Implant placement in the atrophic mandibular posterior region using the inferior alveolar nerve bypass technique after assessing the bone relative to the mandibular canal: A prospective interventional pilot study

ABSTRACT

Introduction: Rehabilitation of the atrophic posterior mandible is very challenging because the distance between the crest of the ridge and the inferior alveolar canal (IAC) is very less. Inferior alveolar nerve bypass is a technique in which implants are placed bypassing the nerve, lingually or buccally. The objectives are to assess the bone around the mandibular canal on buccal and lingual sides and place implants in the posterior region of the atrophic mandible using the inferior alveolar nerve bypass technique.

Materials and Methods: The bone with respect to IAC in 60 sites from 10 patients was assessed on both sides of the atrophic mandible. Measurements were taken at 10 mm, 20 mm, and 30 mm from the mesial aspect of the retromolar pad. After assessment, 20 implants were placed bypassing IAC in five patients, and postoperatively, neurosensitivity test was performed. Descriptive analysis was used to compare the different measurements from the retromolar pad on the right and left sides. Unpaired 't' test was used. A *P* value less than 0.05 was considered as statistically significant.

Results: The distance of the bone relative to IAC was statistically insignificant on right and left sides. Neurosensitivity test was negative on the first postoperative day. However, after the first and third months, there was positive response on the right side in 80% subjects and 100% on the left side.

Conclusions: Dental implants were placed successfully in the atrophic mandible, bypassing the IAC. IAC is placed more lingually toward the medial border of the retromolar pad and then becomes buccally in the premolar region. Buccal bypass is safer and easier than lingual bypass due to the lingual position of IAC.

Keywords: Atrophic mandible, dental implants, inferior alveolar canal, nerve bypass, posterior mandible

INTRODUCTION

Rehabilitation of the atrophic posterior mandible by implant placement is very challenging because the distance between the crest of the ridge and the inferior alveolar canal (IAC) is very less in atrophic cases.[1,2] The rate of mandibular resorption is approximately three to four times higher than maxillary resorption. Atrophy in the posterior region is more than in the anterior region; hence, denture fabrication is difficult in such cases due to poor retention and stability[3,4] and patients are unable to wear such dentures at all. Such patients are usually called oral invalids. There are many treatment options for implant placement in the atrophic mandible, like bone augmentation, use of short implants,

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guided bone regeneration, All-on-4, repositioning of nerves (lateralization/transposition), and nerve bypass. Every procedure has its own merits and demerits; thus, a judicious selection is required.

As per the literature, short implants are as effective as standard-length implants. Crestal bone loss is the main indicator of implant success, which is comparable between standard length implants and short implants. The advantages of short implants are less treatment time as compared to grafting, less discomfort to patients, no grafting procedure, less risk for neurosensory disturbances, and less cost.[5,6] However, sometimes, resorption is so severe that even short implants cannot be placed.

Bone augmentation is another method for implant placement in the atrophic posterior mandible, which usually needs prior soft tissue augmentation as well because a sufficient amount of attached and keratinized tissue is not there for achieving closure. Certain limitations of autografts include donor site morbidity, second surgical site, unpredictable resorption, and limited bone volume of graft. Augmentation procedures require two to three surgeries, which increases costs, time, greater risk of patient morbidity, and complications such as infection and graft loss.[7,8]

In the all-on-four technique, four implants are placed in the anterior region of jaws, in which two anterior implants are axially placed and two posteriors are tilted. Prosthesis is fabricated up to 12 teeth. The advantages of the all-on-four technique are a high success rate, reduction in posterior cantilever length, elimination of need of bone grafting, avoidance of injury to anatomical structures, and immediate loading. However, this procedure is very technique-sensitive and the length of the cantilever cannot be extended beyond limit; hence, the number of teeth is reduced in this technique.[9,10]

Implant-supported overdenture is a predictable treatment option for the atrophic posterior mandible. It can be supported by two to four implants in the anterior mandible. Implant-supported prosthesis prevents bone loss, improves chewing efficiency in comparison of complete denture, and improves stability and esthetics; however, it may not satisfy the psychological need of patients because it is removable prosthesis.[11,12]

