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Nerve relocation, Nerve transposition,
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Case series

IMMEDIATE LOADING AFTER IMPLANT PLACEMENT WITH RELOCATION OF THE INFERIOR ALVEOLAR NERVE IN ATROPHIC MANDIBLES: A 1-YEAR RETROSPECTIVE CASE SERIES

PURPOSE. To retrospectively evaluate clinical outcomes of immediately loaded implant supported restorations in atrophic mandibles subjected to inferior alveolar nerve relocation to allow placement of dental implants.

MATERIALS AND METHODS. Consecutively treated patients having a follow-up of 1 year after loading of implants immediately placed after relocation of the inferior alveolar nerve were included. Outcomes measures were implant and prothesis success and any type of complications with particular attention to post-operative neurosensory dysfunction.

RESULTS. Data from 16 consecutive patients rehabilitated with 38 implants were identified. All prostheses could be immediately placed, none failed and no patient dropped-out up to one year after loading. Only one implant failed. One day postoperatively, all patients had dysesthesia or paresthesia. At 2 weeks 11 patients had a total neurological recovery and one had a partial recovery, while the four remaining patients did not recover. One mandible fractured 3 weeks after implant placement. At 1-year post-loading, one patient was still affected by neurosensory dysfunction and three partially recovered (one of these had it pre-operatively). The patient with the fractured mandible, recovered completely.

CONCLUSIONS. Implant placement in atrophic mandibles after inferior alveolar nerve relocation could be considered a viable alternative to vertical augmentation procedures, offering in addition the possibility of loading implants immediately, however severe complications are not uncommon.

CONFLICT OF INTEREST STATEMENT
This study was completely self-supported, and no financial support has been sought or obtained, not even in form of free materials.

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INTRODUCTION

A remodeling process of the alveolar bone begins after tooth extraction progressing for months due to the lack of function and the loss of blood supply from periodontal ligament[1]. Bone resorption occurs in both vertical and horizontal directions, mostly buccally[2]. The residual resorption patterns have been classified by Cawood and Howell[3].

Possible treatment options for the rehabilitation with implant-supported prostheses of posterior mandibles are bone augmentation procedures and 4 to 6 mm short implants[4-6]. There are several augmentation techniques, including inlay or onlay bone grafting, distraction osteogenesis and vertical guided bone regeneration, however all these procedures are associated with high morbidity, they need long rehabilitation periods (up to one year or even longer), they require multiple interventions and visits, are financially demanding, and moreover may not be very predictable[7-10].

Short implants (4-to 6 mm long) were successfully used in the treatment of posterior edentulism (1-6), but at least 4 mm of bone above the mandibular canal are needed and they were not loaded immediately[6-10].

For many years, onlay bone graft techniques were considered to be the gold standard treatment with good survival rates, but complications such as graft resorption or graft exposure have been highlighted by several studies. Moreover simultaneous implant placement as well as immediate loading are often not possible[11].

In atrophic posterior mandibulae, immediate loading without grafting might be possible using short implants or with longer implants placed after relocation of the Inferior Alveolar Nerve (IAN) by lateralization/transposition[12,13].

Nerve "lateralization" is performed by creating a bone window in the cortical bone of the jaw, posterior to the mental foramen without including it. The so-called "transposition" variation includes the mental foramen in the cut to have a better mobility of the IAN. A recent review, including 33 articles, reported that among the 269 patients who underwent transposition, 93% of them had immediate neurosensory disturbance, and 15% persistent neurosensory disturbance, while in 350 patients who underwent lateralization, the immediate neurosensory disturbance was recorded in 93% of patients and persistent neurosensory disturbance in 6% of them[13]. Among medium- and long-term complications reported there were neurosensory dysfunction, implants failures, fracture of the mandible, pain and necrosis of the adjacent mesial tooth.

The aim of this retrospective case series is to evaluate implant and prothesis success and any type of complications with particular attention to post-operative neurosensory dysfunction of immediately loaded implant supported restorations in atrophic mandible subjected to inferior alveolar nerve relocation to allow placement of dental implants.

MATERIALS AND METHODS

Study design

This study included a retrospective case series with unblinded assessment of consecutive partially or totally edentulous patients treated with inferior alveolar nerve lateralization or transposition and implant supported prostheses from 2017 to 2022 at the Department of Dentistry, IRCCS San Raffaele, Milan, Italy.

The study was approved by the local Ethics Committee with number CE/INT/10/2015. All patients signed an informed consent form to treatment which clearly indicated all potential surgical risks, especially of paresthesia. The study was reported according to the Reporting of Observational Studies in Epidemiology (STROBE: https://www.strobe-statement.org/).

Participants

Inclusion criteria were:

- partially or totally edentulous patients having less than 6 mm of bone height above the mandibular canal requiring a fixed implant supported prosthesis.

Exclusion criteria were:

- history of severe systemic diseases contraindicating oral surgical intervention.
- Any report of bisphosphonate therapy.
- History of recent bone resection or radiation therapy as part of an oncological treatment.

Surgical procedures

All subjects were treated by the same surgeon (R.V.) with administration of 2 g of amoxicillin plus clavulanic acid or 0.6 g clindamycin for allergic patients 1 hour before nerve transposition. Local anesthesia and intravenous sedation were administered and patients rinsed for 1 minute with 0.2% chlorhexidine mouthwash prior to surgery.

