

Superiorization of the Inferior Alveolar Nerve and Roofing for Extreme Atrophic Posterior Mandibular Ridges with Dental Implants

Fares Kablan

Department of Oral and Maxillofacial, Galilee Medical Center, Naharyia, Israel

Abstract

Introduction: Posterior mandibular ridges with extreme atrophy are usually combined with superficial location of the mental nerve and inferior alveolar nerves (IAN) and with a short residual mandibular ridge. As a result, dental implants cannot be placed in conjunction with IAN transposition alone. The aim of this paper is to introduce a new treatment approach to treat those patients. **Patients and Methods:** Eleven patients with 18 extreme atrophic posterior mandibular ridges characterized by superficial location of the IAN and short residual ridge had been treated during a 4-year period. The treatment approach included superior transposition of the IAN (IAN superiorization), 18 onlay bone block grafts harvested from the calvarial bone, implants placement through the block, and repositioning of the nerve under the onlay graft (IAN roofing). Patients were examined every 2–3 weeks; they received panoramic radiograph immediately after the surgery, at 4 months, at 6 months, and then once a year. Fixed prosthesis was performed after 4–5 months. **Results:** The donor sites of the bone blocks healed very well. The increase of bone height ranged between 4 and 6 mm at the recipient sites, and 63 long implants were placed (10–13 mm). All the patients were hospitalized 1–3 days. The healing process was uneventful, and the nerve recovery lasted a maximal period of 6 months. The implant success and survival rates were 100%. All patients received fixed prosthesis. The functional outcomes were satisfactory with marked improvement in the quality of life of the patients. The follow-up period was 12–58 months. **Conclusions:** Superiorization of the IAN and roofing is a fast and predictable option to treat extremely atrophic posterior mandibular ridges with fixed prosthesis supported by dental implants.

Keywords: Anodontia, atrophic mandible, calvarial bone, dental implant, nerve lateralization, nerve transposition, onlay graft

INTRODUCTION

Teeth loss is one of the most common causes of reduced quality of life in adults, and edentulism can be debilitating handicap.^[1] Dental implants have become a widely accepted treatment option for both partially and completely edentulous patients.^[2] Rehabilitation of edentulous posterior mandibular regions with severe ridge atrophy using implants is subject to anatomical, surgical, and biological difficulties and poses a challenge to the dental team.^[3] This can be due to poor quality and quantity of the residual bone, especially in patients with long-term edentulism.^[4] Most patients wearing complete dentures complain progressive loss of stability during phonetics and mastication, and many of them look for fixed rehabilitation. Furthermore, progressive loss in the posterior mandible may lead to superficialization of the alveolar nerve that might cause pain to denture wearers during mastication. Osseointegrated

dental implants are often placed in the posterior mandible, mostly for support of fixed restorative prosthesis, but in many cases, the bone has atrophied such that sufficiently long fixtures cannot be placed without encroaching on the inferior alveolar nerve (IAN). In that situation, restorative options include the use of short implants, onlay bone grafting to increase the ridge height, and more complicated and detailed imaging studies to

Address for correspondence: Dr. Fares Kablan,
Department of Oral and Maxillofacial, Galilee Medical Center,
Naharyia, Israel.
E-mail: kablanp1@gmail.com

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allow positioning of implants alongside the nerve canal during the procedure.^[3-7]

Completely edentulous mandible, with severe atrophy, may be rehabilitated with fixed full-prosthesis supported by four or six implants with excellent mid-term clinical outcomes. Overdenture supported by 2–4 implants at the interforaminal area is also widely used as a predictable treatment option.^[8,9] The partially edentulous posterior mandible, with severe atrophy, is a common scenario, and lack of sufficient bone height above the IAN makes the treatment with dental implant challengeable and confusing even for the experienced clinicians. Recently, short implants become a popular alternative for the atrophic jaws.^[6,7] At the posterior mandible, at least of 6 mm of residual bone height and width above the IAN is required for the placement of short implants. When the bone height over the IAN is <6 mm, IAN reposition has been widely used as an alternative to bone grafting and short implants.^[10,11]

Edentulous posterior mandible with extreme atrophy, which is compatible with Cawood and Howell Class VI,^[12] is more challenging due to several factors which include superficial location of the IAN and the mental nerves, reduced residual bone height over the IAN that ranged between 0 and 3 mm, severe resorption of the basal bone with total mandibular height being <8 mm, and a concave mandibular crest that is usually located below the floor of the mouth level and the buccal vestibule. Under those circumstances, the surgical approach may be adapted to address those challenges.

