Inferior Alveolar Nerve Lateralization and Immediate Dental Implant Placement in Severely Resorbed Mandibles: A Clinical Trial

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Background:

Alveolar bone resorption is initiated following tooth extraction or loss as a consequence of diminished mechanical loading and disruption of the physiologic bone remodeling balance, leading to progressive atrophy of the residual ridge. Significant interindividual variability as well as intraindividual variations over time and across various regions of the residual ridge are observed in the rate and extent of alveolar bone resorption after tooth loss [1].

A recent systematic review evaluated the dimensional changes in the hard and soft tissues of the alveolar process up to 12 months following tooth extraction [2]. Because of anatomical and biomechanical differences, the maxilla and mandible show different patterns and magnitudes of alveolar bone resorption after tooth loss. Studies have shown that bone loss in the maxilla usually happens more quickly, with an average vertical reduction of 1.5–2 mm in the first six months and up to 40–60% of ridge width over the course of three to five years. On the other hand, cortical bone resorption in the mandible is typically slower but more noticeable, especially in the anterior region, where height loss can reach 4-5 mm in the first year. Nonetheless, there is a great deal of variation based on variables like systemic health, periodontal phenotype, and occlusal forces. Because the buccal bone plates in the posterior regions of both jaws are thinner, they tend to resorb more quickly, whereas the mandibular anterior ridge, supported by dense cortical bone, often retains greater residual volume [3].

The mechanism of bone resorption that occurs after tooth loss has been fully understood; it is explained as the organic components of intracellular substance being removed by proteolytic action of osteoclasts. On the other hand, the inorganic salts are dissolved by the chelating action of osteoclasts as resorption takes place. The osteocytes released may revert back to osteoblasts or osteoclasts depending upon physiologic and pathologic demands [4]. Residual ridge resorption (RRR) may continue beyond the alveolar bone to affect the basal bone of the upper and lower jaws, sometimes leaving only a thin cortical plate on the inferior border of the mandible or virtually no maxillary alveolar process on the upper jaw. In the lower jaw, a knife-edge ridge might result from severe buccolingual resorption that may be masked by redundant or inflamed soft tissue, which can be detected by palpation or by lateral cephalometric radiographs [4].

Several classification systems have been proposed to describe the extent and pattern of mandibular ridge resorption. Atwood's [1], Cawood and Howell's [5], Lekholm and Zarb's Classification [6], and Seibert's Classification [7]. Cawood and Howell's classification is the most widely used classification in general assessment in dental implantology and describes six stages of ridge resorption: Class I: Dentate ridge, Class II: Immediately post-extraction, Class III: Well-rounded ridge (favorable for dentures), Class IV: Knife-edged ridge (reduced width), Class V: Flat ridge (loss of height and width), and Class VI: Depressed ridge (severe resorption with basal bone loss) [5].

RRR is a multifactorial biomechanical disease that results from a combination of anatomic, mechanical, and metabolic determinants [8-10]. The mandible ridge undergoes resorption largely from the occlusal plane due to the mandible's greater width at the inferior border compared to the remnant alveolar ridge in the posterior region of the mouth. The resorption action increasingly separates the left and right ridges. Consequently, RRR is centripetal in the maxilla and centrifugal in the mandible [4]. Tallgren, Atwood, and Coy [11, 12] found the mean ratio of anterior maxillary to anterior mandibular RRR was 1:4. Therefore, on average, RRR is greater in the mandible than in the maxilla.

The placement of implants in severely resorbed posterior mandibles (Cawood-Howell categorization classes V and VI) is problematic due to inadequate bone volume, reduced attached and unattached mucosa, and the superficial positioning of the inferior alveolar nerve

[13]. Numerous therapeutic modalities have been suggested in the literature to tackle this issue, including the insertion of short implants, sandwich osteotomy, vertical ridge augmentation, and distraction osteogenesis. An alternative approach involves exposing the Inferior Alveolar Nerve (IAN) by laterally displacing it from the canal through nerve lateralization or transposition [14, 15].