If extractions were needed, teeth were extracted with an atraumatic technique to preserve the alveolar bone[14]. A para-crestal incision was made from canines, at the buccal side in the alveolar mucosa, and a full-thickness buccal flap was raised to expose the buccal bone plate up to the retromolar trigone. Great care was given to avoid tension at the emergence of the mental nerve. Divergent mesial and distal vertical incisions were performed taking into account the vascularization of mandibula. A minimally invasive vestibular corticotomy was performed using a round bur mounted on a straight handpiece under abundant irrigation, from 3 mm distal to the mental foramen up to 6 to 7 mm distal to the future most distal implant planned position, at the same height of the mental foramen. This osteotomy was enlarged to expose the inferior mandibular canal with a piezo-surgery device (Piezo-surgery Touch, Mectron, Carasco, Italy). The vestibular access to the IAN was coronal to the nerve from mesial to distal, guided by the position of the exposed mental nerve or by a surgical guide. At this point, different surgical approaches for relocating the IAN (lateralization or transposition) were used. Ideally, we wished to perform only lateralization procedures, however, when at planning stage the IAN was too deeply bucco-lingually (more than 3 mm) located into the bone on when the lack elasticity of the nerve noticed at surgery, precluded the lateralization, a transposition procedure was used instead.

Lateralization of IAN

A bone slot was created with piezosurgery on the coronal part of the residual bone, in a different position than the planned implant site, to facilitate retrieval and mobilization of the vascular nerve bundle. Through this slot, the nerve was then pulled outside its bony canal with a mini blunt spatula and was kept dislocated by applying collagen sponge, which limited bleeding and kept the space for the osteo-inductive properties of the coagulum. Being the lateralization procedure less invasive than the transposition, it was our first choice.

Transposition of IAN

If the IAN was too deeply located or in presence of intra-surgical difficulties due to the lack of elasticity of IAN, a transposition was implemented using mini-invasive instruments. The medullary bone 3 mm mesial to the mental foramen was removed to intercept the incisive nerve. It was isolated and cut to allow better mobility and distal transposition of the mental nerve. Also in this case, resorbable collagen sponges were applied.

Three types of titanium implants from the same manufacturer (Winsix Implants, BIOSAFIN, Trezzano Rosa, Italy) were placed: TTx (Torque Type, external hexagon); TTi (Torque Type, internal hexagon) with a cylindrical shape and a conical apex; K (Kappa, internal hexagon with a different threads design) with a cylindrical shape. These implants have a micro rough surface (MRS) made by means of subtractive processes entailing sandblasting and acid-etching. All implants had a 3.8 mm diameter and different lengths (**TABLE 1**).

TABLE 1 CHARACTERISTICS OF THE INCLUDED PATIENTS

Inter-vention	Sex	Age	Partial/ Total Edentulism	Implant Position & Length	Bone height above mandibular canal	Total mandibular height	Type of implants
01 (L)	M	66	Partial	37 – 11mm 36 – 11mm 34 – 13mm	4 mm 4 mm 3 mm	12 mm 12 mm 13 mm	K K TTI
02 (L)	F	65	Partial	36 – 9mm 35 – 9mm	2 mm 3 mm	10 mm 10 mm	TTI TTI
03 (T)	F	58	Partial	37 – 9mm 35 – 11mm 34 – 11mm	4 mm 4 mm 3 mm	11 mm 12 mm 12 mm	TTx TTx TTx
04 (L)	M	72	Partial	35 – 11mm 36 – 11mm	2 mm 1 mm	13 mm 12 mm	TTI TTI
05 (L)	M	63	Partial	37 – 9mm 35 – 11mm 34 – 11mm	3 mm 4 mm 3 mm	9 mm 12 mm 12 mm	TTI TTI TTI
06 (T)	F	57	Partial	44 – 13mm 46 – 11mm	5 mm 2 mm	14 mm 13 mm	TTx TTx
07 (2T)	F	62	Total	35 – 13mm 32 – 13mm 42 – 11mm 45 – 13mm	3 mm 5 mm 4 mm 3 mm	14 mm 14 mm 13 mm 14 mm	TTx TTx TTx TTx
08 (2T)	M	70	Total	34 – 9mm 32 – 9mm 42 – 9mm 44 – 9mm	3 mm 3 mm 3 mm 5 mm	10 mm 10 mm 10 mm 10 mm	TTx TTx TTx TTx
09 (2T)	F	55	Total	36 – 11mm 34 – 9mm 32 – 11mm 42 – 11mm 44 – 9mm 46 – 11mm	5 mm 4 mm 5 mm 5 mm 3 mm 2 mm	12 mm 10 mm 11 mm 12 mm 9 mm 12 mm	TTI TTI TTI TTI TTI TTI
10 (2T)	F	69	Total	35 – 9mm 32 – 11mm 42 – 11mm 44 – 9mm 46 – 11mm	3 mm 5 mm 5 mm 3 mm 1 mm	10 mm 12 mm 12 mm 10 mm 11 mm	TTI TTI TTI TTI TTI
11 (2T)	F	65	Total	36 – 11mm 35 – 9mm 32 – 9mm 42 – 11mm 45 – 11mm	3 mm 5 mm 5 mm 3 mm 2 mm	11 mm 10 mm 10 mm 12 mm 12 mm	TTI TTI TTI TTI TTI