The aim of this paper is to introduce a predictable new method to treat this patient population and to address these challenges by nerve transposition combined with onlay bone graft, simultaneous dental implant insertion, and repositioning of the IAN under the onlay block.

PATIENTS AND METHODS

Fourteen patients had been treated by this technique from October 2014 to April 2019 and followed 12–58 months [Table 1]. Two patients with a follow-up <12 months were excluded from the study. Therefore, this retrospective study includes 18 mandibular posterior segments in 11 patients who had been treated with superiorization of the IAN and roofing. All the mandibular sites had severe resorption that were evaluated with cone-beam computerized tomography (CBCT) prior the surgery and showed a superficial location of the IAN, residual bone above the nerve ranged from 0 to 3 mm, and the total mandibular height ranged from 4 to 8 mm. Seven adult patients had early teeth extractions, and four young patients suffered from oligodontia or anodontia. All surgeries were performed under general anesthesia and the patients were hospitalized 1–3 days after the surgery. The surgical treatment was completed in one surgery that included calvarial split bone block harvest, accessing and lifting of the IAN from the superior portion of the crest (superiorization of the IAN); onlay bone grafting; implant placement through the onlay graft

and the mandibular ridge; and the IAN repositioning under the onlay bone block (roofing of the IAN). Primary closure of the soft tissue flap at the recipient site was achieved by a buccal free fat graft (BFFG). Follow-up includes clinical examination twice during the 1st month, once a month for additional 6 months, and then once a year. The inferior alveolar function and recovery were followed by familiar neurosensory tests. The first orthoradiograph was obtained immediately after the surgery, the second after 4 months, the third after rehabilitation, and then once a year. All patients received fixed prosthesis over the implants, and the rehabilitation work was allowed 4 months after the surgery.

Surgical procedure

The calvarial bone was accessed through an approximately 6–8 cm cranio-caudal scalp incision at the parietal skull [Figure 1a], and bone blocks were obtained from the outer bone skull table. The outline and the external craniotomy of the blocks were performed with straight fissure burs, and the block harvest was completed using chisels [Figure 1b]. The inner cortical plate was completely preserved [Figure 1c and d], and the entire medullar bone layer between the two corticals was collected to fill the gaps at the recipient site. The bone blocks were stored in saline [Figure 1e], and the scalp incision was sutured.

At the mental foramen region in the recipient site [Figure 2a], the incision was performed along the lingual side of the crest to avoid damaging the mental nerve, more posteriorly the incision was performed carefully, and its location was evaluated by the IAN location and pathway inside the residual bone observed at the CBCT [Figure 2b]. The flap was then carefully elevated. The access to the nerve was performed from the thin superior portion of the residual bone covering the IAN [Figure 2b]. Shaving of the thinned-out bone that is usually fast and easy was performed carefully proceeding from the mental nerve posteriorly, until full exposure of the IAN [Figure 2c]. The release of the IAN from the bone was gently performed with blunt curette. The superior access to the nerve and its lifting from the superior part of the crest is a new approach and is named “superiorization of the IAN” [Figure 2d]. After the completion of the nerve mobilization out from the bone, implant site preparations were performed through the crest engaging the lower border for primary stability of the implants. Attention was made to prevent perforation of the lower border to keep integrity of the atrophied mandible. The next step was the adaptation of the harvested bone block to the ridge dimensions and implant site preparation through the block that was performed on the surgical table. Thereafter, the dental implants were inserted through the bone block into the prior prepared implant sites at residual bone. In this way, longer implants were placed on the one hand, and they were simultaneously used to fix the onlay bone block to the mandibular bone [Figure 2e]. Thereafter, trimming of the sharp edges of the grafted onlay bone block was performed and the IAN was repositioned under the bone block that acts as a roof of the nerve. The procedure of repositioning the IAN under the

