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CASE REPORT

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# Ridge augmentation—The new field of computerized guided surgery: A technical note for minimal-invasive bone splitting

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**Abstract**

Different instrumentation procedures of the alveolar ridge expansion technique (ARST) with or without Guided Bone Regeneration have proven to be effective for successful implant placement in cases of alveolar bone width between 3mm and 6mm. Conventional bone splitting techniques require flap arising. This technical note demonstrates a method for flapless guided bone splitting. For this purpose, a newly developed surgical guide with internal irrigation channels was used.

Using CAD-CAM additive technology, a narrow slot along the field of interest and a pin of a cooling pipe was designed and implemented in a surgical guide template. The bone split was performed flapless through the surgical guide while the cooling pipe was connected to it.

During surgery, the piezo-driven instrument was moved within that slot, and the irrigation solution was directly rinsing it at point of entry through the irrigation channel. This procedure was performed on a 3.3 mm wide alveolar ridge achieving over 3 mm of bone gain.

The described method combines several positive aspects. The micro-invasive flapless surgical procedure might improve postoperative healing. Additionally, sufficient cooling of the bone might lead to less thermal affection of bone cells and less resorption of the cortical bone. However, systematic studies are needed to confirm the observations of the presented case report.

**KEYWORDS**

alveolar ridge augmentation, CAD-CAM, computer-assisted, cooling, irrigation, surgery, template

## 1 | INTRODUCTION

Different instrumentation procedures of the alveolar ridge expansion technique (ARST) with or without Guided Bone Regeneration have proven to be effective for successful implant placement in cases of alveolar bone width between 3 mm and 6 mm. Conventional bone splitting techniques require flap arising. This technical note demonstrates a method for flapless guided bone splitting. For this purpose, a newly developed surgical guide with internal irrigation channels was used. Using CAD-CAM additive technology, a narrow slot along the field of interest and a pin of a cooling pipe was designed and implemented in a surgical guide template. The bone split was performed flapless through the surgical

**Clinical Trial Registration:** The registration of the present study was not necessary.

guide while the cooling pipe was connected to it. During surgery, the piezo-driven instrument was moved within that slot, and the irrigation solution was directly rinsing it at point of entry through the irrigation channel. This procedure was performed on a 3.3 mm wide alveolar ridge achieving over 3 mm of bone gain. The described method combines several positive aspects. The micro-invasive flapless surgical procedure might improve postoperative healing. Additionally, sufficient cooling of the bone might lead to less thermal affection of bone cells and less resorption of the cortical bone. However, systematic studies are needed to confirm the observations of the presented case report.

Ridge augmentation procedures (RAP) have been well documented as pre-prosthetic ridge plasty to improve the hold of tegumental-supported dentures.[1] With the use of dental implants, the indication of RAPs has been extended.[2] In 1992, Simion et al introduced a new technique to enlarge collapsed alveolar ridges.[3] They published a case series presenting immediate implant placement associated with a split-crest technique. In literature, different procedures of ridge augmentation have been described, with and without interpositional bone grafting, use of fine surgical drills, or piezoelectrical-driven instruments (Tolstunovl, et al).

In the case of a regular implant width of approximately 4 mm, ridge splitting is indicated when the remaining bone width is <6 mm.[4] Considering the minimal alveolar bone width for surgical purposes, the minimum alevolar width is 3-4 mm, at least 1 mm of trabecular bone should be presented between the cortical plates to allow the bone to spread and maintain a good blood supply[5] (Khairnar, et al). Under these circumstances, the bone can be spread adequately on either side of the ridge and maintain adequate blood supply.[6]

Especially in cases with narrow alveolar bone width, ridge splitting is a technique-sensitive procedure (Khairnar, et al). Ridge splitting creates a self-space making defect (Mestas, et al). The working tip should be precisely moved during surgery. Unpresice movement of the tip could lead to unwanted fracture lines in the buccal or lingual cortical plate.[7]

