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# Computer-Guided Bone Lid Technique for Surgical Extraction of Deeply Impacted Mandibular Third Molars: A Technical Report

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**Abstract:** The extraction of mandibular impacted third molars is one of the most common procedures in oral surgery. One of the extraction methods consists of the preparation of a buccal bone lid to obtain access and remove the tooth. This technique aims to reduce bone loss, promote bone healing distal to the second molar, and increase the accessibility to the impacted tooth, particularly in cases of concomitant pathologies or proximity to the mandibular canal. The procedure benefits from the application of 3D printing technologies to produce cutting guides that, combined with piezosurgery, allow deeply impacted third molar extractions with excellent preoperative planning and extreme localisation precision, as well as predictable repositioning and fixation of the bone lid. The objective of this article is to present two clinical cases of the application of the bone lid technique to extract deeply impacted third molars using 3D printed guides with different designs and piezosurgery.

**Keywords:** bone lid; 3D printed guide; piezosurgery; wisdom tooth extraction; CAD-CAM; osteotomy

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## 1. Introduction

The extraction of impacted mandibular third molars represents one of the most commonly performed procedures in oral and maxillofacial surgery. The lower third molars are the most frequently impacted teeth, as they are the last to erupt and there is often inadequate space in the arch for eruption [1,2]. Pericoronitis, destructive caries lesions, and periodontal defects have often been observed in cases of partially erupted impacted third molars [3]. By contrast, non-inflammatory cysts, such as developmental dentigerous cysts, are more frequently reported in association with completely unerupted third molars [4–6]. In a recent systematic review, the pooled prevalence rate of odontogenic cysts and tumours in association with impacted third molars was found to be 5.3% [4]. Even though it is still controversial, the prophylactic extraction of impacted third molars, such as their early removal, might decrease the prevalence of the associated pathologies [3,4,7,8].

In cases of deeply impacted teeth, the standard surgical approach involving crestal access and extensive alveolar bone removal frequently entails the alteration of the mandibular profile and a high risk of neurological damage [9,10]. To date, the best surgical technique for the extraction of the third molar does not seem to have been defined in terms of reduced postoperative complications [11]. The bone lid technique was originally introduced for access to the maxillary sinus and in lower molar apical root resection surgery [12,13]. Since then, it has been applied in various clinical scenarios including the removal of impacted mandibular teeth or benign tumours [14–18]. For these indications, in 2009, Degerliyurt et al. proposed adopting the bone lid technique in combination with piezosurgery to safeguard the inferior alveolar nerve during surgeries [18]. The bone lid technique involves the establishment of a bone window of appropriate size and thickness, preferably performed using thin cutting instruments such as the microsaw or piezosurgery. The fixation of the lid at the end of the procedure is often unnecessary owing to the precise and thin bevelled osteotomies that favour an easy repositioning of the self-retentive lid. In cases of the reduced stability of the bone lid, various fixation devices have been proposed, such as plates, screws, osteosynthesis wires, sutures, or acrylic adhesives [19–23].

The technique has been demonstrated to be advantageous in terms of bone healing, allowing, in many cases, implant placement in the healed site if implant therapy is required [24,25]. Indeed, this conservative technique, apparently more complex than a traditional ostectomy-based approach, enables the maintenance of the alveolar bone, thus minimising or eliminating the need for subsequent bone augmentation procedures.

In the context of personalised dentistry and minimally invasive oral surgery, digital planning and 3D printed surgical guides are becoming essential tools to perform accurate and predictable osteotomies in terms of location, angulation, and cutting depth. The application of computer-assisted osteotomy guides has been associated with favourable outcomes for several indications, including the removal of alveolar bone pathologies [26], orthognathic surgeries [27], corticotomy [28], tooth extraction [29–31], inferior alveolar nerve lateralisation [32], bone harvesting [33], and apical surgery [34].

The aim of this report is to describe two cases of impacted mandibular third molar extractions, approached with the computer-guided bone lid technique performed using piezosurgery and two different stabilisation methods for the repositioned bone window.

## 2. Description of the Cases

Two patients were referred for the extraction of clinically asymptomatic impacted left mandibular third molars. Informed consent was obtained and the two cases belonging to the case collection were approved by the Padova Hospital Ethical Review Board (Prot. 3719/AO/2016). The first patient, a 47-year-old healthy male, was referred for the suspicion of an odontogenic cyst associated with a horizontally oriented impacted tooth 38 incidentally discovered on a panoramic radiograph (case 1) (Figure 1). Case 2 consisted of a horizontally oriented deeply impacted tooth 38 in a 31-year-old healthy male patient, responsible for an increased probing depth distal to the adjacent second molar. In both cases, the unerupted teeth were close to the mandibular canal (Figure 2). Preoperative cone-beam computed tomography (CBCT) was performed in both cases, and the main inclusion criteria for the adoption of the technique were evaluated, namely, the considerable thickness of the buccal bone cortex at multiple points, i.e., >2 mm, and the need to enhance the control of the operatory field in the presence of anatomical limits (inferior alveolar nerve). CBCT allowed the design and production of a 3D printed surgical guide following the SafeCut® workflow (SafeCut®, GuidedSurgery2.0 s.r.l., Padova, Italy).

