Computer-guided bone lid osteotomy with piezosurgery

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Summary

Aim: **The aim of this paper is to present a case of mandibular cyst in proximity to the left inferior alveolar nerve and the adjacent teeth successfully treated with computer-guided bone lid technique.**
Case presentation: **A patient was referred to our Department with an asymptomatic radiolucent lesion in the left mandible coinciding with the edentulous site of a second premolar. The lesion was confirmed using cone-beam computed tomographic imaging. Two tooth-supported computer-aided design/computer-aided manufacturing guided surgical templates were designed and produced to guide the piezoelectric tips on the planned osteotomy planes. The cystic lesion was accessed through a buccal bone lid fashioned using a piezoelectric device. The lesion was removed and the bone lid was returned to its original position and stabilized with fixation microplates.**
Conclusions: **Alveolar bone lesions can be treated successfully with bone lid techniques using piezosurgery. Computer-guided bone surgery offers the advantages of accurate and conservative surgical planning, enabling a safer and easier procedure.**

Key words: bone lid, CAD-CAM, computer-guided surgery, customized templates, cyst, piezosurgery.

Introduction

The removal of alveolar bone lesions or impacted tooth in the mandible may lead to extensive residual bone defects, as a result of both the pathology or tooth itself and the ostectomy, which must guarantee an adequate access and visibility to the surgical field (1-3).
As alternative to the traditional ostectomy, the bone lid technique has been proposed as a valuable conservative method for accessing alveolar bone diseases (2,4). Briefly, this technique consists in fashioning and removing a bone window, which is subsequently repositioned at the end of the surgery. The lid is then fixed in place with miniplates (1,4), transfixation screws (2), ligatures (5,6), or adhesive acrylic tissue (7). Rigid fixation may not be necessary in case of high stability of the repositioned bone lid (2).
As compared to the traditional approach, this technique provides better access and visibility to the surgical site, allows to restore the integrity of the bony wall avoiding secondary bone defects due to access osteotomies and, in cases of close proximity to the alveolar nerve, allows to easily identify and protect the nerve reducing the risk of neurological damages (1, 3, 8). The osteotomy for designing the bony lid can be performed with fissure burs (9), oscillating saws (10), microsaws (2), or piezosurgery (1, 3, 4, 8). The use of the piezosurgery enables beveled, thin, and precise osteotomies, and facilitates the repositioning and fixing of the bone lid (1). In addition, its use is particularly indicated when the lesion is in proximity of delicate structures, such as the inferior alveolar nerve, considering its selective and soft tissue sparing abilities, avoiding soft tissue injury also in cases of accidental contact with the cutting tip (8, 11). Beside the piezosurgery, computer-aided design and computer-aided manufacturing (CAD-CAM) can be used to advantage in the bone lid technique, as they have demonstrated their validity in various surgical procedures requiring individually guided osteotomies (12-14).
The aim of this case report is to describe the application of computer-guided surgery to controll the angle

and depth of the osteotomy lines to use in fashioning a bone lid. A mandibular cyst proximal to the mandibular canal and the adjacent teeth was treated using two complementary CAD-CAM templates.

Case

1) Case presentation

A healthy 52-year-old male patient was referred to our Department with a radiolucent lesion in the left mandible coinciding with the edentulous site of a second premolar. The patient was clinically asymptomatic and the lesion was an incidental radiographic finding. Preoperative cone-beam computed tomography (CBCT) (Fig. 1) revealed an unilocular radiolucent area with well-defined margins proximal to the mental foramen, mandibular canal and adjacent teeth. The lesion was surrounded by bony walls at least 1 mm thick.