Lateralization and nerve transposition are two methods of nerve repositioning. The main advantage of these procedures is there is no need to wait for a long duration or more surgeries as in bone augmentation procedures. However, it carries risk of neurosensory disturbances like hypoesthesia, paresthesia, and hyperesthesia, which resolve usually, but, in some cases, permanent deformation may occur.[13]

To avoid aforesaid complications, inferior alveolar nerve bypass is a new technique, in which implants are placed bypassing the nerve, lingually or buccally. The objectives of the present study are to assess the bone with respect to the mandibular canal on buccal and lingual sides and to place implants in the posterior region of the atrophic mandible using the inferior alveolar nerve bypass technique.

MATERIAL AND METHODS

Study design

This study is a prospective interventional pilot study. Complete edentulous patients with the atrophic mandible were selected from the outdoor patient department. Ethical clearance was obtained from Institute Ethics Committee with Ref no. Dean/2018/EC/373 dated 02.01.2018. Informed consent was signed by the patients after explaining the details of the procedure.

Data collection

Twenty-eight subjects were assessed for qualifying the eligibility criteria. A total of 60 sites in ten subjects were taken for assessment of the inferior alveolar canal position, and 20 implants in five subjects were placed bypassing the nerve [Figure 1]. Each subject received four implants in the posterior mandible, that is, two implants in the right and two implants in the left region.

Inclusion criteria

Inclusion criteria were 1) patients with less than 6 mm bone height above the top of the inferior alveolar canal, 2) patients aged 20–70 years, 3) patients without any debilitating illness, and 4) cooperative and motivated patients who were ready to go for a nerve bypass and gave an informed consent.

Exclusion criteria

Exclusion criteria were 1) patients with history of smoking, alcohol, and drug abuse; 2) pregnant females; 3) ongoing steroid therapy, chemotherapy, or radiotherapy; 4) uncontrolled diabetes mellitus; and 5) presence of acute and chronic systemic disorders that can affect wound healing responses.

Pre-surgical procedure

Complete medical and dental history of subjects was taken. Intraoral and extraoral examinations were performed. Orthopantomogram (OPG) was done, and mandibular atrophy was assessed [Figure 2a and b]. Cone beam computed tomography (CBCT) was performed to examine