The inferior alveolar nerve, a major branch of the mandibular nerve, innervates the mandibular teeth, periodontium, lower lip, and jaw. It traverses the lower jaw via the mandibular foramen, encased in firmly bound connective tissue, and subsequently proceeds downward and forward within the mandibular canal, typically situated behind the root apex [13]. Within the mandibular canal, it accompanies the inferior alveolar artery (IAA), vein, and lymphatic vessels, forming the inferior alveolar neurovascular bundle [16, 17]. The assessment of the infra-alveolar nerve canal's relative position and its association with mandibular anatomical landmarks can be therapeutically advantageous in reducing the risk of surgical problems, such as nerve damage, that may arise following invasive mandibular surgeries. Furthermore, the evaluation of bone height and width includes the Cone Beam Computed Tomography (CBCT) study of the trajectory and location of the mandibular canal [18].

Two techniques pertain to the alveolar nerve; the initial technique involves inferior alveolar nerve transposition (IANT) via a bone window fashioned in the cortical bone of the jaw, posterior to the mental foramen, excluding it. The second approach incorporates the mental foramen inside the established bone window and is referred to as IANL [19, 20]. In contrast to graft-based reconstruction methods, the lateralization procedure eliminates the need for donor sites, thereby reducing patient morbidity, lowering expenses, facilitating the immediate placement of long implants (as it utilizes all available jawbone), and averting a six- to eight-month waiting period for treatment [21]. IAN lateralization is a complex surgical operation that necessitates the exposure of the neurovascular bundle from its dense bone compartment and sufficient retraction, with the prompt implantation of an implant. This operation necessitates substantial clinical expertise, anatomical understanding, and the capability to address any complications [22-25].

Varying methods of IANL and immediate implant placements that have used drills, burs, or saws have been reported [26, 27]. Disturbances in postoperative neurosensory function of the IAN are common. The risk of IAN morbidity created some controversy, which resulted in the limited use of this classic technique [28]. To tackle problems in edentulous instances, especially those with atrophic mandibles, various surgical procedures utilizing osseointegrated implants have been devised [29]. Onlay bone grafting, a prevalent approach, necessitates a secondary surgical site and entails hazards including graft resorption, infection, and the requirement for two surgical procedures, thereby prolonging the entire treatment duration [29-31]. The bone quality in the posterior mandible is generally lower than that of the anterior area. Utilizing short implants to circumvent the mandibular canal often results in initial implant anchorage that is monocortical and comparatively unstable [32].

The key benefits of IAN relocation encompass the utilization of standard-length implants with bicortical anchorage, hence augmenting primary stability, which is essential for effective osseointegration. Implants accompanied by nerve relocation have a reduced risk of bone loss when compared to short implants implanted under analogous conditions [33]. In instances when the vertical bone height is below 5 mm—insufficient for even small implants—IAN repositioning is the advised procedure [34]. This treatment enhances resistance to occlusal stresses and guarantees an appropriate implant-to-prosthesis connection. In comparison to bone grafting, IAN relocation presents multiple advantages: it can be executed under local anesthetic, eliminates the need for a donor site, incurs cheaper expenses, and is linked to diminished morbidity [14, 35]. The present study aimed to investigate the efficacy of the IANL procedure for dental implants in the atrophied mandibles.

Patients and Methods:

This is a prospective randomized clinical trial. The study was carried out in patients with posterior mandibular atrophies among selected cases from patients attending Faculty of Dentistry dental polyclinics and some private dental clinics in Sana'a City from 10 July 2024 to 20 April 2025. The minimal calculated sample size was nine cases (G-power sample calculator; Effect size, 99.99; α err prob, 0.05; Power, 0.80; and Df, 7) [36]. The age of patients was above 18 years, according to [36]. Patients included in the study were those who have a bone height above the IAN that ranged from 0.5 to 7.0 mm and patients with bone width less than 5 mm in the planned dental implant sites. All patients were informed about alternative treatments and given information regarding all steps of the procedure, the risks of the surgery, and possible postoperative neurosensory dysfunction. All explanations were given to the patients verbally and in a written manner. Patients with active infections, uncontrolled diabetes, or a history of radiotherapy, chemotherapy, or oral cancer surgery were excluded from this study. Demographic data (name, age, gender, occupation, address, phone number, and habits) were collected using a preformed questionnaire. Present and past medical and dental history was also recorded for all patients. All patients received a thorough dental examination (extra-oral and intra-oral examination) in dental clinics using a dental mirror, ball-tipped WHO dental probe, and dental tweezers. Sterile examination tools by autoclave class B were used. Clinical examination included oral health and oral hygiene status, interarchdistance, dimensions of edentulous ridge, and soft tissue condition. Panoramic radiographs were taken to assess the condition of the patients' teeth and jawbone, as well as to detect any oral infections requiring treatment. These images also served as baseline documentation for comparison before and after treatment. CBCT revealed significant vertical and horizontal bone loss (bone quantity) and bone density (bone quality) in the mandibular premolar and molar areas, with the residual bone above the IAN ranging from 0.5 to 7.0 mm. All cases' mandibles were classified as class V (flat ridge form, inadequate in height and width) or class VI (depressed ridge form, with some basilar loss evident) according to the Howell-Cawood classification [5]. All patients were provided written informed consent and received a modified questionnaire of that proposed by Hashemi to register any ND and success rate of dental implant after the operation [37].

Surgical protocol:

At the outset, both the patients and instruments were prepared for the procedure. The surgical setup included dental examination instruments, an anesthesia kit (stainless-steel syringe, needle, and anesthesia cartridge), a scalpel with a No. 15 blade, a periosteal elevator, a Minnesota retractor, a piezoelectric device (Mectron Piezosurgery Device, Mectron) with burs, elastic tape for nerve lateralization, a Woodpecker dental implant device, AnyRidge MegaGen dental implants, a centrifuge with tubes and resorbable collagen membrane, 3/0 suture material, and a complete set of sterilization instruments. Local anesthesia was administered using lidocaine with adrenaline at a concentration of 1:80,000. A 27-gauge long needle was used with a stainless-steel syringe to perform IAN, lingual nerve, and long buccal nerve blocks. A triangular mucoperiosteal flap was performed; a crestal incision as well as an envelope with vertical releasing incision began from the retromolar region and was carried forward to the distal for the canine. A scalpel and blade were used to expose the alveolar crest and lateral body of the mandible of the posterior area. Then the mucoperiosteal flap was reflected by a periosteal elevator, and the mental nerve was then identified and relieved from the underlying tissue to free the mucoperiosteal flap during reflection, and then all flaps were reflected by a Minnesota retractor.

Piezoelectric osteotomy:

For the purpose of inferior alveolar nerve lateralization, a linear occlusal cortical osteotomy was performed with a piezoelectric device (Mectron Piezosurgery Device, Mectron) by Piezosurgery osteotomy burs from the prepared implant bed into a medial and distal direction, extending 3–4 mm in length bilaterally, with a depth compatible with the existing thickness of the cortical bone [38].

The osteotomy separates the implant bed into 2 relatively equal parts. Subsequently, anterior and posterior vertical osteotomies (8–15 mm in length) are performed on the buccal surface of the mandible with the piezoelectric device to a depth compatible with the thickness of the cortical bone. A horizontal osteotomy is then performed with the piezoelectric device at the apical level to unite the vertical osteotomies and define a square bone window [38].

Nerve lateralization:

The cortical bone block is removed with the aid of a periosteal elevator and kept hydrated in saline solution. After osteotomy, the mandibular canal is exposed, and the IAN is gently manipulated to remove cancellous bone fragments that may hinder a full mobilization of the IAN. The nerve was retracted laterally by a specially fabricated instrument (elastic tape), according to [39], and carefully protected in a way to allow implant bed preparation through its medial surface up to the desired bone depth.

Implant placement:

The AnyRidge MegaGen dental implants were then inserted to the ideal locking depth, in accordance with the predetermined position and direction. The selected implants should be long enough to allow anchorage in the basal cortical bone of the mandibular body and provide adequate locking and stability [38].

Inlay autogenous bone graft repositioned:

The inner surface of the previously harvested bone block can be contoured using specialized piezoelectric tips to ensure precise adaptation to the defect site at the end of the surgery, promoting close bone-to-implant contact. This approach results in an optimal inlay autogenous bone graft, which is the basis for the technique's name. The bone block is then repositioned and secured in its original location to effectively close the bone defect [38]. In the final step, soft tissues were carefully approximated and sutured using interrupted stitches with 3-0 silk sutures.