2) CAD-CAM workflow

The CAD-CAM SafeCut® workflow (SafeCut®, GuidedSurgery2.0 srl, Padova, Italy) was adopted (15,16). The Digital Imaging and Communication in Medicine (DICOM) datasets were processed with diagnostic and analytical software (3Diagnosys® 4.0, 3DIEMME®, Como, Italy). Anatomical structures such as the alveolar canal, the mental foramen, the mental nerve and the dental roots in the area of the lesion were identified. Ideal bone cutting planes were defined (angle and depth) following specific targets, which included: performing the osteotomies as close as possible to the roots of the adjacent teeth and the mental foramen, while avoiding any contact with them and not invading the periapical areas of the teeth; ensuring the maximal extension of the bone lid in relation to the bone disease; creating a long bevel along the osteotomies; fashioning a bone lid of adequate thickness and area. The projections of the planned cutting planes defined the shape of the surgical guide (Fig. 2). The template's lateral contours guide the piezoelectric insert simply by applying pressure on it. The final guide design, including the anchorage to the adjacent teeth, was shaped using a CAD software (PlastyCAD, 3DIEMME®, Como, Italy). Two complementary surgical guides were planned to facilitate the

Figure 1. Panoramic view (a) and axial view (b) obtained from the preoperative CBCT. An unilocular radiolucent area is detectable in the posterior left mandible in close proximity to the mandibular canal and mental foramen.

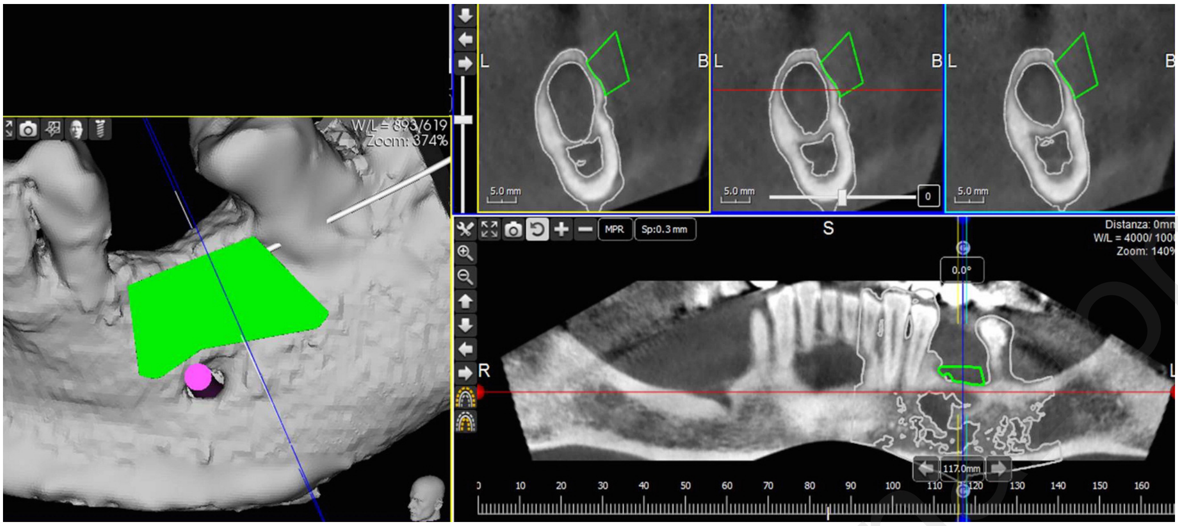

Figure 2. Preoperative osteotomy planning. The morphology of the surgical templates is designed so as to obtain osteotomies at a safe distance about 1-1.5 mm from the adjacent teeth, the mental nerve, and the mandibular canal. The size of the bone lid was designed to be as ample as possible, avoiding the crestal area, for the placement of a delayed implant.

surgical workflow, one for the upper osteotomy and one for lateral and lower osteotomies. The surgical guides were made of medical polyamide by means of a CAM process (3Dfast srl, Padova, Italy).

