Bernhard Pommer Gabor Tepper André Gahleitner Werner Zechner Georg Watzek

# New safety margins for chin bone harvesting based on the course of the mandibular incisive canal in CT

#### Authors' affiliations:

Bernhard Pommer, Gabor Tepper, André Gahleitner, Werner Zechner, Georg Watzek, Department of Oral Surgery, Bernhard Gottlieb School of Dentistry, Medical University of Vienna, Vienna, Austria André Gahleitner, Department of Diagnostic Radiology, Division of Osteoradiology, General Hospital, Medical University of Vienna, Vienna, Austria

## Correspondence to:

Dr Bernhard Pommer Department of Oral Surgery Bernhard Gottlieb School of Dentistry Medical University of Vienna Waehringer Strasse 25a A-1090 Vienna Austria Tel.: +43 I 4277 67011 Fax: +43 I 4277 67019 e-mail: bernhard.pommer@meduniwien.ac.at

Date: Accepted 26 February 2008

#### To cite this article:

Pommer B, Tepper G, Gahleitner A, Zechner W, Watzek G. New safety margins for chin bone harvesting based on the course of the mandibular incisive canal in CT. *Clin. Oral Impl. Res.* **19**, 2008; **1312–1316** doi: 10.1111/j.1600-0501.2008.01590.x Key words: augmentation, donor site morbidity, graft technique, mandibular nerve, symphysis

#### Abstract

**Objectives:** Altered pulp sensitivity of anterior lower teeth is a frequent finding following chin bone harvesting. Persistent loss of tooth sensitivity has been reported in up to 20% of the patients. The aim of this study was to evaluate current recommendations for the location of the harvest zone with respect to the course of the mandibular incisive canal (MIC), the intrabony continuation of the mandibular canal mesial to the mental foramen. **Material and methods:** On computed tomographic (CT) scans of 50 dentate mandibles, the MIC was located and its distance to the root apices, to the labial bony surface, and to the inferior margin of the mandible was assessed. The risk of nerve injury and the percentage of patients suitable for chin bone grafting were calculated.

**Results:** Respecting current recommendations for chin bone grafting, the content of the MIC was endangered in 57% of the CTs. Therefore, new safety margins are suggested: the chin bone should be harvested at least 8 mm below the tooth apices with a maximum harvest depth of 4 mm.

**Conclusions:** Applying the new safety recommendations and proper patient selection in chin bone harvesting could reduce the risk of altered postoperative tooth sensitivity due to injury of the mandibular incisive nerve.

Bone grafting procedures have become standard care in patients with insufficient bone volumes at potential implant recipient sites (Von Arx et al. 2005). Osseous ridge deficiencies require restoration before implant surgery to enable reliable and esthetic implant placement (Widmark et al. 1997). The need to repair dentoalveolar atrophy and bone defects has resulted in the use of various techniques and sources of graft material. Despite recent advances in bone-substitute technology, the use of autogenous bone grafts continues to represent the 'gold standard' in reconstructive surgery of the oral and maxillofacial region because of their osteoinductive, osteoconductive, and nonimmunogenic properties (Nkenke et al. 2002). Autotransplant bone grafts still provide the most rapid and predictable results in terms of resultant bone quality and quantity (Raghoebar et al. 2001). A variety of extra- and intraoral donor sites are available to the surgeon including the iliac crest, tibia, ribs, calvarium, zygoma, maxilla, and mandible (Misch et al. 1992). The obvious advantages of bone grafts from intraoral sites are convenient surgical access, avoidance of cutaneous scarring, reduced operation time, use of local anesthesia on an outpatient basis, and therefore lower costs. Furthermore, intraoral bone grafts are favored because of the identical embryonic origin of donor and receptor sites, as ectomesenchymal bone exhibits less resorption due to faster revascularization compared with bone of mesenchymal origin (Koole 1994).

