Partial Lateralization of the Nasopalatine Nerve at the Incisive Foramen for Ridge Augmentation in the Anterior Maxilla Prior to Placement of Dental Implants: A Retrospective Case Series Evaluating Self-Reported Data and Neurosensory Testing

Istvan Urban, DMD, MD, PhD[1]
Sascha A. Jovanovic, DDS, MS[2]
Daniel Buser, Prof Dr Med Dent[3]
Michael M. Bornstein, Prof Dr Med Dent[4]

The objective of this study was to assess implant therapy after a staged guided bone regeneration procedure in the anterior maxilla by lateralization of the nasopalatine nerve and vessel bundle. Neurosensory function following augmentative procedures and implant placement, assessed using a standardized questionnaire and clinical examination, were the primary outcome variables measured. This retrospective study included patients with a bone defect in the anterior maxilla in need of horizontal and/or vertical ridge augmentation prior to dental implant placement. The surgical sites were allowed to heal for at least 6 months before placement of dental implants. All patients received fixed implant-supported restorations and entered into a tightly scheduled maintenance program. In addition to the maintenance program, patients were recalled for a clinical examination and to fill out a questionnaire to assess any changes in the neurosensory function of the nasopalatine nerve at least 6 months after function. Twenty patients were included in the study from February 2001 to December 2010. They received a total of 51 implants after augmentation of the alveolar crest and lateralization of the nasopalatine nerve. The follow-up examination for questionnaire and neurosensory assessment was scheduled after a mean period of 4.18 years of function. None of the patients examined reported any pain, they did not have less or an altered sensation, and they did not experience a "foreign body" feeling in the area of surgery. Overall, 6 patients out of 20 (30%) showed palatal sensibility alterations of the soft tissues in the region of the maxillary canines and incisors resulting in a risk for a neurosensory change of 0.45 mucosal teeth regions per patient after ridge augmentation with lateralization of the nasopalatine nerve. Regeneration of bone defects in the anterior maxilla by horizontal and/or vertical ridge augmentation and lateralization of the nasopalatine nerve prior to dental implant placement is a predictable surgical technique. Whether or not there were clinically measurable impairments of neurosensory function, the patients did not report them or were not bothered by them. (Int J Periodontics Restorative Dent 2015;35:169–177. doi: 10.11607/prd.2168)

[1]Assistant Professor, Graduate Implant Dentistry, Loma Linda University, Loma Linda, California, USA; Director, Urban Regeneration Institute, Budapest, Hungary.
[2]Academic Chair, Global Institute for Dental Education (gIDE), Los Angeles, California, USA; Private Practice, Los Angeles, California, USA.
[3]Professor and Chairman, Department of Oral Surgery and Stomatology, School of Dental Medicine, University of Bern, Bern, Switzerland.
[4]Associate Professor, Department of Oral Surgery and Stomatology, School of Dental Medicine, University of Bern, Bern, Switzerland.

Correspondence to: Dr Istvan A. Urban, Urban Regeneration Institute, Sodras utca 9, Budapest, Hungary 1026; fax: +3612004447; email: istvan@implant.hu.

In the literature, the nasopalatine canal is described as being located in the midline of the palate, posterior to the maxillary central incisors.[1] The canal begins at the nasal floor with an opening at either side of the septum (known as the foramina of Stenson).[2] The two canals often merge on their way to the palate. The funnel-shaped oral opening of the canal in the midline of the anterior palate is known as the *incisive foramen* and

is usually located immediately below the incisive papilla. The canal contains the nasopalatine (incisive) nerve and the terminal branch of the descending nasopalatine artery, as well as fibrous connective tissue, fat, and small salivary glands.[3,4] Regular anatomical features and variations of the nasopalatine canal have been described and can be classified into three groups[5–9]: (1) a single canal, (2) two parallel canals, and (3) variations of the Y-shape type of the canal with one palatal opening and two or more nasal openings.

Patients usually consider the esthetic outcome of dental implant therapy in the anterior maxilla an essential factor—often even surpassing functional aspects.[10–12] Implant contact with neural tissue may result in failure of osseointegration or lead to sensory dysfunction.[6,13] In view of these potential complications, the morphology and dimensions of the nasopalatine canal should be properly evaluated prior to placement of dental implants to replace missing maxillary central incisors.[14] Invasive procedures such as enucleation, application of a bone graft and subsequent implant insertion,[15] or placement of dental implants directly into the canal for rehabilitation of the severely atrophied maxilla[16] have been presented when considering treatment modalities in or near this sensitive region.

