Int. J. Oral Maxillofac. Surg. 2009; 38: 139–145
doi:10.1016/j.ijom.2008.11.017, available online at http://www.sciencedirect.com

International Journal of
Oral &
Maxillofacial
Surgery

Clinical Paper
Pre-Implant Surgery

Clinical survey of neurosensory side-effects of mandibular parasymphyseal bone harvesting

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L. Sbordone, G. B. Menchini-Fabris, P. Toti, C. Sbordone, L. Califano, F. Guidetti: Clinical survey of neurosensory side-effects of mandibular parasymphyseal bone harvesting. Int. J. Oral Maxillofac. Surg. 2009; 38: 139–145.

Abstract. The aim of the present survey was to assess neurosensory disturbances and/or tooth-pulp sensitivity losses after mandibular parasymphyseal bone-harvesting procedures. Twenty-eight harvesting areas in 16 patients were surveyed. Mucosal and skin sensitivity of the chin/lower lip, divided into four regions, were determined via Pointed-Blunt and Two-Point-Discrimination Tests. Pulp sensitivity of the mandibular teeth from the left second bicuspid to the right second bicuspid was tested by cold vitality preoperatively and 12 months postoperatively. Teeth were grouped according to sensitivity alterations and distance from the harvesting defects, as measured on CT scans, and statistically significant differences sought. At 12 months, 29% of preoperatively vital cuspids overlying the harvesting defects revealed pulp-sensitivity losses; no patient reported anaesthesia or analgesia; hypoaesthesia was present in 4% (8 sites; 2 patients), hypoalgesia was present in 3% (5 sites; 2 patients) and Two-Point-Discrimination Tests yielded pathologic responses in 5% of tested areas (10 sites; 4 patients). Teeth with and without pulp sensitivity changes were statistically indistinguishable regarding distances between root apices or mental foramen and the harvesting defect. The loss of pulp sensitivity in any tooth cannot be predicted simply on the basis of the distance between its apex and the harvesting osteotomy line.

Keywords: chin bone graft; mandibular parasymphyseal bone harvesting; pulp sensitivity loss; hypoaesthesia; hypoalgesia.

Accepted for publication 13 November 2008
Available online 6 January 2009

Autologous bone grafts provide rapid, predictable results in terms of reconstructed bone quality and quantity, and are considered the ‘gold standard’[1]. The mandible is the most accessible site for autogenous bone harvesting, providing a number of advantages: highly dense cortical grafts of intramembranous origin; minimal resorption; good maintenance of osseous density; no cutaneous scarring; and good patient compliance[7].

Mandibular bone can be harvested from the ramus or the symphysis[7]. Bone harvesting from the mandibular ramus may result in fewer complications than chin harvesting, but surgical access may, in some cases, be more difficult than in the anterior mandible[7]. Harvesting symphyseal bone grafts offers several advantages: easier access; bone type and quantity suitable for most augmentation procedures; low morbidity; short operating time; outpatient procedures; and minimal graft resorption[7]. Immediate complications, including postoperative pain and swelling, wound dehiscence, infection and haematoma formation, have been described[4]. The reported short- and long-term neurosensory disturbances include changes in lip sensibility (hypoaesthesia or anaesthesia) and alteration or loss of pulp sensitivity in the lower front teeth[4,9,10,15]. Recently, a parasymphyseal harvesting approach has also been described[2] (Fig. 1a).

The purpose of this study is to estimate the frequency of, and identify factors associated with, inferior alveolar nerve and pulpal injuries following harvesting mandibular parasymphyseal autogenous bone grafts. It also aims to verify whether the radiographically detected distances between the harvesting defect margins and sensitive anatomical structures are associated with an increased risk of nerve injuries.

Materials and methods

Study design/sample

A retrospective chart review was conducted of patients receiving mental bone harvesting for osseous augmentation procedures from January 2002 to December 2004. Consecutive patients affected by maxillomandibular atrophy requiring osseous reconstruction and seeking implant-supported fixed restorations were considered. Patients who did not require osseous reconstruction or implant placement in the anterior mandibular region, from second right to second left bicuspid underwent mental bone harvesting via a parasymphyseal approach and were included in the study.