The mandibular symphysis is a very common intraoral donor site for autogenous bone grafts and has been used successfully in a variety of clinical applications (Raghoebar et al. 2001). The chin graft provides both cortical and medullary bone necessary for osteoinduction and osteoconduction (Cranin et al. 2001). The mandibular interforaminal region is generally considered a safe surgical area, involving few risks of damage to vital anatomic structures. However, the anterior mandible contains intrabony vascular canals (Gahleitner et al. 2001; Tepper et al. 2001) as well as the mandibular incisive canal (MIC), the intrabony continuation of the mandibular canal mesial to the mental foramen (Mardinger et al. 2000). This little noticed anatomic structure carries a major neurovascular bundle, the mandibular incisive nerve, and accompanying vessels, for innervation and vascular supply of the lower anterior dentition, i.e. incisors, canine, and first premolar (De Andrade et al. 2001). Therefore, the position of the MIC has to be kept in mind during chin bone harvesting procedures (Obradovic et al. 1993).

Even though the mandibular symphysis is considered to have an excellent riskbenefit ratio, frequent complications have been described following chin bone harvesting (Hoppenreijs et al. 1992; Nkenke et al. 2001). Donor site morbidity involves intraopertive bleeding, wound dehiscence, mental nerve injury, pulp canal obliteration, as well as loss of pulp sensitivity of the anterior lower teeth, the latter representing neuropraxia of the mandibular incisive nerve (Raghoebar et al. 2001). Review of the literature shows that negative pulp sensitivity has been reported postoperatively in up to 80% of patients after chin bone harvesting. Up to 20% of patients demonstrated persistent loss of tooth sensitivity (Table 1). These neurosensory disturbances occurred while respecting the generally recommended safety margins defining the harvest zone as being 5 mm anterior to the mental foramen, 5 mm below the tooth apices, and 5 mm above the lower border of the mandible (Hunt & Jovanovic 1999). However, these safety recommendations are not based on knowledge of the position and course of the MIC. The aim of the present investigation was to evaluate the current safety recommendations with the help of computed tomography (CT) and, from these results, derive strategies to prevent postoperative sensitivity impairment in patients subjected to chin bone harvesting.

# Material and methods

Routine CT scans of 50 dentate mandibles were acquired with a conventional CT scanner (Tomoscan SR-6000, Philips, Eindhoven, the Netherlands) using a standard dental CT investigation protocol (1.5 mm slice thickness, 1.0 mm table feed, 120 kV, 75 mA, 28 scan time, 100-120 mm field of view, high-resolution bone filter). The age of the patients (18 men and 32 women) ranged between 25 and 71 years, with a mean age of 47.2 years. Exclusion criteria involved poor visibility of the MIC in CT and partial edentulism or pathologic findings in the interforaminal region. Orthoradial images were reformatted from the axial slices bilaterally at the position of the middle and lateral incisor, the canine, and the first premolar. On these reformatted images, the MIC was located and the following distances were assessed: (a) distance from the MIC to the tooth apex, (b) distance from the MIC to the labial bony surface, and (c) distance from the MIC to the lower margin of the symphysis (Fig. 1). Measurements were performed by two independent observers (B. P. and G. T.) using the Easy Vision Workstation (Philips) with a technical accuracy of 0.1 mm and a maximum interobserver variability of 0.5 mm.

Utilizing these data, possible interferences of imaginary osteotomies (1–10 mm deep) with the MIC were assessed, and the percentage of patients carrying the risk of nerve injury by these osteotomies was calculated. The same risk estimation was performed for harvesting bone at a distance of 1-10 mm from the apices of the teeth. Combining the two factors 'depth of bone graft' and 'distance to the apices.' the risk of injuring the MIC in the generally recommended harvest zone (5 mm anterior to the mental foramen, 5 mm below the tooth apices, and 5 mm above the lower border of the mandible) was computed. Various settings of these two factors were likewise tested to identify the configuration featuring the minimal risk of nerve injury. Each setting was analyzed for sufficient symphyseal bone height for harvesting bone blocks with a diameter of either 6, 8, or 10 mm.