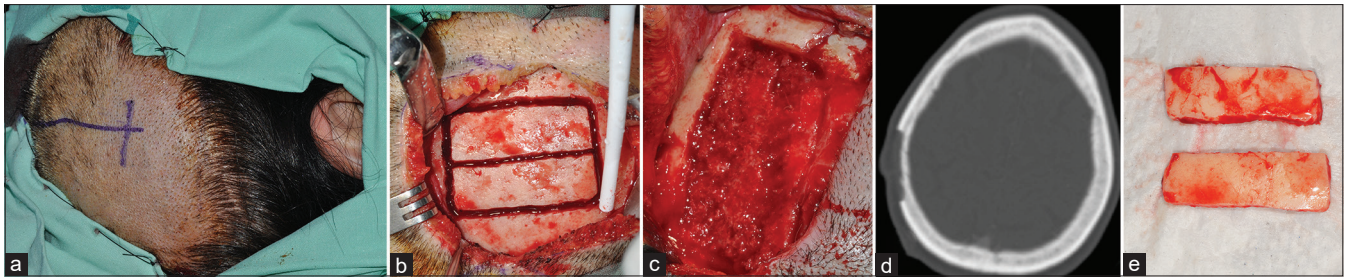


Figure 1: Calvarial bone block harvest. (a) The donor site was marked at the parietal skull. (b) A full-thickness flap was obtained, and the design and the bone block osteotomy were performed. (c and d) The inner cortical bone plate was completely preserved. (e) The obtained bone blocks