The objective of this study was to assess implant therapy with staged guided bone regeneration (GBR) in the anterior maxilla by lateralization of the nasopalatine nerve and vessel bundle. The primary outcome variables of this investigation were measurements of neurosensory function following augmentative procedures and implant placement using a standardized questionnaire and clinical examination.

Method and materials

Patient selection

This retrospective study reported on patients referred for implant therapy in the anterior maxilla who were treated with a lateralization of the nasopalatine nerve and vessel bundle from February 2001 to December 2010 using a staged approach. All included patients presented with a bone defect in the anterior maxilla in need of a horizontal and/or vertical ridge augmentation prior to dental implant placement. Only patients in good physical health and the ability to maintain good oral hygiene were treated with bone-grafting procedures. All patients were fully informed about the entire treatment prior to the surgeries and gave written consent for the procedure. Patients were not eligible for this treatment if they were current smokers, reported excessive alcohol consumption, or had uncontrolled systemic conditions or periodontal disease.

Surgical procedure

Patients were operated on under general or local anesthesia. Patients were premedicated with amoxicillin (2 g) 1 hour before surgery and took 500 mg penicillin three times a day for 1 week following surgery. In the event of a penicillin allergy, clindamycin (600 mg) was used for premedication and following surgery (300 mg four times a day for 1 week). Patients were instructed to rinse with 0.2% chlorhexidine solution for 1 minute to disinfect the surgical site, and a sterile surgical drape was applied to minimize the potential contamination from extraoral sources. A local anesthetic (Septanest with adrenaline, 1:100,000, Septodont) was applied.

The flap design was chosen to ensure a primary, tension-free closure after the bone-grafting procedure due to the increased dimension of the ridge. Therefore, a remote flap was performed, including a midcrestal incision into the keratinized gingiva and vertical releasing incisions with a surgical scalpel. The two divergent vertical incisions were placed at least one tooth away from the planned augmentation site. In edentulous areas, the vertical incisions were placed at least 5 mm away from the augmentation site. After primary incisions were made, periosteal elevators were used to reflect a full-thickness flap beyond the mucogingival junction and at least 5 mm beyond the bone defect. On the palatal side, the flap was elevated to include the neurovascular bundle of the nasopalatine canal and to visualize the incisive foramen of the canal (Figs 1 and 2). A nonresorbable, titanium-reinforced expanded polytetrafluoroethylene (e-PTFE) barrier membrane (Gore-Tex Regenerative Membrane, Titanium-Reinforced, W. L. Gore & Associates)

or titanium-reinforced high-density PTFE membrane (Cytoplast Ti-250 Titanium-Reinforced Membrane, Osteogenics Biomedical) was fixated to at least two points on the palatal side with titanium bone tacks (Master Pin Control, Meisinger) and/or titanium screws (Pro-Fix Tenting Screw, Osteogenics Biomedical) to retract and reflect the neurovascular bundle from the canal and site of surgery (Fig 3). During the entire intervention, care was taken not to cut or damage the neurovascular bundle. Either particulated autogenous bone from intraoral donor sites (ramus or chin) or a combination of autogenous bone and anorganic bovine bone-derived mineral (ABBM; Bio-Oss, Geistlich) was placed into the region of the incisive foramen of the canal. The autogenous particulated bone graft or composite bone graft also was placed horizontally and vertically in the area of the defect (Fig 4). The membrane was then folded to cover the augmented area and affixed with additional titanium pins on the buccal side (Fig 5). Once the membrane was fixated, the flap was mobilized to allow for a tension-free, primary closure using periosteal releasing incisions. Further details regarding vertical and horizontal ridge augmentation have been published in previous studies.[17,18]

The surgical site was allowed to heal for at least 6 months before placement of dental implants with concomitant membrane and screw/pin removal (Fig 6). All patients received fixed implant-supported restorations and entered into a tightly scheduled maintenance program.