Surgical methods

Patient suitability for parasymphyseal harvesting procedure was assessed by preoperative CT scan. All surgery was performed under general anaesthesia. 2% mepivacain with epinephrine (20 mg/ml + 12.5 μg/ml) was administered locally to reduce bleeding. One or two blocks, depending on need, were harvested from the parasymphyseal area, according to the procedure described by Balaji[2], but using a horizontal mucosal incision 5 mm apical to the muco-gingival junction. No material was used to fill the residual defect in the donor area.

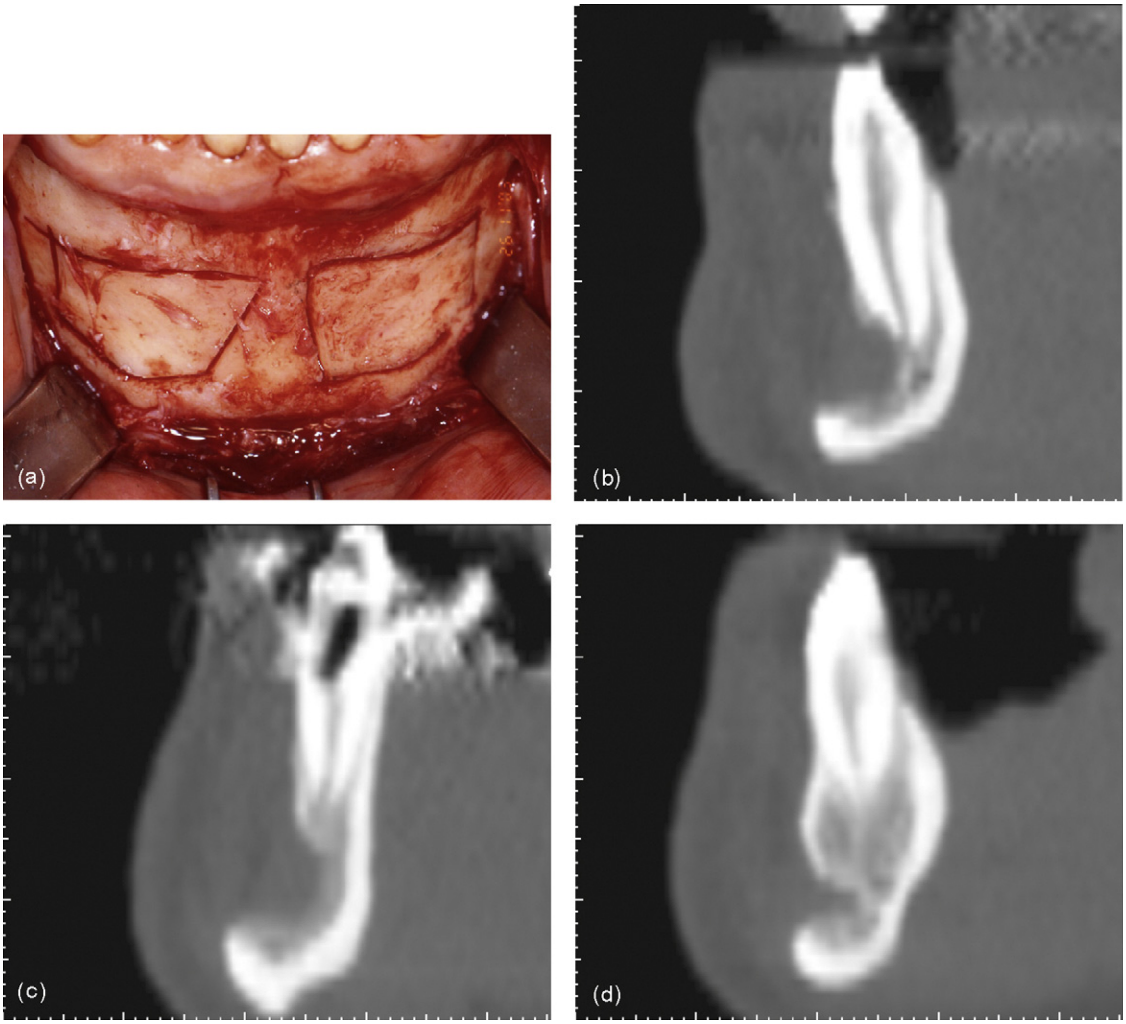

Fig. 1. (a) Bilateral mandibular parasymphyseal bone-block harvesting sites with osteotomy lines; CT of mandibular parasymphyseal bone-block harvesting sites: (b–c) CT cross-sectional image of donor sites with safety area invaded and thermal sensitivity of the cuspids maintained; (d) CT cross-sectional image of the donor site with safety area respected and loss of cuspid pulp sensitivity.

