Vertical splitting of the mandibular body as an alternative to inferior alveolar nerve lateralization


Abstract. The aim of this study was to present and evaluate a modified technique to inferior alveolar nerve lateralization (IANL) that allows the placement of longer implants in the posterior mandibular region. One hundred and forty-three consecutive patients were enrolled in this study; these patients had between 1.8 and 8 mm residual crestal height above the mandibular canal. Vertical splitting of the mandibular body was performed using piezoelectric surgery followed by bone expansion and insertion of special conical implants of 10 and/or 12 mm in length. Two hundred and sixty-nine osteotomies were performed and 636 implants were inserted, with a survival rate of 99% at the end of 12 months. Immediately postoperative there was an alteration of sensation in the lip/chin area in 8.5% of cases; 4.1% regained full sensation within 10–14 days, 2.6% after 8 weeks, and 0.7% had persistent paresthesia that did not affect their daily activities. Progressively increasing pain and numbness was present in 1.1%; the implants were removed 6 months postoperatively. This is a relatively simple procedure that has no limitations in clinical situations with minimal bone height. It allows for greater implant stability, and the risk of neurological disturbance is minimal.

Key words: inferior alveolar nerve lateralization; ridge-splitting; threaded bone expanders; piezosurgery; dental implants; posterior mandible.

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height in the posterior region of the mandible. However, a minimum height of approximately 8 mm of remaining bone above the mandibular canal is required.9,10

The alternative treatment that has been suggested and researched is the lateralization of the IAN (IANL), which allows placement of longer implants, gives better initial stabilization, and reduces the treatment time.11–13 However, nerve repositioning is a complex procedure, with a high risk of complications. This has caused some clinicians to express concern about the routine use of these procedures.

The major clinical difficulties associated with IANL are temporary or permanent dysfunction of the nerve and mandibular fractures associated with the placement of endosseous implants following IANL.16,17

The ridge-splitting/expansion technique is aimed at the creation of a new implant bed by longitudinal osteotomy of the alveolar bone. The buccal cortex is repositioned laterally by green stick fracture. This technique is usually performed simultaneously with implant placement and significantly shortens the treatment time.18,19

The aim of this study was to present and evaluate vertical ridge-splitting as an alternative technique to IANL for the rehabilitation of severely atrophic posterior mandibles.

Materials and methods
This study was designed prospectively and was started in 1998. One hundred and forty-three consecutive patients (97 females and 46 males) aged between 45 and 70 years (mean 53 years) were included in this study. The patients received a total of 636 implants in the posterior region and were recruited between June 1998 and September 2011. Any patient with unilateral or bilateral partial or total mandibular edentulism, with a residual bone height over the mandibular canal of between 1.8 mm and 8 mm (mean height 4.17 mm) was included in this study. Patients with immunologic diseases, uncontrolled diabetes mellitus, osteoporosis, or other contraindicating systemic conditions were excluded from participation. The position of the IAN and the mental foramen were assessed radiographically using orthopantomograms and computerized tomography (CT) scans, and the distance between the IAN and the crest of the alveolar ridge was measured at relevant points in order to perform the osteotomies (Figs. 1 and 2). All patients were informed about the risks and benefits of the procedure and they provided written informed consent for the treatment.

All patients received an injection containing 1 vial of methylprednisolone sodium succinate (Solu-Moderin® 125 mg; Pfizer, Spain) and 1 vial of lincomycin HCl (Lincocin® 600 mg; Pfizer, Spain) 1 h preoperatively, and they were asked to rinse with 0.2% chlorhexidine gluconate antiseptic solution immediately prior to surgery. All patients were operated on under local anaesthesia: articaine HCl 4% and

Fig. 1. A patient with a severely resorbed bilateral edentulous posterior mandible.

Fig. 2. (a) Preoperative orthopantomogram showing bilateral severely resorbed posterior ridge and the position of the mental foramen and IAN. (b) Preoperative sagittal CT scan showing the exact position of the IAN.
epinephrine 1:100,000 (Septocaine\textsuperscript{10}, Septodont, France). The anaesthetic technique used was infiltration anaesthesia at the alveolar crest, the lingual nerve, and the buccal nerve. A midcrestal incision, centred in the keratinized tissue, was designed through the edentulous span and retromolar pad to allow a minimum of 1–2 mm keratinized gingiva on both sides of the flap. In most cases, this was slightly shifted to the lingual side. A full-thickness mucoperiosteal lingual flap was reflected with extreme caution to prevent tears in the periosteum. The buccal aspect of the alveolar ridge was then exposed via subperiosteal dissection to visualize the mental neurovascular bundle.