Figs 1 to 6 *A single representative case of a partial surgical lateralization of the nasopalatine nerve and vessel bundle.*

Fig 1 (left) *Buccal and* (right) *occlusal views of the anterior maxillary site show the missing central incisors with prominent incisive papillae.*

Fig 2 *Occlusal view after elevation of a mucoperiosteal full-thickness flap. The nasopalatine nerve and vessels are reflected with the palatal flap without severing these structures.*

Fig 3 *A titanium-reinforced polytetrafluoroethylene (PTFE) membrane is fixated with titanium pins in between the canal and the palatal flap to serve as a barrier between the augmentation of the alveolar crest and the neurovascular bundle.*

Fig 4 *Autogenous particulated bone graft is used to augment the deficient ridge and the nasopalatine canal.*

Fig 5 *Occlusal view of the nonresorbable PTFE membrane after augmentation.*

Fig 6 (right) *Occlusal view of the regenerated ridge after 8 months of healing upon insertion of the dental implants. Note that the previous site of the canal is now part of the crest (*) and that the neurovascular bundle is part of the palatal mucoperiosteal flap (arrow).*
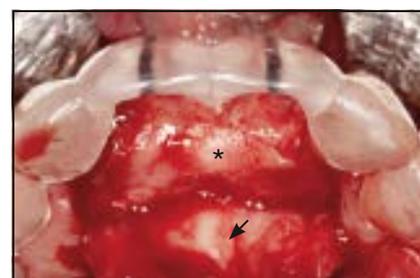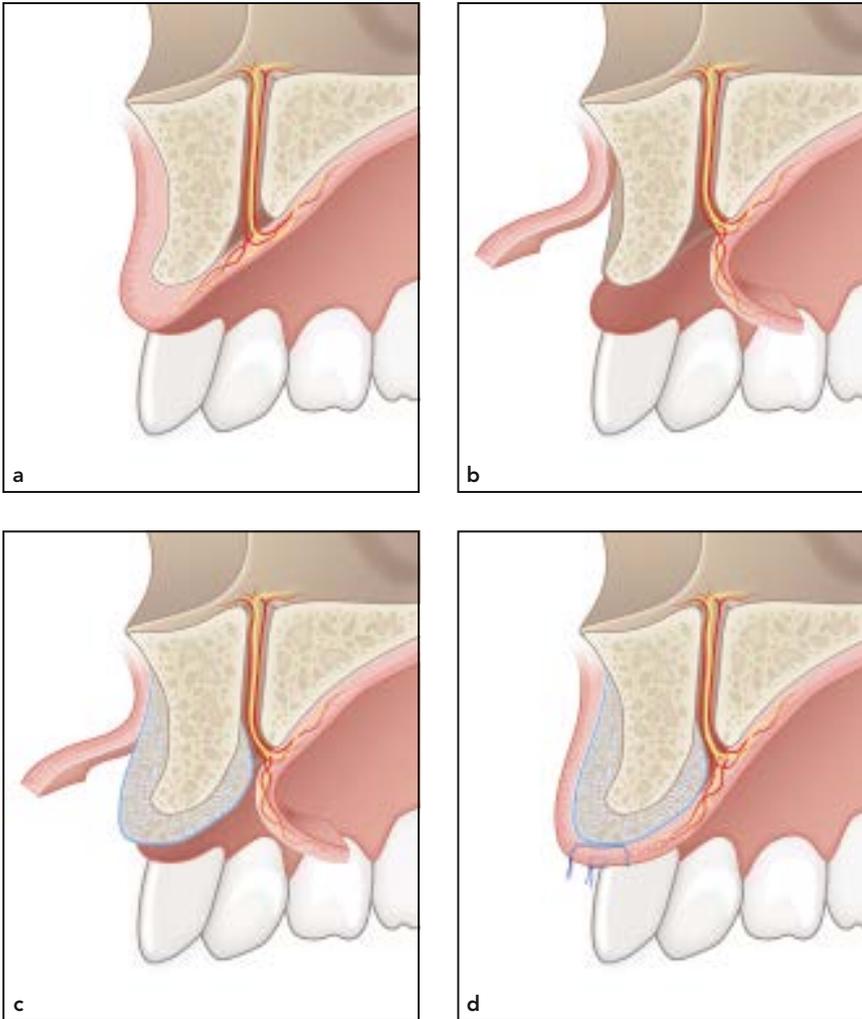
Fig 7 *Schematic drawing illustrates the principles of the surgical procedure. (a) The nasopalatine canal is located posterior to the maxillary central incisors, begins at the nasal floor (foramina of Stenson), has an oral opening in the midline of the anterior palate (incisive foramen), and contains the nasopalatine (incisive) nerve and the terminal branch of the descending nasopalatine artery. In this illustration, the central incisor is missing, and the alveolar process exhibits signs of bone resorption. (b) A remote flap procedure is performed, including a midcrestal incision into the keratinized gingiva. On the palatal side, the flap is elevated to include the neurovascular bundle of the nasopalatine canal and to visualize the incisive foramen of the canal. (c) After posterior deflection/lateralization of the neurovascular bundle, autogenous particulated or composite bone graft is placed into the region of the incisive foramen of the canal and also horizontally and vertically in the area of the defect. The membrane (blue line) is then folded to cover the augmented area. (d) Once the membrane is stabilized, the mucoperiosteal flap is mobilized to permit tension-free, primary wound closure using periosteal releasing incisions.*

The schematic drawings in Fig 7 depict the principles of the procedure.