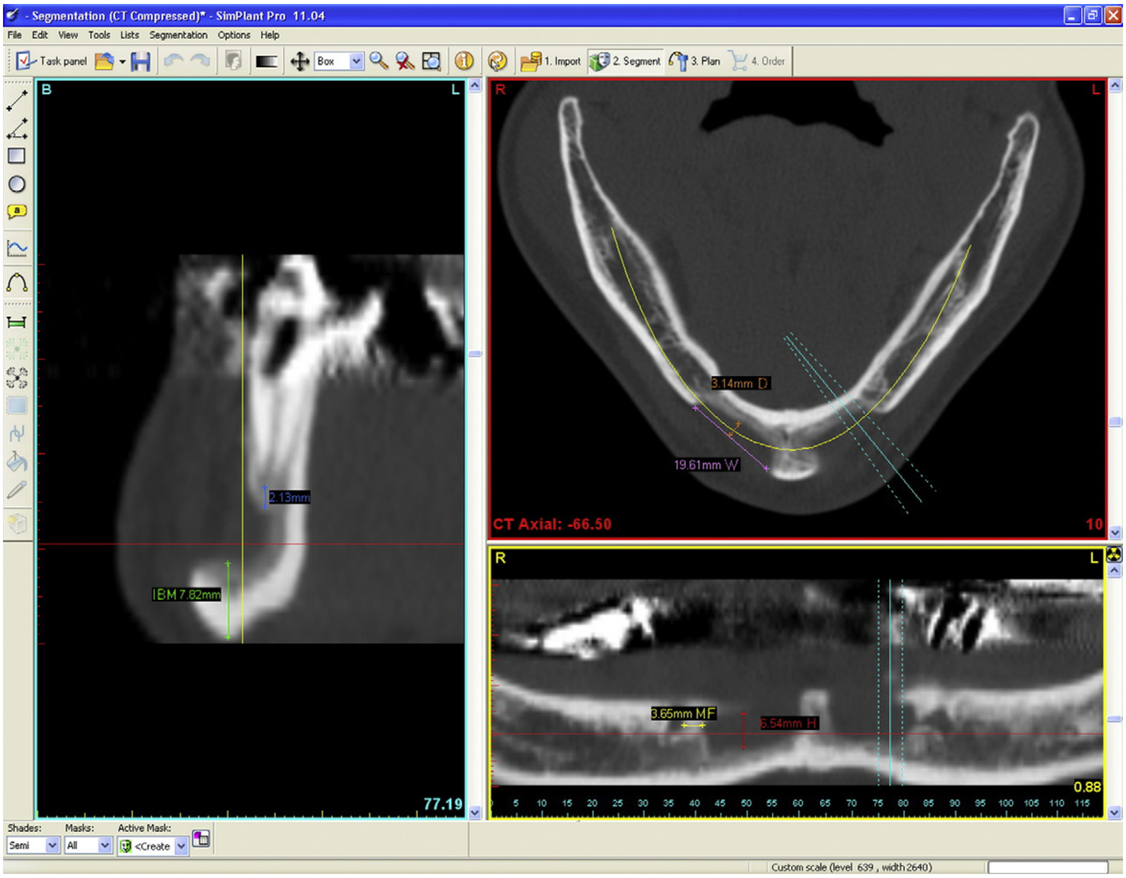

Fig. 2. CT of mandibular parasymphyseal bone-block harvesting sites: display of the software SimPlant Pro 11.04 showing in cross-section, distance measurements between the cuspid apices and the harvest defect superior border (in blue), and between the harvest defect inferior border and the inferior border of the mandible (IBM in green); in axial view, harvesting site width (W in violet) and depth (D in orange) measurements; in panorex, measurements of the harvesting site height (H in red) and the distance between the mental foramen and the nearest bone harvest defect margin (MF in yellow). The solid cyan lines in the axial and panorex views show the cross-section at which measurements were made.