Post-operative care:

Patients received standard postoperative care instructions and were advised to avoid chewing on the operated side. A soft and liquid diet was recommended during the implant osseointegration period. Anti-inflammatory drugs, analgesics, and antibiotics were administered according to established protocols. Neurostimulatory drugs (methylcobalamin) can be administered shortly after surgery, depending on the patient's sensory perception and the IAN trauma extension. Sutures are removed only after confirmation of edge repair, usually 12 days after surgery. Implants are loaded 90 to 120 days after insertion [38].

Post-operative follow-up:

Testing of nerve function and implant success rate during the scheduled follow-up visits was scheduled on the day after the procedure and at 1, 3, and 6 months immediately following the surgery [40]. Patients were asked about pain and neurosensory disturbance classified as positive (including paresthesia, dysesthesia, and hyperesthesia) or negative (such as hypoesthesia and anesthesia). The incidence and duration of neurosensory disturbance were evaluated by the light touch test using cotton or gauze. A cotton tip applicator is used to determine sensation (Static Touch Detection Tests), and a pinprick test is done with an insulin needle and the tip of an explorer probe at predetermined intervals of time. Neurosensory evaluation was carried out on the 1st and 7th postoperative days and every month thereafter for up to 6 months. The areas of impaired nerve function were mapped and followed during each follow-up appointment. The evaluation of nerve function was performed by two calibrated examiners. [34] The implant success rate was done by primary stability during insertion by ratchet, then X-rays (panorama and CBCT) were taken at 3 months and 4 months after implant insertion to check for marginal bone loss (MBL). The degree of osseointegration of the implants was determined by examining whether or not the implants were both painless and immobile when under torque and while loading and whether or not any pathology was detected in the X-rays during the examination [34].

Abutments and prosthodontic procedures:

In this study, all patients received prosthetic rehabilitation using AnyRidge (MegaGen) implants with multi-unit abutments to ensure a predictable and efficient restorative phase. The multi-unit abutments, designed by the manufacturer, were selected based on implant angulation and soft tissue thickness, with both straight and angled options (15° and 25°) and various collar heights available to accommodate individual anatomical variations. These abutments helped standardize the prosthetic platform, simplify the restoration delivery, and improve long-term outcomes. All prostheses were cement-retained, except for one case where a screw-retained restoration was employed. The use of multi-unit abutments played a key role in managing implant angulation and facilitating a smooth and accurate prosthodontic alignment.

Data management and statistical analysis:

All data were collected and then analyzed using statistical software (SPSS Version 27; SPSS Inc., Chicago, USA). Descriptive analyses were performed as frequency and proportion for categorical variables and the mean and standard deviation of quantitative variables. Analytical statistics were performed to find out the association between variables (demographic characteristics, neurosensory disturbance, and success rate of implant) with IANL. Non-parametric tests were done to measure the differences between pre- and post-times of operation (Fridman and Wilcoxon tests). $P < 0.05$ was considered statistically significant.

List of Abbreviations:

Abbreviations

Definition

IAN

Inferior Alveolar Nerve

IANL

Inferior Alveolar Nerve Lateralization

IANT

Inferior Alveolar Nerve Transposition

RRR

Residual Ridge Resorption

CBCT

Cone Beam Computed Tomography

ND

Neurosensory Disturbances

MC

Mandibular Canal

PRF

Platelet-Rich Fibrin

MBL

Marginal Bone Loss

Declarations:

Ethics approval and consent to participate: The study design adhered to the tenets of the Declaration of Helsinki and was approved by the Medical Research Ethics Committee in the Faculty of Medicine at Sana'a University; ethical approval was obtained (Approval Number: OMFS:14/06/2024). Detailed explanation of the procedures was provided for all participants. Verbal and written consent were obtained from all participants; all patients agreed to be involved in the study.

Clinical trial number: not applicable.