Follow-up examinations

In addition to the maintenance program, patients were recalled for a clinical examination and to answer a questionnaire to assess any changes in the neurosensory function of the nasopalatine nerve at least 6 months after function. The patients were asked the following questions:

1. Do you have pain in the area of augmentation/implant placement (yes/no)?
2. Do you have less or altered sensation in the area of surgery (yes/no)?
3. Do you have a "foreign body" feeling in the area of surgery (yes/no)?
4. Are you satisfied with the outcome (graded from 0 [no] to 5 [perfect])?
5. Would you do the same procedure again (yes/no)?

In addition, a neurosensory test was carried out using a blunted needle to check for any changes in sensations by gently touching the surface of the oral mucosa. The palatal sensibility of the soft tissues in the region of the

Table 1 Overview of patients and surgical sites treated with horizontal/vertical ridge augmentation and lateralization of the nasopalatine nerve

Patient	Sex	Age* (y)	Extension of defect size/gap	Number of implants inserted	Graft composition	Healing time Graft (mo)	Implant (mo)	Loading (y)
1	M	28	5 teeth	3	Autograft	15	8	10.5
2	F	33	4 teeth	3	Autograft	6.5	7	10
3	F	46	2 teeth	2	Autograft	8	6	8
4	F	52	6 teeth	5	Autograft + ABBM	9	12	7
5	F	51	4 teeth	3	Autograft + ABBM	10	10	6
6	F	32	1 tooth	1	Autograft + ABBM	7	6	6
7	F	42	4 teeth	4	Autograft + ABBM	8	7.5	5.5
8	F	32	1 tooth	1	Autograft + ABBM	8	7	5.5
9	M	29	1 tooth	1	Autograft + ABBM	12	8	4.5
10	F	29	2 teeth	2	Autograft + ABBM	8.5	12.5	1
11	M	34	1 tooth	1	Autograft + ABBM	9.5	6.5	3.5
12	F	24	4 teeth	4	Autograft + ABBM	9.5	7	3
13	F	22	1 tooth	1	Autograft + ABBM	8	5.5	3
14	F	22	2 teeth	2	Autograft + ABBM	16.5	10.5	1.75
15	F	31	4 teeth	4	Autograft + ABBM	9.5	24	0.58
16	F	52	2 teeth	2	Autograft + ABBM	10	7.5	2
17	F	34	4 teeth	2	Autograft + ABBM	6.5	5.5	2
18	F	54	5 teeth	3	Autograft + ABBM	8	8	1.5
19	F	44	4 teeth	4	Autograft + ABBM	12	10	0.75
20	F	34	5 teeth	3	Autograft + ABBM	8.5	10.5	0.125

M = male; F = female; autograft = autogenous bone; ABBM = anorganic bovine-derived bone mineral.
*Patient's age at time of bone grafting.

maxillary canines and incisors was evaluated and graded as normal, hypersensitivity, hyposensitivity, or anesthesia as indicated by the patient.

Statistical analysis

All data were first analyzed descriptively. Kruskal-Wallis and nonparametric analysis of variance tests using the method described by Brunner et al[19] were applied to evaluate the influence of age, sex, extension of the gap, number of dental implants inserted, and tooth location on neurosensory outcomes. The level of significance for all tests was $P < .05$. All statistical tests were performed using R 2.15.1 (R 2.15.1 for Windows, Institute for Statistics and Mathematics of the WU).

Results

Twenty patients participated in this investigation from February 2001 to December 2010. The mean age was 36.3 years (range: 22 to 54 years), and the group comprised 3 men and 17 women (Table 1). The mean time period from augmentation of the alveolar crest and nerve lateralization to dental implant placement was 9.5 months (range: 6.5 to 16.5 months). Healing in all 20 grafting

| Table 2 | Overview of the neurosensory assessment of the palatal sensibility of the palatal mucosa at the region of the maxillary canines and incisors* |||||||

	Tooth no.*						Sample (N = 20)
	13	12	11	21	22	23	
Hypersensitivity	0	0	1	1	0	0	1 (5%)
Hyposensitivity	0	1	3	3	0	0	5 (25%)
Anesthesia	0	0	0	0	0	0	0 (0%)
Normal	20	19	16	16	20	20	14 (70%)