The Digital Imaging and Communication in Medicine (DICOM) datasets were processed with dedicated diagnostic and analytical software (3Diagnosys® 4.0, 3DIEMME®, Como, Italy). Structures such as the third molar, the pericoronal radiolucent area, the mandibular canal, and the roots of adjacent teeth were identified. Ideal bone-cutting planes were defined (angle and depth) in order to perform the osteotomies as close as possible to the roots of the adjacent teeth while avoiding any contact with them. The projections of the planned cutting planes allowed long-bevel osteotomies and the fashioning of a bone lid of adequate thickness and extent. The final guide design, including the anchorage to the adjacent teeth and the position of the stabilisation screw, was shaped using computer-aided design (CAD) software (PlastyCAD, 3DIEMME®, Como, Italy). The surgical guides were made of medical polyamide by means of a computer-aided manufacturing (CAM) process (3Dfast s.r.l., Padova, Italy) and were designed to have both dental and bone stabilisation. In case 1, the template had an internal cutting profile and an anterior fixation screw (Figure 1), whereas in case 2, the template appeared as a solid with an external guide profile. Furthermore, the fixation screw was envisaged in the centre of the solid, with the expectation of using the same bone hole to stabilise the bone lid at the end of the operation using a longer screw anchored to the lingual cortical bone.

The surgical procedures were performed under local anaesthesia and conscious sedation. A full-thickness flap of sufficient width was raised to easily place and secure the guide with a 1.3 mm fixation screw (Synthes GmbH, Oberdorf, Switzerland). Subsequently, osteotomies were performed following the internal (case 1) or external (case 2) contour of the template using a piezoelectric surgical device (Piezosurgery® Flex, Mectron S.p.A., Carasco, Italy) with a thin 0.25 mm insert (Mectron, insert OT12S). In case 2, a second insert was used to partially cut the cortical bone apically (Mectron, insert OT8L). The bone lid was detached and immediately placed in sterile saline in case 1, while in case 2, it remained partly anchored to the bone apically. In case 1 (Figure 3), a minimal pericoronal osteotomy was performed at tooth 38 with the piezoelectric insert OT12S, and then it was extracted using elevators without odontotomy. Then, the pericoronal lesion was excised and placed in 10% buffered formalin for histological examination. The residual cavity was inspected and washed, and the lid repositioned and fixed back in place with a linear mini-plate stabilised with four fixation screws (Synthes GmbH). In case 2 (Figure 4), the tooth was extracted after crown sectioning, and the bone lid was repositioned and stabilised as planned using a longer screw anchored to the lingual cortical bone penetrating throughout the same hole. The flaps were then repositioned and sutured.