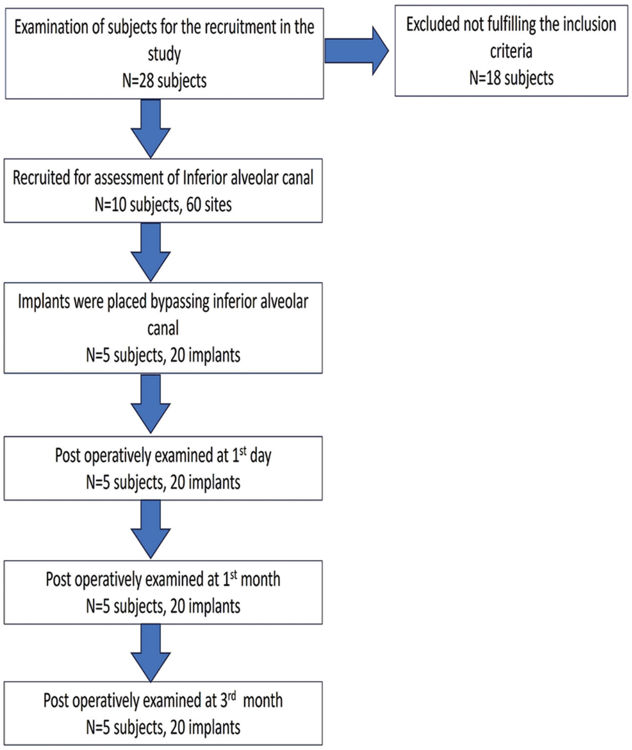

Figure 1: Flow chart of subject participation

the three-dimensional architecture of the mandible [Figure 3]. The bone beneath the retromolar pad revealed a different architecture as compared to the bone surrounding this Therefore, the retromolar pad bone was taken as a stable land mark and a vertical line was drawn on the mesial aspect of the retromolar pad bone and three points at 10 mm, 20 mm, and 30 mm from this line were taken on the body of the mandible to assess the dimensions of the bone relative to the inferior alveolar canal on these points [Figure 4a]. The distance was calibrated from the superior border of the canal to the alveolar crest, from the inferior margin of the canal to the lower border of the mandible, from the lingual margin of the canal to the lingual cortical plate, and from the buccal margin of the canal to the buccal cortical plate and the diameter of the canal at the said locations [Figure 4b] and designated as A, B, C, D, E, F, and G, respectively [Table 1].

Based on the aforesaid readings, customized single-piece implants of commercially pure titanium (cp-Ti) were designed and fabricated for all the selected subjects so that its lowermost threads engage the inferior cortical plate of the mandible/buccal cortex of the mandible and the uppermost thread is at least 2 mm below the lower aspect of the inferior alveolar canal. The implant dimension at the apex was 2.5 mm (outer diameter), and the width of the threaded portion gradually increased to 3.5 mm (outer diameter) in the most crestal thread. The internal diameter was 2.2 mm

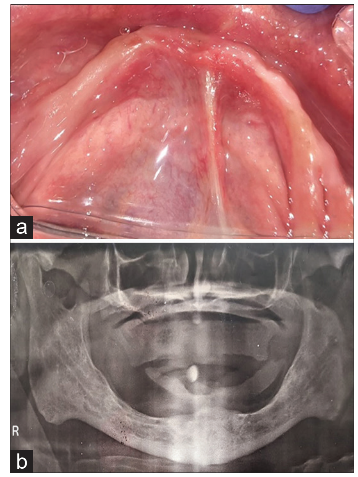

Figure 2: (a) Edentulous preoperative mandibular ridge; (b) Preoperative OPG of edentulous mandibular ridge

Table 1: Designations from the inferior alveolar canal to the various aspects

Designation	Description
X	10 mm distance from mesial border of retromolar pad
Y	20 mm distance from mesial border of retromolar pad
Z	30 mm distance from mesial border of retromolar pad
A	Alveolar crest to top of IAC
B	Width at mandibular crest
C	Distance between buccal margin of IAC and buccal cortical plate
D	Distance between lingual margin of IAC and lingual cortical plate
E	Distance between alveolar crest and inferior border of mandible
F	Distance between inferior margin of IAC and inferior border of mandible
G	Diameter of IAC

throughout, except at the tip, where it was pointed. Implants were made up of soft titanium (grade 1 cp-Ti) to be bent easily and do not fracture because of higher ductility due to low oxygen content. 2.2 mm of the smooth narrow portion was there below the head of implant to accommodate soft tissue and facilitate bending of implants.

Surgical phase

The patient was premedicated with antibiotics and analgesics 1 day prior to the surgery. On the day of surgery, extraoral part preparation was done with 7.5% betadine scrub, and 0.2% chlorhexidine mouthwash was used as preprocedural rinse. 2% lidocaine with 1:80,000 adrenaline was administered intraorally for local infiltration in the mandibular posterior region. Nerve blocks were not given to get the patient's feedback and to avoid nerve injury. After anesthesia, a mid-crestal incision was done and flap was raised to expose the bone at the surgical site. Here, the external oblique ridge and buccal surface of the mandible were key guiding landmarks for orienting the drill. The implant was self-tapped into prepared osteotomy. Osteotomy was started with lance drill and then extended by 2 mm pilot drill to full length. Customized single-piece implants made up of commercially pure titanium were placed. Flap was approximated and sutured. Postoperative instructions were given to patients. Patients were advised to continue the medications for 7 days and to maintain proper oral hygiene. Patients were recalled after 24 hours to assess pain, swelling, and numbness.