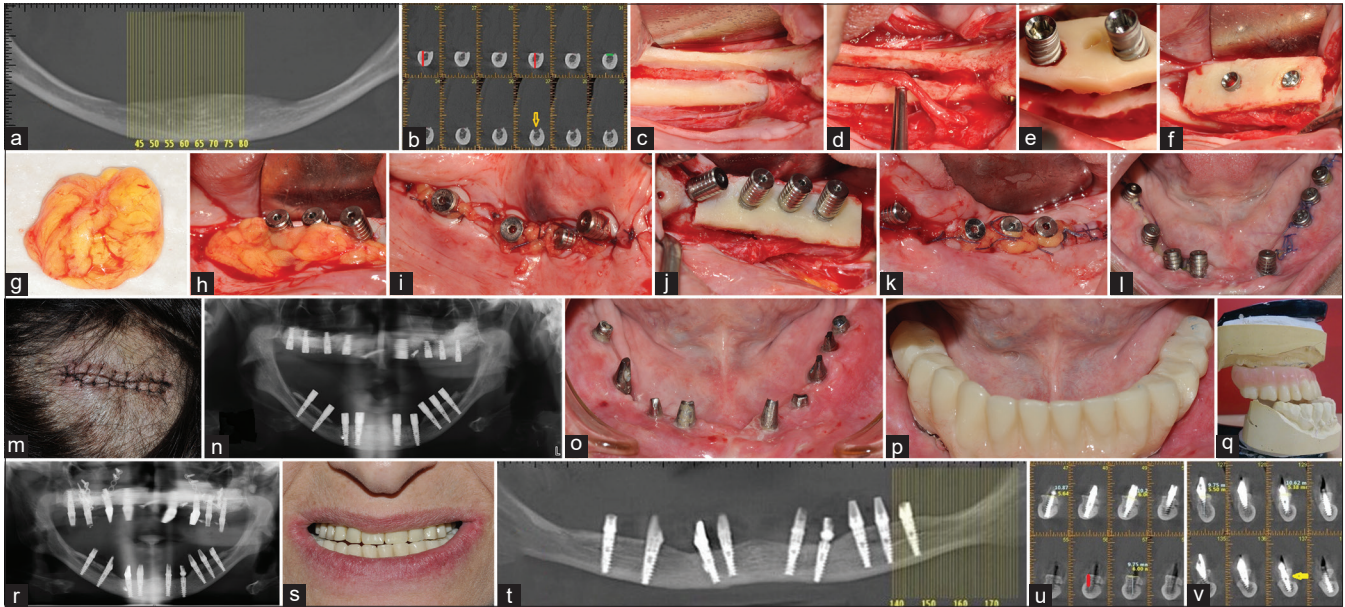


Figure 2: The treatment sequence of superiorization of the inferior alveolar nerve and roofing. (a and b) Panoramic and cross-sectional views demonstrate the extreme atrophy of full edentulous mandible with superficial location of the inferior alveolar nerve, small posterior mandibular height, and severely concaved posterior ridges. (c) accessing the inferior alveolar nerve was achieved from the superior portion of the crest. (d) Incision of the incisive nerve and lifting of the inferior alveolar nerve “superiorization of the IAN.” (e) Insertion of the dental implants through the onlay graft into the residual bone, the implants acts as the fixation methods of the block. (f) Repositioning of the inferior alveolar nerve beneath the onlay graft that in turn acts as a roof over the nerve “roofing.” (g-i) Buccal-free fat graft was used to enhance primary double-layered soft tissue closure at the recipient site. (j and k) Superiorization and roofing of the left posterior mandible of the patient. (l) Clinical view 2 weeks after the surgery. (m) Skull wound healing. (n) Panoramic radiograph, 2 weeks after the surgery. (o and p) Temporary rehabilitation after 4 months. (q) Models prediction revealed Class III relationships between the two jaws. (r) Panoramic view showed the LeFort I surgery performed to advance the maxilla. (s) fixed prosthesis over the installed implants. (t-v) Cone beam computerized tomography obtained 2 years after the surgery demonstrated, excellent integration of the bone graft without resorption, successful osseointegration of the implants and signs of inferior alveolar nerve canal regeneration

grafted bone block is named “roofing of the IAN” [Figure 2f]. The obtained medullar bone from the skull was mixed with allograft and used to fill the gaps between the onlay and the mandibular bone. Free-fat graft harvested from the buccal fat bad (BFFG) was utilized to enhance primary double layer soft tissue closure of the recipient site [Figure 2g-i]. The same procedure was made at the left side of the patient atrophied mandible [Figure 2j and k].

Postoperative care and follow-up

Patients were prescribed an antibiotic regimen for 7 days and postoperative oral hygiene instructions include mouth rinsing twice daily with chlorhexidine 0.12 for 2 weeks followed by topical application of chlorhexidine gel at the operated site for

additional 2 weeks. The patients were instructed a liquid diet for 6 weeks. Healing was uneventful without dehiscence of the wound at the 2 weeks of follow-up visit [Figure 2l and m]; at this time, the sutures were removed and an orthoradiograph was obtained [Figure 2n]. Thereafter, the patients were examined once a month; the follow-up included, in particular, the nerve recovery and wound integrity at the recipient sites. At 4 months, a temporary fixed prosthesis-supported implant was allowed [Figure 2o and p]. Clinical evaluation revealed skeletal Class III relationship [Figure 2q], and the patient underwent LeFort I osteotomy for maxillary advancement [Figure 2r]. Thereafter the patient received fixed prosthesis [Figure 2s] CBCT obtained 2 years after the surgery showed an excellent integration of the grafted bone block,

successful osseointegration of the dental implants, and signs of new nerve canal regeneration around the repositioned nerve under the grafted onlay block [Figure 2t-v].

Illustrative case 1

A 50-year-old woman was referred by her maxillofacial surgeon for IAN transposition and placement of dental implants due to extreme mandibular atrophy. The patient was healthy. Her teeth were extracted at an early age. She had a convenient removable full prosthesis on the maxilla, and overdenture supported two implants at the mandible. The patient was interested in fixed prosthesis at her mandible because of severe problems with phonetics, eating, and frequent attacks of neuralgic pains at her lower jaw. Clinical examination revealed an unstable overdenture-supported two old implants; pain was obtained by pressure over the denture at the posterior mandible bilaterally. She also had severe concavity of the posterior ridges distal to the implants. Her cheeks were at the same level of the floor of the mouth [Figure 3a and b]. On CBCT; extreme resorption of her mandible was apparent as demonstrated by the short mandibular height of 5–6 mm in average, superficial location of the mental nerve and IANs bilaterally, and severe concavity of the posterior ridges [Figure 3c-e]. The patient was informed about the new surgical approach, and the patient stated that she will agree with any surgical procedures that will provide her a fixed prosthesis. Written informed consent was obtained. Under general anesthesia, one surgical procedure was performed and includes harvesting of calvarial bone blocks [Figure 3f], bilateral superiorialization of the IAN, onlay bone grafts, insertion of dental implants through the onlays and the residual ridges, and roofing of the IANs by repositioning

of the nerves under the onlay bone blocks [Figure 3g-j]. The old two implants were replaced. Her healing was uneventful [Figure 3k and l]; full recovery of the nerve function was documented after 8 weeks. Her final prosthetic work was completed after 6 months by fixed prosthesis supported the inserted eight implants [Figure 3m and n]. This patient was operated at July 2015.