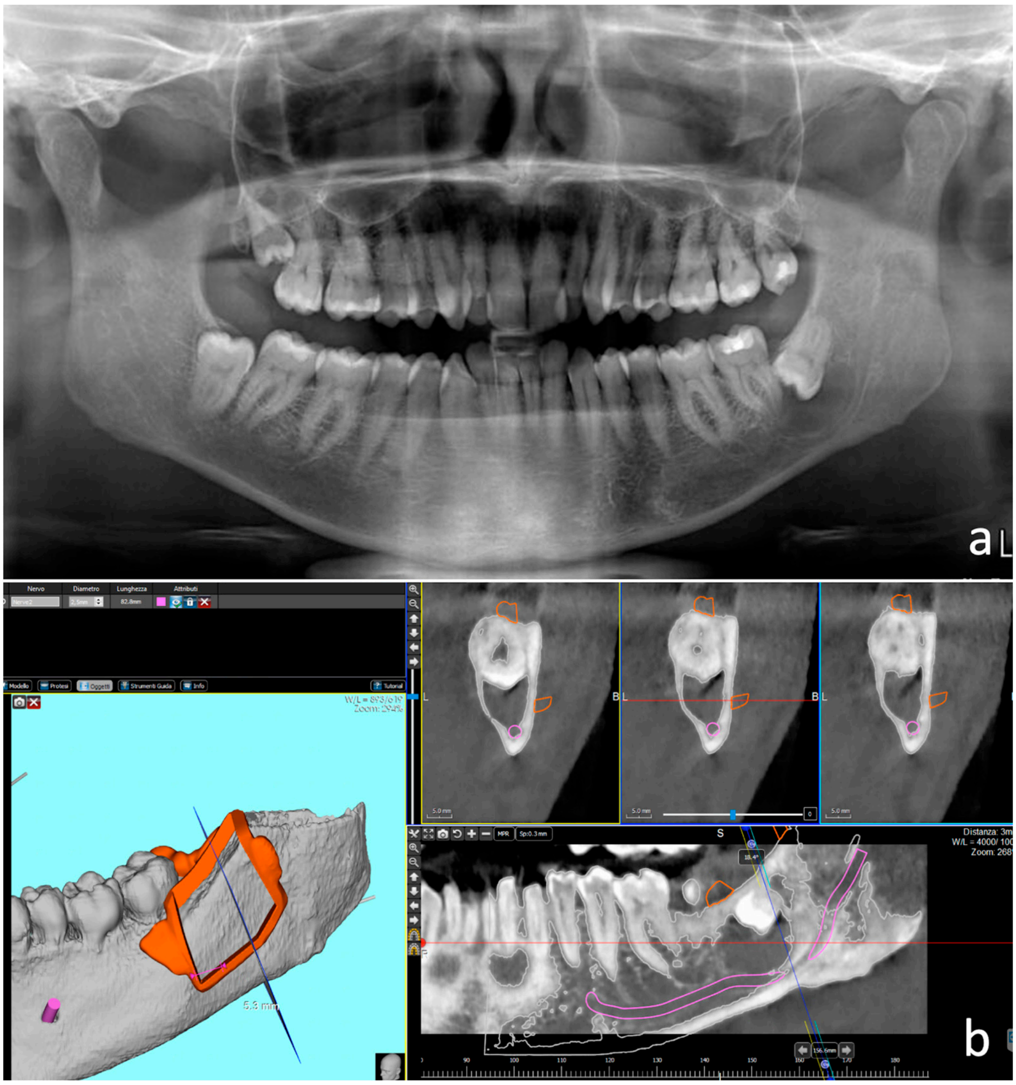


**Figure 1.** Case 1. Odontogenic follicular cyst associated with fully included tooth 38. (**a**) Orthopantomography; (**b**) CT scan with the design of the cutting guide for the bone lid execution. The guide was designed with mixed bony and dental support, and stabilisation by a mesial fixation screw.