# Results

The mean distance  $(\pm \text{ standard deviation})$ of the MIC to the apices of the first premolar, the canine, the lateral, and middle incisor amounted to 5.6  $\pm$  2.4, 5.2  $\pm$  2.4,  $6.6 \pm 2.4$ , and  $5.3 \pm 2.2 \text{ mm}$ , respectively. The mean distances of the MIC to the labial bony surface of the mandible at these positions were  $3.4 \pm 1.1$ ,  $4.2 \pm 1.5$ ,  $4.2 \pm 1.5$ , and  $4.4 \pm 1.4$  mm, respectively. The distance of the MIC to the lower margin of the symphysis averaged  $10.7 \pm 1.9$ ,  $10.3 \pm 2.2$ ,  $11.1 \pm 2.5$ , and 14  $\pm$  2.8 mm, respectively. No statistically significant difference between the left and the right patient side was observed (P > 0.05).

Table 2 demonstrates the positive correlation between the depth of the bone graft and the risk of nerve injury, and the negative correlation between the distance to the root apices and the risk of nerve injury. Table 3 shows that application of the current

 Table 1. Prospective studies reporting postoperative and persistent loss of sensitivity in

 the anterior lower teeth (percentage per patient) after chin bone harvesting

| Publication             | Sample size | Postoperative (%) | Persistent (%) |
|-------------------------|-------------|-------------------|----------------|
| Chiapasco et al. (1999) | 15          | 80                | 13.3           |
| Dörtbudak et al. (2002) | 31          | 32.3              | 6.5            |
| Joshi (2004)            | 27          | 18.5              | 7.4            |
| Misch (1997)            | 31          | 29                | 0              |
| Nkenke et al. (2001)    | 20          | 35                | 20             |
| von Arx et al. (2005)   | 30          | 43.3              | 3.3            |



*Fig. 1*. Measurement procedure on reformatted computed tomography (CT) image (upper left corner) at tooth 34: (a) distance from the mandibular incisive canal (MIC) to the tooth apex, (b) distance from MIC to the labial bony surface, and (c) distance from MIC to the lower margin of the symphysis.

*Table 2.* Calculated risk of injury to the MIC harvesting chin bone grafts with a depth of 1–10 mm, respectively, keeping a distance to the tooth apices of 1–10 mm

| Depth of the<br>bone graft (mm) | Risk of<br>nerve injury (%) | Distance to the apices (mm) | Risk of<br>nerve injury (%) |
|---------------------------------|-----------------------------|-----------------------------|-----------------------------|
| 1                               | 0                           | 1                           | 100                         |
| 2                               | 3                           | 2                           | 100                         |
| 3                               | 24                          | 3                           | 97                          |
| 4                               | 56                          | 4                           | 90                          |
| 5                               | 80                          | 5                           | 75                          |
| 6                               | 93                          | 6                           | 63                          |
| 7                               | 97                          | 7                           | 43                          |
| 8                               | 98                          | 8                           | 24                          |
| 9                               | 99                          | 9                           | 14                          |
| 10                              | 100                         | 10                          | 8                           |

Table 3. Comparison of current and new safety margins for chin bone harvesting in terms of location of the harvest zone, risk of injury to the mandibular incisive canal (percentage per patient), and sufficient bone height for a graft diameter of 6, 8, and 10 mm (percentage per patient)

|  | Current safety margins | New safety margins |
|--|------------------------|--------------------|
| Depth of the bone graft (mm)               | 5                      | 4                  |
| Distance to the tooth apices (mm)          | 5                      | 8                  |
| Distance to the lower border               | 5 mm                   | Intact             |
| Distance to the mental foramen (mm)        | 5                      | 5                  |
| Risk of injury to the MIC (%)              | 57                     | 16                 |
| Sufficient bone height for 6 mm graft (%)  | 86                     | 90                 |
| Sufficient bone height for 8 mm graft (%)  | 62                     | 74                 |
| Sufficient bone height for 10 mm graft (%) | 34                     | 56                 |

safety recommendations was not possible in all patients (due to insufficient bone height) and endangered the content of the MIC in 57% of the patients. Of all the positions and dimensions of the harvest zone tested out, the setting carrying the lowest risk of nerve damage while still being applicable in a high percentage of the population is thus recommended as a new safety margin.

