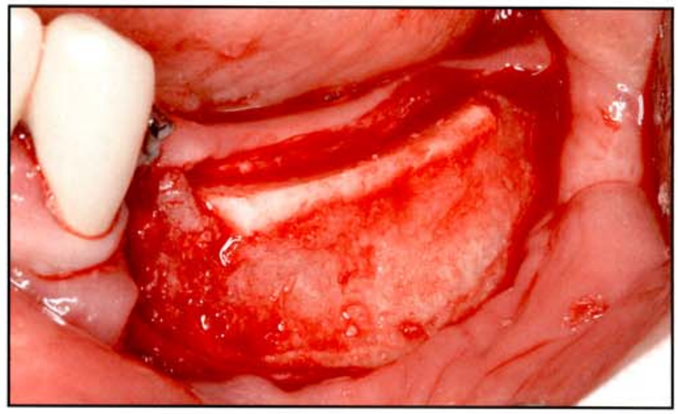


Fig 1b *Two allografts were grafted at the osteotomy site.*

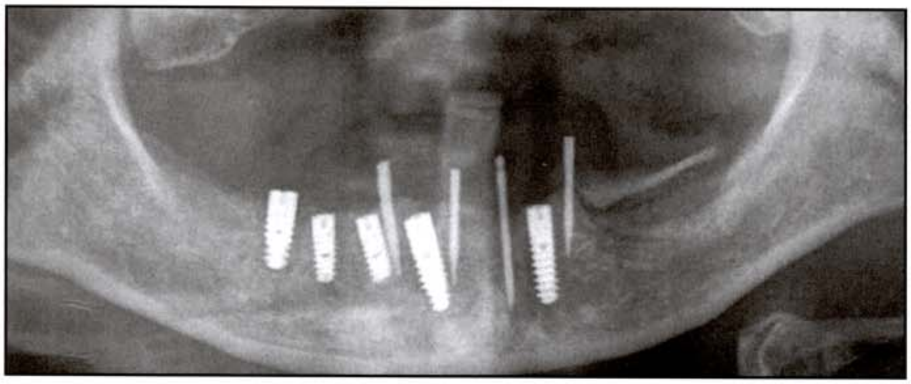


Fig 1c *Postoperative radiograph of patient 1.*

in the soft tissue. Piezoelectric bone surgery can maintain the lingual periosteum and preserve the flap.[7–12] Maintaining an intact lingual flap is very important to ensure maximum blood supply for survival of the mobile bone segment and new bone formation from the interpositional bone graft.

In this case series, three patients who underwent vertical bone augmentation using the sandwich technique with a piezoelectric device in the atrophic mandible were evaluated, and histomorphometric analysis of the grafted mineral allograft was carried out.

Method and materials

Patient 1

A 62-year-old woman visited the Department of Oral and Maxillofacial Surgery, Catholic University Medical Center of Daegu, for placement of implants in the edentulous left posterior mandible. The bone height at this site was about 7 to 8 mm above the inferior alveolar nerve. The sandwich technique was performed at this edentulous site for vertical bone augmentation on July 5, 2005.