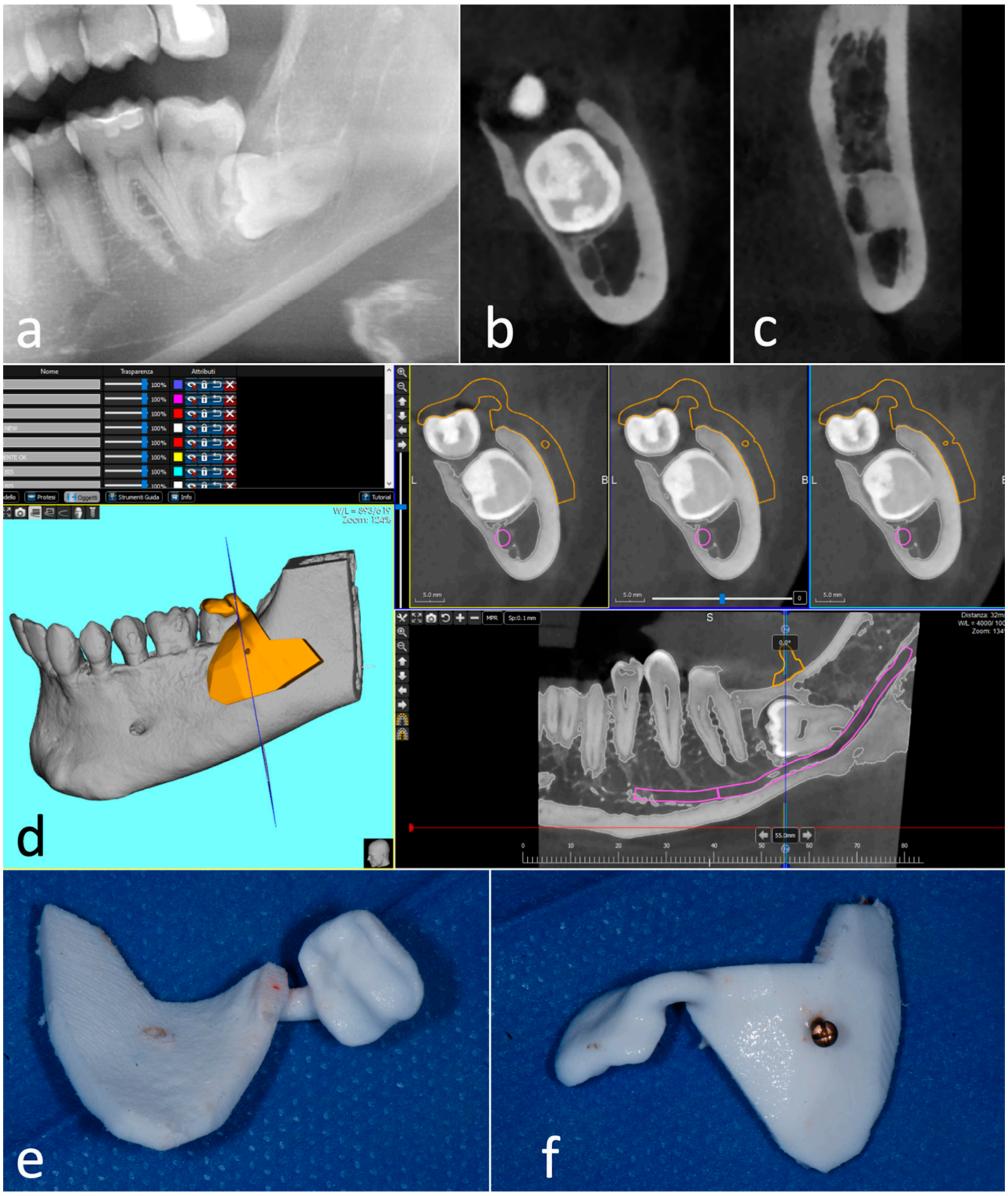


**Figure 2.** Case 2. Impacted tooth 38 with periodontal probing distal to 37. (**a**) Preoperative orthopantomography; (**b**,**c**) details of the CT scan demonstrating the consistent thickness of the buccal wall and the proximity to the mandibular canal; (**d**) surgical guide planning; (**e**,**f**) surgical guide with the fixation screw inserted.

Both patients were discharged with appropriate analgesic and antibiotic therapy and follow-ups were performed at 7 and 30 days postoperatively and after 1 year. In case 1, a histological examination was deposed for follicular cyst. Healing occurred without complications. Immediate postoperative CBCT scans revealed a perfect match between the contours of the template and the osteotomy lines performed. Radiologic follow-up was performed at 1 year with orthopantomography and CT scan, showing the healing of the lesion and the complete mandibular reossification. The reintegration of the bone lid without gaps and the stability of the plate were observed (Figure 5). In case 2, bone healing was detected on the 1-year CBCT scans, even if some areas of lower density could be seen at the level of the extraction socket. The cutting lines were still partially visible and the screw was in place surrounded by high-density bone (Figure 6). In both cases, no symptoms were associated with the screws and plate; hence, there was no indication for a second surgery for their removal.