3) Surgery
Surgery was performed under local anesthesia and sedation. A full-thickness flap was reflected buccally and adequate access to the alveolar bone lesion was assured by means of a buccal bone lid. The surgical guides were inserted and stabilized by anchoring them to a tooth. Piezosurgery® (Mectron Medical Technology, Carasco, Italy) was used in the bone mode with the UNIVR tip (Mectron, Italy).
The osteotomies were completed by placing the side of the piezoelectric insert facing against the outer faces of the two surgical guides. The surgical templates unequivocally defined the direction of the cutting action. The depth was established on volumetric image analysis. In accordance with the preoperative plan, the mesial and distal cuts were made to a variable distance of 1-1.5 mm from the adjacent teeth, while the inferior cut was made at least 1.5 mm above the mental foramen (Fig. 3a-c). After its removal (Fig. 3d), the bone lid was placed in sterile saline solution. The diseased tissue was removed (Fig. 3e) and the buccal bone lid was put back in its original position and stabilized with 1.3 mm fixation microplates (Synthes GmbH, Oberdorf, Switzerland) (Fig. 3f). The gingival flap was then put back in place and sutured. Postoperative CBCT scans revealed a perfect match between the contours of the templates and the osteotomic lines performed (Fig. 4). The histopathological findings were consistent with a residual cyst. No complication occurred. Bone lid healing and bone defect filling were assessed 1 year after surgery on radiological follow-up (Fig. 5).

Discussion and conclusion

Achievements in three-dimensional radiographic imaging techniques and computer technologies, together with advances in CAD-CAM techniques enable digital data from a surgical plan to be transferred to real clinical settings using computer-milled templates or stereolithographic surgical guides (17). The proposed method provided the means to control osteotomy design predictably and very safely and accurately, extending the applicability of the bone lid technique to sites where there is a risk of damaging anatomical structures. Tooth-supported surgical templates can be positioned easily, and enable an unequivocal insertion. They allow adequate bone lid dimensions to be obtained, thereby ensuring an adequate access to the alveolar bone lesion, and a clear identification of its extension during the surgical procedure. Predetermined wide beveled margins can be obtained, facilitating the repositioning of the bone lid and increasing the contact surface at the bone-to-bone interface, which also improves the bone lid's revascularization (1, 2, 4). The successful filling of a residual alveolar defect with bone relies mainly on the achievement of a stable blood clot in a self-contained chamber (18), and the bone lid technique seems to favor this biological process.
The bone lid is usually repositioned and secured with fixation microplates. Pre-plating can be done during the surgical procedure, before the bone lid is raised, or the microplates can be fashioned in advance on a stereolithographic model (19). Alternatively, custom-made titanium CAD-CAM fixation plates can be manufactured (13).
Computer-guided implant surgery is rapidly developing and expanding (17). The use of customized CAD-CAM surgical cutting guides has been described in