Neurosensitivity tests included subjective clinical sensory testing methods such as static light touch detection test (SLTDT), brush directional discrimination test (BDDT), thermal discrimination test cold (TDTC), and thermal discrimination test hot (TDTH), which were performed postoperatively at the 1st day, 1st month, and 3rd month, following implant placement. In light touch detection test, the patient closes his eyes and says "yes" whenever he feels a light touch to the face and points to the exact spot where he felt the touch. In brush directional test, the patient tells if any sensation is detected and in which direction the filament or brush moved. In thermal discrimination test (cold and hot), different instruments can be used for thermal testing, including thermodes and Minnesota thermal disks, and ice, ethyl chloride sprays, acetone, and water. In all the tests, yes or no response was noted.[14]

Prosthetic phase

After implant placement, abutment preparation was performed [Figure 5a] and impressions were taken with polyvinyl siloxane impression material. Impressions were sent to the laboratory for further prosthetic work [Figure 5b]. Metal bar (cobalt chrome) was fabricated with 2 mm thickness. A minimum gap of 2 mm was present between the bar and mucosa to avoid tissue impingement. The bar was tied in the patient's mouth [Figure 6a]. Wax rims were fabricated on bar. Horizontal and vertical jaw relations were taken with wax occlusal rims. Teeth arrangement was done, and denture trial was performed in the patient's mouth [Figure 6b].

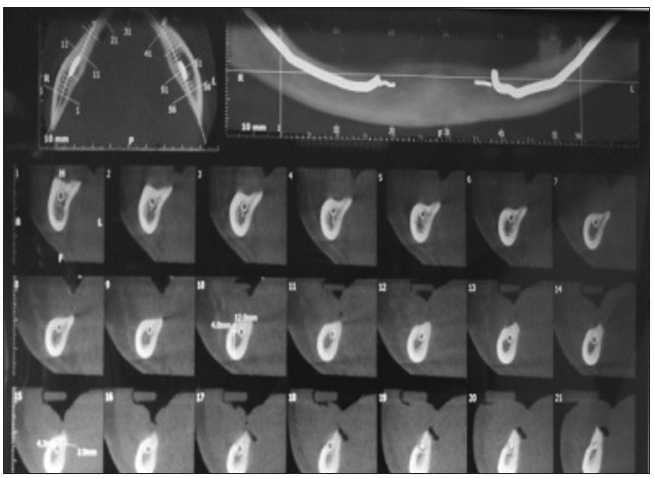

Figure 3: Preoperative CBCT

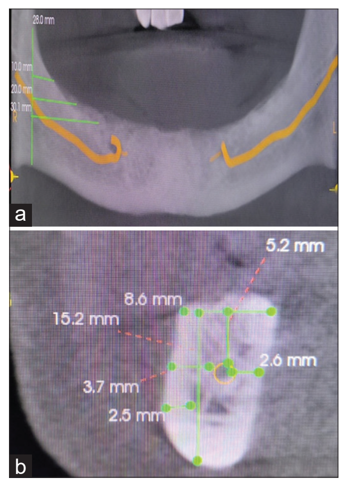

Figure 4: (a) CBCT showing IAC and distance from the retromolar pad; (b) Measurements from the Inferior alveolar canal

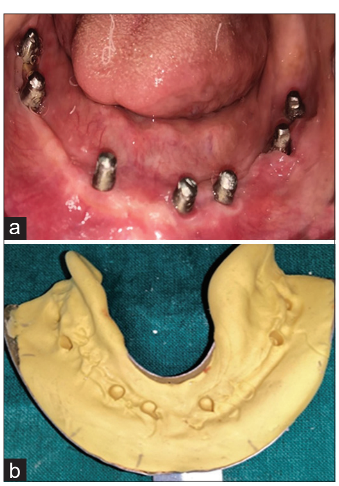

Figure 5: (a) Abutment preparation after implant placement; (b) Impression making