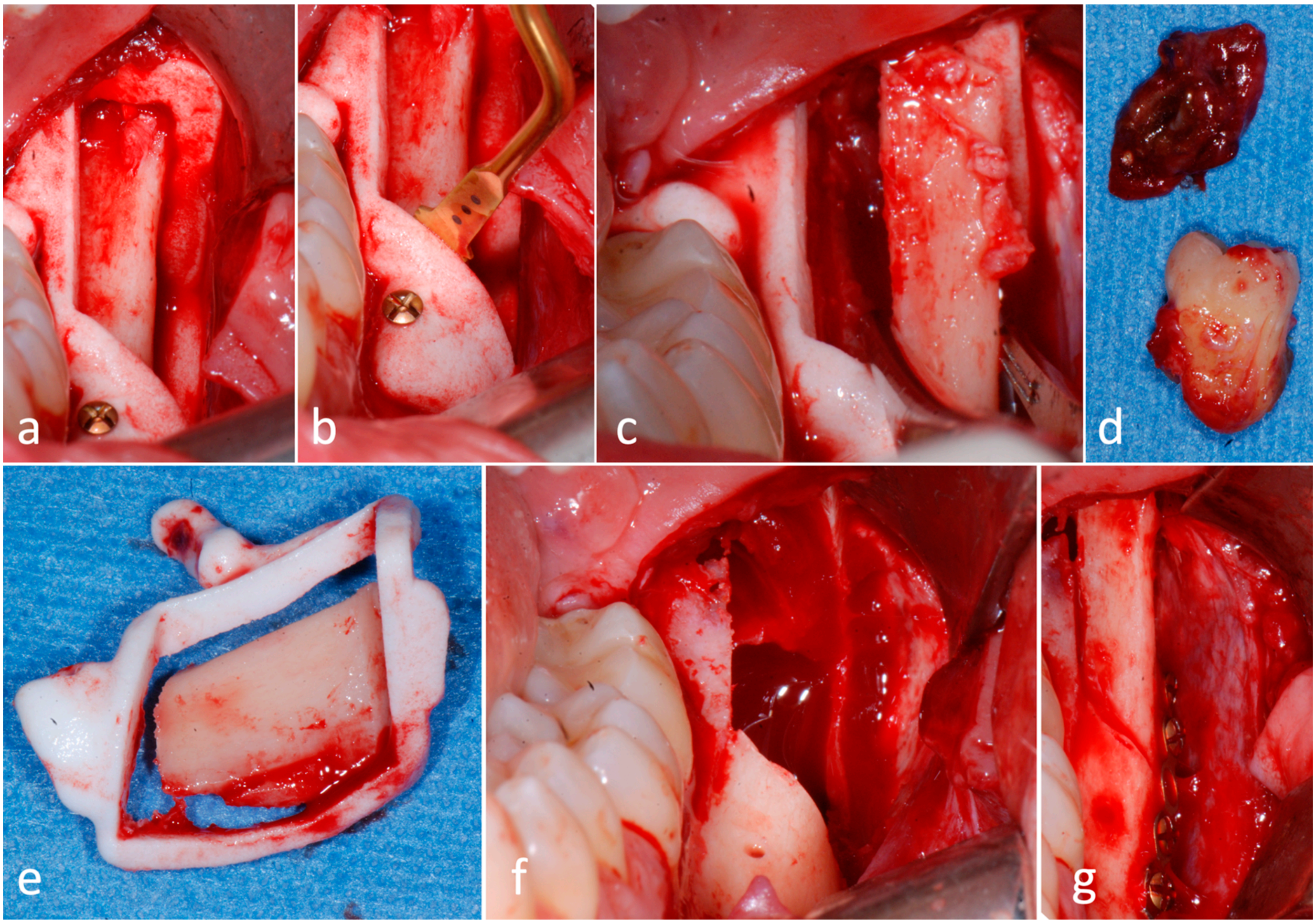


**Figure 3.** Case 1. Surgical procedure. (**a**) The cutting guide is in place; (**b**) osteotomy is performed using piezoelectric surgery; (**c**) detachment of the bone lid; (**d**) the extracted tooth 38 and the removed cyst; (**e**) the bone lid and the cutting guide; (**f**) the surgical site once the tooth had been extracted and the cyst excised; (**g**) the bone lid is repositioned and fixed mesially with an osteosynthesis plate.

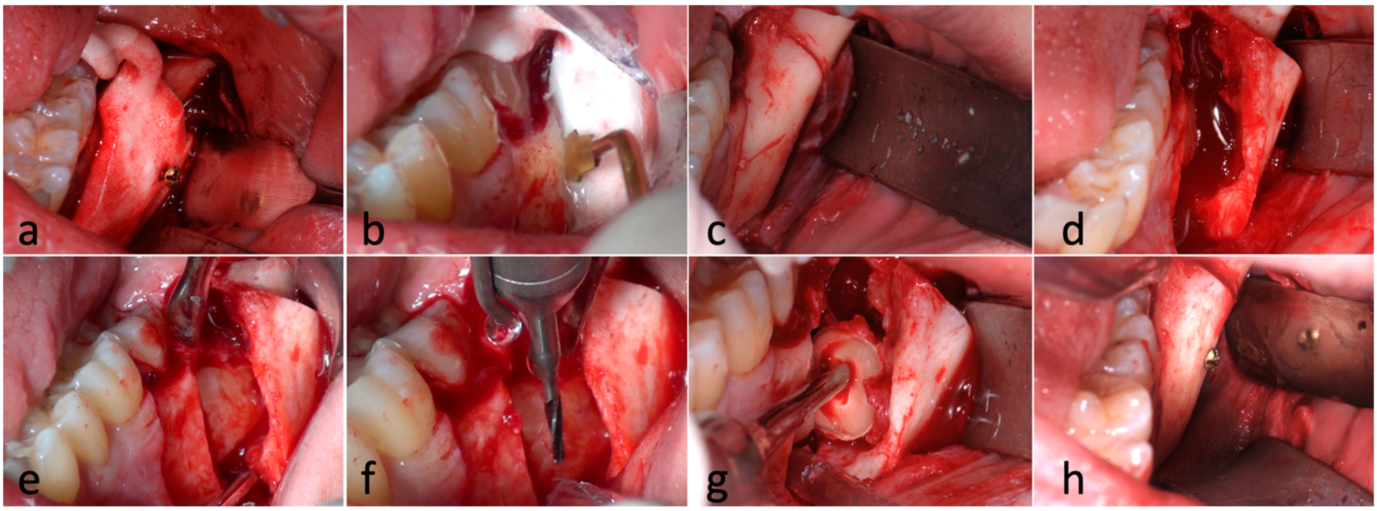


**Figure 4.** Case 2. Surgical procedure. (**a**) The guide in position; (**b**) osteotomy performed with piezoelectric surgery; (**c**) the osteotomy lines; (**d**) the partial detachment of the lid; (**e**) the impacted tooth once the lid had been detached; (**f**) the coronal odontotomy; (**g**) the extraction of the roots; (**h**) the lid repositioned and fixed with the transcortical screw.