Inter-vention	Sex	Age	Partial/ Total Edentulism	Implant Position & Length	Bone height above mandibular canal	Total mandibular height	Type of implants
12 (2T)	M	75	Total	35 – 11mm 32 – 11mm 42 – 11mm 45 – 11mm	2 mm 3 mm 3 mm 1 mm	12 mm 12 mm 12 mm 12 mm	TTI TTI TTI TTI
13 (2T)	M	62	Total	35 – 13mm 32 – 13mm 42 – 11mm 45 – 11mm	3 mm 4 mm 3 mm 2 mm	15 mm 15 mm 12 mm 14 mm	TTI TTI TTI TTI
14 (2T)	F	68	Total	35 – 9mm 32 – 9mm 42 – 9mm 45 – 9mm	2 mm 3 mm 4 mm 3 mm	11 mm 12 mm 12 mm 12 mm	TTI TTI TTI TTI
15 (2T)	M	66	Total	35 – 11mm 32 – 11mm 42 – 11mm 45 – 11mm	6 mm 3 mm 2 mm 2 mm	15 mm 14 mm 13 mm 14 mm	TTI TTI TTI TTI
16 (2T)	F	63	Total	35 – 11mm 32 – 11mm 42 – 11mm 45 – 11mm	4 mm 5 mm 3 mm 2 mm	14 mm 15 mm 14 mm 14 mm	TTI TTI TTI TTI

L = Lateralization, T = Transposition, and 2T = Double Transposition. All implants had a 3.8 mm diameter.
TTx = Torque Type, external hexagon; TTi = Torque Type, internal hexagon; K = internal hexagon with a different threads design

The implant site preparation was performed following the drill sequence as described by the manufacturer, under abundant saline irrigation, to engage the lower cortex of the mandible to achieve higher primary stability. Implants were placed by a handpiece at low speed and without irrigation with an insertion torque greater than 50 Ncm. The exposed implant vestibular surfaces, accessing the mandibular canal, were covered by collagen sponges, on which the IAN vascular-nervous bundle was positioned. Healing screws at least 4 mm long were placed to have enough height compared to the thickness of the surrounding soft tissues. The remaining bone defect was filled with autologous bone taken with a bone scraper near the surgical site. Flap were then sutured by primary intention with Vicryl 4.0, leaving the healing screws exposed.

Prosthetic procedures

Immediate provisional prostheses were manufactured from a diagnostic impression obtained before surgery. Healing screws were removed and abutments were positioned. EA (Extreme Abutment) of the same implant brand were used since they allow to modify the vertical axis of emergency of the implant platform according to the occlusal plan. The access holes on the provisional prostheses were enlarged to make them fit onto the abutments. After checking the height and occlusal contacts of the provisional prosthesis, a self-curing resin was used to fill-in the gap between the prostheses and the abutments. In partially edentulous patients, whenever possible, the contacts in static and lateral occlusion were completely removed (non-occlusal immediate loading), whereas contacts were made homogeneous in full prostheses. Abutments were unscrewed with the provisional protheses which were finished and polished, and then screwed back with 25 Ncm torque. Prostheses were polished again after a second occlusal check. The definitive prothesis were delivered 6 months after implantation.

Antibiotic therapy was carried on for 6 days, taking 1 g of amoxicillin plus clavulanic acid or 0.3 g clindamycin every 12 hours and patients were suggested to take non-steroidal anti-inflammatory drugs (NSAIDs) to control pain once a day for at least 3 days.

Post-operative checks were performed immediately after surgery, and then at 1 day, 1, 2 and 4 weeks, 3 and 6 months, and 1 year.

The following clinical outcome variables were recorded:

- prosthesis failures, defined as the need of prothesis replacement for any reasons;
- implant failures; defined as the need of implant removal (mobile implants were considered failures);
- any complication;
- Neurosensory Dysfunction Test: test for the evaluation of skin sensitivity in reference to the functionality of the inferior alveolar nerve and mental nerve. A standardized and repeatable test, known as "2PD" (Two-point discrimination)[15,16], was applied before surgery and after 2-week, six months and one year. In brief, two compass points, defined as point A and point B, were used 15 mm apart. Point A was positioned in the center of the lower lip and point B at the indicated distance ipsilateral to where the surgery was performed. The patient had to indicate, with his eyes closed, whether he was able to discriminate the two points as separate. Answer "YES" the evaluation for sensitivity was positive; answer "NO" the evaluation for sensitivity was negative. In case sensitivity was improved but still negative the neurosensory dysfunction was considered partial recovered. The test was made by the surgeon who performed the transpositions (R.V.)