Nowadays, surgical methods become more predictable due to more precise preoperative planning.[8,9] Maxillofacial surgery planning is often assisted by computer software.[10] However, the treatment plan has to be transferred precisely during the surgery. Therefore, different approaches have been established in implant planning.[11-13] In addition to the conventional free-hand method, static guide systems can be applied. With the behalf of computer-aided design and computer-aided manufacturing (CAD-CAM), customized guides can be generated.[14,15]

Several studies have shown that guided surgery is more accurate in transferring the planned implant position to the clinical site resulting in less technical sensitivity compared to the conventionally free-hand method.[16-19] However, it has been reported that the use of surgical guides causes overheating of the bone because the guide blocks irrigation.[20] This phenomenon is well documented when piezoelectric-driven tips are used.[21,22]

Dynamic guide systems have been developed to avoid the irrigation blocking while maintaining high surgical accuracy. Dynamic guidance is computerized navigational technology that assists in preoperative planning, as well as real-time surgical motion tracking. With this system, the clinician can correlate the location of the handpiece and selected tip with both internal anatomical structures and the surgical plan.[13,23] Due to the high costs and the high logistical effort, dynamic guide systems are used less often.[24] In order to combine the advantages of the static and dynamic guide systems, the conventional static guide system was modified.

This technical note describes a technique for flapless guided bone splitting using a newly developed CAD-CAM fabricated surgical guide with an internal irrigation channel.

## 2 | MATERIAL AND METHODS (CASE PRESENTATION)

### 2.1 | Ethics approval

The ethics committee of the Hanover Medical School was involved in the study and came to the conclusion that an ethics vote is not necessary in this case. As a result, an approval number was not assigned.

### 2.2 | Medical conditions of the patient

The 41-year-old female patient is in good general condition. She is a nonsmoker, normal weight, has no previous diseases and does not have any regular medication. According to the ASA Physical Status Classification System the patient is classified as ASA I.

### 2.3 | Preoperative planning

The patient was presented, demanding her missing tooth 46 to be replaced by an implant restoration. As the alveolar crest in that region was resorbed vertically, no sufficient bone width seemed to be available for implant placement.

In the field of interest, the CBCT-scan showed a bone width of 3.3 mm (Figure 1). For most accurate and minimally invasive implant placement, a fully guided flapless implant surgery was planned. Therefore, the CBCT-scan was performed and implemented into a specific planning software (coDiagnostiX, Version 9.14, Dental Wings). According to the principles of backward planning, the planned restoration was superimposed on the segmentation model of

**FIGURE 1** Preoperative CBCT-scan showing the lower jaw—axial and parasagittal plane

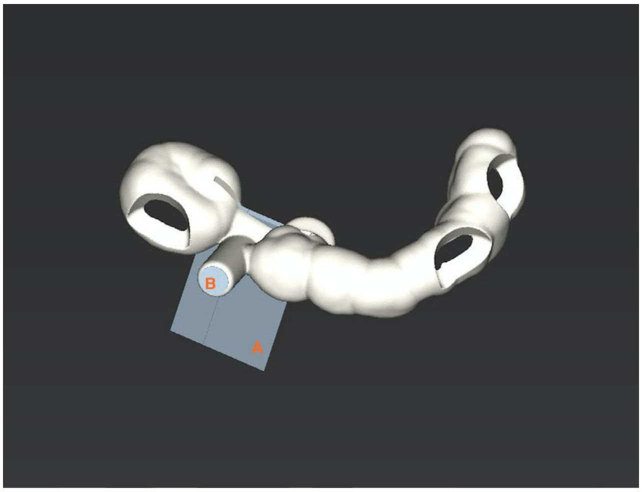


**FIGURE 2** Sleeve design (A) representing the osteotomy plane; Sleeve design (B) representing the irrigation tube slot

the CBCT-scan for prosthetic-driven implant positioning. The surgical guide was designed as recommended by the software-manual.