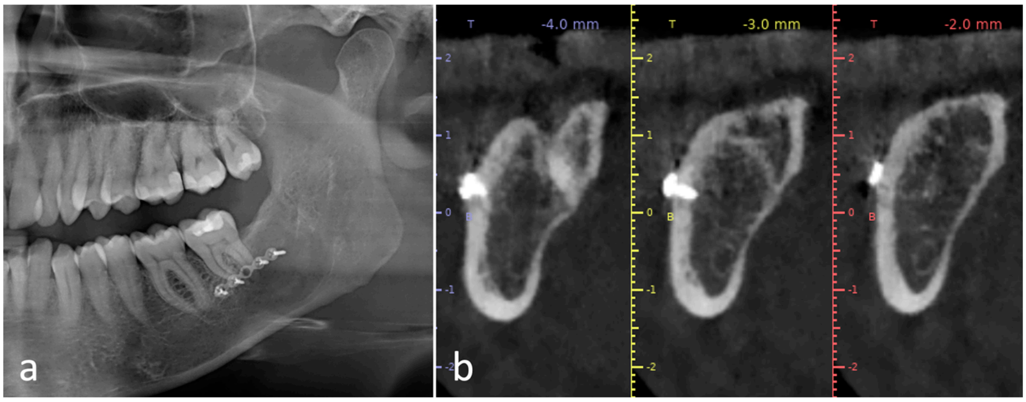


**Figure 5.** Case 1. Postoperative radiological follow-up at 1 year. (**a**) Detail of the panoramic radiograph; (**b**) details of the CT scan distally to tooth 37.

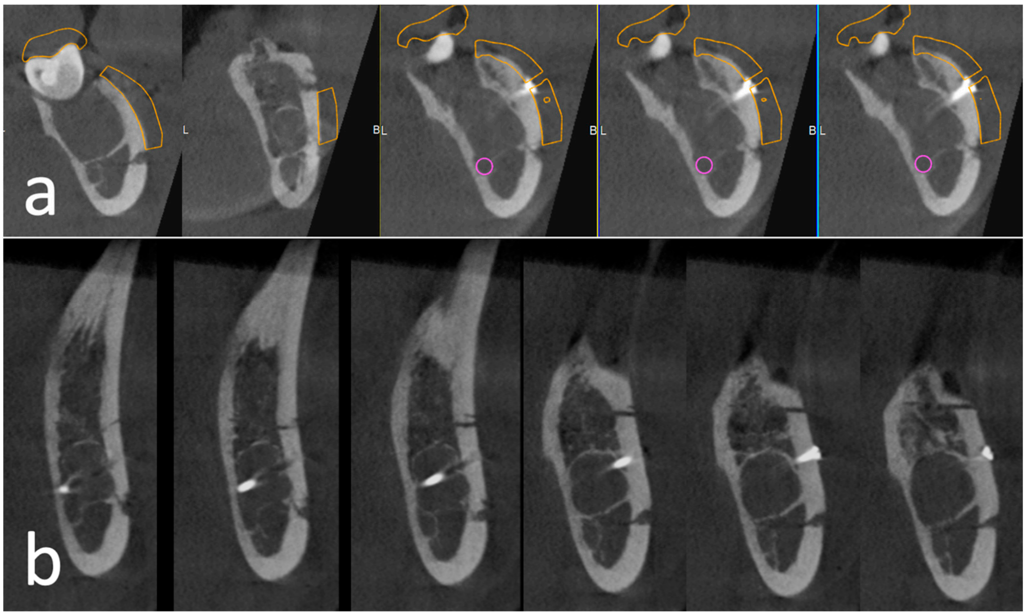


**Figure 6.** Case 2. Radiological follow-up. (**a**) Immediate postoperative control: the alignment of the osteotomy with the preoperative planning is visible; (**b**) 1-year follow-up.

## 3. Discussion

The extraction of deeply impacted mandibular third molars generally requires major ostectomies that may lead to the weakening of the mandible and to compromised healing of the alveolar bone distal to the second molar. An extensive Cochrane Library review on surgical techniques for the removal of mandibular wisdom teeth stated that firm recommendations were not available [11]. Modern alveolar surgery should be accurate and minimally invasive [29]. In this regard, the exposure of impacted teeth and possibly associated lesions through a bone lid performed with piezoelectric surgery has been justified as a technique capable of giving excellent visibility, minimal bone loss, precise cutting ability, and enabling the protection of the inferior alveolar nerve [18]. The main shortcoming of this technique is the risk of sequestration of the bony lid. However, the frequency of this complication is low. In a recent scoping review including 752 bone lids [17], bone lid resorption, necrosis, and removal were rather uncommon and occurred in only 20 cases.