Illustrative case 2

A 55-year-old woman was referred to our department with bilateral severe bone resorption of the posterior mandible. Her medical history was uneventful. She reported a history of 15 years of using a partial mandibular removable prosthesis and complained about recent hyperesthesia from her prosthesis that extremely affected her quality of life. Her clinical evaluation revealed six natural anterior teeth located at the intraforaminal region, with good periodontal condition. The posterior mandibular regions revealed concave contour of the residual ridges bilaterally that were located inferior to the floor of the mouth level. A neuralgic pain was obtained during palpation over the mental nerves region. The CBCT showed extreme atrophy of the posterior mandibular ridges bilaterally with total mandibular height of 6 mm in average and superficial location of the mental and the IANs at both right and left sides of the mandible [Figure 4a-c]. A step deformity was obvious between the anterior teeth-bearing area and both posterior residual ridges. The patient was provided a detailed explanation about the new approach, and after she understood and agreed, she signed informed consent. Under general anesthesia, the patient underwent harvesting of calvarial bone blocks and mandibular surgery that included superiorialization of the IAN, onlay bone

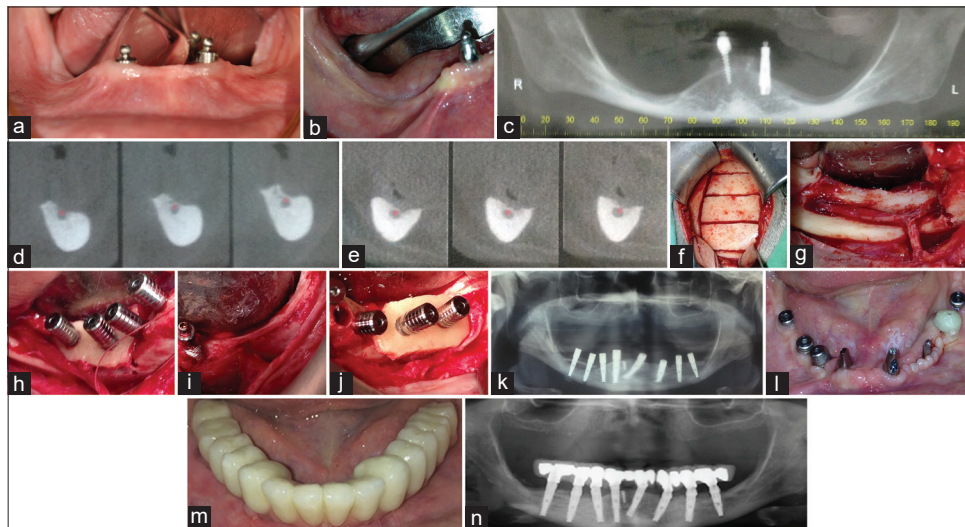


Figure 3: Case 1. (a and b) Clinical views demonstrated an edentulous mandible with severe atrophy. (c-e) Cone-beam computerized tomography views demonstrated extreme mandibular atrophy, total posterior mandibular height <8 mm, superficial location of the mental and inferior alveolar nerve bilaterally, and bilateral severely concaved posterior ridges. (f) The parietal bone as the donor site for the bone blocks. (g) The exposure of incisive, mental, and inferior alveolar nerves achieved via superior access (right side). (h) The only graft that was fixed with the placed implants and the inferior alveolar nerve repositioned under the onlay bone graft (right side). (i) Superficially located of the mental nerve and the inferior alveolar nerve (left side). (j) The only graft was fixed with the placed implants and the inferior alveolar nerve repositioning under the onlay bone graft (left side). (k) Panoramic radiograph obtained 2 weeks after the surgery. (l) Clinical view, 1 month after the surgery with excellent healing. (m and n) Fixed prosthesis over the inserted implants and excellent integration of the onlay bone blocks

block grafting, implants insertion, roofing of the nerves by repositioning of the nerves bilaterally under the grafted bone blocks, and BFFG grafting [Figure 4d]. The procedures were performed in one surgery in December 2014. The healing process went very well, and the final fixed rehabilitation completed 6 months after the operation [Figure 4e and f]. Further, follow-up visits at 24 [Figure 4g], [Figure 4h], and 58 months [Figure 4h] revealed stable outcomes. The final outcomes were satisfactory for the patient daily functions, with resolving of the neurologic main complains prior the surgery.