## 2.4 | Surgical guide fabrication

The integration of the slots for the instrument and the irrigation pipe into the surgical guide was performed in an additional step:

For integrating that slot, a generic sheet-shaped sleeve, representing the future osteotomy plane, was created and implemented into the guide (Figure 2). This resulted in the subtraction of the sleeve body from the guide and finally creating the slot (Figure 3).

For the irrigation channel, the ending of the cooling pipe of the irrigation system was measured manually and recreated as 3D-model in CAD-software (3D Builder, Windows 10, Microsoft, Redmond, Washington, USA). This model was imported as a generic guide sleeve into coDiagnostiX software and implemented into the surgical guide (Figure 2). The irrigation channel was positioned to hit the bone by crossing the working axis of the osteotomy instrument during the preparation (Figure 4). The designed guide was manufactured using a 3D-printer (Varseo S, Bego, Bremen, Germany) (Figure 5).

## 2.5 | Surgical procedure

The surgical guide was set in position. First, the mucosa was crestally cut through the slot of the guide using a scalpel blade (blade no. 11, B. Braun Melsungen AG). Connecting the cooling pipe to the surgical guide allowed the cooling solution to flow through the internal irrigation channels of the surgical guide. Then the piezoelectrical-driven instrument

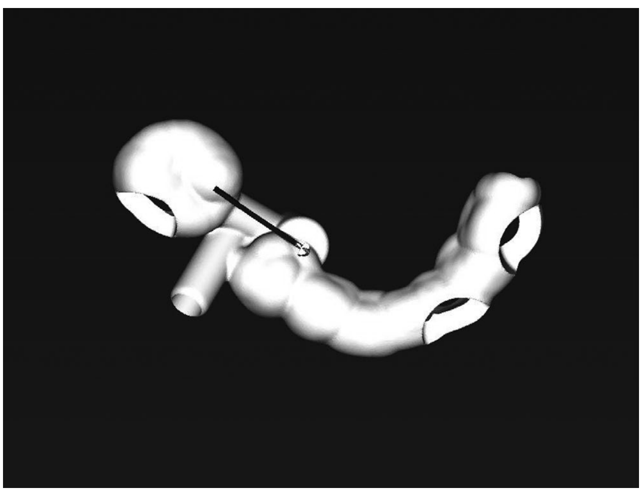

**FIGURE 3** Final design of the surgical guide—aerial view

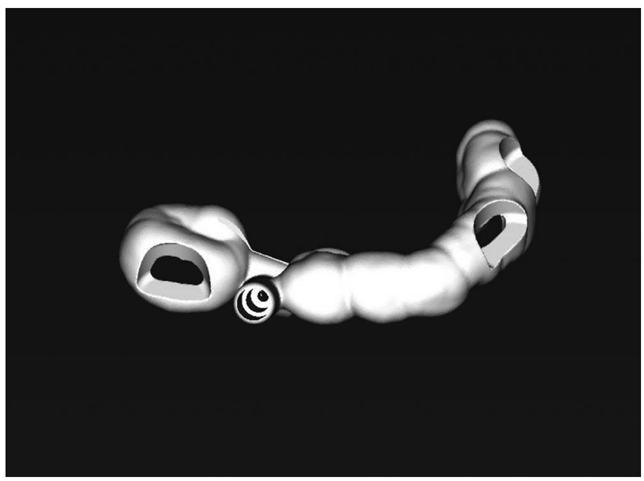

**FIGURE 4** Final design of the surgical guide—lateral view

**FIGURE 5** Surgical guide connected to the irrigation tube

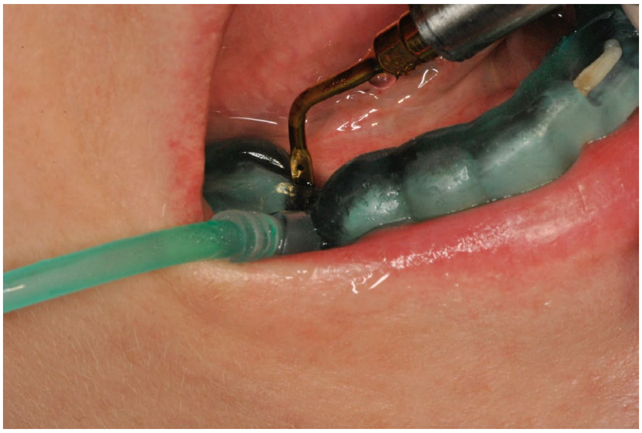

**FIGURE 6** Guided bone splitting

tip (OT7, Mectron S.p.A.) was inserted through the slot and the hold constant oro-vestibular angulation during surgery (Figure 6). After the alveolar crest was splitted, a screw-like bone spreader (D2005, Bone Spreading and Condensing systems, Hager & Meisinger GmbH) was inserted in the created gap. By screwing in the bone spreader the gap was widened. The widened gap was filled with bovine augmentation material (Cerabone, Botiss biomaterials GmbH). A porcine collagen membrane (Jason membrane, Botiss biomaterials GmbH) was placed over the augmented area and slightly pushed under the adjacent soft tissue. Sutures sealed the region.