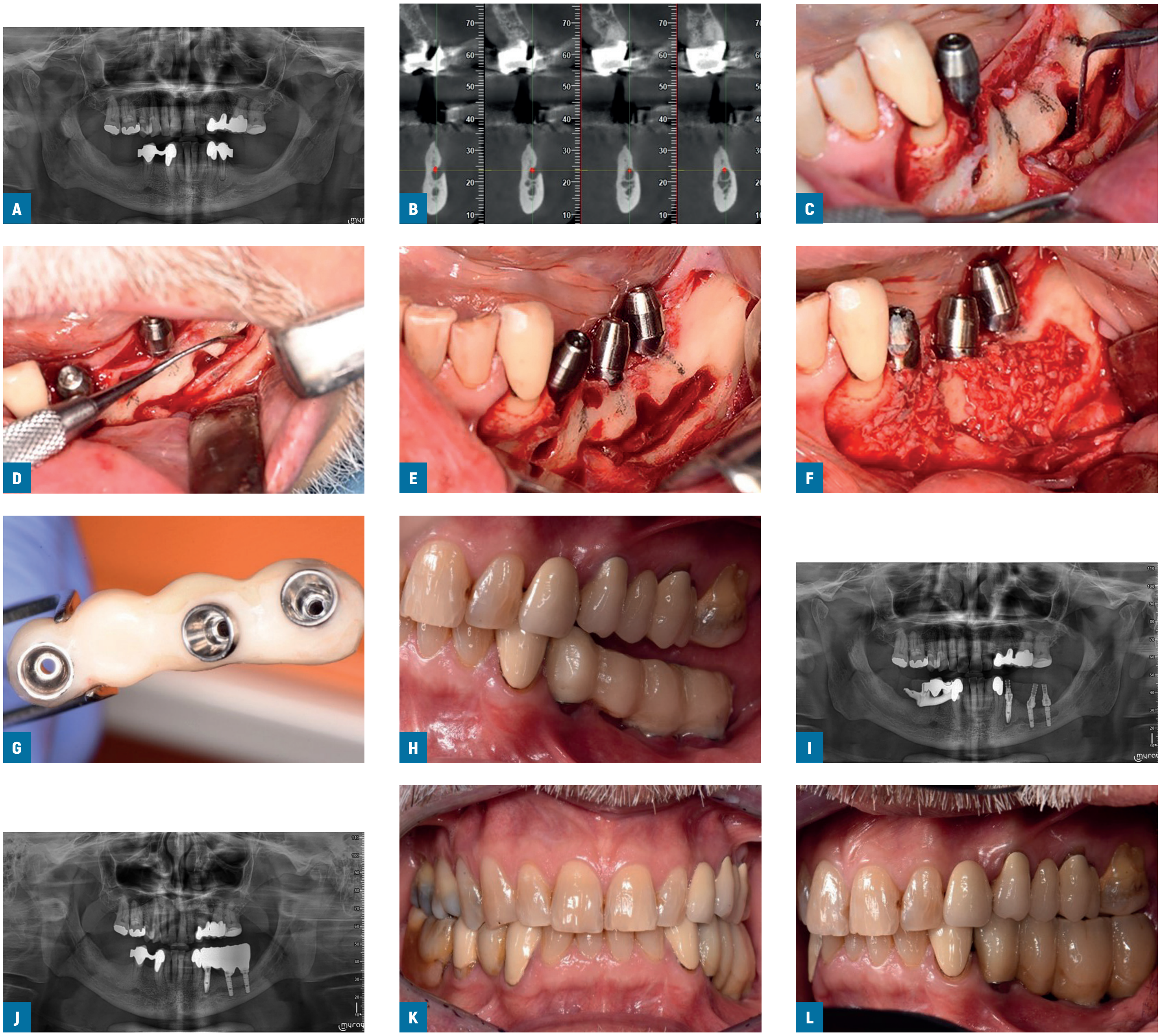
Since each patient's pre-operative and post-operative CBCT was saved in the records, it was possible, for the purpose of this study, to measure bone volumes above the mandibular canal at each implant site to allow readers to better understand why it was decided to implement a nerve transposition and not to place short implants. Screenshot of CBCTs were superimposed on each implant position to detect vertically and horizontally the available bone before implant placement to calculate the available bone height and width above the mandibular canal and the mandible height between crestal and apical basal bone. A single examiner (S.C.) performed volume, area, and linear measurements, retrospectively, without a specific calibration.

Statistical Analysis

Descriptive statistics were calculated using the Matrix Laboratory software (Microsoft Excel 2024, CA, USA). Variables are described as mean and standard deviation or median (interquartile range).