RESULTS

During 4 years, from October 2014 to January 2018, 18 posterior mandibular segments (4 unilateral and 7 bilateral) in 11 patients had been treated with superiorialization of the IAN and roofing. The patients group had two men and nine women, with a mean age of 45 years and range of 20–63 years. Sixty-three implants were placed with mean length of 11.5 mm and range of 10–13 mm. The donor sites of the bone blocks healed very well with minimal postoperative complaints or visible scar. No cerebral injuries were encountered at the donor site, and the patient recovered uneventfully, without early or late infections. The increase of bone height was 4–6 mm at the recipient sites. All the patients were hospitalized 1–3 days. The healing of the recipient sites was uneventful, and the nerve recovery lasted over a maximal period of 6 months. The implant success rate was 100%, and the survival rate

was also 100% during the follow-up period. The resorption of the onlay bone graft was minimal. All patients received fixed prosthesis 6 months after the operations. The outcomes were satisfactory with remarkable improvement of function and quality of life. On three patients, CBCT was obtained after 2 years and showed signs of canal regeneration surrounding the repositioned IAN under the onlay bone block. The follow-up period is 12–58 months.

DISCUSSION

Reduced alveolar bone height may limit the placement of dental implants, especially in the posterior mandible due to the presence of the IAN. In every case, the aim of the available bone expansion techniques is to obtain at least 10 mm of bone above the dental nerve for safe implant insertion. Each of these options poses a risk of complications or potential for dimensional graft loss.^[4-6] Short implants are recently widely used to rehabilitate atrophic posterior mandible, but they need at least 7 mm bone height and 6 mm bone width above the nerve.^[6,7] Overdentures had been used as an option for rehabilitation of fully edentulous mandibles; however, because of their partial mucosal support at the posterior regions, patients may experience pain resulting from compressing of the retroforaminal zones during function and may lead patients who have long-standing overdenture to inquire and seek rehabilitation with fixed prosthesis-supported dental implants.

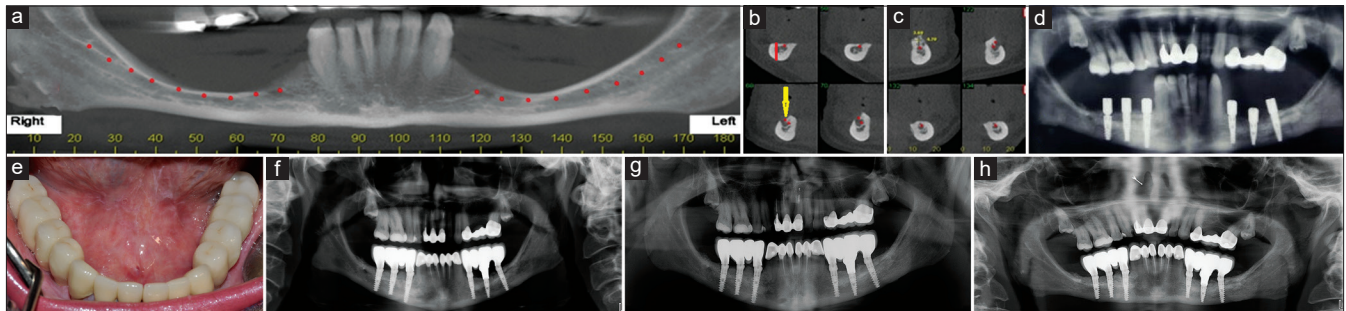


Figure 4: Case 2. (a) Panoramic view of cone-beam computerized tomography preoperative. (b and c) Cone-beam computerized tomography cross-sections demonstrated the severe resorption of posterior mandibular ridges, and superficial location of inferior alveolar nerves. (d) Panorex after the operation one-stage surgery; the onlay bone graft, and the implants *in situ*. (e and f) Clinical and radiographical views after rehabilitation. (g) Panorex 24 months after the surgical treatment. (h) Panorex 58 months after the surgery