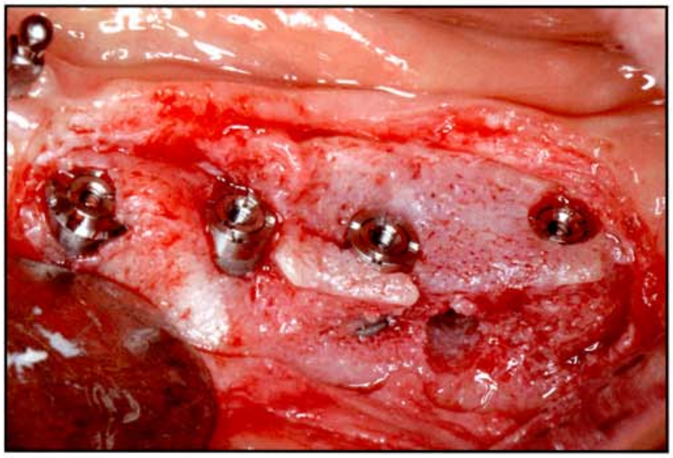
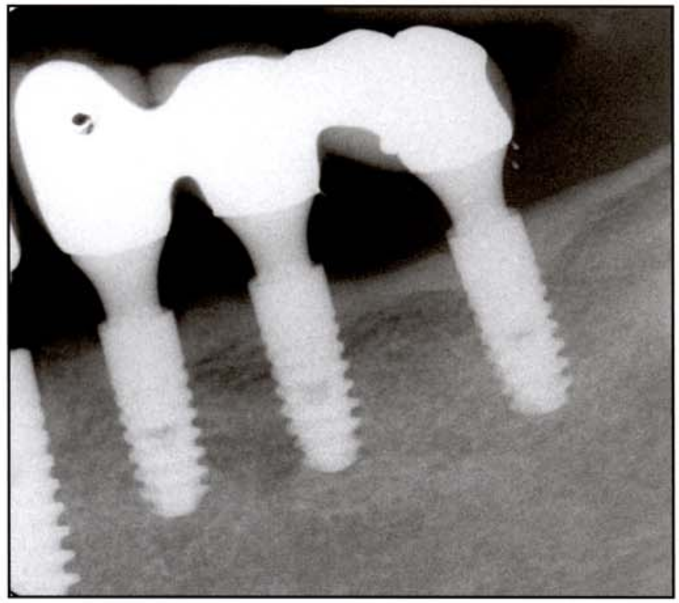


Fig 1d *Three implants were placed after a bone biopsy was performed at the grafted site.*

Fig 1e (right) *Radiographic outcome after 33 months in function. Note the stable marginal bone.*



A vestibular incision was performed in the mandibular left molar area. The buccal flap was reflected and the alveolar bone was exposed. Then, the mental foramen and nerve were verified. One horizontal osteotomy about 3 to 4 mm above the inferior alveolar nerve and two divergent vertical osteotomies to the lingual cortex were performed using the piezoelectric device (Surgybone, Silfradent) (Fig 1a). After finishing all complete osteotomies, the resulting segmented bone was elevated up to 6 mm using a chisel.

Two allografts (OrthoBlast II, IsoTis Orthobiologics; Tutoplast cancellous microchips, Tutogen Medical) were grafted in the space between the basal bone and the segmented bone, and a reabsorbable collagen membrane (Tutogen Pericardium, Tutogen Medical) was placed over the grafted site (Fig 1b). Five implants (Ankylos, Friadent) were placed from the left canine to the right first molar area of the mandible. The exposed implant surface was covered by the same allograft and the same barrier membrane. Four mini-implants (IMTEC) were placed for immediate function (Fig 1c).

The augmented site was exposed to perform a biopsy and to place three implants (Ankylos) after a 4-month healing period (Fig 1d). After 5 months, the definitive restoration was cemented. The crestal bone remained stable and the implant-supported prosthesis functioned well for over 33 months of follow-up (Fig 1e).

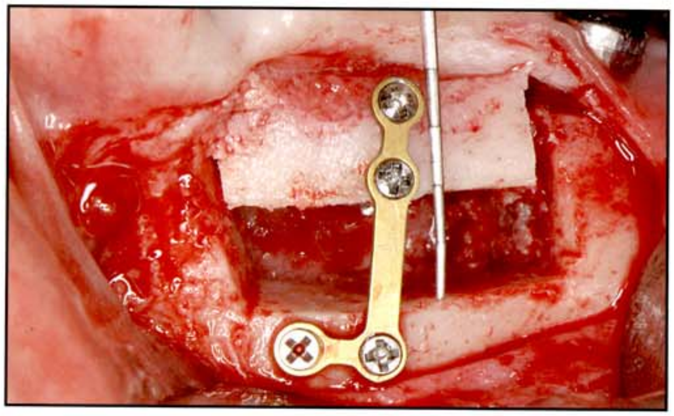


Fig 2a *The segmented bone was elevated up to about 6 mm and fixed with an L-shaped microplate and miniscrews.*