Consent for publication: NA

Availability of data and materials: The authors confirmed that the raw data that support the findings of this study are available from the corresponding author upon reasonable request.

Competing interests: The authors declare that they have no competing interests.

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Authors' contributions: HS & YA performed the surgical interventions and collected data from the patients and drafted the manuscript. MA performed the conceptualization of the study and was a major contributor in writing the manuscript. YA, AA, and TA revised the clinical work and the draft manuscript. All authors read and approved the final manuscript.

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References:

.1 Atwood DA: **Reduction of residual ridges: a major oral disease entity**. *Journal of Prosthetic Dentistry* 1971, **26**(3):266-279.

.2 Tan WL, Wong TL, Wong MC, Lang NP: **A systematic review of post-extractional alveolar hard and soft tissue dimensional changes in humans**. *Clinical oral implants research* 2012, **23**:1-21.

.3 Wang RE, Lang NP: **Ridge preservation after tooth extraction**. *Clinical oral implants research* 2012, **23**:147-156.

.4 Burugupalli P, Kranthikiran G, Gajavalli S, Nair KC, Raju A: **Changes in the form and structure of residual ridges: An Overview**. *Trends Dent Implantol (Demo)* 2020, **9**:20-31.

.5 Cawood J, Howell R: **A classification of the edentulous jaws**. *International journal of oral and maxillofacial surgery* 1988, **17**(4):232-236.

.6 Lekholm U: **Patient selection and preparation**. *Tissue-integrated protheses: osseointegration in clinical dentistry* 1985:199-209.

.7 Seibert J: **Reconstruction of deformed, partially edentulous ridges, using full thickness onlay grafts. Part II. Prosthetic/periodontal**. *Compend Contin Educ Dent* 1983, **4**:549-562.

.8 Gupta A, Tiwari B, Goel H, Shekhawat H: **Residual ridge resorption: a review**. *Indian J Dent Sci* 2010, **2**(2):7-11.

.9 Jahangiri L, Devlin H, Ting K, Nishimura I: **Current perspectives in residual ridge remodeling and its clinical implications: a review**. *The Journal of prosthetic dentistry* 1998, **80**(2):224-237.

.10 Kumar TA, Naeem A, Verma A, Mariyam A, Krishna D, Kumar PK: **Residual ridge resorption: The unstoppable**. *Int J Appl Res* 2016, **2**(2):169-171p.

.11 Atwood DA: **Postextraction changes in the adult mandible as illustrated by microradiographs of midsagittal sections and serial cephalometric roentgenograms**. *Journal of Prosthetic Dentistry* 1963, **13**(5):810-824.

.12 Tallgren A: **The continuing reduction of the residual alveolar ridges in complete denture wearers: a mixed-longitudinal study covering 25 years**. *Journal of Prosthetic Dentistry* 2003, **89**(5):427-435.

.13 Ji C: **howell rA. reconstructive preprosthetic surgery. i**. *Anatomical considerations int J oral Maxillofac surg* 19.82-20:75 ,91

.14 Rosenquist B: **Fixture placement posterior to the mental foramen with transpositioning of the inferior alveolar nerve**. *International Journal of Oral & Maxillofacial Implants* 1992, **7**.(1)

.15 Jensen O, Nock D: **Inferior alveolar nerve repositioning in conjunction with placement of osseointegrated implants: a case report**. *Oral Surgery, Oral Medicine, Oral Pathology* 1987, **63**(3):263-268.

.16 Rodella LF, Buffoli B, Labanca M, Rezzani R: **A review of the mandibular and maxillary nerve supplies and their clinical relevance**. *Archives of oral biology* 2012, **57**(4):323-334.

.17 Pogrel MA, Dorfman D, Fallah H: **The anatomic structure of the inferior alveolar neurovascular bundle in the third molar region**. *Journal of oral and maxillofacial surgery* 2009, **67**.2454-2452:(11)

.18 Khorshidi H, Raoofi S, Ghapanchi J, Shahidi S, Paknahad M: **Cone beam computed tomographic analysis of the course and position of mandibular canal**. *Journal of maxillofacial and oral surgery* 2017, **16**:306-311.