The further evolution of this technique is the application of computer-guided surgery: the osteotomy is designed precisely thanks to cutting guides. The technique may appear more complex than a standard extraction with osteotomy; however, the results in the literature depict excellent bone volume recovery, enabling implant rehabilitations without the need for regenerative procedures [24,25].

Computer-guided osteotomies have also been proposed for bone harvesting from various intraoral and extraoral districts with excellent results in terms of harvesting precision in relation to the planning of the desired volume of the graft and duration of the procedure [33,35–38].

Piezoelectric surgery appears advantageous over other instruments used for osteotomies. A broad range of inserts are currently available, including saw-shaped inserts presenting a saw thickness below 0.3 mm. Piezosurgery has been associated with reduced bone trauma [39], increased visibility of the surgical field due to the cavitation effect, and ease and safety of use in areas otherwise difficult to access [40]. Further advantages derive from its combined use with digital technologies. In recent years, computer-guided surgery using piezoelectric devices has been proposed for a variety of applications, including minor [28,41–44] and major orthognathic surgery [45–47], extractions [29,31], endodontic surgery [34,48,49], and mandibular lesion resection [26,50], as well as cranial vault resection and reconstruction [35]. With regard to the material of the guides, several materials have been employed so far, including titanium [45], polyethylene perephthalate glycol (aka PETG) [47], polymethyl methacrylate (PMMA) [28], and polyamide [33,46], as in the current study.

By using the approach reported in the present article, case-specific stereolithographic surgical guides can be designed during the preoperative surgical planning on CBCT 3D images using dedicated software, and then manufactured through a CAM process. The position, angulation, direction, and depth of the osteotomy can be controlled during the planning phase, optimising the bone lid design [33]. The digital planning procedure allows the creation and selection of different designs. The footprint of the template, in relation to the anatomical structures to be met, primarily guides the choice of the design. With this technical case report, we have intentionally presented two different surgical guide designs: case 1 includes a guide in the shape of a window, whereas in case 2, the guide consisted of a solid piece. It has to be noted that this method allows control over numerous factors, including the protection of adjacent anatomical structures (e.g., teeth, mandibular canal, and mental nerve) and the provision of sufficient width for obtaining access to the teeth and pathologies, as well as the minimal bulk and high stability of the guide [29]. With regard to the last concept, the precise fitting of the template to the cortical bone is crucial to guide the movement of the cutting tool as preoperatively planned.

The firmness of the guide can be achieved with a dental [44] or bone support, or both [31,45]. As previously recommended for computer-guided bone harvesting from the posterior mandible using the same workflow as in the present investigation [33], it seems preferable to produce a template with an extra reference point on the closest tooth rather than a complete bone-borne cutting guide. Indeed, CBCT images taken before and immediately after surgery revealed an average root-mean-square discrepancy of 0.52 mm (0.30–0.97), with enhanced values recorded in the presence of an additional reference point on the nearest tooth, independently of whether it was designed considering preoperative CBCT or intraoral scan data [33]. Furthermore, the highest displacement discrepancies were registered in the mesial and distal osteotomies owing to the inaccurate placement of the template in the antero-posterior direction [33]. The importance of maintaining a safe distance from the surrounding anatomical structures and tooth roots was also emphasised by Cassetta and Ivani in their work assessing the accuracy of computer-guided piezocision [42]. The authors concluded that a safety distance of at least 1.5 mm should be considered during the planning phase.

In line with the present work, encouraging results of the computer-guided bone lid technique using 3D printed guides and piezosurgery were also reported by Tang et al. [29]. Clinical and radiological findings at 6 months from the extraction of six maxillary supernumerary teeth and four mandibular impacted teeth demonstrated good bone formation in the extraction area, which was found to be completely filled with new bone. The bone profile recovery and alveolar ridge height at the surgical site were essentially similar to the preoperative situation; moreover, the bone window was fully reintegrated, osteotomy lines were not visible, and no soft tissue introflection could be detected.

For the extraction of the mesiodens in the premaxilla in eight patients (four per group), Hu et al. utilised piezosurgery to create a bone lid pedicled on the superior mucoperiosteal attachment either with free-hand or computer-guided surgery [31]. All patients recovered uneventfully and all teeth were extracted successfully, without any alteration of anatomic landmark position (anterior nasal spine position and nasolabial angle value). However, similar to what has been reported in implantology [51,52], the use of static guides was found to be timesaving in comparison to free-hand bone lid preparation [31]. The reduced duration of surgery, when positively correlated to lower scores of patients' pain and discomfort, may represent a positive factor [53]. The higher efficiency of the combined use of piezosurgery and 3D printed surgical guides over standard surgery has also been documented for genioplasty, with mean surgical times of 47 and 53 min, respectively [47].