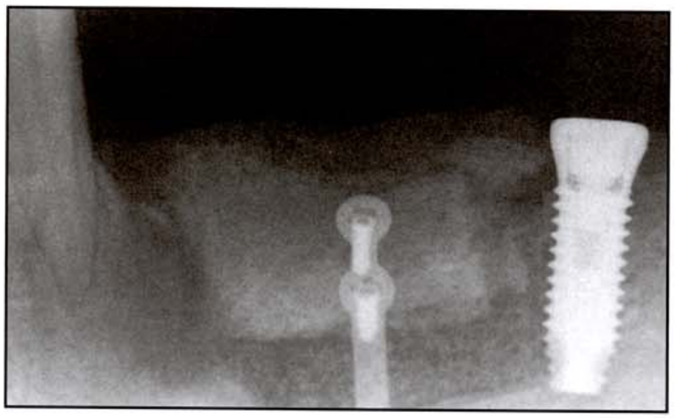


Fig 2b *Postoperative radiographic findings for patient 2.*

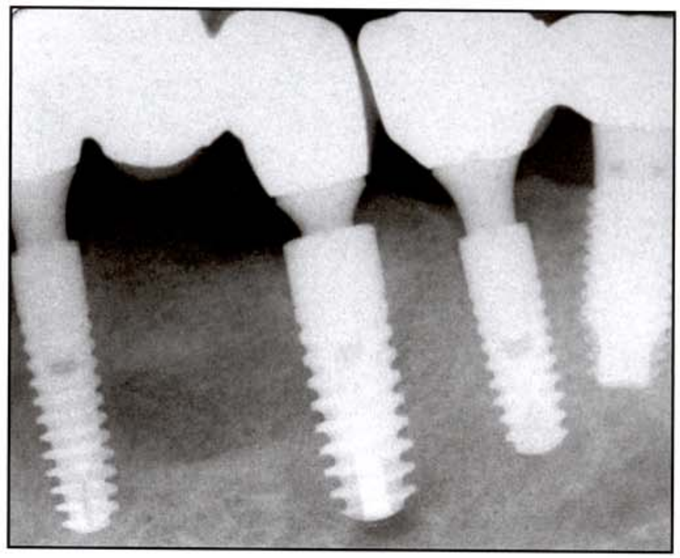


Fig 2c (right) *Radiographic outcome at 40 months in function. Note the stable marginal bone.*

Patient 2

A 56-year-old man was referred to the department from a private practice. Vertical bone resoprtion was found resulting from failed guided bone regeneration and the removal of two implants in the left edentulous premolar area of the mandible. Before implant placement, vertical augmentation was performed using the sandwich technique on September 30, 2005.

The surgical procedure used for the osteotomy was the same as that of patient 1. However, the lifted bone segment was fixed with an L-shaped microplate and miniscrews (Jeil) (Fig 2a). An allograft (Orthoblast II) was grafted into the space between the basal bone and the segmented bone, and a resorbable barrier membrane (Tutogen Pericardium) was placed over the graft site. Vertical augmentation of 6 mm was achieved (Fig 2b).

After a 4-month healing period, a bone biopsy of the grafted area was obtained and the fixation plate was removed. Three implants (two 14-mm-long and one 11-mm-long, Ankylos) were placed. After 5 months of healing, the definitive prosthesis was cemented. Bone height remained stable throughout radiographic follow-up and the prosthesis functioned well for 40 months of follow-up (Fig 2c).

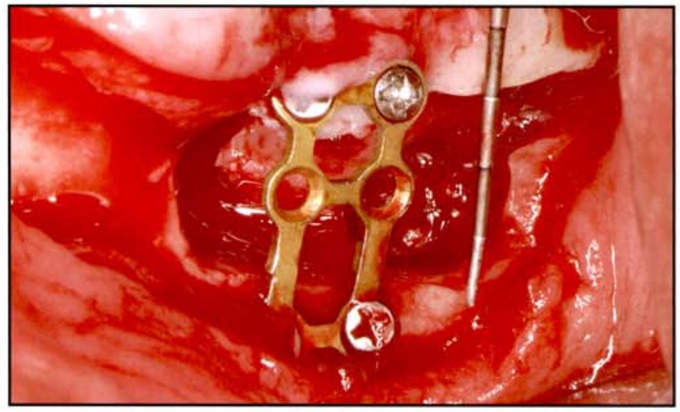


Fig 3a *Segmented bone was elevated up to about 6 mm and fixed with a matrix-type microplate.*