The lower margin of the mandible was preserved to avoid altering the chin contour (Fig. 1).

All patients received amoxicillin and clavulanic acid (2 g/i.v. 1 hour preoperatively and subsequently 1 g b.i.d. i.v. or p.o. for 7 days) and a 0.12% chlorhexidine rinse (b.i.d. for 2 weeks). Postoperative pain was controlled by i.v. administration of ketorolac 90 mg + tramadol 200 mg over 24 h through an elastomer device. In all cases, titanium dental implants were inserted into the grafted areas 3–5 months after the reconstructive stage.

Variables and data collection

Sensory losses due to inferior alveolar nerve damage or pulpal injuries, and muco-cutaneous neurosensory disturbances were tested preoperatively and 12 months postoperatively.

As part of the standard treatment protocol, all patients were subjected to CT scanning (High Speed double detector CT scanner, General Electric Medical System, Milwaukee, WI, USA) 2–4 months after the harvesting and reconstruction procedures in order to plan implant positioning. The margins between the harvesting defect and sensitive anatomical structures were examined radiographically using SimPlant Pro 11.04 (Materialise Dental Italia. Via L. Fincati 13/f, 00154 Roma, Italia), as shown in Fig. 2.

Point assessment of the CT scan included identifying the positions of the root apices of the teeth from the mandibular left second bicuspid to the right second bicuspid and measuring the dimensions of the harvesting site (W, width; H, height; D, depth; Vol, volume). Measurements were made of: the distances between the nearest border of the bone harvest defect and other anatomical structures, such as adjacent root apices; the distances between the mental foramina and the nearest border of the bone harvest defect (MF, distance to mental foramen); and the distance between the inferior border of the harvest defect and the inferior border of the mandible (IBM, distance to inferior mandibular border) (Fig. 2). The measurements were made by two of the authors and consensus established.

Inferior alveolar nerve function was evaluated on both sides by the Pointed-Blunt Test[9] and the Two-Point-Discrimination Test[5]. To obtain a precise map of the sensitivity of the region associated with the inferior alveolar nerve, and particularly the mental nerve, the region was separated[6], into four areas: median chin region; paramedian region; region of the mental foramen; and vermilion of the lower lip. The results of the numerically unquantifiable, qualitative tests have been expressed in terms of the following classification: normaesthesia/-algesia, hypoaesthesia/-algesia, hyperaesthesia/-algesia, anaesthesia/-algesia and paraesthesia for the Pointed-Blunt Test[9]. Results of the Two-Point-Discrimination (TPD) Test, conducted with a Zielinsky calliper, were classified as: $TPD \geq 15$ mm; $10 \leq TPD < 15$; $5 \leq TPD < 10$; 10; $0 \leq TPD < 5$. As the normal range of

Table 1. Size of bone harvest defects (*n* = 28) and distances of bone defects to adjacent anatomical structures.

	Right side		Left side		Total	
	Mean ± SD	Range (min–max)	Mean ± SD	Range (min–max)	Mean ± SD	Range (min–max)
W (mm)*	18.3 ± 2.8	13.3–22.5	19 ± 4.8	12–22.5	18.7 ± 3.9	12–22.5
H (mm)*	8.5 ± 2	4.5–11.8	8.8 ± 2.1	4.5–12	8.6 ± 2	4.5–12
D (mm)*	4.5 ± 1.6	2.6–8	4.7 ± 1.3	2.6–6.1	4.6 ± 1.4	2.6–8
Vol (mm^3)	659 ± 216	411–896	758 ± 291	373–1200	706 ± 253	373–1200
IBM(mm)*	6.9 ± 2.2	3.8–11.7	6.2 ± 1.8	3.3–10.1	6.6 ± 2.1	3.3–11.7
MF (mm)*	6.4 ± 2.6	1.8–12	6 ± 3.2	2–14.3	6.3 ± 3	1.8–14.3

Defect parameters: W, width; H, height; D, depth; Vol, volume (WxHxD); MF, distance from mental foramen; IBM, distance to inferior mandibular border.