This ridge augmentation achieved a bone width of 6.5 mm (Figure 7).

## 3 | DISCUSSION

In this technical note, an approach to integrate bone split into the portfolio of guided surgery and implementing an external cooling irrigation system into a surgical guide was presented. Therefore, the patient's consent was obtained for the publication of the present case report.

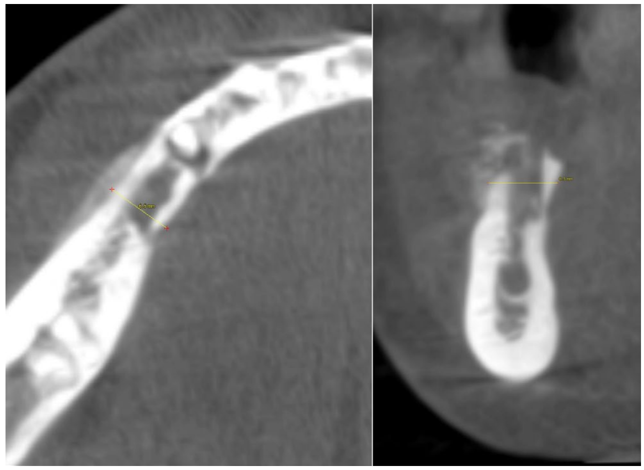

**FIGURE 7** Postoperative CBCT-scan showing the lower jaw—axial and parasagittal plane

In case of highly resorbed ridges, ridge augmentation using autograft and block graft have shown reliable results in successfully augmenting in horizontal and vertical dimension.[25]

These bone-grafting techniques require a full flap and grafting material in granular form or as a solid bone block.[26] In most cases, a collagenous membrane covers the augmented area. To ensure a tension-free cover of the augmented field, the periosteal of the flap has to be sliced. From literature, it is often described that periosteal slicing more likely leads to postoperative pain and swelling compared to a flapless approach.[27] These techniques are related to invasiveness, additional donor site, postoperative pain and swelling (Chiapasco, et al). In contrast, a moderate horizontal ridge defect (≥3 mm, <6 mm) does not require such traumatic technique to be applied (Khairnar, et al).

The alveolar ridge splitting represents an alternative treatment option for augmenting horizontal bone defects comprising triangular V-shaped crests with adequate bone height.[28] This more noninvasive technique can be carried out easily, without much trauma to the patient (Simion, et al).[29,30]

Hence, when the bucco-lingual bone width is ≥3 mm but <6 mm, alveolar ridge augmentation using a ridge splitting and bone expansion technique is a preferable option[29,30] (Simion, et al, Khairnar, et al).