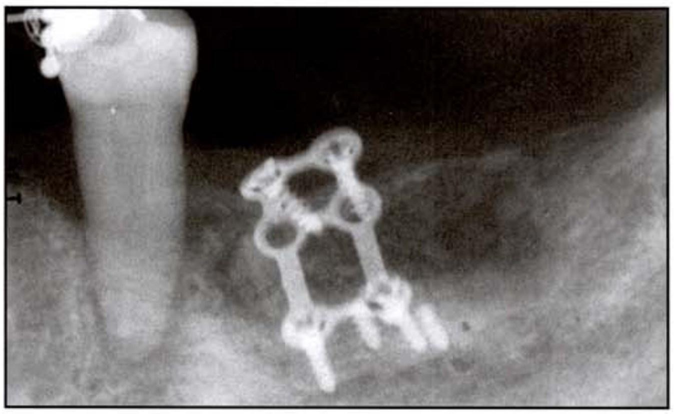


Fig 3b *Postoperative radiographic findings for patient 3.*

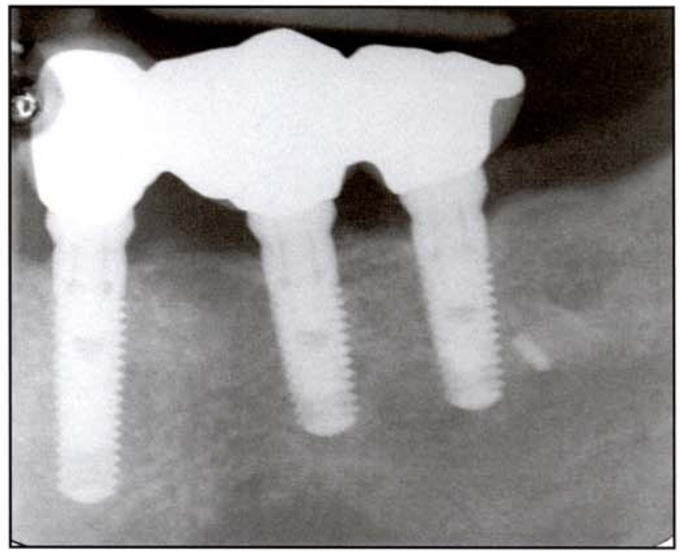
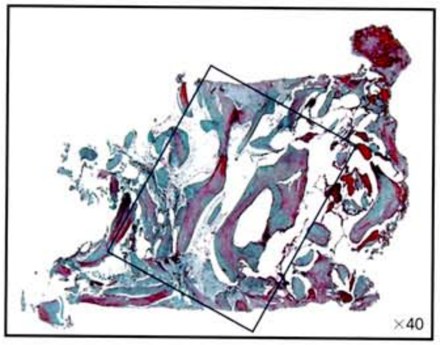


Fig 3c (right) *Radiographic outcome at 19 months in function. Note the stable marginal bone.*

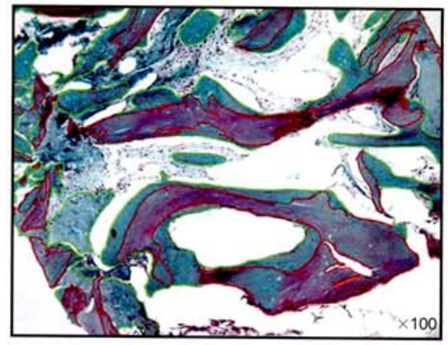
Patient 3

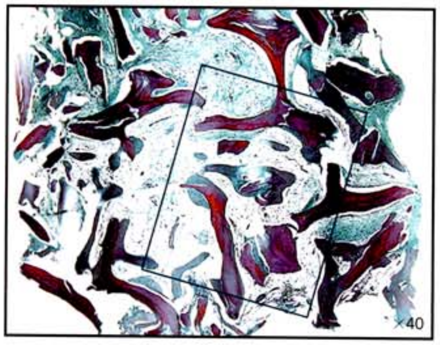
A 48-year-old man visited the department for an implant-supported prosthesis in both the maxilla and mandible because of edentulism. He had no special medical history. The patient had a moderate vertical bone deficiency in the edentulous left mandible. Sandwich augmentation was performed on May 8, 2006.