In the mental foramen zone, the osteotomy was performed lingual to the crest of the alveolar ridge, using the osteotomy inserts of NSK VarioSurg\textsuperscript{11}, increasing the depth slowly and gradually until the inferior mandibular cortex was reached. Threaded bone expanders (Microdent System, Barcelona, Spain) were then used sequentially up to expander number 3. This served to displace the buccal wall (containing the neurovascular bundle) buccally, without injuring the nerve, and to prepare the implant bed. Special conical implants of 3.8 mm or 4.2 mm diameter and 10 mm or 12 mm length (MV implants, Microdent System) were then threaded in place. These implants are specially fabricated to be used with threaded bone expanders. The tapered design of these implants with a 2 mm diameter towards the apex allows bone displacement without injuring the nerve.

A modification of the procedure was performed in the second and third molar zone. The osteotomy was done buccally in the area corresponding to the distal root of the second molar and the roots of the third molar, until the inferior cortex was reached. This was followed by the use of the expanders to displace the buccal cortex away from the lingual wall containing the neurovascular bundle. This allowed the placement of another one or two implants without injuring the nerve. Conical implants of 3.8 mm or 4.2 mm diameter and a length of 10 mm or 12 mm (MV implants) were then threaded in place engaging the inferior cortex, aiming towards a tricortical anchorage (buccal, lingual, and inferior) to achieve primary stability (Fig. 3).

The mucoperiosteal flap was then closed using polypropylene monofilament sutures. An orthopantomogram was carried out immediately after surgery to check the direction and position of the implants. Provisional restorations were delivered at the same visit in most cases.

The postsurgical therapy protocol consisted of injecting the patient with the methylprednisolone sodium succinate 125 mg and lincomycin 600 mg mixture for two days after surgery, together with ibuprofen 600 mg twice daily for 3 days. A soft diet and appropriate oral hygiene were prescribed for 2 weeks, including rinsing with 0.2% chlorhexidine gluconate twice daily. The sutures were removed 10 days after the operation, and definitive restorations were delivered to the patients 3–6 months postoperatively (Fig. 4).

The postoperative control period was standardized for all patients; they were followed up weekly during the first month following surgery, and monthly thereafter for a period of 6 months, and then attended for a regular annual follow-up (up to 13 years for some patients). Neurosensory alterations of the lower lip and/or chin and radiographic controls were periodically monitored. Impaired sensitivity in an affected area was recorded as hypoesthesia, and a complete loss of sensation as anaesthesia or dysesthesia, while itching, tingling, or a prickly sensation was recorded as paresthesia. In addition, patients underwent objective assessment of the outcome in the form of a static light touch test with cotton-tipped applicator. A pin prick sensation test was also performed using a sharp and blunt dental probe for the lip and chin area, with the patient’s eyes closed.

![Fig. 3. (a) Osteotomy using piezosurgery on the left side. (b) and (c) Sequential use of threaded bone expanders in the premolar and molar regions. (d) Intraoperative orthopantomogram showing the position of the implants on the right side and expanders on the left. (e) Intraoperative orthopantomogram showing the position of the implants and the expander at the third osteotomy site. (f) Postoperative orthopantomogram. (g) Coronal CT showing the position of the implants in relation to the IAN.](image-url)
Results

One hundred and forty-three patients were enrolled in this study and underwent 269 osteotomies between June 1998 and September 2011. Among them, 126 patients underwent bilateral surgeries and 17 unilateral surgeries. A total of 636 implants were inserted in these patients: 371 implants in the molar region and 265 implants in the premolar region. The implants were all conical of 3.8 mm diameter (221 implants of 10 mm length and 22 implants of 12 mm length) or 4.2 mm diameter (168 implants of 10 mm length and 225 implants of 12 mm length).

In one osteotomy, the buccal cortical bone was fractured while screwing the implant, and this was treated immediately by creating perforations in the cortical bone for mechanical retention of the corticocancellous bone block, which was then covered by a collagen membrane (Osteobiol TecnoS3 Dental, Italy) (Fig. 5). Healing was uneventful and the implants were stable 12 months postoperatively.