* Measurements by CT scan.

the simultaneous spatial limit is 7–14 mm, distances of <15 mm were considered normal[9]. The measurement was repeated three times at each follow-up session.

The pulp sensitivity of all mandibular teeth present from the left second bicuspid to the right second bicuspid was evaluated via cold vitality testing with carbon dioxide snow[11].

Age (years), gender and smoking habits of patients were also recorded.

Statistical analysis

The Wilcoxon rank sum test (exact two sided P-values) was used for comparisons of paired samples for rank-scaled variables. The Kruskal–Wallis test with Bonferroni correction was chosen for comparison of more than two groups of unpaired data. *P* values ≤ 0.05 were considered significant. The data were subjected to Pearson's χ^2 analysis with YATES correction when necessary.

Results

Twenty-four bilateral and four monolateral (divided equally between right and left) mandibular parasymphyseal harvesting areas were surveyed in 16 patients (4 smokers): 12 male and 4 female, ranging in age from 34.6 to 62 years (mean 51.2 ± 7.6). No patient had previous anterior mandibular surgery or experienced anaesthesia/analgesia of the inferior alveolar nerves.

Table 1 shows the sizes of the harvest defects and their distances from adjacent anatomical structures. Table 2 presents the mean distances of the overlying teeth's apices to the nearest defect margin. The postoperative clinical course of all sites was uneventful, and all patients were satisfied with their chin profile.

Teeth cold vitality test

154 teeth were examined preoperatively in the 16 patients for pulp sensitivity: 14 did not respond to the test because they were endodontically treated and/or covered by prosthetic crowns and were excluded from the survey. Preoperatively, vital teeth overlying the harvesting defects (*n* = 57) were divided into two groups according to the distance between their apices and the superior border of the defect (>5 mm and ≤5 mm). Table 2 shows the thermal sensitivity data for the teeth. About 60% of the teeth with apices at ≤5 mm from the proximal osteotomy line retained their vitality postoperatively, while one-third of the teeth with apices >5 mm from the osteotomy line lost vitality; the differences between groups were not statistically significant.

Table 3 reports the mean distances between the donor defect and root apices grouped according to pulp thermal sensitivity changes: group A losing, and group B retaining vitality; no statistically significant differences resulted.

A subgroup of teeth, represented by 24 cuspids alone, was further divided into

Table 2. Distances of bone defect to apices of mandibular incisors, canines and bicuspids. Pulp sensitivity changes in mandibular incisors/canines following bone harvesting from the parasymphysis area.

			Negative CO_2 test at 12-month follow-up		Positive CO_2 test at 12-month follow-up	
Tooth	Mean ± SD (mm)	Range (min–max) (mm)	'Safety distance' ≤5 mm	'Safety distance' >5 mm	'Safety distance' ≤5 mm	'Safety distance' >5 mm
LCN (*n* = 12)	1.7 ± 3.2	−1.8–7	3	0	9	0
LLI (*n* = 13)	4.4 ± 2.5	1–10.1	5	1	2	5
LCI (*n* = 3)	5.4 ± 1.9	3.7–7.6	1	0	1	1
RCI (*n* = 4)	5.8 ± 2.3	4–8.3	1	1	1	1
RLI (*n* = 13)	5.3 ± 1.4	3–7.8	2	3	5	3
RCN (*n* = 12)	2.5 ± 1.5	0–4.3	3	1	6	2
Total (*n* = 57)			15*	6*	24*	12*

RCN, right canine; RLI, right lateral incisor; RCI, right central incisor; LCI, left central incisor; LLI, left lateral incisor; LCN, left canine.

* γ^2 Yates' *p*-value = 0.938.

Table 3. Mean distance of bone defect to root apices with and without pulp sensitivity changes (*n* = 57).

	Teeth with sensitivity changes (*n* = 21) Group A	Teeth without sensitivity changes (*n* = 36) Group B	*P**
Mean distance to apex (mm)	4.2 ± 2.1	3.8 ± 2.8	0.5236

* Two-sided exact Wilcoxon rank sum tests.

Table 4. Mean distance between the most proximal osteotomy line and cuspid apex ($n = 24$), and percentages of teeth loosing thermal sensitivity. Statistical analysis among groups 1, 2 and 3.

