A Computer-Guided Bone Block Harvesting Procedure: A Proof-of-Principle Case Report and Technical Notes

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During autogenous mandibular bone harvesting, there is a risk of damage to anatomical structures, as the surgeon has no three-dimensional control of the osteotomy planes. The aim of this proof-of-principle case report is to describe a procedure for harvesting a mandibular bone block that applies a computer-guided surgery concept. A partially dentate patient who presented with two vertical defects (one in the maxilla and one in the mandible) was selected for an autogenous mandibular bone block graft. The bone block was planned using a computer-aided design process, with ideal bone osteotomy planes defined beforehand to prevent damage to anatomical structures (nerves, dental roots, etc) and to generate a surgical guide, which defined the working directions in three dimensions for the bone-cutting instrument. Bone block dimensions were planned so that both defects could be repaired. The projected bone block was 37.5 mm in length, 10 mm in height, and 5.7 mm in thickness, and it was grafted in two vertical bone augmentations: an 8 × 21-mm mandibular defect and a 6.5 × 18-mm defect in the maxilla. Supraimposition of the preoperative and postoperative computed tomographic images revealed a procedure accuracy of 0.25 mm. This computer-guided bone harvesting technique enables clinicians to obtain sufficient autogenous bone to manage multiple defects safely.


Key words: bone block, computer-guided surgery, mandibular bone harvesting

Because of its biologic properties, autogenous bone is still considered one of the most predictable materials for reconstruction procedures in implant dentistry.¹,² Many bone-harvesting protocols have been described for different instruments, including burs, piezosurgical devices, diamond disks, and saws.³⁻¹⁰ Nevertheless, intraoral bone harvesting has been associated with some negative aspects, including insufficient volume at the donor site in relation to the amount of required bone, risk of neurologic and/or dental root damage, and patient postoperative discomfort.²,¹¹⁻¹³ The risk of damage to anatomical structures represents the biggest complication and the major limitation of this procedure. During surgery, the surgeon has few reference points to which he can relate the anatomical information obtained from the analysis of the volumetric images, such as the mandibular canal, the mental nerve, or the positions of dental roots. Because of this, some authors have suggested avoiding a complete cut of the cortical plate in the apical portion of the ramus/external oblique ridge area, where the alveolar canal is located, to limit the risk of nerve damage.⁶,⁷,¹⁰,¹² To date, no instrument or method used for cutting the mandible is able to fully avoid damage to anatomical structures because the free-hand three-dimensional working direction cannot be controlled.

Nowadays, modern computer-assisted techniques allow surgeons to perform guided implant placement with an acceptable degree of accuracy¹⁴ and to perform preoperative virtual surgery.¹⁵ Computer-assisted surgery using stereolithographic three-dimensional models and cutting guides¹⁶,¹⁷ has been implemented. This virtual surgical planning is an effective method for mandibular reconstruction with vascularized bone flaps, allowing high accuracy in terms of position and shape.¹⁸ Moreover, in a recent case report, Jacotti et al proposed the use of a dehydrated homologous bone block, formed using a computer-aided design/computer-assisted manufacture (CAD/CAM) system, to avoid the need to harvest an autogenous bone block and to ensure that a block could be created that fits perfectly above the alveolar crest for horizontal bone augmentation.¹⁹ In the field of autogenous bone harvesting, Rinaldi et al proposed creating a surgical template made on a stereolithographic model of the patient.²⁰ This approach enables the
surgeon to acquire information regarding the superficial positions of the osteotomy lines (contour of the harvestable bone block on the bone surface) during the surgical procedure. However, no information is included to help direct the cutting tool to perform a safe osteotomy; thus, the risk of anatomical structure damage is reduced but still present. The aim of this case report is to demonstrate the feasibility of performing a bone block mandibular harvesting procedure by applying the technology of computer-guided surgery. The method described takes advantage of a computer-guided procedure to control the angulation and depth of the osteotomy lines to maximize the harvestable bone block volume needed for the reconstruction of single or multiple defects.

CASE REPORT AND TECHNIQUE

A 43-year-old partially dentate nonsmoking woman who presented with two bone defects in the area where implants were planned was selected for the autogenous bone augmentation procedure. The patient was fully informed of the surgical procedures and treatment alternatives. Cross-sectional images (reformatted computer tomographic [CT] scan images) were obtained preoperatively for assessment of the crest dimension and to plan the bone block harvesting. One vertical bone defect was located in the mandible (in the left second premolar and first and second molar areas) and the other was in the maxilla (in the right second premolar and first and second molar areas). The mandibular defect was 8 mm high and 21 mm in length, and the maxillary defect was 6.5 mm high and 18 mm long (Fig 1).