# Discussion

Autotransplant bone is associated with the necessity of a second surgical intervention introducing the risk of donor site morbidity. In preimplantologic surgery, the patients' acceptance of disorders emerging in previously healthy regions is generally reduced, as complications at the donor site are not considered part of the repair procedure (So & Lui 1996). Avoiding nerve damage at a donor site is an essential ethical and forensic issue, because a variety of donor sites for autogenous bone are available and alveolar reconstruction might as well be accomplished by the use of bonesubstitute materials (Nocini et al. 1999). While each donor site has its own inherent problems hardly comparable with each other (Von Arx & Kurt 1998), the surgeon's choice must be well grounded and justifiable.

If the MIC is injured in the course of chin bone harvesting, pulpal sensitivity and vascularity of all teeth mesial to the damage may be affected. Investigations in alveolar segmental (sub-apical) osteotomies revealed that teeth usually maintain vital pulps (i.e., revascularize) even after complete disruption of their nerve and blood supply (Hutchinson & MacGregor 1972; Pepersack 1973). This might be explained by the numerous anastomoses from the sublingual artery to the MIC (Tepper et al. 2001) preserving the pulpal vascularity (Von Arx & Kurt 1998). By contrast, lost pulpal nerve supply usually takes 3-12 months to recover (Hutchinson & Mac-Gregor 1972). Although studies illustrate a continuous improvement of lost tooth sensitivity over time (Table 1), it is unlikely that non-reacting teeth will revert to a positive reaction after the twelfth postoperative month (Pepersack 1973). Although endodontic therapy is not indicated in these teeth unless clinical signs of pulpal necrosis become apparent (Nkenke et al. 2001), nerve injury undoubtely discredits the success of the operation (Obradovic et al. 1993).

The present examination of CT scans of 50 dentate patients has shown that respecting the generally recommended safety

margins (abstracted by Hunt & Jovanovic 1999) carries a significant risk of nerve damage. Based on these data, the following adaptations should be established to the current recommendations:

## Depth of harvest defect

In any case, the depth of the harvest defect should be limited to a monocortical graft, leaving the lingual cortex intact to reduce the risk of bleeding in the floor of the mouth (Hofschneider et al. 1999; Clavero & Lundgren 2003). If a maximum depth of 4 mm is not exceeded, nerve damage can be avoided in almost half of the patients (regardless of the distance to the apices!). As the thickness of the labial cortical plate averages 2 mm in this region (Park et al. 2004), a 4-mm-thick graft consists of onehalf of cortical bone favorable to osteoconduction, and to the other half of the medullary bone promoting osteoinduction.

## Distance to the tooth apices

If the distance of the most superior bone cut to the tooth apices is extended from 5 to 8 mm, nerve damage can be avoided in over 75% of the patients (regardless of the depth of the harvest defect!). The recommendation to avoid osteotomies closer than 8 mm from the tooth apices is in accord with investigations by Obwegeser (1968) and Neukam et al. (1981). By setting the bone cut in a right angle to the vestibular plain of the symphysis (Fig. 2B), additional distance to the MIC can be achieved because of the lingual inclined morphology of the symphysis (Quirynen et al. 2003).

#### Distance to the lower border

Several clinical studies have reported that the preoperative chin contour and facial profile is preserved by leaving the inferior bone margin of the symphysis intact (Misch 1997; Nkenke et al. 2001; Booij et al. 2005). Not only should the integrity of the lower rim be maintained but also the midline protrusion should be spared to prevent chin ptosis and labio-mental fold irregularities.

## **Patient selection**

According to the present study, the symphysis can be used as a donor site in 56% of the patients to harvest a graft of 10 mm diameter, in 74% a graft of 8 mm diameter,



*Fig.* 2. (a). Current (right-hand side) and new (left-hand side) safety margins demonstrated on a human cadaver mandible. (b). Preserved integrity of the MIC on orthoradial image (new safety margins). (c). Discontinuation of the MIC on axial CT slice (current safety margins).

and in 90% a graft of 6 mm diameter. The residual 10% of the population are not suitable for chin bone harvesting. In these patients, the available volume of chin bone is so limited that the symphysis can hardly be considered without risking nerve damage. If greater amounts of bone are required, another donor site, a combination of intraoral donor sites, or volume expansion of the graft with bone-substitute materials should be considered (Montazem et al. 2000).