*FDI tooth-numbering system.

procedures was uneventful; there were no signs of infection or premature membrane exposure. After insertion of a total of 51 dental implants (2.55 implants per patient), a mean period of 9 months (range: 5.5 months to 2 years) was allowed for osseointegration before prosthetic restoration and loading. During the follow-up period, all cases were clinically and radiographically stable without signs of peri-mucositis or peri-implantitis resulting in a 100% survival and success rate. The follow-up examination for questionnaire and neurosensory assessment was scheduled after a mean period of 4.18 years of function (range: 1.5 months to 10.5 years).

Analysis of the questionnaire data

None of the 20 patients examined during the follow-up visit reported any pain in the area of augmentation/implant placement, and they did not have less or an altered sensation in the area of surgery and did not experience a "foreign body"

feeling. The patients graded their subjective satisfaction with the procedure with a mean value of 4.9 on a 5-point scale (19 patients gave a 5, and only 1 gave a 3). When asked whether they would undergo the same surgical and prosthodontic therapy again, 18 patients (90%) gave a favorable answer, and 2 patients (10%) said they would not do it a second time.

Analysis of the neurosensory assessment

The neurosensory tests of the palatal sensibility of the soft tissues in the maxillary anterior region revealed that the oral mucosa of the canines reacted normally to irritation with the blunted needle. Of the soft tissues in the region of the lateral incisors, only one area exhibited hyposensitivity. As for the mucosal area of the central incisors, two regions reacted with hypersensitivity, and six with hyposensitivity. There were no cases of anesthesia (Table 2). Overall, 6 patients out of 20 (30%) showed at least one soft

tissue region with a neurosensory alteration at a mean period of 4.18 years after restoration. Thus, the risk of a neurosensory change after ridge augmentation with lateralization of the nasopalatine nerve was 0.45 mucosal teeth regions in the anterior maxilla (canine to canine) per patient.

Age (P = .410), sex (P = .781), extension of the gap (P = .452), and number of dental implants inserted (P = .321) were not significant variables for changes of the neurosensory status. Only tooth location was a statistically significant parameter for neurosensory changes (P < .01), with the palatal mucosa in the region of the central incisors indicating the greatest risk.

Discussion

Due to the close anatomical relationship between the nasopalatine canal and the roots of the maxillary central incisors, insertion of dental implants to replace missing teeth in this region is considered a surgically challenging procedure. Furthermore, as the anterior maxilla is known to be a region with high esthetic, phonetic, and functional demands, ideal positioning of dental implants is only possible when based on accurate treatment planning.[12,20] Recent publications showed that the facial bone wall in the anterior maxilla (ie, esthetic zone) is often thin (less than 1 mm).[12,21] In a recent study analyzing the patient pool referred to a specialty clinic for implant surgery over a 3-year period, 78.6% of the

dental implants inserted in the anterior maxilla were combined with a simultaneous and 7.5% with a staged GBR procedure to compensate for bone resorption after tooth loss.[22] The technique presented in this case series is reserved for less frequent clinical situations with buccal bone resorption and unfavorable position or shape of the nasopalatine canal and incisive foramen. In such cases, buccal bone grafting alone would still result in facial malpositioning of the dental implants due to the position and dimension of the nasopalatine canal.

Quite invasive procedures have been presented to deal with the nasopalatine canal, such as enucleation, application of autogenous cancellous bone harvested from the chin, and subsequent implant insertion. In a case series of four patients, none complained about a change of sensation in the anterior palate in the follow-up examinations, and they were unaware of any changes when asked directly.[15] Nevertheless, an objective neurosensory assessment was not performed with the patients treated. A similar technique with augmentation of the nasopalatine canal using a mixture of demineralized freeze-dried bone and tricalcium phosphate and placement of dental implants directly into the canal has been described by Scher.[23] In the present case series, the course, morphology, or shape of the canal was not altered by surgical means. The surgical approach was quite conservative and tried to spare the neurovascular structure of the nasopalatine canal by combining

horizontal and vertical bone grafting with a lateralization of the vital structures in the region of the incisive foramen only.

