Guided Implant Placement Using an Internally Cooling Surgical Template: A Technical Note

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Cooling irrigation during implant bed preparation is mandatory to avoid overheating. Due to the surgical guide design, external cooling systems do not reach the point of entry of the implant burr. Here, a new technique for irrigation during guided implant surgery for direct rinse of the burr is described. Using computer-aided design/computer-aided manufacturing additive technology, a pin of a cooling pipe was designed and implemented in a surgical guide template. The implant bed preparation was performed while the cooling pipe was connected to the surgical guide. During surgery, the irrigation solution was directly rinsing the burr at the point of entry through the irrigation channel. The use of a cooling surgical guide seems to improve the cooling of the bone during implant bed preparation. This might lead to less thermal effect of bone cells. However, systematic studies are needed to confirm the observations of the presented case report.

Key Words: guided surgery, irrigation, CAD/CAM

BACKGROUND

Implant bed preparation is performed by drilling or by using piezoelectric-driven instruments. Both methods lead to an increase in the local bone temperature. To prevent these complications, cooling during implant bed preparation is crucial.

In several studies, it was shown that overheating of the bone reaching temperatures of 47°C for 1 minute could cause irreversible damage.[1–4] This impairs the bony turnover that affects osseointegration and the long-term survival rate of dental implants.[5]

Liu et al[6] described 3 ways of heat generation: the heat coming from the deforming power of the cutting layer, from the friction between the rake face of the cutter and chip, and from the friction between the drill surface and the wall.[2,6,7] The third way is much lower than the others and of no clinical relevance.

The temperature during drilling procedures could also be influenced by different factors. Möhlenrich et al[4] identified 4 different influencing factors: operator, manufacturer, site, and patient. Regarding the operator, pressure, movement, speed, and duration of the drill can influence temperature elevation. High drill speed and dense bone type have a further affect on temperature increase, in contrast to the material of the drill.[4,6,8] From the manufacturer's side, drill design, drill sharpness, and irrigation system influence heat generation. In addition, cortical thickness, depth drilled, patient age, and bone density affect heat during preparation. Additionally, Barrak et al[7] observed that drill diameter and drill wear influence temperature elevation. Repeated drill sterilizations, use of disinfectants, saline irrigation solutions, and metal-to-metal contact (in the case of guided surgery) can increase wear level.[5,9] Misir et al[10] found that guided drilling led to mean peak temperature elevations more than 7°C higher than conventional osteotomy.

To avoid heat generation, a sufficient irrigation system must be ensured. Different irrigation systems are described in the literature.[4,6,10–12] The irrigation solution can reach the bone using internal or external irrigation drilling systems.[11,12]

Since guided flapless implant surgery was introduced, implants can be placed more accurately, with less risk of injuring adjacent anatomical structures and less postoperative discomfort than conventionally experienced.[13–15] Several studies have described the advantages of guided flapless implant surgery.[15–19] The literature regarding potential disadvantages is scarce; however, a few scientists have investigated potential disadvantages, especially the overheating of the bone during guided implant surgery.[2–4,6,7]

The present case introduces a guided flapless implant surgery using a surgical guide, with internal irrigation channels and internally cooled drills. The patient's consent was obtained for the publication of the present case report.

CASE PRESENTATION

An 80-year-old female edentulous patient presented wearing full dentures in the upper and lower jaw. As the alveolar crest of the lower jaw was resorbed, sufficient hold for the denture was not achievable by tegumental support alone. Therefore, at least 2 implants were recommended in the interforaminal area.

The panoramic X ray showed sufficient bone height in the intraforaminal region. For the most accurate and minimally

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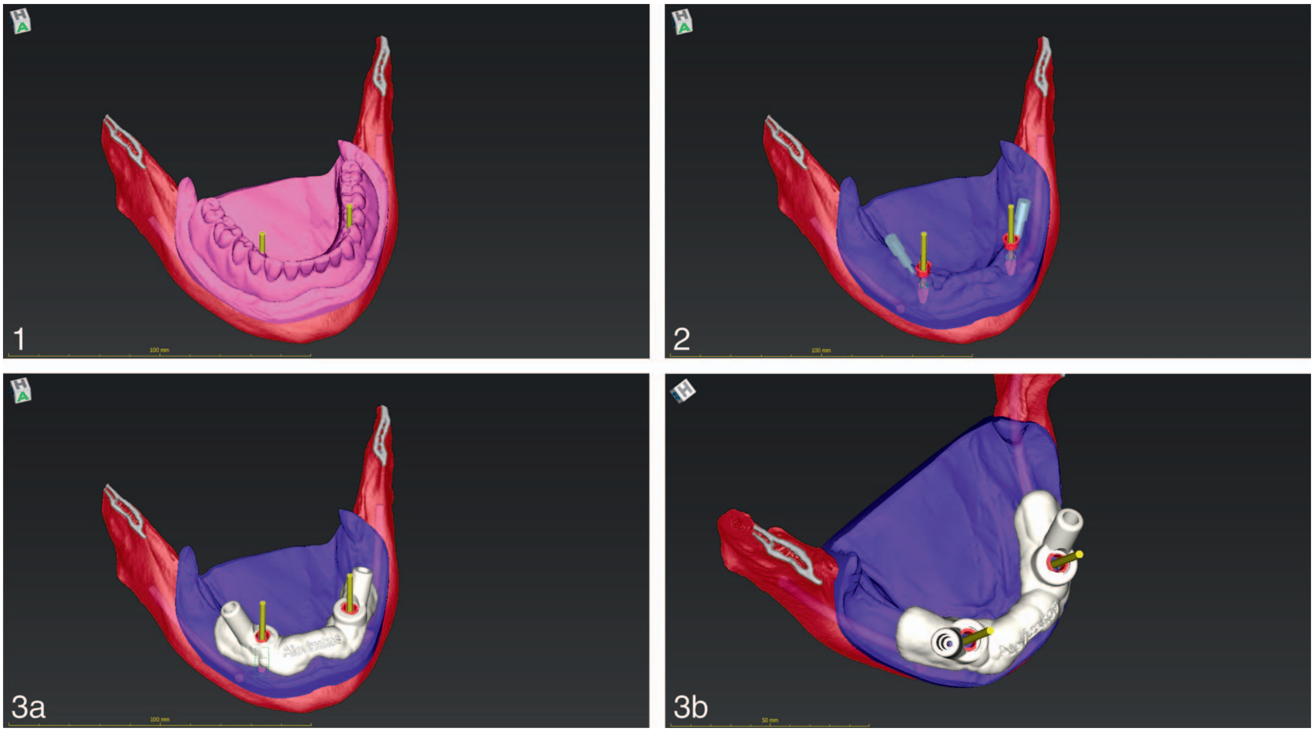