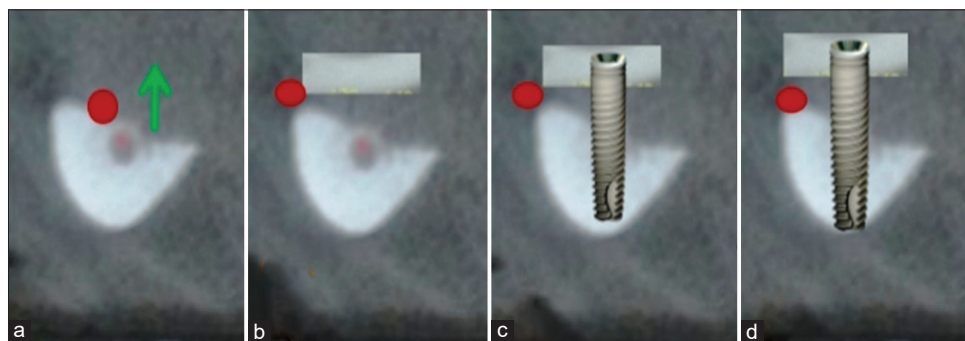


Figure 5: Summary – Superiorialization of the inferior alveolar nerve and roofing step by step. (a) Superior transposition of the inferior alveolar nerve. (b) Onlay bone graft. (c) Implants insertion. (d) Repositioning of the inferior alveolar nerve under the bone block (roofing)

Full edentulous mandible with extreme atrophy in patients who look for rehabilitation with fixed prosthesis-supported dental implants, or posterior mandibular edentulism with extreme atrophy in the presence of healthy interforaminal teeth, pose a difficult challenge for dental implant placement and may jeopardize IAN repositioning.^[11-13] IAN mobilization and repositioning for implant placement was first published by Jensen and Nock in 1987.^[14] It is generally performed in two ways: (1) lateralization that is performed posterior to the mental foramen and (2) transposition that is performed including the mental foramen and sectioning the incisive branch.^[2] In cases where the residual bone height over the IAN canal at the posterior mandible is more than 3mm, the access to the nerve can be performed by corticotomy through the buccal cortex parallel to the nerve location, and the IAN is mobilized laterally. After dental implant placement, the nerve is then repositioned into the buccal access window.

In the cases treated with the present approach, several unique factors might co-exist and jeopardize the use of a different approach. Those factors include (1) the IAN is located at a superficial position in the residual ridge as a result of extreme resorption characterized by bone height over the IAN that ranged from 0 to 3 mm; (2) the total mandibular height is <8 mm; and (3) the residual posterior ridge contour is severely concaved. Several practical questions could be asked in this scenario. First, what is the best way to access the IAN because the conventional two ways to mobilize the nerve, lateralization or transposition, via a buccal corticotomy, may not be applicable? In the present report, a new approach is presented and was performed during the surgery; the access to the IAN was achieved by ostectomy or shaving of the thin residual bone covering the nerve at the superior portion of the crest, and it is considered an easy and fast procedure

to expose the IAN. After full exposure of the nerve, the mobilization of the IAN out of the canal is performed by lifting it to the superior direction. Both the superior access to the nerve and its superiorly lifting are named in this report as “superiorization.” Superiorization of the IAN can be considered as a third approach (in addition to known two; lateralization and transposition). The second question, what is the best way to augment the residual ridge?, on those cases onlay bone graft is considered for several targets which include bone augmentation of the short mandibular height (<8 mm) for inserting of long implants, correcting the concave residual ridge that make the final rehabilitation more functional and more comfortable for the patient, and becoming a roof where the IAN can be repositioned. This is named in this report as “roofing” of the IAN. Roofing of the nerve has two advantages; the first is protecting the repositioned nerve; otherwise it will be located directly under the mucosa and the prosthesis. The second is enhancing the IAN canal regeneration around the repositioned nerve as it was observed by the postoperative CBCT scans obtained for the treated patients. Additional component in this new approach is the fixation of the onlay bone block with the dental implants that placed simultaneously. The fixation is considered stable due to the anchorage of the dental implants into the inferior mandibular cortex.