The surgical osteotomy procedure was the same as that used for patients 1 and 2. The segmented bone was elevated up to 6 mm and fixed with a matrix-shaped microplate and miniscrews (Jeil) (Figs 3a and 3b). An allograft (Orthoblast II) was inserted into the space between the basal bone and the segmental bone, and a resorbable barrier membrane (Tutogen Pericardium) was used to cover the area. After a 6-month healing period, the microplate was removed and a bone biopsy was obtained from the bone-grafted area. Two 10-mm-long implants (TSV, Zimmer) were placed in the augmented site. Bovine bone (OCS-B, NIBEC) mixed with fibrin adhesive (Green Plaster, Green Cross) was grafted to reinforce the augmented ridge next to the implants. After 5 months of healing, the definitive prosthesis was cemented. The crestal bone remained stable and the implant-supported prosthesis functioned well during the 19 months of follow-up (Fig 3c).

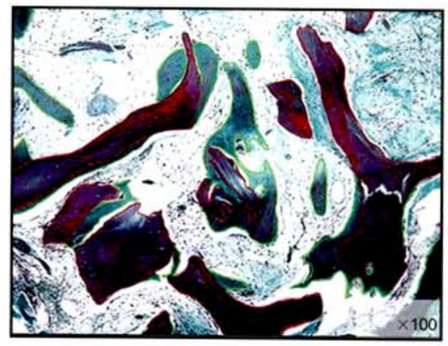


Figs 4a and 4b *Histologic findings of patient 1 showing 13% of new bone, 21.1% of graft bone, and 66.0% of fibrovascular marrow. Green = vital new bone, red = grafted dead bone, white = fibrovascular marrow (modified Goldner trichrome).*





Figs 5a and 5b *Histologic findings of patient 2 showing 12.6% of new bone, 24.8% of graft bone, and 62.6% of fibrovascular marrow. Green = vital new bone, red = grafted bone, white = fibrovascular marrow (modified Goldner trichrome).*



Histologic preparation and histomorphometric analysis

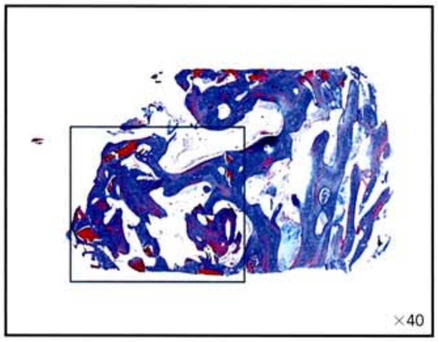
Biopsy specimens were fixed immediately in 4% formaldehyde for 24 hours at 4°C and decalcified in 10% formic acid for 3 days. After dehydration in an ascending series of alcohols, the biopsies were embedded in paraffin and 5-μm-thick sections parallel to the longitudinal axis of the biopsy specimen were prepared using a microtome. Sections were stained with Mayer hematoxylin and eosin or Goldner trichrome for light microscopy.

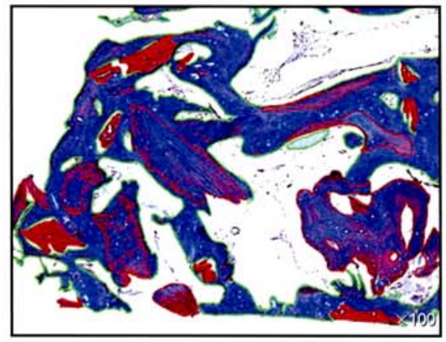
Measurements on the histologic sections were performed using a computerized technique; photomicrographs were taken using an Olympus BH_2 microscope equipped with an Olympus DP50 digital camera. Measurement fields were selected by visual monitoring of the microscopic image on a screen. After digitization of the picture, image processing with an image analysis system (iMT image analysis software, iMTechnology) was performed. The following histomorphometric data were collected: the total bone volume was calculated as the amount of mineralized bone tissue as a percentage of the total tissue volume according to Parfitt et al,[13] the mineralized bone tissue that contained areas of empty osteocyte lacunae was defined as the nonvital grafted bone and its volume was expressed as a percentage of the total tissue volume, and the fibrovascular marrow tissue volume was presented as the percentage of soft tissue volume versus total tissue volume.