Artzi et al[24] described a technique to graft the anterior maxilla with simultaneous placement of dental implants without removal of the nasopalatine nerve and vessels. The authors inserted a corticocancellous chin block graft from the symphyseal area into the incisive foramen, thus pushing the nasopalatine nerve branches posteriorly. In the case described, sensation was normal at all times, although the method of neurosensory function assessment was not further specified by the authors. In the present study, a slightly modified approach is presented. First, all sites were rehabilitated using staged GBR in the anterior maxilla and lateralization of the nasopalatine nerve and vessel bundle. In a second surgical intervention, dental implants were placed with concomitant membrane and screw/pin removal. Subjective assessment of the neurosensory status following these interventions using a standardized questionnaire demonstrated that none of the patients were experiencing pain, they did not have less or an altered sensation, and did not experience a "foreign body" feeling in the area of surgery. Nevertheless, objective testing of the palatal sensibility using a blunted needle revealed that 6 patients out of 20 (30%) experienced at least one tooth with neurosensory alteration. The most frequent finding was hyposensitivity. Hypersensitivity was found

palataly to only one tooth in one patient, and no cases of anesthesia were encountered.

In a recent study from the Netherlands, the authors used a similar lateralization technique of the nasopalatine nerve by mobilizing the bundle to the palatal side combined with augmenting the site with autogenous bone harvested from the retromolar region in five patients.[25] In that study, implants were inserted after a healing period of 3 months. The authors reported that postoperatively three patients (60%) perceived an altered sensation in the palate, but those complaints resolved spontaneously within 3 months. Objective assessment of the sensibility of the palate after 12 months was done using a wisp of cotton and a needle. In all five patients tested, no disturbance was observed. Similar findings regarding sensory alterations were also reported in a sensibility study from Spain, in which dental implants were positioned in the nasopalatine canal in a case series of seven patients.[16] Five patients experienced minor sensory alterations during the first weeks after surgery. At the long-term follow-up 3 to 7 years after the intervention, all patients expressed a normal sensation upon neurosensory examination of the anterior palate with a periodontal probe. The differences in those findings of the neurosensory assessments compared to the data in the present study may be attributed to the larger sample size, the differences in the time point after surgery when performing neurosensory testing (weeks to

years), and the separate evaluation of the palatal sensation at the oral mucosa of each tooth in the anterior maxilla from canine to canine. It has to be pointed out that for the present case series the time points for the neurosensory assessments were not standardized, and, therefore, ranged from 1.5 months to 10.5 years after implant placement due to the retrospective nature of the study. Thus, it may be possible that transient neurosensory disturbances could not have been accounted for in the present investigation. Nevertheless, the other studies mentioned all concurred that whether there were objective impairments of neurosensory function or not, the patients did not report them or were not bothered by them when asked.

Similar findings also were reported for other minor oral surgical interventions in the anterior palate. A prospective study evaluating sensory disorders after separation of the nasopalatine nerve during removal of impacted and palatally displaced maxillary canines revealed no subjective or objective neurologic impairments more than 4 weeks after the intervention.[26] A retrospective analysis that included a control group in which the neural structure had been left intact during surgery showed similar results.[27] In that study, 5 of 45 patients (11%) in whom the neurovascular structure was separated during the operation had a small area of altered sensation, but the author stated this was not significant, neither for the patient nor statistically between the two groups.

That patients are not bothered by minor sensory alterations, most often a reduced sensibility following surgical interventions in the anterior palate, is in clear contrast to altered skin/mucosal sensation after surgical trauma due to implant placement in the region of the mental foramen or transpositioning of the inferior alveolar nerve, which has been frequently reported in the literature.[28–33] Therefore, anatomical characteristics and variations of the path of the mandibular canal, mental foramen, and incisive canal are often described in the context of surgical intervention in this area.[34–36]

Conclusions

On the basis of the data from the present study, the following can be concluded:

- Regeneration of bone defects in the anterior maxilla by horizontal and/or vertical ridge augmentation and lateralization of the nasopalatine nerve and vessels prior to dental implant placement is a predictable surgical technique when applying strict patient inclusion criteria.
- Self-reported questionnaire data demonstrated that none of the 20 patients in the study reported any pain, altered sensation, or a "foreign body" feeling in the area of surgery.
- Six patients (30%) experienced at least one soft tissue region with a neurosensory alteration.

Thus, the risk of a neurosensory change after augmentation with lateralization of the nasopalatine nerve was 0.45 mucosal teeth regions in the anterior maxilla (canine to canine) per patient.

- Only tooth location was a statistically significant parameter for neurosensory changes ($P < .01$) with the palatal mucosa in the region of the central incisors having the greatest risk. Age, sex, extension of the gap, and number of dental implants inserted were not significant variables.

Acknowledgments

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