If these new safety margins for chin bone harvesting are respected, the risk of injury

to the MIC can be lowered to 16%. If proper patient selection is applied additionally, a residual risk of only 6% remains. The present study indicates that the procedure of harvesting mandibular symphyseal bone is predictable if performed in the correct manner. By following a strict surgical protocol, the risk of transient or persistent loss of tooth sensitivity can be minimized. A prospective clinical study is currently being carried out to determine the effective postoperative morbidity of chin bone grafting following these new recommendations.

## References

- Booij, A., Raghoebar, G.M., Jansma, J., Kalk, W.W. & Vissink, A. (2005) Morbidity of chin bone transplants used for reconstructing alveolar defects in cleft patients. *The Cleft Palate–Craniofacial Journal* 42: 533–538.
- Chiapasco, M., Abati, S., Romeo, E. & Vogel, G. (1999) Clinical outcome of autogenous bone blocks or guided bone regeneration with e-PTFE membranes for the reconstruction of narrow edentulous ridges. *Clinical Oral Implants Research* 10: 278–288.
- Clavero, J. & Lundgren, S. (2003) Ramus or chin grafts for maxillary sinus inlay and local onlay augmentation: comparison of donor site morbidity and complications. *Clinical Implant Dentistry & Related Research* **5**: 154–160.
- Cranin, A.N., Katzap, M., Demirdjan, E. & Ley, J. (2001) Autogenous bone ridge augmentation using the mandibular symphysis as a donor. *The Journal* of Oral Implantology 27: 43–47.
- De Andrade, E., Otomo-Corgel, J., Pucher, J., Ranganath, K.A. & St George, N. (2001) The intraosseous course of the mandibular incisive nerve in the mandibular symphysis. *The International Journal of Periodontics & Restorative Dentistry* **21**: 591–597.
- Dörtbudak, O., Haas, R., Bernhart, T. & Mailath-Pokorny, G. (2002) Inlay autograft of intra-membranous bone for lateral alveolar ridge augmentation: a new surgical technique. *Journal of Oral Rehabilitation* 29: 835–841.
- Gahleitner, A., Hofschneider, U., Tepper, G., Pretterkleber, M., Schick, S., Zauza, K. & Watzek, G. (2001) Lingual vascular canals of the mandible: evaluation with dental CT. *Radiology* **220**: 186–189.
- Hofschneider, U., Tepper, G., Gahleitner, A. & Ulm, C. (1999) Assessment of the blood supply to the mental region for reduction of bleeding complications during implant surgery in the interforaminal region. *The International Journal of Oral & Maxillofacial Implants* 14: 379–383.
- Hoppenreijs, T.J., Nijdam, E.S. & Freihofer, H.P. (1992) The chin as a donor site in early secondary osteoplasty: a retrospective clinical and radiological evaluation. *Journal of Cranio–Maxillo–Facial Surgery* 20: 119–124.
- Hunt, D.R. & Jovanovic, S.A. (1999) Autogenous bone harvesting: a chin graft technique for particulate and monocortical bone blocks. *The International Journal of Periodontics & Restorative Dentistry* 19: 165–173.