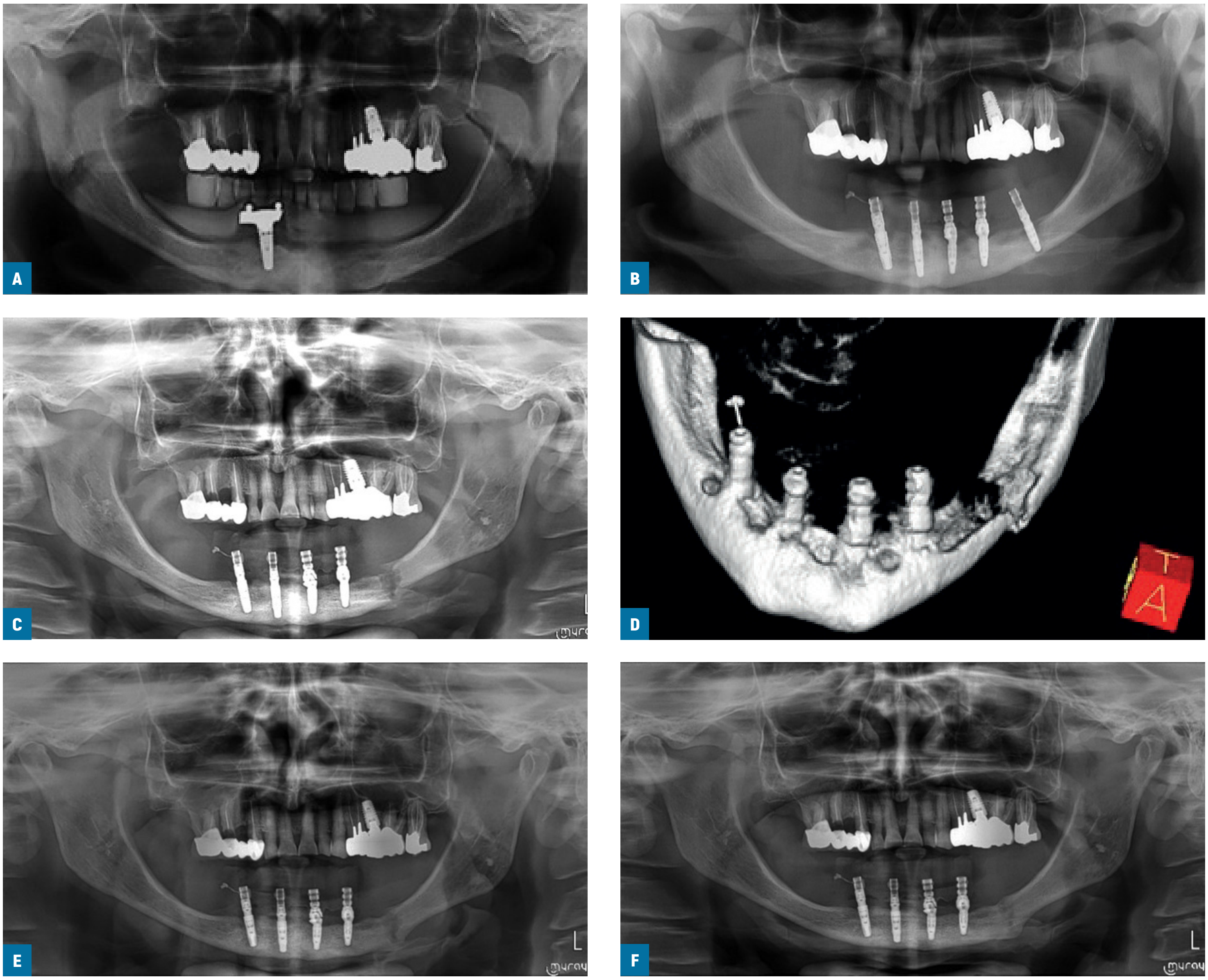
RESULTS

Data of 16 patients (7 males and 9 females) consecutively rehabilitated with 59 implants were collected (**TABLE 1**; **FIGS. 1 A-L**). No patient dropped out and all could be assessed at all planned time intervals. Patients aged 64.7 ± 5.4 years at the time of intervention. The mean available bone height above the mandibular canal was 3.3 ± 1.2mm (range 1 to 6 mm) highlighting the impossibility to place short implants and the mean total mandibular height was 12.1 ± 1.6 mm (range from 9 to 15 mm) suggesting a potential risk of post-operative mandibular fracture. Details of patients and procedures characteristics are presented in **TABLE 1**. Ten patients were treated with a cross-arch prostheses, while the other six with partial fixed prostheses.



FIGS. 1 A-L: *OPT of patient 1, a male aged 58 years with bilateral posterior mandibular edentulism (A). On the posterior left side a lateralization/transposition approach with immediate loading was suggested. Screenshot of CBCT in correspondence of mental nerve and of implants planned in position 36 and 37. The alveolar bone height in correspondence of mental nerve was of 7 mm and for sites 36 and 37 was 6 mm and 5 mm, respectively (B). Tooth 34 was extracted and an implant was immediately placed and the corticotomy to access the IAN was performed (C). The distal implant was placed managing the lateralization of the nerve (D); the third implant was placed (E) and the nerve was gently released on a collagen sponge (F). Resin provisional prothesis after polishing (G) and after positioning to check occlusal contacts (J). OPT just after immediate loading (K). 1 year after delivery of the definitive prosthesis: OPT (H), frontal (I) and lateral (L) pictures*

No intra-operative complications occurred. All patients presented episodes of minor inflammation, edema and paresthesia during the first days after implant placement. Five post-operative complications occurred in four patients: one mandibular fracture 3 weeks after implant placement and four cases of postoperative dysesthesia. The mandibular fracture determined the loss of the implant involved in the fracture line without affecting the provisional prosthesis which remained supported by four other implants. The fracture healed spontaneously after 4 months. During the healing period the patient ate soft food and took one painkiller a day for the first 2 weeks (**FIGS. 2A-F**). No other implant or prosthesis failed over the 1 year of follow-up. At 1-year post-loading four patients were still affected by partial paresthesia, but one of these patients had already it pre-operatively for other reasons.



FIGS. 2 A-F: *Pre-operative OPT for a planned double transposition (A); immediate post-operative OPT with the immediate loading of a full-arch fixed prothesis on five implants (B). Fracture of mandible 3 weeks after implants placement in OPT (C) and CBCT (D) immediately after the implant failed. Orthopantomography taken 2 months (E) and 6 months (F) after implant placement, showing complete fracture healing*

Neurosensory Dysfunction Test was evaluated before surgery and all patients did not report any neurosensory dysfunction with the exception for one patient who had a paresthesia caused by placement of an implant touching the emergence of the mental nerve. In **TABLE 2** the outcome of the individual sensory test after the surgery are reported.