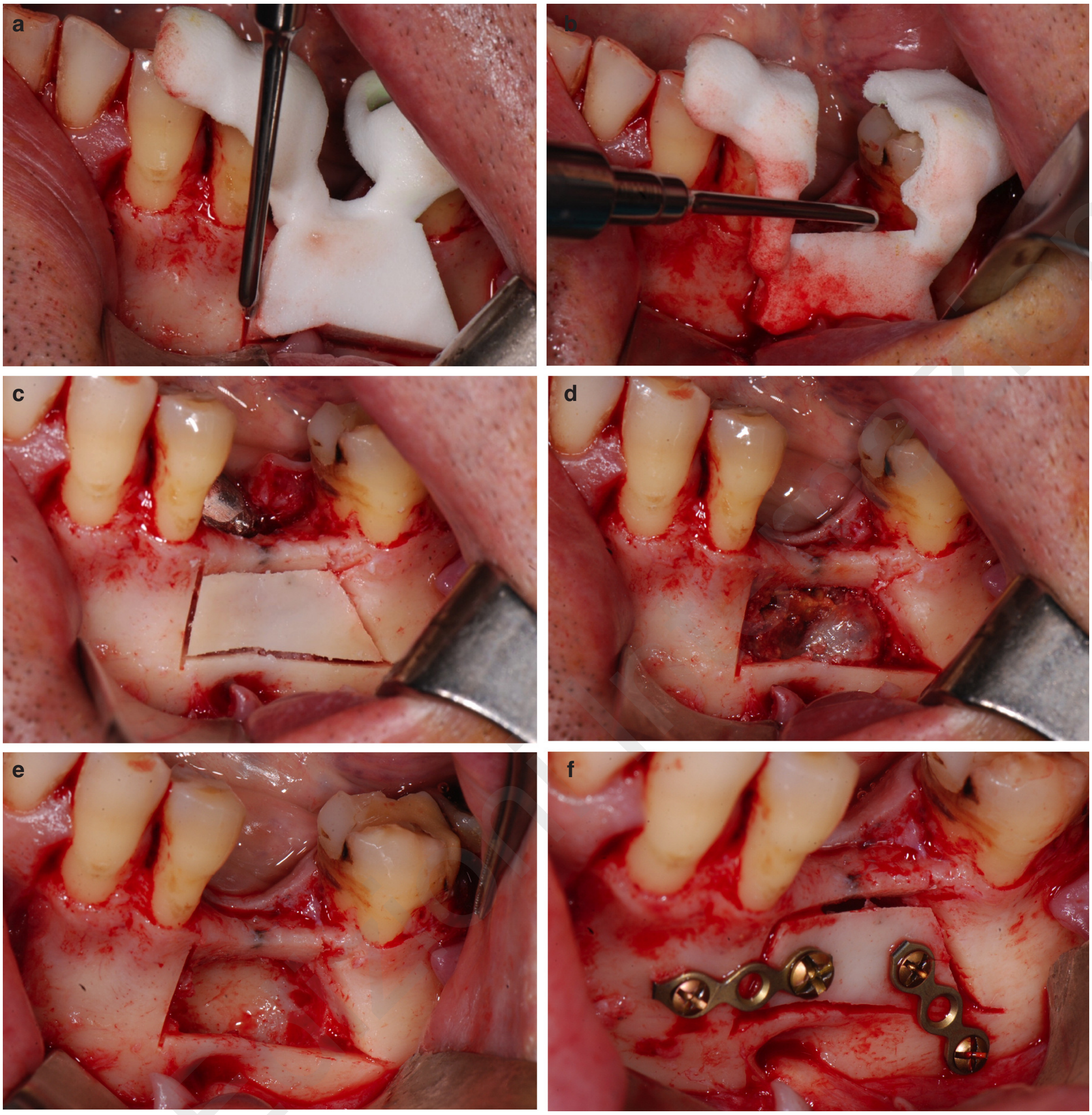

Figure 3. Surgical procedures. The two complementary surgical guides are shown in (a) and (b). (a) The first surgical guide is inserted and stabilized on the adjacent teeth. Inferior and lateral osteotomies are cut with the side of the piezoelectric insert (UNIVR) facing against the external inferior and vertical faces of the surgical guide; (b) the second guide is then inserted and the upper osteotomy is performed in much the same way; (c) mandibular buccal bone lid fashioned using piezosurgery, prior to its detachment; (d) adequate access to the alveolar bone lesion is assured; (e) Residual alveolar bone defect after removal of the lesion. The mental nerve is clearly intact; (f) the buccal bone lid is put back in place and fixed with microplates.

orthognathic procedures too (12,13,19). Milano et al. (20) reported using the piezocision technique as a combination of micro-incisions and localized piezoelectric bone surgery to accelerate orthodontic treatment in adult patients. Piezocision was combined with the use of computed tomography. The depth and location of the corticotomies were planned on a three-dimensional model of the arch, and a surgical guide was fashioned and used during the procedure to avoid damaging the dental roots.

In the bone regeneration field, Felice et al. (14) reported using guided osteotomies in sandwich techniques and inlay block procedures in the posterior atrophic mandible: they used a customized CAD-CAM polymethyl methacrylate surgical template obtained by milling. The Authors' proposed surgical guide helped the surgeon to identify the most appropriate osteotomic path on the bone surface, but no 3D information was provided on the axes of the cutting planes.