Results

The alveolar bone height was increased up to about 6 mm before implant placement. Patients using fixation with the microplate and miniscrews showed less resorption of bone height than the nonfixed patient. Approximately 1 mm of bone resorption occurred in patient 1, but 0.2 mm occurred in patients 2 and 3 at the final follow-up (over 1 year after piezoelectric sandwich bone augmentation) (Figs 1e, 2c, and 3c). No complications such as neurosensory disturbance were demonstrated.

In all patients, new bone was regenerated favorably without any inflammatory or foreign-body reactions using the piezoelectric sandwich augmentation technique. The percentage of total bone volume was 34.1%, 37.4%, and 59.5%, while the percentage of fibrovascular marrow tissue was 65.9%, 62.6%, and 40.5% in patients 1, 2, and 3, respectively. The percentage of vital new bone was 13.0% (patient 1), 12.6% (patient 2), and 36.4% (patient 3) of total bone tissue (Figs 4 to 6).





Figs 6a and 6b *Histologic findings of patient 3 showing 36.4% of new bone, 23.1% of graft bone, and 40.5% of fibrovascular marrow. Blue = newly formed bone matrix, red = grafted dead bone, white = fibrovascular marrow (trichrome staining).*

Discussion

Since the late 1970s when Härle first reported the use of a visor osteotomy to augment the atrophic mandible, many clinicians have modified and developed pedicled or interpositional grafts.[14–20] These methods have been used to increase the retention of prostheses in the past, but recently, alveolar augmentation has been used for the placement of implants.

It is necessary that clinicians try to obtain adequate bone height above the inferior alveolar nerve for placing implants without nerve damage and to obtain successful osseointegration. Politi and Robiony[20] found that the alveolar basal bone sandwich osteotomy has the advantage of guaranteeing a greater vascular supply to the inlay graft than to an onlay graft, which is less subject to resorption. Jensen et al[21] observed that distraction osteogenesis can produce the same result, but what is being advocated here is to perform the sandwich osteotomy when the magnitude of correction is small, in the order of 3 to 6 mm of vertical movement. Egbert et al[22] reported that the inferior alveolar nerve is located lingually in many atrophic mandibles, and therefore insufficient space is available to make a sandwich osteotomy lingual to the foramen without damaging the nerve. But Jensen[3] claimed that all patients had some transient postsurgical paresthesia, the longest lasting 6 weeks, and that the paresthesia was likely related to flap retraction of the mental nerve.

In the three patients reported here, the piezoelectric device was used for precise control of the osteotomy to reduce trauma to the nerve and soft tissue during the procedure.[7–12,23] No neurosensory disturbance was found in any patient. The lingual periosteum and flap should be maintained for maximum blood supply to the segmented bone. Piezoelectric bone surgery has benefits for the sandwich augmentation procedure. The lingual periosteum and flap can be maintained because this type of procedure does not work in soft tissue or the neurovascular bundle.

Extensive new bone formation of allografts in bone defects has been reported by many researchers.[24–28] The mineral allograft materials, which were inserted between the basal and segmented bone in these patients, showed favorable new bone formation over a short healing period. In all patients, the histologic analysis of the allograft at the light microscopic level showed calcified new bone having an organized matrix surrounded by an immature bone matrix or osteoid. Elevated bone segments showed favorable bone regeneration whether it was fixed or not; the segmented bone showed less bone resorption in the fixation cases than in the nonfixation case.

Conclusion

The piezoelectric sandwich bone augmentation technique is considered to be an easier procedure for both clinicians and patients than autogenous block bone grafts because a donor site is not required and it can be applied for the vertical augmentation of a moderate bone defect before implant placement.

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