TABLE 2 RESULTS OF THE NEUROSENSORY DYSFUNCTION TEST AT EACH TIME-POINT

Patient number	1 day	2 weeks	1 month	3 months	6 months	1 year
01 (L)	NSD	NSD	NSD	R	R	R
02 (L)	NSD	PR	PR	PR	PR	PR
03 (T)	NSD	NSD	NSD	PR	PR	PR
04 (L)	NSD	R	R	R	R	R
05 (L)	NSD	R	R	R	R	R
06 (T)	NSD	NSD	NSD	NSD	NSD	PR
07 (2T)	NSD	R	R	R	R	R
08 (2T)	NSD	R	R	R	R	R
09 (2T)	NSD	R	R	R	R	R
10 (2T)	NSD	NSD	NSD	NSD	NSD	NSD
11 (2T)	NSD	R	R	R	R	R
12 (2T)	NSD	R	R	R	R	R
13 (2T)	NSD	R	R	R	R	R
14 (2T)	NSD	R	R	R	R	R
15 (2T)	NSD	R	R	R	R	R
16 (2T)	NSD	R	R	R	R	R

L = Lateralization; T = Transposition; 2T = Double Transposition; NSD = Presence of Neurosensory Dysfunction; PR = partial recovery; R = complete recovery. Patient 03 had a neurosensory dysfunction before lateralization and Patient 11 had a post-operative mandibular fracture (FIGS. 2 A-F).

After 2 weeks eleven patients reported complete recovery from neurosensory dysfunction, two of them were treated with the lateralization procedure and nine the double transposition. At 1 month no changes were recorded compared with 2 weeks. At 3 months, the patient initially presenting neurosensory dysfunction before the surgery had a partial recovery and another patient who received a lateralization had complete recovery. At 6-month no other changes were recorded.

After 1-year, one patient, treated with a double transposition procedure still presented neurosensory dysfunction while three patients reported partial recovery, but one of them, as reported, had complete neurosensory dysfunction before the surgery due to previous implant surgery, while the patient who suffered from mandibular fracture recovered completely his neurological sensitivity.

DISCUSSION

Transposition and lateralization of the IAN, in the present study, have shown a high success rate at 1 year after implant placement with only one implant lost due to a mandibular fracture. These results are comparable to the results other studies[17,18], but implants in our study were loaded immediately. However, the main problem with this procedure is the possibility of the onset of neurosensory disorders which may be permanent. This altered sensitivity manifests itself in the form of hypoesthesia and from the results of the present study appears to be temporary in most of the cases but not solved after 1 year in four cases out of 16 patients. Other authors reported similar results[19-21].

A recent systematic review on these techniques highlighted that it is possible to place dental implants in atrophic posterior mandibles just after nerve relocation with high patient satisfaction, but till now the level of evidence is poor due to the high numbers of biases of the included studies[16]. Moreover, lateralization seems to cause less persistent neurosensory disturbances compared to transposition. None of included studies in that review performed immediate loading as in the present study. Just one case report presented immediate loading on implants placed with a modified technique of inferior alveolar nerve lateralization[22].

Autogenous bone grafts are commonly used to augment in height mandibular bone defects using intraoral donor sites, such as the symphysis and ramus of the mandible[23]. Autologous bone is considered the gold standard for augmentation procedures because of the osteogenic, osteoinductive, and osteoconductive properties[10,23]. Grafts can be used according to the inlay technique (also known as interpositional or sandwich technique) or as onlay directly on the area to be reconstructed to allow the placement of dental implants above the mandibular canal. The sandwich osteotomy technique was first described by Schettler in 1976 and it consisted of an interpositional graft of iliac bone[24]. One of the main difficulties was the management of soft tissues to preserve the blood supply of the displaced bone fragment. Furthermore, the original technique included harvesting bone from the iliac crest, which requires general anesthesia and hospitalization. In 2007, Marchetti and co-workers modified the technique by describing a dislocation of the mandibular crestal bone with concomitant preservation of the lingual periosteum to facilitate the healing process[25]. Considering the morbidity associated with intra- and extraoral bone grafting, different bone substitutes (allografts and xenografts) are widely used because of their decreased morbidity compared with autologous bone harvesting[26-30]. Some studies have compared different techniques for vertical bone augmentation of the posterior mandible with the interpositional technique and it seems that autologous bone blocs yielded similar clinical and radiological results compared with bovine anorganic blocs that was less invasive and may be preferable than harvesting bone from the iliac crest[31]. The main limitation of the interpositional technique is that at least 4 mm of bone must be available above the mandibular canal to make the procedure technically feasible. Onlay techniques represent an alternative to the inlay augmentation procedures, however the amount of vertical bone gain which can be obtained is a bit inferior than what can be obtained with interpositional grafting[32-34]. Bone substitutes block should not be used as onlay to augment mandibles due to the exceedingly high failure rates[35], moreover short implants, 4 to 6 mm long, achieved similar clinical results as longer implants placed in augmented bone up to 8 years after loading[4], so that short implants could be a preferable choice, especially in mandibles, since the treatment is faster and cheaper, and associated to a lower number of complications[7,10,36-38]. With the approach used in the present study, longer implants could be placed using all the available native bone in height allowing immediate loading in all treated patients. Therefore, the present protocol could be considered a treatment option for those patients with severely atrophic posterior mandibles wishing to have an immediate prosthesis in function.

In the present study the main complications occurred were the paresthesia and the mandibular fracture. While the fracture healed without negative sequelae, 1 year after loading four patients were still affected by paresthesia, thought three patients improved over time. It would be interesting to follow this cohort of patients up to 5 years to evaluate whether further decrease in paresthesia could occur over time.

The surgeon tried to perform lateralization whenever possible, because cutting the incisal nerve can induce a sensory deficit. Interestingly, in the presence of a higher degree of atrophy, the nerve is more superficial, making the procedure simpler and less traumatic.