.19 Peleg M, Mazor Z, Chaushu G, Garg AK: **Lateralization of the inferior alveolar nerve with simultaneous implant placement: a modified technique**. *International Journal of Oral & Maxillofacial Implants* 2002, **17**.(1)

.20 Kan JY, Lozada JL, Goodacre CJ, Davis WH, Hanisch O: **Endosseous implant placement in conjunction with inferior alveolar nerve transposition: an evaluation of**

neurosensory disturbance. *International Journal of Oral & Maxillofacial Implants* 1997, **12**.(4)

.21 Friberg B, Ivanoff C, Lekholm U: **Inferior Alveolar Nerve Transposition in Combination With Brånemark replant Treatment**. *International Journal of Periodontics & Restorative Dentistry* 1992, **12**.(6)

.22 Steinberg MJ, Kelly PD: **Implant-related nerve injuries**. *Dental Clinics of North America* 2014, **59**(2):357-373.

.23 Zuniga JR, Meyer RA, Gregg JM, Miloro M, Davis LF: **The accuracy of clinical neurosensory testing for nerve injury diagnosis**. *Journal of oral and maxillofacial surgery* 1998, **56**(1):2-8.

.24 Zuniga JR: **Sensory outcomes after reconstruction of lingual and inferior alveolar nerve discontinuities using processed nerve allograft—a case series**. *Journal of Oral and Maxillofacial Surgery* 2015, **73**(4):734-744.

.25 Grant B-TN, Pancko FX, Kraut RA: **Outcomes of placing short dental implants in the posterior mandible: a retrospective study of 124 cases**. *Journal of oral and maxillofacial surgery* 2009, **67**(4):713-717.

.26 Ferrigno N, Laureti M, Fanali S: **Inferior alveolar nerve transposition in conjunction with implant placement**. *International Journal of Oral & Maxillofacial Implants* 2005, **20**.(4)

.27 Smiler DG: **Repositioning the inferior alveolar nerve for placement of endosseous implants**. *International Journal of Oral & Maxillofacial Implants* 1993, **8**.(2)

.28 Beirne OR, Worthington P: **Problems and Complications in Implant Surgery The Surgeon's Perspective**. *Oral and Maxillofacial Surgery Clinics of North America* 1991, **3**(4):993-1000.

.29 Misch C: **Implantes dentais contemporâneos**: Elsevier Brasil; 2011.

.30 Romeo E: **Reabilitação oral com prótese implantossuportada para casos complexos**: Santos Livraria Editora; 2007.

.31 Rosenquist B: **Implant Placement in Combination With Nerve Transpositioning: Experiences With the First 100 Cases**. *International Journal of Oral & Maxillofacial Implants* 1994, **9**.(5)

.32 Blahout R, Hienz S, Solar P, Matejka MH, Ulm CW: **Quantification of bone resorption in the interforaminal region of the atrophic mandible**. *International Journal of Oral & Maxillofacial Implants* 2007, **22**.(4)

.33 Vasco MAA, Hecke MB, Bezzon OL: **Analysis of short implants and lateralization of the inferior alveolar nerve with 2-stage dental implants by finite element method**. *Journal of Craniofacial Surgery* 2011, **22**(6):2064-2071.

.34 Díaz JF, Gías LN: **Rehabilitation of edentulous posterior atrophic mandible: inferior alveolar nerve lateralization by piezotome and immediate implant placement**. *International journal of oral and maxillofacial surgery* 2013, **42**(4):521-526.

.35 Dario LJ, English Jr R: **Achieving implant reconstruction through bilateral mandibular nerve repositioning**. *Journal of the American Dental Association (1939)* 1994, **125**(3):305-309.

.36 Rathod M, Kshirsagar RA, Joshi S, Pawar S, Tapadiya V, Gupta S, Mahajan V: **Evaluation of neurosensory function following inferior alveolar nerve lateralization for implant placement**. *Journal of maxillofacial and oral surgery* 2019, **18**:273-279.

.37 Deryabin G, Grybauskas S: **Dental implant placement with inferior alveolar nerve repositioning in severely resorbed mandibles: a retrospective multicenter study of implant success and survival rates, and lower lip sensory disturbances**. *International Journal of Implant Dentistry* 2021, **7**(1):44.