Although the introduction of the bone lid technique for endodontic surgery dates back to the 1980s [13], only recently has it been ameliorated by the use of surgical guides and piezoelectric surgery [54]. A thorough description of the advantages of computer-generated precision endodontic surgical stents (PRESSs) is presented in two works from the same group [34,49]. According to the authors, the main indication consists of the treatment of endodontic lesions in the posterior regions, especially in the mandible, in the presence of large buccal bone thickness and proximity to the inferior alveolar nerve. Despite a relative slowness in performing the osteotomy, the technique exhibited definite benefits for the patient in terms of increased intraoperative safety and postoperative comfort. The benefits for the operators (residents) were also reported, namely, accelerated regeneration time and increased trainee confidence level and number of planned posterior surgical procedures.

Compared to the present report, in the above-mentioned works on PRESSs, a thicker piezo insert was utilised (0.75 mm) together with calcium sulphate to close the gaps around the repositioned bone lid, while no means of fixation were utilised [34,49]. The choice of thick inserts may result in a larger gap size and, consequently, reduce the stability of the repositioned lid and increase the risk of bone sequestration. One of the keys to the success of the procedure is probably the use of thin inserts. When angulated inserts thicker than 0.25 mm become necessary, as for the apical osteotomy in case 2, it might be preferable to opt for a partial-thickness osteotomy followed by a greenwood fracture of one or more margins of the lid. Once repositioned, the lid will then be more stable, thus reducing the need for rigid fixation devices and accelerating the final surgical steps.

A specific application of this technique is the protection of the inferior alveolar nerve. In a case series comprising seven patients, i.e., four with chronic mandibular osteomyelitis and three with cementoma with pain, a template was designed to guide the osteotomy line above the canal, and piezosurgery was employed for osteotomy [50]. The current perception threshold (CPT) was used to objectively evaluate the skin sensation of the lower lip after surgery. As a main result, no significant difference was found in pre-/postoperative CPT difference between the operated and the unaffected side.

Finally, some considerations can be made regarding the satisfaction of the clinicians. High satisfaction with the use of surgical cutting guides was reported for genioplasty, with all of the surgeons feeling reassured regarding the risk of injury to the surrounding anatomical structures and, for the most part, also satisfied with the stability of the device [47]. All practitioners expressed their desire to reuse a surgical guide. No difference in surgical complications such as hematoma or swelling or risk of secondary infection can be expected by using a computer-guided approach together with piezosurgery. On the other hand, it was stated that the protection of the anatomical structures (e.g., the inferior alveolar nerve) was "obvious" and it was indicated as the main advantage of this technique. Indeed, some authors agree that the use of surgical guides to perform precise planned osteotomies is particularly indicated for younger surgical practitioners [33,34].

Lastly, the applicability of this technique could be undoubtedly extended in dental practices since it is economically quite affordable when using open-source software and desktop 3D printing technologies [47]. This fact, associated with the improved time efficiency, may help satisfy patients' expectations of this modernised treatment concept [53].

## 4. Conclusions

In conclusion, a computer-guided bone lid osteotomy using piezosurgery can modify the surgical approach to the extraction of deeply impacted teeth adjacent to relevant anatomical structures. This surgical method, although apparently more complex, offers undisputed advantages such as precise surgical planning, reduced operative times, protection of the post-extraction alveolar defect, and favourable bone healing at the extraction site with preservation of volume. This translates into greater confidence for the operator and benefits for the patient derived from the greater precision and individualisation of the procedure. The study of the tomographic examination and the design of the surgical template require expertise and working times that are often not mentioned: a specialised technician was consulted for the realisation of the presented cases, and the total preoperative working time was about three hours. These aspects need to be considered in the overall case management in addition to the cost–benefit perspective.

Future studies should be conducted to compare the computer-guided bone lid technique to other ostectomy-based techniques, not only in terms of objective clinical and radiographic parameters, but also in terms of patient-reported outcome measures (PROMs). Furthermore, although this type of approach has been presented in the literature for many decades, a better definition of the type of treatable pathologies and any limitations (e.g., age) may be necessary in the future.

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**Institutional Review Board Statement:** The authors declare that the described procedures comply with the World Medical Association Declaration of Helsinki on medical research protocols and ethics of 1975, revised in 2013. The two cases belong to the case collection approved by the Padova Hospital Ethical Review Board (Prot. 3719/AO/2016, February 2016).

**Informed Consent Statement:** The authors confirm that the patients were fully informed about their conditions 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 patients occurring in any part of the paper were removed prior to submission.

**Data Availability Statement:** The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy.

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**Conflicts of Interest:** The authors declare no conflicts of interest.

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