The main limitations of the present study are its retrospective nature and the small sample size. However, the present technique can be predictable and effective but is a complex procedure. Computer-guided planning on CBCT with a bony-supported guided surgical mask could help in guiding the osteotomy over the mandibular canal, decreasing the risk of intra and post-surgical complications.

CONCLUSIONS

Whitin the limitation of this study, using all the native bone through lateralization or transposition techniques of the mandibular nerve allows for immediate loading to be performed with high success rates, making this rehabilitation protocol a valid therapeutic option for patients with severe mandibular bone atrophy, especially if requiring immediate protheses. However, there is a high risk of neuro-sensory disorders that tend to recover in one year. Randomized controlled trials with adequate sample sizes are needed to better evaluate this treatment option in relation to alternative treatment protocols.

REFERENCES

1. Covani U, Giammarinaro E, Panetta D, Salvadori PA, Cosola S, et al. Alveolar Bone Remodeling with or without Collagen Filling of the Extraction Socket: A High-Resolution X-ray Tomography Animal Study. J Clin Med. 2022;11(9):2493.
2. Tan WL, Wong TL, Wong MC, Lang NP. A systematic review of post-extractional alveolar hard and soft tissue dimensional changes in humans. Clin. Oral Implant. Res. 2012;23:1-21.
3. Cawood JI, Howell RA. A classification of the edentulous jaws. Int J Oral Maxillofac Surg. 1988;17(4):232-6.
4. Felice P, Barausse C, Pistilli R, Ippolito DR, Esposito M. Short implants versus longer implants in vertically augmented posterior mandibles: result at 8 years after loading from a randomised controlled trial. Eur J Oral Implantol. 2018;11(4):385-95.
5. Esposito M, Barausse C, Pistilli R, Piattelli M, Di Simone S, Ippolito DR, et al. Posterior atrophic jaws rehabilitated with prostheses supported by 5 × 5 mm implants with a nanostructured calcium-incorporated titanium surface or by longer implants in augmented bone. Five-year results from a randomised controlled trial. Int J Oral Implantol. 2019;12(1):39-54.
6. Felice P, Barausse C, Pistilli R, Ippolito DR, Esposito M. Five-year results from a randomised controlled trial comparing prostheses supported by 5 mm long implants or by longer implants in augmented bone in posterior atrophic edentulous jaws. Int J Oral Implantol. 2019;12:25-37.
7. Esposito M, Buti J, Barausse C, Gasparro R, Sammartino G, et al. Short implants versus longer implants in vertically augmented atrophic mandibles: A systematic review of randomised controlled trials with a 5-year post-loading follow-up. Int J Oral Implantol. 2019;12:267-80.
8. Felice P, Barausse C, Pistilli R, Kalemaj Z, Esposito M. Four-mm-long versus longer implants in augmented bone in posterior atrophic jaws: Three-year post-loading results from a multicentre randomised controlled trial. Clinical Trials in Dentistry. 2020;2:5-26.
9. Felice P, Pistilli R, Barausse C, Piattelli M, Buti J, Esposito M. et al. Posterior atrophic jaws rehabilitated with prostheses supported by 6 mm long 4 mm wide implants or by longer implants in augmented bone. Five-year post-loading results from a randomised controlled trial. Int J Oral Implantol. 2019;12:57-62.
10. Esposito M, Grusovin MG, Coulthard P, Worthington HV. The efficacy of various bone augmenta-

tion procedures for dental implants: a Cochrane systematic review of randomized controlled clinical trials. Int J Oral Maxillofac Implants. 2006;21(5):696-710.