In the presented clinical case, an interpositional bone grafting with flapless access was performed.

The bone split was performed using a guided piezo-driven surgical instrument. Piezoelectrical-driven devices are easier to use, provide more alveolar bone width gain, and cause less trauma to the bone compared to the conventional instruments such as mallets and osteotomies.[6,31,32] They are more suitable to prevent any trauma to the vulnerable anatomical structures such as mucosa, nerves, and blood vessels. Since there is less trauma to the bone, it results in faster healing.[6]

The surgical guide used in the presented clinical case was modified using CAD-CAM by implementing a slot for the bone split and an additional irrigation system. Regarding the instrument handling, in the present case, the working tip was guided through the cutting slot inside the template. These guidance-limited movements in vestibulo-oral direction might result in fewer deviations and decreased risk of fracture lines in either side cortical plates. Connecting the cooling pipe to the surgical guide through a tip allows the cooling through the internal irrigation channels of the operation site. Clinically, more irrigation solution reaches the tip during the osteotomy.

Overheating of the bone during osteotomy has a negative impact on bone healing.[33-36] Therefore, sufficient irrigation must be ensured. Applying an adequate irrigation system is essential when performing guided surgery.

Insufficient cooling has been discussed widely as a disadvantage of guided surgery.[20,34-38] The guide blocks external irrigation, and this results in higher temperatures on the bone.[20] Especially in the case of piezosurgery, overheating is an often-reported phenomenon.[39-41] An in-vitro study of Lajalo et al investigated the heat generation of conventional drills versus a piezosurgery unit. They concluded that piezosurgery bone preparation was two times more likely to increase the osteotomy temperature by 10°C, with significantly higher temperatures than was caused by conventional drilling at the apical cortical portion of the osteotomy.[42] This overheating might lead to bone damage. Therefore, sufficient irrigation must be ensured.

Overheating of the bone is not only preventable by adjusting the preparation procedure but also by modifying the surgical guide. Internal irrigation channels could be implemented into the surgical guide enabling the irrigation solution to hit the bone by crossing the working axis of the guided instrument during osteotomy and thus increase the cooling efficiency.[20]

The use of CAD-CAM, as described in this technical note, enables an improvement of the patients' postoperative situation and cooling irrigation during guided osteotomy with no additional costs or affection of the workflow.

Regarding the cortical bone, our approach might reduce the postoperative resorption by remaining the cortical bone connected to the periosteal. Guided flapless surgery leads to less postoperative pain, bleeding, discomfort, shorter surgery time, and reduced healing time.[35,43,44] Also, postoperative resorption of the cortical bone is less by applying the flapless approach.[45]

## 4 | CONCLUSION

A newly developed CAD-CAM fabricated surgical guide with an internal irrigation channel for flapless bone split was presented.

The flapless technique for the guided bone split has the potential to improve postoperative healing and the cooling of the bone.

Here, the implementation of an internal cooling channel inside the surgical guide might lead to less thermal affection of bone cells and less resorption of the cortical bone.

However, systematic clinical studies are needed to confirm the observations of the advantages of the presented technique.

## ACKNOWLEDGMENTS

We declare that all authors have read the guidelines on ethical considerations. We have not received any funding for this study.

## CONFLICT OF INTEREST

We declare that there are no conflicts of interest.

## AUTHOR CONTRIBUTIONS

VA and CvS: conceived the idea. CvS: involved in surgery. VA, MS, and GM: led the writing.

## ETHICAL APPROVAL

The ethics committee of the Hanover Medical School was involved in the study and came to the conclusion that an ethics vote is not necessary in this case. As a result, an approval number was not assigned.

## PATIENT CONSENT STATEMENT

All persons involved had provided their informed consent prior to inclusion in the study.

## DATA AVAILABILITY STATEMENT

Data sharing not applicable to this article as no datasets were generated or analyzed during the current study.

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