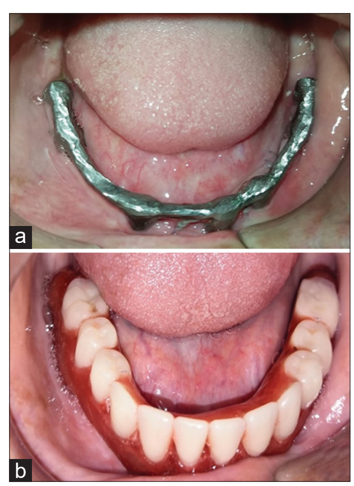

Figure 6: (a) Metal bar trial; (b) Denture trial

After curing, final prosthesis was checked for occlusion in centric and eccentric position and was cemented [Figure 7]. Postoperative OPG [Figure 8] and CBCT [Figure 9] were taken.

Statistical analysis

All the data were tabulated in Excel and subjected to statistical analysis using SPSS version 21. Descriptive analysis was used to compare the different measurements from the retromolar pad on right and left sides. Unpaired 't' test was used. A P value less than 0.05 was considered as statistically significant. Mann–Whitney test was applied to assess the data collected from neurosensitivity test.

RESULTS

In this study, seven males and three females with an average age of 69.4 years were assessed for the IAC position and quantity of bone relative to IAC. Measurements were taken at 10 mm (X), 20 mm (Y), and 30 mm (Z) distances from the mesial border of the retromolar pad bone on both sides of the mandible, and a total of 60 sites were assessed and the measurements are presented in Table 2. The average distance between the buccal aspect of IAC and the facial aspect of the buccal cortical plate is maximum at the X-location, that is, 10 mm (4.89 mm on the right side and 5.29 mm on the left side of the mandible) from the medial border of the retromolar pad, which is the site of the third/second molar usually, and minimum at the Z-location, that is, 30 mm (3.63 mm on the right side and 4.34 mm on the left side) from the medial border of the retromolar pad, which is usually the site of the second premolar. Therefore, implant placement bypassing the IAC is safer in the X-location than at the Z-location. The difference in value of A, B, C, D, E, F, and G at X, Y, and Z locations was statistically insignificant on right and left sides.

After assessing the IAC position and quantity of bone relative to IAC, 20 customized single-piece implants in five subjects (i.e., 4 implants per subject) were placed after the nerve by pass technique in the atrophic posterior mandibular region. Neurosensitivity test was negative on the 1st day postoperatively. However, after 1 month and 3 months, there was positive response in 80% patients on the right side