Group	Mean distance(mm)	Percent of teeth loosing thermal sensitivity	Compared groups			p^*	p°
1	6.5 ± 0.8	33%	1	*vs*	2	0.5714	1
2	5.5 ± 1.5	40%	1	*vs*	3	**0.0071**	1
3	1.4 ± 1.7	26.3%	2	*vs*	3	**0.0008**	0.963

° Pearson's χ^2 test with YATES correction; df = 1.

[*] Two-sided exact Wilcoxon rank sum tests. Statistically significant values are in **bold**. Kruskal-Wallis test shows that the median of at least one sample group differs significantly from the others.

Table 5. Mean and standard deviation of bone defect size and distances from defect proximal margin to mental foramen and inferior mandibular border in patients with or without pulp sensitivity loss ($n = 26$).

	Parasymphyseal donor sites with at least one tooth loosing pulp sensitivity ($n = 11$) Group I	Parasymphyseal donor sites without associated pulp sensitivity loss ($n = 15$) Group II	P^*
W(mm)	20.3 ± 4.4	17.4 ± 3.3	0.0776
H (mm)	9 ± 2.2	8.5 ± 2	0.3619
D (mm)	4.3 ± 1.2	4.5 ± 1.4	0.8838
Vol (mm^3)	717 ± 201	664 ± 290	0.4320
MF (mm)	5.8 ± 2.3	6.4 ± 3.2	1
IBM (mm)	6.4 ± 1.6	6.8 ± 2.3	0.7357

Defect parameters: W, width; H, height; D, depth; Vol, Volume (WxHxD); MF, distance from mental foramen; IBM, distance to inferior mandibular border.

[*] Two-sided exact Wilcoxon rank sum tests. All non-significant.

three groups (1, 2, 3) according to the distance between their apices and the most proximal osteotomy line: >5 mm; ≥ 4 mm; < 4 mm. Comparisons across the three groups for the percentages of teeth with sensitivity loss revealed no statistically significant difference, despite the statistically significant differences between the group 3 distances and the others (Table 4). In all cases, the loss of cuspid sensitivity was also accompanied by sensitivity losses in the same-side lateral and central incisors.

All the harvesting areas where at least one tooth lost pulp sensitivity were included in a group denominated I, while the remaining were assigned to group II. Table 5 presents the harvesting defect sizes and distances from adjacent anatomical structures for groups I and II, and the associated statistical analysis.

Mucosal and cutaneous sensory function tests

The 28 cutaneous and mucosal regions were subdivided into 112 skin and 84 mucosal areas and examined. Using the Pointed-Blunt Test, six mucosal areas were hypoaesthesic on preoperative evaluation; 13 at the 12-month postoperative control. Eight cutaneous areas showed decreased tactile sensitivity preoperatively with one additional area postoperatively. Five mucosal areas and 4 skin areas were hypoalgesic preoperatively, increasing to 8 mucosal and 6 skin at the 12-month control. As shown in Tables 6–8 the results reveal no statistically significant pre/post-surgery difference. Regarding the distances from the harvesting defect proximal margin to the inferior border of the mandible or mental foramen, no statistically significant differences were found between patients with or without aesthesia/algesia alterations.

Using the Two-Point-Discrimination Test normal range responses were obtained in 80 mucosal and 108 cutaneous areas preoperatively, which decreased after harvesting to 75 and 103, respectively. As shown in Tables 6 and 7, the data revealed no statistically significant differences. Age, gender and smoking were statistically unrelated to inferior alveolar nerve neurosensory changes.

Table 6. Pre-surgical results of qualitative and quantitative tests in the 16 patients.