Recovery of the surgical site was uneventful in all but seven osteotomies (2.6%), in which wound dehiscence developed at the surgical site 9–14 days postoperatively. All cases were treated by local debridement and irrigation using warm saline and chlorhexidine 0.2% daily until complete healing was achieved.

Regarding the neurosensory assessment, impaired sensation in the lip and/or chin region in the form of hypoesthesia or paresthesia was reported in 23 IAN osteotomies (8.5%) postoperatively; of those, 4.1% had recovered full sensation within 10–14 days, while 2.6% reported paresthesia in the lower lip, which disappeared 6–8 weeks following intramuscular injections of vitamin B complex every other day for a month. Persistent hypoesthesia at the end of the follow-up period was reported by 0.7%, although the altered sensation was neither annoying nor interfered with daily activities. Upon objective testing of these patients, the only complaint was not being able to differentiate between sharp and blunt objects. A progressively increasing numbness and tingling sensation in the lip and chin region occurred in 1.1% at 6 months postoperatively due to encroachment of the implants on the mental nerve; these implants were removed.

Eight implants were removed (1.3%) at 2–4 months after insertion. Three implants were mobile due to the absence of primary stability at the time of implant insertion and were replaced with 5 mm diameter conical implants, which were successfully osseointegrated. Three implants were removed due to persistent annoying feelings of pain and paresthesia that had not subsided at 6 months after surgery. Two implants were found to be mobile at the time of uncovering the implants and were removed without affecting the stability of the final prosthesis.

Discussion

The posterior mandible presents a challenge to clinicians because of the presence of the inferior alveolar nerve (IAN). Laterization of the IAN has routinely been practiced in clinical dentistry prior to implant placement. However, conflicting data in the literature from studies on the incidence of IAN dysesthesia in conjunction with this procedure has led to debate as to its appropriate use.16,17 Therefore, this study was designed to overcome the difficulties and limitations associated with the prosthetic rehabilitation of severely resorbed posterior mandibles.

When first seeking guidance as regards the amount of bone needed above the mandibular canal when performing IANL, 3–5 mm is suggested by Jensen et al.,14 who were the first to introduce guidelines regarding bone height in such procedures. Likewise, Kan and co-workers15 recommend a minimum of 5 mm of bone to be present above the mandibular canal to perform IANL. In our research, we introduced extreme cases of resorbed alveolar bone and the results are similar to those of cases with adequate bone height above the mandibular canal.

Infiltration anaesthesia proved to be effective throughout the whole procedure, enabling the patient to sense the danger of coming close to the IAN. The effectiveness of infiltration anaesthesia in implant surgery has been verified by Eitzig et al.,18 who placed 52 implants in 29 patients in the posterior mandible using mandibular supraperiosteal infiltration anaesthesia and had a success rate of more than 90%. They concluded that this anaesthetic technique is a safe and effective method for posterior mandibular implant surgery. Also, Heller and Shankland19 state that supraperiosteal infiltration permits the patient to warn the surgeon if the surgical procedure is endangering the IAN, thus preserving its integrity.

The occurrence of mandibular fracture following IAN transposition and implant placement in the posterior region of an atrophic mandible has been reported in the literature, emphasizing the need to make small osteotomies and to preserve the bone in order to avoid weakening the mandible.16,17 Therefore, the osteotomies in our study were performed using piezoelectric surgery, as recent studies have presented piezoelectric surgery as a technique that allows precise bone cutting and the preservation of soft tissues, including nerves. The tip of the instrument vibrates at different ultrasonic frequencies, providing a selective cut. The technique has been shown to be feasible in IANL since it favours smaller osteotomies and the preservation of the neurovascular bundle.23–25 Furthermore, many authors have demonstrated, both clinically and experimentally, that no dental nerve injury takes place even though direct contact of the working tip with the alveolar nerve is assumed.28–31

This has also been affirmed by Sohn et al.,32 who have applied the piezoelectric technique in various oral surgical situations. They concluded that this system achieves deep micrometric bone cuts resulting in precise and easy-to-control osteotomies, in contrast to rotary burs or reciprocation saws. Moreover, they have stated that the piezoelectric system can split a very narrow ridge with minimal loss or perforation of bone. In addition, this device reduces patient fear and stress during surgery performed under local anaesthesia, because it makes much less noise and vibration than conventional rotary instruments.