Figure 7: Final prosthesis

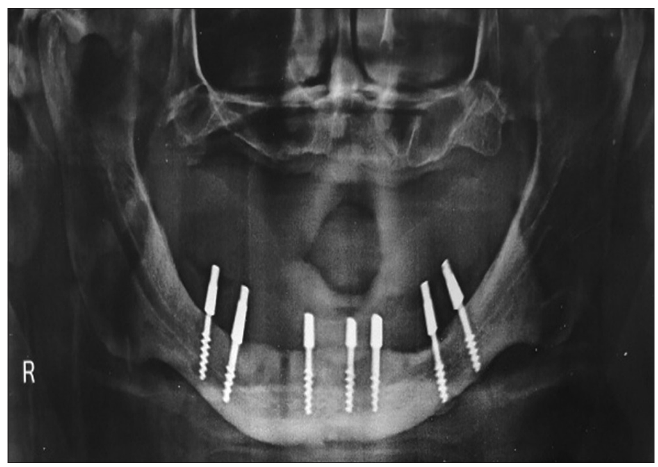

Figure 8: Postoperative OPG after implant placement

Figure 9: Postoperative CBCT showing implant placement after nerve bypass

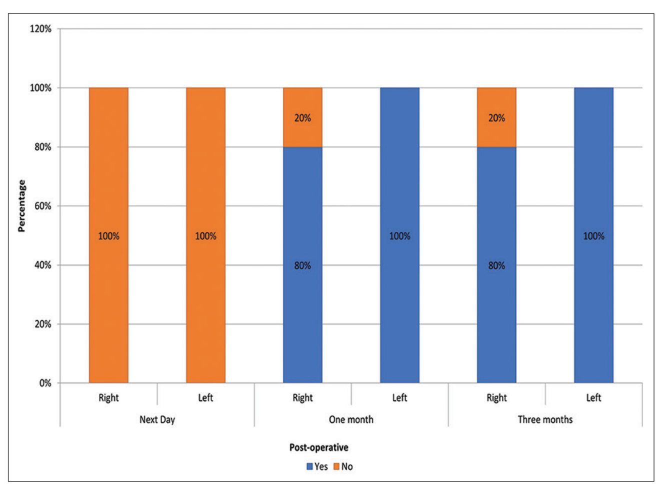

Figure 10: Results of neurosensitivity test

Table 2: Assessment of IAC at three different locations from retromolar pad

Measurements	Side	10 mm from Retromolar pad (X)		20 mm from Retromolar pad (Y)		30 mm from Retromolar pad (Z)	
		Mean±SD mm	*P* (unpaired *t* test)	Mean±SD Mm	*P* (unpaired *t* test)	Mean±SD mm	*P* (unpaired *t* test)
A	Right	3.74±0.74	0.716*	3.64±0.88	0.923*	3.42±0.98	0.876*
	Left	3.92±0.94		3.63±1.11		3.33±1.2	
B	Right	7.63±1.66	0.511*	7.41±1.76	0.306*	7.36±1.69	0.395*
	Left	8.05±1. 07		8.13±1.25		7.91±1.05	
C	Right	4.89±0.79	0.411*	4.30±0.62	0.190*	3.63±0.74	0.165*
	Left	5.28±1.23		4.84±1.08		4.34±1.35	
D	Right	2.53±0.96	0.864*	2.49±0.87	0.938*	2.71±0.75	0.712*
	Left	2.46±0.82		2.46±0.82		2.83±0.67	
E	Right	12.32±2.01	0.924*	12.17±1.79	0.762*	12.17±1.86	0.826*
	Left	12.22±2.56		11.87±2.50		11.95±2.49	
F	Right	8.62±2.22	0.720*	8.53±1.85	0.726*	8.75±1.89	0.770*
	Left	8.29±1.80		8.24±1.78		8.51±1.71	
G	Right	1.97±0.37	0.903*	1.97±0.37	0.953*	1.97±0.37	0.953*
	Left	1.95±0.34		1.98±0.36		1.98±0.36	

*Statistically insignificant (the *P* value was less than 0.05)

Table 3: Response to neurosensitivity test

Test	Response	Next day			One month			Third month		
		Right	Left	*P*	Right	Left	*P*	Right	Left	*P*
SLTDT	Yes	0%	0%	1*	80%	100%	0.317*	80%	100%	0.317*
	No	100%	100%		20%	0%		20%	0%	
BDDT	Yes	0%	0%	1*	80%	100%	0.317*	80%	100%	0.317*
	No	100%	100%		20%	0%		20%	0%	
TDTC	Yes	0%	0%	1*	80%	100%	0.317*	80%	100%	0.317*
	No	100%	100%		20%	0%		20%	0%	
TDTH	Yes	0%	0%	1*	80%	100%	0.317*	80%	100%	0.317*
	No	100%	100%		20%	0%		20%	0%	

SLTDT: Static light touch detection test. BDDT: Brush directional discrimination test. TDTC: Thermal discrimination test cold. TDTH: Thermal discrimination test hot. *The *P* value was less than 0.05 (statistically insignificant)

and 100% on the left side [Table 3 and Figure 10]. Results of neurosensitivity test were statistically insignificant between the right side and left side of the mandibular posterior region.

DISCUSSION

Edentulism results into reduced masticatory efficiency and residual ridge resorption. The mandible has lesser overall basal seat surface area, and the presence of the tongue complicates the problem.[3] Thus, retention and optimum functions become a problem with conventional denture stability. In such cases, even the surgical guides are not very helpful in placing implants because of the low stability and unpredictable implant placement. Therefore, relying on surgical landmarks and acumen of the surgeon is preferable.