11. Schwartz-Arad D, Levin L. Intraoral autogenous block onlay bone grafting for extensive reconstruction of atrophic maxillary alveolar ridges. J Periodontol. 2005;76(4):636-41.
12. Pimentel AC, Sanches MA, Ramalho GC, Roman-Torres CV, Manzi MR, et al. Lateralization Technique and Inferior Alveolar Nerve Transposition. Case Rep Dent. 2016;2016:4802637.
13. Allavéna J, Nicot R, Majoufre C, Schlund M. Inferior alveolar nerve repositioning surgical techniques and outcomes - a systematic review. J Stomatol Oral Maxillofac Surg. 2024;125(1):101631.
14. Menchini-Fabris GB, Toti P, Crespi R, Crespi G, et al. A Retrospective Digital Analysis of Contour Changing after Tooth Extraction with or without Using Less Traumatic Surgical Procedures. J Clin Med. 2022;11(4):922.
15. 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. Int J Oral Maxillofac Implants. 1997;12(4):463-71.
16. Abayev B, Juodzbalys G. Inferior Alveolar Nerve Lateralization and Transposition for Dental Implant Placement. Part II: a Systematic Review of Neurosensory Complications. J Oral Maxillofac Res. 2015;6(1):e3.
17. Rathod M, Kshirsagar RA, Joshi S, Pawar S, Tapadiya V, et al. Evaluation of Neurosensory Function Following Inferior Alveolar Nerve Lateralization for Implant Placement. J Maxillofac Oral Surg. 2019;18(2):273-9.
18. Jensen J, Reiche-Fischel O, Sindet-Pedersen S. Nerve transposition and implant placement in the atrophic posterior mandibular alveolar ridge. J Oral Maxillofac Surg. 1994;52(7):662-8.
19. Palacio García-Ochoa A, Pérez-González F, Negrillo Moreno A, Sánchez-Labrador L, Cortés-Bretón Brinkmann J, et al. Complications associated with inferior alveolar nerve reposition technique for simultaneous implant-based rehabilitation of atrophic mandibles. A systematic literature review. J Stomatol Oral Maxillofac Surg. 2020;121(4):390-6.
20. Ferrigno N, Laureti M, Fanali S. Inferior alveolar nerve transposition in conjunction with implant placement. Int J Oral Maxillofac Implants. 2005;20(4):610-20.
21. Kikuta S, Iwanaga J, Kusukawa J, Tubbs RS. Anatomical study: the potential movability of the inferior alveolar nerve. Oral Surg Oral Med Oral Pathol Oral Radiol. 2019;128(4):353-6.
22. Eldibany R, Rodriguez JG. Immediate loading of one-piece implants in conjunction with a modified technique of inferior alveolar nerve lateralization: 10 years follow-up. Craniomaxillofac Trauma Reconstr. 2014;7(1):55-62.
23. Laviv A, Jensen OT, Tarazi E, Casap N. Alveolar sandwich osteotomy in resorbed alveolar ridge for dental implants: a 4-year prospective study. J Oral Maxillofac Surg. 2014;72(2):292-303.
24. Schettler D. Sandwich technic with cartilage transplant for raising the alveolar process in the lower jaw. Fortschr Kiefer Gesichtschir. 1976;20:61-3.
25. Marchetti C, Trasarti S, Corinaldesi G, Felice P. Interpositional bone grafts in the posterior mandibular region: a report on six patients. Int J Periodontics Restorative Dent. 2007;27(6):547-55.
26. Minetti E, Gianfreda F, Bollero P, Annicchiarico C, Daniele M, et al. Comparative Histological Analysis of Dentine-Derived Tooth Grafts in Maxillary vs Mandibular Socket Preservation: A Retrospective Study of 178 Cases. Dent J (Basel). 2024;12(10):320.
27. Zhao R, Yang R, Cooper PR, Khurshid Z, Shavandi A, et al. Bone Grafts and Substitutes in Dentistry: A Review of Current Trends and Developments. Molecules. 202;26(10):3007.
28. Barone A, Ricci M, Mangano F, Covani U. Morbidity associated with iliac crest harvesting in the treatment of maxillary and mandibular atrophies: a 10-year analysis. J Oral Maxillofac Surg. 2011;69(9):2298-304.
29. Barone A, Toti P, Menchini-Fabris GB, Felice P, Marchionni S, et al. Early volumetric changes after vertical augmentation of the atrophic posterior mandible with interpositional block graft versus onlay bone graft: A retrospective radiological study. J Craniomaxillofac Surg. 2017;45(9):1438-47.
30. Dioguardi M, Spirito F, Quarta C, Sovereto D, Basile E, et al. Guided Dental Implant Surgery: Systematic Review. J Clin Med. 2023;12(4):1490.
31. Felice P, Marchetti C, Iezzi G, Piattelli A, Worthington H, et al. Vertical ridge augmentation of the atrophic posterior mandible with interpositional bloc grafts: bone from the iliac crest vs. bovine anorganic bone. Clinical and histological results up to one year after loading from a randomized-controlled clinical trial. Clin Oral Implants Res. 2009;20(12):1386-93.
32. Atieh MA, Alsabeeha NH, Payne AG, Ali S, Faggion CMJ, et al. Interventions for replacing missing teeth: alveolar ridge preservation techniques for dental implant site development. Cochrane Database Syst Rev. 2021;4(4):CD010176.
33. Gastaldi G, Felice P, Pistilli V, Barausse C, Ippolito DR, et al. Posterior atrophic jaws rehabilitated with prostheses supported by 5 × 5 mm implants with a nanostructured calcium-incorporated titanium surface or by longer implants in augmented bone. 3-year results from a randomised controlled trial. Eur J Oral Implantol. 2018;11(1):49-61.
34. Felice P, Pistilli R, Lizio G, Pellegrino G, Nisii A, et al. Inlay versus onlay iliac bone grafting in atrophic posterior mandible: a prospective controlled clinical trial for the comparison of two techniques. Clin Implant Dent Relat Res. 2009 Oct;11 Suppl 1:e69-82.
35. Pistilli R, Felice P, Piatelli M, Nisii A, Barausse C, et al. Blocks of autogenous bone versus xenografts for the rehabilitation of atrophic jaws with dental implants: preliminary data from a pilot randomised controlled trial. Eur J Oral Implantol. 2017;7(2):153-71.
36. Felice P, Pistilli R, Barausse C, Piattelli M, Buti J, et al. Posterior atrophic jaws rehabilitated with prostheses supported by 6-mm-long 4-mm-wide implants or by longer implants in augmented bone. Five-year post-loading results from a within-person randomised controlled trial. Int J Oral Implantol (Berl). 2019;12(1):57-72.
37. Esposito M, Pistilli R, Barausse C, Felice P. Three-year results from a randomised controlled trial comparing prostheses supported by 5-mm long implants or by longer implants in augmented bone in posterior atrophic edentulous jaws. Eur J Oral Implantol. 2014;7(4):383-95.
38. Felice P, Barausse C, Pistilli R, Ippolito DR, Esposito M. Five-year results from a randomised controlled trial comparing prostheses supported by 5-mm long implants or by longer implants in augmented bone in posterior atrophic edentulous jaws. Int J Oral Implantol (Berl). 2019;12(1):25-37.