Furthermore, Holtzclaw and co-workers33 have demonstrated that treating
posterior mandibular horizontal alveolar ridge deficiencies using the piezoelectric hinge-assisted ridge split procedure can achieve significant gains in horizontal ridge width. No neurosensory complications were observed and all dental implants were successful.

The osteotomies reached the inferior mandibular cortex to allow for longer implants to be placed. This was followed by mobilization of the bone segment containing the IAN using threaded bone expanders. This served to prepare the site to receive implants without the need for drilling and at the same time allowed expansion of narrow ridges to adapt to implants with 4.2 mm and 5.10 mm platforms.

Threaded bone expanders, when they were first introduced by the author in 1997 to the Spanish Society of Implants (SEI), were initially used for expansion of narrow ridges with great success due to their atraumatic nature. In addition, the manual technique takes advantage of the natural elasticity of the bone, thus allowing expansion of the ridge and at the same time condensation of trabecular bone and increasing bone density while preparing the implant bed.

Fig. 5. (a) Fractured cortical bone. (b) Perforating the buccal cortex for mechanical retention. (c) Fragmented corticocancellous bone graft. (d) Collagen membrane stabilized by implant cover screws. (e) Repositioned mucoperiosteal flap.
According to Chiapasco et al., after studying 392 patients treated with bone splitting/expansion of narrow edentulous ridges and immediate placement of implants, the survival and success rates of implants placed in the expanded ridges are consistent with those related to implants placed in native, non-reconstructed bone and they seem to withstand the biomechanical demands of loading.

On the other hand, Sohn et al. performed a lateral ridge expansion technique in 32 patients with narrow edentulous posterior mandibular ridges. The piezoelectric saw or Er:YAG laser was used for osteotomies and the chisel and mallet were used to expand the buccal segment. Of the 23 patients who underwent the immediate lateral expansion technique, fracture of the thin buccal cortical plate occurred during ridge-splitting in five patients. This was the rationale for using the threaded bone expanders in this study. The key to proper expansion is a slow gradual technique with controlled application of force that leads to gradual expansion and minimal site trauma.

This technique also allows implants to pass alongside and not into the nerve canal, thus preserving the integrity of the nerve. Moreover, the implants engage the inferior mandibular cortex to achieve a tricortical anchorage and thus better primary stability. Whenever possible, three implants were placed rather than two for greater stability. This is recommended by Farzad et al., who evaluated implant stability in 34 patients treated with implant supported bridges in the posterior mandible and concluded that whenever possible the surgeon should aim at placing three rather than two implants in the posterior mandibular region. Furthermore, they stated that achieving primary stability at the time of surgery is important and may motivate the use of a long implant to achieve cortical anchorage for obtaining primary stability. This was also confirmed by Morrison et al., who carried out a retrospective evaluation of 20 patients who had undergone IANL transposition. They concluded that one of its advantages is the ability to place longer fixtures and to engage the inferior cortex for greater initial stability, as well as the use of a greater number of implants, which improves the overall strength of the final prosthesis.

The postoperative neurosensory complications rate using this technique is considerably lower than reported in other studies following IANL prior to implant placement, in which it generally occurs in 35–40% of patients, although such complications are temporary in the majority of cases.

Neurosensorial disturbance following IANL was researched histologically by Yoshimoto et al., who observed that bone modelling between the IAN bundle and implant surface takes place as early as 14 days postoperatively at high bone mineral apposition rates and that healing occurs first around the implant surface followed by later bone apposition closer to the IAN. The remodelling observed at regions in proximity to the IAN led to the formation of a new mandibular canal wall, which further supports the decrease in nerve sensitivity after a few weeks.

As for the implant success rate, we had a 99% success rate relying on the data gathered from periodic orthopantomograms at follow-up appointments and patient self-evaluation. In this study we did not have any criteria to measure implant stability, as the research was undertaken to introduce an alternative technique for managing complicated edentulous posterior mandibles, and the follow-up criteria were mainly related to the evaluation of neurosensorial alterations.

In conclusion, the present study shows that ridge-splitting of the body of the mandible followed by lateral expansion of the cortical plate of bone using threaded bone expanders is less traumatic than the conventional IANL technique and has no limitations in clinical situations with minimal bone height above the IAN canal. It allows for greater implant stability in atrophic posterior mandibles by installing wider, longer, and greater numbers of implants. Also, the risk of permanent neurological dysfunction is minimal.

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Competing interests

None declared.

Ethical approval

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References


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