In the present study, ten complete edentulous cases with extreme atrophy of mandibular ridges were assessed for location of IAC and bone available relative to this at 60 sites. The results of the present study showed that the third or second molar site is safer as compared to the second premolar because the average distance between the buccal aspect of IAC and the facial aspect of the buccal cortical plate is more. Standard length implants of 10 mm can be placed even in these extremely atrophied cases. Levine *et al.* (2007)[15] performed a study in which the average distance between the buccal cortical margin of IAC to the buccal cortical margin of the mandible was 4.6 mm in whites and 5.9 mm in nonwhites. They have shown a decline in distance between the buccal aspect of IAC and the facial aspect of the buccal cortex with increasing age. Yeh *et al.* (2018)[16] performed a study in France and stated that the average distance between the buccal margin of IAC and the buccal cortical plate changes from the distal of the second molar to the mesial of the first molar was 5.8 ± 1.2 mm to 4.4 ± 1.1 mm, respectively.

In the present study, the average available bone between the lingual margin of IAC to the lingual cortex is maximum at the Z-location (2.71 mm on the right side and 2.83 mm on the left side) and minimum at the X-location (2.53 mm on right and 2.46 mm on left side), but the difference is insignificant. Therefore, implant placement by lingual bypass is difficult as compared to buccal bypass as it may cause nerve injury. Kilic *et al.* (2009)[17] performed a study on Turkish population and reported that IAC is closer to the lingual cortex in the third molar region in edentulous, partially edentulous, and dentulous groups. In the first and second molar regions, IAC was closer to the lingual side for dentulous and partially dentulous groups, but in the edentulous group, buccal and lingual distances were nearly the same. Gowgiel *et al.* (2018)[18] reported that upon dissection, the neurovascular bundle was always close to the lingual cortex. Pyun *et al.* (2011)[19] stated that IAC is located slightly lingual at the mandibular first and second molar positions. IAC is more buccally placed in the second premolar position.

Kim *et al.* (2009)[20] classified the buccolingual position of IAC into three types: a) Type 1 (70%) IAC followed the lingual cortical plate within the mandibular body and ramus; b) Type 2 (15%) IAC followed the middle of the ramus behind the second molar and the lingual plate passing through the second and first molar; c) Type 3 (15%) IAC followed the middle or lingual one third of the mandible from the ramus to the body.

In the present study, the average diameter of IAC was nearly the same at all locations (X, Y, Z) from the mesial border of the retromolar pad. The mean maximum diameter of the canal was 1.98 mm on the right side and 1.97 mm on the left side, which is based on Indian population. Rajchel *et al.* (1986)[21] performed a study on Asian population (in Thailand) and stated that the diameter of IAC was 2 mm to 2.4 mm, lower. Obradovic *et al.* (1993)[22] performed a study in Seria and reported that the diameter of IAC was 2.6 mm, Ikeda *et al.* (1996)[23] performed a study in USA and reported that the diameter was 3.4 mm, Sato *et al.* (2005)[24] performed a study on Japanese cadaver and stated that the diameter was 5 mm, and Kilic *et al.* (2009)[17] performed a study on Turkish population and reported that the mean maximum diameter of the mandibular canal was 2.52 mm.

In the present study, the average distance between the superior aspect of IAC and the alveolar crest was 3.74 mm on the right side and 3.92 mm on the left side, less than 6 mm. Kilic *et al.* (2009)[17] reported that this distance was 14.06 mm. Levine *et al.* (2007)[15] reported this distance was 17.4 mm in dentulous patients. Thus, the cases selected for this study had extremely resorbed ridges.

The mean maximum distance between the bottom of the canal and the base of the mandible was 8.75 mm on the right side and 8.51 mm on the left side of the mandible. Kilic *et al.* (2010)[17] reported that the mean of this distance in their study was 10.52 mm. Gowgiel *et al.* (1992)[18] found that this distance was 10 mm in histological examination on cadavers. Yu and Wong (2008)[25] reported that the distance from the inferior margin of the canal to the mandibular base was 7.6 mm.