As a routine procedure during the surgery, healing caps are used over the dental implants to avoid an additional surgery for exposure, and a free-fat tissue graft obtained from the buccal fat pad (BFFG) was used for tension-free double-layer closure of the recipient sites.^[15] The use of the calvarial split bone graft has been utilized in the field of dental implants, with high success rate and long-term stability due to less tendency of this graft to resorb.^[16-21] These findings are comparable to

Table 1: Patients and methods

| Patient number | Site number | Age (years) | Gender | Surgery date | Side | Bone height over IAN (mm) | Mandibular height | Number of implants | Implant length | Follow-up months |
|----------------|----------------|-------------|--------|--------------|-----------|---------------------------|-------------------|--------------------|----------------|------------------|
| 1 | 1.1 1.2 | 55 | Female | 10/2015 | Bilateral | 2-3 | 5-7 | 6 | 11.5-13 | 58 |
| 2 | 2.3 | 40 | Female | 01/2015 | Right | 1-2 | 6-8 | 2 | 13 | 56 |
| 3 | 3.4 | 60 | Female | 03/2015 | Right | 1.5-2.5 | 7-8 | 3 | 13 | 55 |
| 4 | 4.5 4.6 | 63 | Female | 04/2015 | Bilateral | 0.5-2 | 6-8 | 8 | 10-13 | 54 |
| 5 | 5.7 | 62 | Female | 04/215 | Left | 1-2 | 6-8 | 3 | 11.5-13 | 54 |
| 6 | 6.8 6.9 | 60 | Female | 05/2015 | Bilateral | 0-2 | 7-8 | 6 | 13 | 53 |
| 7 | 7.10 7.11 | 50 | Female | 07/2015 | Bilateral | 0-1 | 4-6 | 8 | 10-11.5 | 51 |
| 8 | 8.12 8.13 | 22 | Male | 10/2015 | Bilateral | 2-3 | 6-8 | 8 | 11.5-13 | 48 |
| 9 | 9.14 9.15 | 55 | Female | 11/2015 | Bilateral | 1-2 | 4-6 | 8 | 10-13 | 47 |
| 10 | 10.16 | 20 | Female | 06/2016 | Right | 2-3 | 5-7 | 3 | 10-11.5 | 40 |
| 11 | 11.17 11.18 | 20 | Male | 9/2017 | Bilateral | 2-3 | 4-6 | 6 | 10-13 | 25 |

IAN=Inferior alveolar nerve

the stability of the results observed in our patients. Additional important factor that the calvaria was used as the donor site in our cases is the absence of bone block donor sites intraorally.

The rationale and the stages of the current approach are summarized in Figure 5.

Several approaches have been reported in the literature to treat such patients. The oldest approach that had been successfully used is the Bosker implant.^[22] Lopes *et al.* reported that a case utilizing large profile unlock bone plate to reinforce a severely resorbed mandible showed greater height <5 mm, but the rehabilitation was completed with overdenture supported by four short implants inserted in the anterior mandibular region.^[23] Weinstein *et al.* reported rehabilitation of atrophic mandible with fixed full prosthesis supported by four implants,^[24] but this was applicable due to the possibility to insert implants at the interforaminal region.

In the patient's population that have been treated according to the present approach, in our knowledge, there is no additional available or reported options that can complete the treatment with convenient functional full-fixed prosthesis-supported dental implants in one surgery and with final prosthetic work that was possible 4 months after the surgery. During the follow-up period of the treated patients who ranged from 12 to 58 months, the stability of the result regarding bone loss, implant survival, and the functional outcomes for the patients have been satisfying and encouraging the patients and the treatment team to use this approach to treat patients with similar anatomical, topographical conditions of the atrophied mandibles and with similar functional and psychological demands of patients.

CONCLUSIONS

The superiorization of the IAN and roofing can be considered a practical, fast, and predictable method to treat extremely atrophic posterior mandibles, both in partial and complete mandibular edentulous patients, and especially for patients who inquire and look for rehabilitation with fixed prosthesis-supported dental implants.

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Conflicts of interest

There are no conflicts of interest.

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