		Median region		Paramedian region		Foramen		Vermilion	
		number	%	number	%	number	%	number	%
Tactile sensitivity (skin)	Normaesthesia	25	89.3	26	92.9	26	92.9	27	96.4
	Hypoaesthesia	3	10.7	2	7.1	2	7.1	1	3.6
Tactile sensitivity (mucosa)	Normaesthesia	26	92.9	27	96.4	25	89.3		
	Hypoaesthesia	2	7.1	1	3.6	3	10.7		
Pain sensitivity (skin)	Normalgesia	27	96.4	27	96.4	27	96.4	27	96.4
	Hypoalgesia	1	3.6	1	3.6	1	3.6	1	3.6
Pain sensitivity (mucosa)	Normalgesia	27	96.4	26	92.9	26	92.9		
	Hypoalgesia	1	3.6	2	7.1	2	7.1		
Two-point discrimination (TPD skin)	$0 \leq \text{TPD} < 5$	22	78.6	21	75	18	64.3	24	85.7
	$5 \leq \text{TPD} < 10$	3	10.7	4	14.3	5	17.9	2	7.1
	$10 \leq \text{TPD} < 15$	2	7.1	2	7.1	3	10.7	2	7.1
	$\text{TPD} \geq 15$ mm	1	3.6	1	3.6	2	7.1		
Two-point discrimination (TPD mucosa)	$0 \leq \text{TPD} < 5$	16	57.1	17	60.7	12	42.8		
	$5 \leq \text{TPD} < 10$	8	28.6	6	21.4	10	35.7		
	$10 \leq \text{TPD} < 15$	3	10.7	3	10.7	5	17.9		
	$\text{TPD} \geq 15$ mm	1	3.6	2	7.1	1	3.6		

Paraesthesia, hyperaesthesia, anaesthesia, hyperalgesia and analgesia negative for all.

Table 7. Post-surgical results of qualitative and quantitative tests in the 16 patients.

		Median region		Paramedian region		Foramen		Vermilion	
		number	%	number	%	number	%	number	%
Tactile sensitivity (skin)	Normaesthesia	24	85.7	27	96.4	25	89.3	27	96.4
	Hypoaesthesia	4	14.3	1	3.6	3	10.7	1	3.6
Tactile sensitivity (mucosa)	Normaesthesia	25	89.3	25	89.3	21	75		
	Hypoaesthesia	3	10.7	3	10.7	7	25		
Pain sensitivity (skin)	Normalgesia	27	96.4	27	96.4	26	92.9	26	92.9
	Hypoalgesia	1	3.6	1	3.6	2	7.1	2	7.1
Pain sensitivity (mucosa)	Normalgesia	26	92.9	25	89.3	25	89.3		
	Hypoalgesia	2	7.1	3	10.7	3	10.7		
Two-point discrimination (TPD skin)	$0 \leq \text{TPD} < 5$	21	75	20	71.4	17	60.7	22	78.6
	$5 \leq \text{TPD} < 10$	4	14.3	5	17.9	7	25	3	10.7
	$10 \leq \text{TPD} < 15$	0		1	3.6	0		3	10.7
	$\text{TPD} \geq 15$ mm	3	10.7	2	7.1	4	14.3		
Two-point discrimination (TPD mucosa)	$0 \leq \text{TPD} < 5$	17	60.7	15	53.6	12	42.9		
	$5 \leq \text{TPD} < 10$	6	21.4	8	28.6	9	32.1		
	$10 \leq \text{TPD} < 15$	2	7.1	2	7.1	4	14.3		
	$\text{TPD} \geq 15$ mm	3	10.7	3	10.7	3	10.7		

Paraesthesia, hyperaesthesia, anaesthesia, hyperalgesia and analgesia negative for all.

Table 8. χ^2 statistical analysis: pre-surgical *vs* post-surgical.

Tests	Tactile sensitivity	Pain sensitivity	Two-point static discrimination
Skin	1*	0.746*	0.191
Mucosa	0.15*	0.567*	0.488
Total	0.224*	0.392*	0.103

df = 1 for tactile and pain sensitivity; df = 3 for two-point static discrimination.
*YATES correction.

Discussion

To date, literature studies have evaluated the potential residual neurosensory disturbances after bone harvesting from the chin area (Table 9). The present survey aimed to assess the incidence of neurosensory disturbances and/or tooth-pulp sensitivity losses after mandibular parasymphyseal bone harvesting that preserved the middle chin area, both for aesthetic reasons and to maintain the midline strut in the mandible[12].