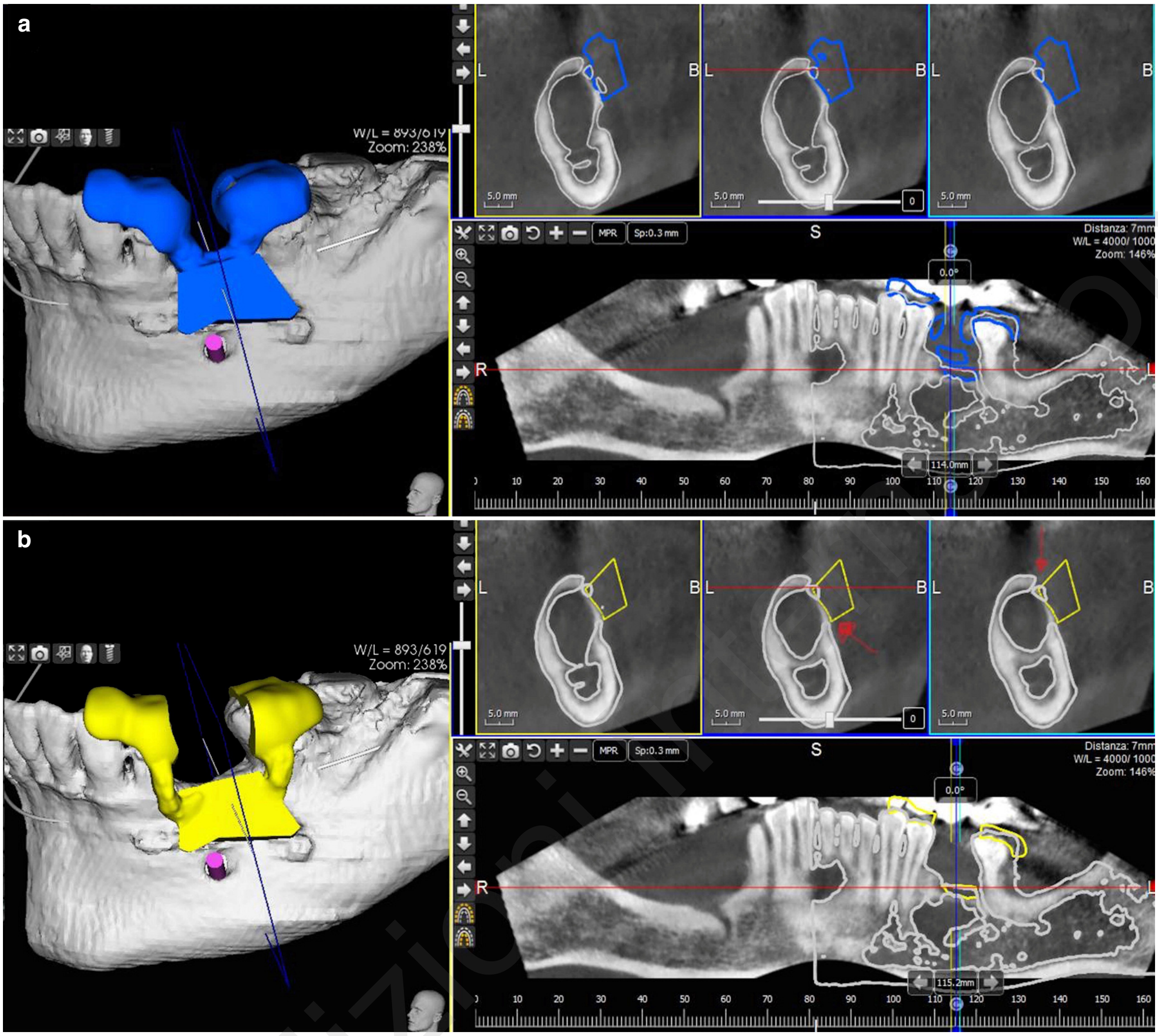

Figure 4. The first (a) and second (b) templates superimposed on the postoperative CBCT. The osteotomies coincide well with the templates' surfaces.

Also autogenous mandibular bone harvesting applying computer-guided surgery was described. As in the present work, bone osteotomy planes were defined beforehand in order to produce a surgical guide, which imposed the 3D working direction to the bone-cutting instrument (15,16).

As for implant surgery, time has to be spent on preoperative planning (17), and it is not easy to estimate the cost-effectiveness of this approach by comparison with conventional surgery, with or without bone lids.