Presurgical Planning

The digital imaging and communication in medicine (DICOM) datasets obtained from the CT scans were processed with diagnostic and analysis software (3Diagnosys 4.0, 3DIEMME), and the mesiodistal linear dimensions of the defects were measured. These measurements were then transferred to the left external oblique ridge, the area of the mandible considered most suitable for bone block harvesting. All anatomical structures, such as the alveolar canal, mental foramina, mental nerve, and dental roots, in the area of the donor site were located using planning software. Ideal bone-cutting planes through each cross-sectional image were defined, with a secure margin from the
The bone block was defined in all three dimensions: length, thickness, and height. The form given to the block was rectangular, with a cranial, an apical, and two vertical sides (one mesial and one distal). The dimensions of the block were planned, and the thickness of the cutting instrument was taken into account. The projected bone block was 37.5 mm in length, 10 mm in height, and 5.7 mm in thickness. After the cutting planes were established, their projection outside the bone body/surface defined the internal faces of the surgical guide (Fig 2). Each face guided the direction of the cutting tool when it was simply placed against the surface of the surgical guide. The final guide design, including holes for screwing the guide to the bone, was created with CAD software (PlastyCAD 3DIEMME). The surgical guide was produced in medical polyamide by a CAM process (3Dfast).

**Surgical and Postoperative Protocols**

The patient took antibiotics (amoxicillin, Zimox, Pfizer; 1 g orally every 12 hours for 6 days) beginning the day before surgery. During surgery, the patient was medicated intravenously with a sedative (Dormicum, Roche). The surgery was performed under infiltration of local anesthesia (Ultracain DS forte, Sanofi-Aventis). Surgery started with bone harvesting from the external oblique ridge. The incision line was located on top of the alveolar crest. A distal incision traversed the external oblique ridge, while a releasing incision was performed mesial to the mandibular left canine. A full-thickness flap was elevated to expose the external oblique ridge, and of the ramus and the lateral aspects of the mandibular body. The surgical guide was inserted and secured to the bone with a 1.3-mm-diameter screw. The osteotomy cuts were made with a piezoelectric instrument (Mectron) with the flat side inserted against the internal surgical guide face. The surgical guide defined unequivocally the cutting direction (Fig 2), while the cutting depth was determined by the volumetric image analysis in each osteotomy segment, in which a maximum working depth (Fig 3) was defined. The cranial and mesial osteotomies were performed using insert OT7, the apical with OT8L, and the distal with OT8R (Mectron). Computer planning of the osteotomy lines allowed the instruments to be inserted into the bone deeper than just the cortical plate thickness, thus reducing the inner bone surface that had to be fractured to a minimum. The block was then easily removed by a straight thin elevator, and hammering was not required (Figs 4 and 5). Following the bone block management technique of Khoury,8,21,22 the bone block was bisected into two thinner cortical laminae, which were then grafted vertically to both defects and combined with autogenous bone particles scraped from the same laminae (Fig 6). Flaps were passively sutured following the protocol described by De Stavola and Tunkel.23

The postoperative phase was characterized by swelling and limited pain, but no signs of neurologic deficiencies were seen. A postoperative CT of the patient’s mandible was obtained. The DICOM datasets were processed with diagnostic and analytic software (3Diagnosys 4.0, 3DIEMME) to extract the bone surface in stereolithographic format. The presurgical and postsurgical surfaces were imported into software for medical image processing (Geomagic Qualify 12, Geomagic) and superimposed through a best-fit iterative algorithm using the bone regions outside the harvesting area as reference points. The software calculated the discrepancy between the presurgical and postsurgical images as 0.25 mm (Fig 5).
Four months later, four implants were placed (Xive Cell Plus, Dentsply Implants) (Fig 7) following a computer-guided procedure (ExpertEase, Dentsply Implants). The implants were allowed to heal for 4 months (Fig 8). The outcome of the bone reconstruction procedure, which is not the focus of this manuscript, was comparable with the results reported by De Stavola and Tunkel in a prior study of vertical autogenous bone augmentation.22
CONCLUSIONS

In this patient, two vertical defects were treated with a single bone block harvested from the left external oblique ridge of the mandible. Compared to a traditional approach, surgical time and economic and biologic costs were reduced. In fact, traditionally, each defect with similar dimensions would have required the harvesting of two blocks or the involvement of an extraoral donor site. This case report demonstrated the feasibility of performing mandibular bone harvesting with a computer-guided approach. This approach may improve the effectiveness and predictability of bone-harvesting procedures from the point of view of both bone quantity and safety. Nevertheless, these advantages are still theoretical and must be validated by well-designed studies focusing on individual steps of the surgical phase, such as guide position accuracy, and on the postoperative phase from the patient's point of view regarding the impact of this approach on quality of life.

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REFERENCES