.38 Tomazi MA, da Silveira Gerzson A, Neto AM, da Costa ALP: **In-Block Lateralization as a New Technique for Mobilization of the Inferior Alveolar Nerve: A Technique Case Series**. *Journal of Oral Implantology* 2021, **47**(4):333-341.

.39 Hassani A, Saadat S, Moshiri R, Shahmirzad S, Hassani A: **Nerve retraction during inferior alveolar nerve repositioning procedure: a new simple method and review of the literature**. *Journal of Oral Implantology* 2015, **41**(S1):391-394.

.40 Vetromilla B, Moura L, Sonego C, Torriani M, Chagas Jr O: **Complications associated with inferior alveolar nerve repositioning for dental implant placement: a systematic review**. *International journal of oral and maxillofacial surgery* 2014, **43**(11):1360-1366.

.41 Chiapasco M, Consolo U, Bianchi A, Ronchi P: **Alveolar distraction osteogenesis for the correction of vertically deficient edentulous ridges: a multicenter prospective study on humans**. *Journal of Prosthetic Dentistry* 2004, **92**(6):587.

.42 López-Cedrún JL: **Implant rehabilitation of the edentulous posterior atrophic mandible: the sandwich osteotomy revisited**. *International Journal of Oral & Maxillofacial Implants* 2011, **26**.(1)

.43 Buser D, Dula K, Lang N ,Nyman S: **Long-term stability of osseointegrated implants in bone regenerted with the membrane technique. 5-year results of a prospective study with 12 implants**. *Clinical oral implants research* 1996, **7**(2):175-183.

.44 Dahlin C, Lekholm U, Linde A: **Membrane-Induced Bone Augmentation at Titanium Implants. A Report on Ten Fixtures Fallowed From 1 to 3 Years After Loading**. *International Journal of Periodontics & Restorative Dentistry* 1991, **11**.(4)

.45 Roccuzzo M, Ramieri G, Spada MC, Bianchi SD, Berrone S: **Vertical alveolar ridge augmentation by means of a titanium mesh and autogenous bone grafts**. *Clinical Oral Implants Research* 2004, **15**(1):73-81.

.46 von Arx T, Kurt B: **Implant placement and simultaneous ridge augmentation using autogenous bone and a micro titanium mesh: a prospective clinical study with 20 implants**. *Clinical oral implants research* 1999, **10**(1):24-33.

.47 Babbush CA: **Transpositioning and repositioning the inferior alveolar and mental nerves in conjunction with endosteal implant reconstruction**. *Periodontology 2000* 1998, **17**:183-190.

.48 Meyer RA, Bagheri SC: **A bioabsorbable collagen nerve cuff (NeuraGen) for repair of lingual and inferior alveolar nerve injuries: a case series**. *Journal of Oral and Maxillofacial Surgery* 2009, **67**(11):2550-2551.

.49 Shanti RM, Ziccardi VB: **Use of decellularized nerve allograft for inferior alveolar nerve reconstruction: a case report**. *Journal of Oral and Maxillofacial Surgery* 2011, **69**(2):550-553.

.50 Morrison A, Chiarot M, Kirby S: **Mental nerve function after inferior alveolar nerve transposition for placement of dental implants**. *Journal-Canadian Dental Association* 2002, **68**(1):46-50.

.51 Chrcanovic BR, Custódio ALN: **Inferior alveolar nerve lateral transposition**. *Oral and maxillofacial surgery* 2009, **13**:213-219.

.52 Hashemi H: **Neurosensory function following mandibular nerve lateralization for placement of implants**. *International Journal of Oral and Maxillofacial Surgery* 2010, **39**(5):452-456.

.53 Atef M, Mounir M: **Computer-guided inferior alveolar nerve lateralization with simultaneous implant placement: a preliminary report**. *Journal of Oral Implantology* 2018, **44**(3):192-197.

.54 Garoushi IH, Elbeialy RR, Gibaly A, Atef M: **Evaluation of the effect of the lateralized inferior alveolar nerve isolation and bone grafting on the nerve function and implant**

stability.(Randomized Clinical Trial). *Clinical Implant Dentistry and Related Research* 2021, **23**(3):423-431.