- Hutchinson, D. & MacGregor, A.J. (1972) Tooth survival following various methods of sub-apical osteotomy. *International Journal of Oral Surgery* 1: 81–86.
- Joshi, A. (2004) An investigation of post-operative morbidity following chin graft surgery. *British Dental Journal* 196: 215–218.
- Koole, R. (1994) Ectomesenchymal mandibular symphysis bone graft: an improvement in alveolar cleft grafting? *The Cleft Palate-craniofacial Journal* 31: 217–223.
- Mardinger, O., Chaushu, G., Arensburg, B., Taicher, S. & Kaffe, I. (2000) Anatomic and radiologic course of the mandibular incisive canal. *Surgical* and Radiologic Anatomy 22: 157–161.
- Misch, C.M. (1997) Comparison of intraoral donor sites for onlay grafting prior to implant placement. *The International Journal of Oral & Maxillofacial Implants* 12: 767–776.
- Misch, C.M., Misch, C.E., Resnik, R.R. & Ismail, Y.H. (1992) Reconstruction of maxillary alveolar defects with mandibular symphysis grafts for dental implants: a preliminary procedural report. *The International Journal of Oral & Maxillofacial Implants* 7: 360–366.
- Montazem, A., Valauri, D.V., St-Hilaire, H. & Buchbinder, D. (2000) The mandibular symphysis as a donor site in maxillofacial bone grafting: a quantitative anatomic study. *The International Journal of Oral and Maxillofacial Surgery* 58: 1368–1371.
- Neukam, F.W., Hausamen, J.E. & Kaufmann, K. (1981) Tierexperimentelle Untersuchungen zur Durchblutung des Alveolarknochens und der Zähne nach alveolären Osteotomien in Relation zum Abstand der horizontalen Osteotomielinie zu den Wurzelspitzen. Deutsche Zeitschrift für Mund-, Kiefer- und Gesichts-Chirurgie 5: 369–372.
- Nkenke, E., Radespiel-Troger, M., Wiltfang, J., Schultze-Mosgau, S., Winkler, G. & Neukam F, W. (2002) Morbidity of harvesting of retromolar bone grafts: a prospective study. *Clinical Oral Implants Research* 13: 514–521.
- Nkenke, E., Schultze-Mosgau, S., Radespiel-Troger, M., Kloss, F. & Neukam, F.W. (2001) Morbidity of harvesting of chin grafts: a prospective study. *Clinical Oral Implants Research* **12**: 495–502.
- Nocini, P.F., De Santis, D., Fracasso, E. & Zanette, G. (1999) Clinical and electrophysiological assessment of inferior alveolar nerve function after lateral nerve transposition. *Clinical Oral Implants Research* 10: 120–130.

- Obradovic, O., Todorovic, L., Pesic, V., Pejkovic, B. & Vitanovic, V. (1993) Morphometric analysis of mandibular canal: clinical aspects. *Bulletin du Groupement International pour la Recherche Scientifique en Stomatologie* & Odontologie 36: 109–113.
- Obwegeser, H. (1968) Movement of the lower alveolar process for correction of malocclusions. *Deutsche Zahnärztliche Zeitschrift* **23**: 1075– 1084.
- Park, H.D., Min, C.K., Kwak, H.H., Youn, K.H., Choi, S.H. & Kim, H.J. (2004) Topography of the outer mandibular symphyseal region with reference to the autogenous bone graft. *The International Journal of Oral and Maxillofacial Surgery* 33: 781–785.
- Pepersack, W.J. (1973) Tooth vitality after alveolar segmental osteotomy. *Journal of Maxillofacial Surgery* 1: 85–91.
- Quirynen, M., Mraiwa, N., van Steenberghe, D. & Jacobs, R. (2003) Morphology and dimensions of the mandibular jaw bone in the interforaminal region in patients requiring implants in the distal areas. *Clinical Oral Implants Research* 14: 280–285.
- Raghoebar, G.M., Louwerse, C., Kalk, W.W. & Vissink, A. (2001) Morbidity of chin bone harvesting. *Clinical Oral Implants Research* 12: 503–507.
- So, L.L. & Lui, W.K. (1996) Alternative donor site for alveolar bone grafting in adults with cleft lip and palate. *The Angle Orthodontist* 6: 9–16.
- Tepper, G., Hofschneider, U.B., Gahleitner, A. & Ulm, C. (2001) Computed tomographic diagnosis and localization of bone canals in the mandibular interforaminal region for prevention of bleeding complications during implant surgery. *The International Journal of Oral & Maxillofacial Implants* 16: 68–72.
- Von Arx, T., Hafliger, J. & Chappuis, V. (2005) Neurosensory disturbances following bone harvesting in the symphysis: a prospective clinical study. *Clinical Oral Implants Research* 16: 432–439.
- Von Arx, T. & Kurt, B. (1998) Endoral donor bone removal for autografts. A comparative clinical study of donor sites in the chin area and the retromolar region. *Schweizer Monatsschrift für Zahnmedizin* 108: 446–459.
- Widmark, G., Andersson, B. & Ivanoff, C.J. (1997) Mandibular bone graft in the anterior maxilla for single-tooth implants. Presentation of surgical method. *International Journal of Oral and Maxillofacial Surgery* 26: 106–109.