The use of piezosurgery for the treatment of alveolar bone cysts has been described (21-23).

In a randomized clinical study comparing piezosurgery and conventional rotatory surgery for the enucleation of mandibular cysts, no lesion of the mandible nerve was detected when piezosurgery was used in combination with the bone lid technique. Conventional surgery with rotary instruments resulted in 8% hypesthesia at least up to one week (21).

In Kocyigit et al. (22), different piezosurgery tips were used for performing the osteotomies, for cyst enucleation and apicoectomy, when required. No complication occurred in any of the patients treated using piezosurgery for radicular cyst enucleation; instead in the conventional surgery group, complications were reported, including intraoperative and postoperative bleeding, perforation of the cyst epithelium and difficulties in its complete removal, and recurrence.

In a case of giant dentigerous cyst associated with an ectopic maxillary third molar (23), several piezosurgery tips were successfully used for sinus window osteotomy, for the atraumatic dissection of the cyst and for the extraction of the impacted tooth.

The bone lid technique has been validated as a method for preserving alveolar bone (2,4), so every effort should be made to improve this technique, including CAD-CAM applications based on 3D imaging.

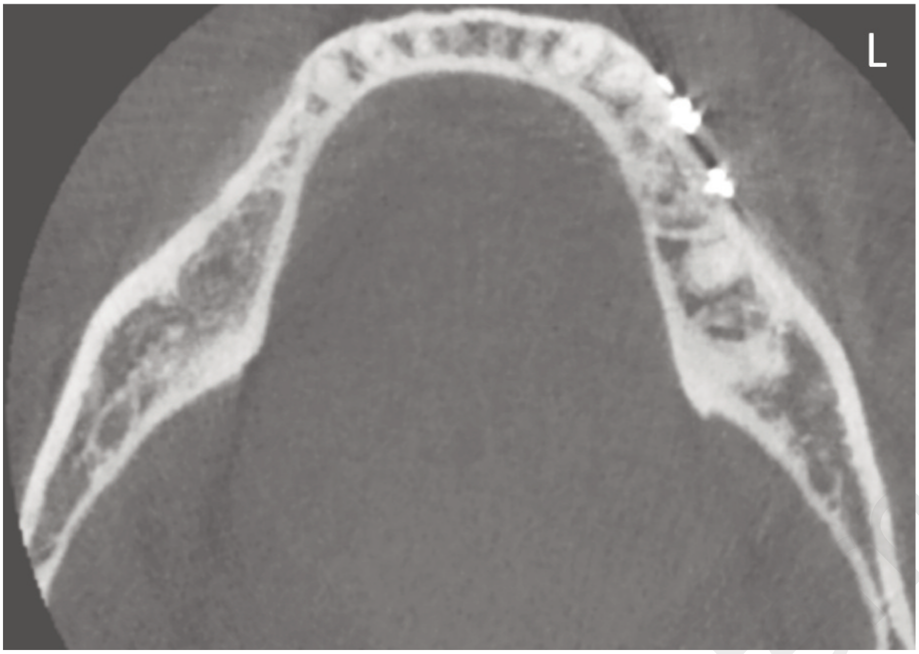

Figure 5. CT scan, axial view, 1 year after surgery. The bone lid is integrated and no residual bone defect is detectable. Fixation screws and miniplates are in place.

Conflict of interest

The Authors have no financial or personal relationships with people or organizations that might inappropriately bias their work.

Acknowledgments

The Authors LDS and AF are the inventors of the PCT/IB2014/061624 “Method for making a surgical guide for bone harvesting” described in this manuscript.

Ethical statement/confirmation of patients' permission

The Authors confirm that the patient was fully informed about his condition and consented to the clinical and surgical procedures performed, which included taking photographs of the lesions and procedures. The Authors confirm that any personal details concerning the patient occurring in any part of the paper or supplementary materials were removed prior to submission. Authors declare that the described procedures comply with the World Medical Association Declaration of Helsinki on medical research protocols and ethics.

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