Nkenke et al.[9] and von Arx et al.[15] stressed the importance of executing osteotomy lines at a 'safety distance' of at least 5 mm from the root apices of the teeth to ensure their continued vitality. In the present survey, when the osteotomy line was within 5 mm of the root apices, 39% of teeth lost pulp sensitivity. Even when the osteotomy was at >5 mm, 33% of the teeth lost vitality, with no statistical difference between the two groups. When the distances between the osteotomy and the apices of teeth retaining vitality were compared with the corresponding figures for the teeth loosing vitality, no statistical differences were found. It should be noted that the mean values for neither group (respectively 3.8 ± 2.8 and 4.2 ± 2.1 mm) respected the safety area.

It appears that invading the 'safety area' with an osteotomy line may not be critical in terms of causing loss of pulp vitality of adjacent teeth. Considering the studies cited in Table 9 for comparison, although all the authors claimed to have respected the 'safety distance' of 5 mm[9,10,15] between the coronal osteotomy line and the anterior root apices, the reported percentage of tooth sensitivity loss is variable. In the present study, when the cuspids are grouped according to the distance of their apices from the most proximal osteotomy line, and the percentages of cuspids loosing vitality in the three groups is compared, no statistical difference results: the percentage varies from 26% to 40%, irrespective

Table 9. Mental bone harvesting procedures.

Author	Harvesting procedure	Patients	Harvesting areas	Length of the study (months)	Percent of pulp sensitivity loss		Percent of neurosensory disturbances	
					at 6 mos	at 12 mos	at 6 mos	at 12 mos
Present study	Parasymphyseal graft	16	28	12	ND	36.8%	ND	cutaneous/mucosal hypoaesthesia 0.9%/8.3% hypoalgesia 1.8%/3.6% TPD 4.5%/6%
Nkenke et al. 2001[9]	Chin graft across symphysis	20	20	12	13.6%	11.4%	hypoaesthesia 5% hypoalgesia 5% TPD 5%	hypoaesthesia 5% hypoalgesia 5% TPD 5%
von Arx et al. 2004[15]	Chin graft across symphysis	30	30	12	8.1%	0.6%	ND	ND
Raghoebar et al. 2001[10]	Chin graft across symphysis	21	21	12	ND	ND	paraesthesia 33%	paraesthesia 33%

of whether the safety distance was respected or not.

It should be noted that harvesting from within the safety area at the cuspid level may eventually affect the thermal responsiveness of the teeth along the distribution of the ipsilateral inferior alveolar nerve. In all the cases studied here, loss of cuspid sensitivity was accompanied by sensitivity loss in the same-side lateral and central incisors. It may be concluded that when surgical harvesting goes beyond the 'safety distance', the loss of pulp sensitivity in a tooth cannot be predicted simply on the basis of the distance between its root apices and the bone defect. Such unpredictability is probably due to variable pathways of the anterior part of the inferior alveolar nerve in the buccal–lingual direction (Fig. 1)[8,13].

In the present survey, no pulpal necrosis or abscess of endodontic origin was encountered after the harvesting procedure. Other authors have described such complications as rare[3], even when the bone defect is near the root apices. This is probably because the presence of several arterial anastomoses may keep the dental pulp viable[14].

Regarding mucosal and cutaneous neurosensory disturbances, the present survey revealed cutaneous hypoaesthesia and hypoalgesia in 1% (1 patient) and 2% (2 patients) respectively, of areas at the 12-month follow-up (Table 8). Nkenke et al.[9] reported cutaneous hypoaesthesic disturbances in 5% of treated areas at the 12-month follow-up; most literature reports describe complete resolution of the neurological disturbances within 1 year.

In the present survey, the mucosal areas of 8% (2 patients) and 4% (2 patients) revealed hypoaesthesic and hypoalgesic sites, respectively, at the 1-year follow-up. The difference between the skin and mucosal areas is probably due to the greater stress on the latter due to its proximity to the elevated flap[15]. Neurosensory disturbances are mainly due to stretching, pressure and releasing incisions near the mental nerve[15].

In conclusion, from the present survey it seems that the parasymphyseal bone harvesting procedure is not without side-effects, in terms of cutaneous and mucosal neurosensory disturbances. Nearby teeth may undergo changes in pulp thermal response. Such a surgical approach often requires executing osteotomy lines that go beyond the 'safety distance' from the cuspid apices. The likelihood of thermal sensitivity alterations seems to be independent of whether this safety area is respected. Confirmation of the current findings and the speculations advanced will require larger studies.

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