.55 Mahmood-Hashemi H: **A modified technique of inferior alveolar nerve repositioning: results in 11 patients**. *Acta Medica Iranica* 2006:273-276.

.56 Lorean A, Kablan F, Mazor Z, Mijiritsky E, Russe P, Barbu H, Levin L: **Inferior alveolar nerve transposition and reposition for dental implant placement in edentulous or partially edentulous mandibles: a multicenter retrospective study**. *International journal of oral and maxillofacial surgery* 2013, **42**(5):656-659.

.57 Gasparini G, Boniello R, Saponaro G, Marianetti TM, Foresta E, Torroni A, Longo G, Azzuni C, Cervelli D, Pelo S: **Long Term Follow-Up in Inferior Alveolar Nerve Transposition: Our Experience**. *BioMed Research International* 2014, **2014**(1):170602.

.58 Dursun E, Keceli HG, Uysal S, Güngör H, Muhtarogullari M, Tözüm TF: **Management of limited vertical bone height in the posterior mandible: short dental implants versus nerve lateralization with standard length implants**. *Journal of Craniofacial Surgery* 2016, **27**(3):578-585.

.59 Kablan F: **Superioralization of the inferior alveolar nerve and roofing for extreme atrophic posterior mandibular ridges with dental implants**. *Annals of Maxillofacial Surgery* 2020, **10**(1):142-148.

.60 Khojasteh A, Hosseinpour S, Nazeman P, Dehghan M: **The effect of a platelet-rich fibrin conduit on neurosensory recovery following inferior alveolar nerve lateralization: a preliminary clinical study**. *International Journal of Oral and Maxillofacial Surgery* 2016, **45**(10):1303-1308.

.61 Nocini PF, De Santis D, Fracasso E, Zanette G: **Clinical and electrophysiological assessment of inferior alveolar nerve function after lateral nerve transposition**. *Clinical Oral Implants Research* 1999, **10**(2):120-130.

.62 Jensen J, Reiche-Fischel O, Sindet-Pedersen S: **Nerve transposition and implant placement in the atrophic posterior mandibular alveolar ridge**. *Journal of oral and maxillofacial surgery* 1994, **52**(7):662-668.

.63 Castellano-Navarro J, Castellano-Reyes J, Hirdina-Castilla M, Suárez-Soto A, Bocanegra-Pérez S, Vicente-Barrero M: **Neurosensory issues after lateralisation of the inferior alveolar nerve and simultaneous placement of osseointegrated implants**. *British Journal of Oral and Maxillofacial Surgery* 2019, **57**(2):169-173.

.64 CAMPOS CG, PICCOLI AP, MARSON FC, ANJOS NETO-FILHO Md, LOLLI LF, SILVA CO: **Subjective assessment of inferior alveolar nerve function after lateralization surgery**. *Dental Press Implantology* 2013.(1)7 ,

.65 Hori M, Sato T, Kaneko K, Okaue M, Matsumoto M, Sato H, Tanaka H: **Neurosensory function and implant survival rate following implant placement with nerve transpositioning: a case study**. *Journal of oral science* 2001, **43**(2):139-144.

.66 Barbu H ,Levin L, Bucur M, Comaneanu R, Lorean A: **A modified surgical technique for inferior alveolar nerve repositioning on severely atrophic mandibles: case series of 11 consecutive surgical procedures**. *Chirurgia (Bucur)* 2014, **109**(1):111-116.

.67 Tabrizi R, Pourdanesh F, Jafari S, Behnia P: **Can platelet-rich fibrin accelerate neurosensory recovery following sagittal split osteotomy? A double-blind, split-mouth, randomized clinical trial**. *International journal of oral and maxillofacial surgery* 2018, **47**(8):1011-10.14

.68 Behnia P, Behnia H, Ghanbari AM, Tabrizi R: **Does leucocyte-and platelet-rich fibrin enhance neurosensory recovery after genioplasty? A double-blind, split-mouth, randomised clinical trial**. *British Journal of Oral and Maxillofacial Surgery* 2023, **61**.539-534:(8)