IAN repositioning is a predictable treatment option for placement of implants in the atrophic mandible. The main advantage of these procedures is that there is no need to wait for a long duration or multiple surgeries as is in the case of bone augmentation procedures. However, it carries risk of neurosensory disturbances like hypoesthesia, paresthesia, and hyperesthesia, which resolve usually, but in some cases, permanent deformation may occur.[8]

To minimize patient discomfort, long treatment duration, and multiple surgeries, inferior alveolar nerve bypass is a technique in which implant is placed by bypassing the IAN lingually or buccally. In the present study, five complete edentulous patients were operated and a total of 20 implants were placed bypassing the IAN. All implants were successful after an average period of 6 months. Neurosensitivity tests were performed after 24 hours of implant placement on both sides of the mandible, and responses to these tests were negative (100%). One month and 3 months later, responses to these tests were 100% positive on the left side and 80% positive on the right side. Only in one patient on the right side, sensation was diminished; however, he had no functional problem in chewing, swallowing, smiling, laughing, or talking. This sensory loss recovered completely after 6 months. In postoperative CBCT, there was 0.9 mm distance between the implant surface and the buccal aspect of IAC in this patient, while in all other cases, this distance was more than 1.2 mm. Mild pressure may be the reason for loss of sensation. Hirsch *et al.* (1995)[26] evaluated neurosensory disturbances after IAN transposition and lateralization and found that nerve function was restored after 3.8 weeks in lateralization cases and 5.7 weeks after transposition. Morrison *et al.* (2002)[27] performed 26 IAN transpositions in 15 patients and stated that up to 1 month of neurosensory disturbances were present in all patients. Hashemi *et al.* (2010)[28] evaluated neurosensory disturbances in 82 patients for IAN lateralization and stated that all patients showed neurosensory disturbances in the first week, but it decreased to 26% after the first month, and after 6 months, it reduced to 3% and remained the same at the end of 1 year. Lorean *et al.* (2013)[29] performed 68 IAN repositionings and 11 nerve transpositions and stated that the duration of short-term transient neural disturbances was 0–4 weeks. No permanent neurosensory disturbances were observed. Khajehahmadi *et al.* (2013)[30] reported that after nerve lateralization and transposition, numbness of lower lip was present up to 1 week. After 3 months, lip sensation was normal in both groups except in one patient, in which this was present at the end of 12 months. Rathod *et al.* (2018)[31] reported 100% restoration of neurosensory function after the IAN lateralization procedure in ten patients. They reported that on the first postoperative day, all patients showed neurosensory disturbances. 20% cases recovered after 4 months, and after 6 months, recovery was 100%.

Data of the present study are more likely to be noncomparable with the previously published studies as approximately all mentioned studies were performed in other countries and this study was performed in India. IAC position and bone around the canal might differ from these aforesaid studies because these are related to different human races. The limitations of the present study are a small sample size and assessment of IAC only in edentulous patients having an extremely resorbed ridge.

CONCLUSION

Within the limitation of the current study, it has been concluded that IAC is more lingually placed toward the medial border of the retromolar pad and then becomes buccally in the premolar region. Implant placement bypassing the nerve buccally is safer than lingual bypass. Standard length implants can be placed by the nerve bypass technique. Response to neurosensitivity tests were negative on the first postoperative day. One month and 3 months later, response to tests was positive 100% on the left side and 80% on the right side, although it recovered completely after 6 months.

List of Abbreviations:

Abbreviations	Definition
OPG	Orthopantomogram
IAC	Inferior alveolar canal
CBCT	Cone beam computed tomography
LTDT	Light touch detection test
BDDT	Brush directional discrimination test
TDTC	Thermal discrimination test cold
TDTH	Thermal discrimination test hot

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Conflicts of interest

There are no conflicts of interest.

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