Figures 1–3. Figure 1. Prosthetic-driven implant positioning in the region of the missing first premolars. **Figure 2.** Setting the guide sleeves (red) and adding generic sleeves (light blue) representing in shape the end of the cooling tube for designing an internally cooled surgical guide. **Figure 3.** The 3-dimensional design of the internally cooled surgical guide.

invasive implant placement, a fully guided, flapless implant surgery was planned. Therefore, a computed tomography scan was performed and loaded to a planning software (coDiagnostiX 9.10, Dental Wings, Montreal, Canada). According to the principles of backward planning, the prosthetic plan was superimposed on the segmentation model of the computed tomography scan for prosthetic-driven implant positioning (Figure 1). The surgical guide was designed following recommendations in the software manual.

Integration of the irrigation pipe into the surgical guide was performed as an additional step. For this purpose, the end of the cooling pipe of the irrigation system was measured manually and recreated as a 3-dimensional model in a computer-aided design software (3D Builder, Windows 10, Microsoft, Redmond, Wash). This model was imported as a generic guide sleeve into the coDiagnostiX software and implemented into the surgical guide (Figures 2 and 3). The irrigation channel was positioned so as to hit the bone by crossing the working axis of the guided burr during preparation and insertion of the implant. The designed guide was manufactured using a 3-dimensional printer (Varseo S, Bego, Bremen, Germany; Figure 4).

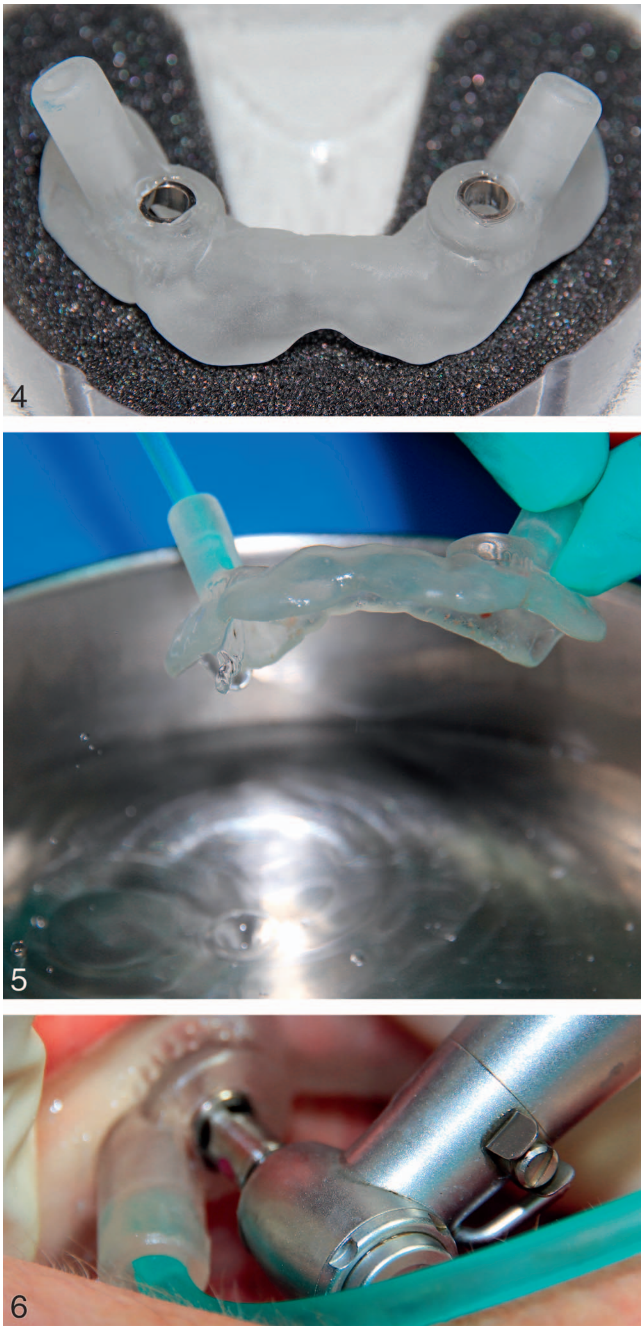
Connecting the cooling pipe to the surgical guide allowed the cooling solution to flow through its internal irrigation channels (Figure 5). The diameter of the cooling port was the same size as the cooling pipe (3 mm), allowing the irrigant to flow unhindered through the surgical guide. The irrigant was refrigerated (7°C) normal saline. After the minimally invasive transmucosal surgery protocol, implant bed preparation was performed while the irrigant was delivered through the peristaltic pump with a maximum flow rate of 65 mL/min. The implants were placed with a sufficient primary stability torque of 35 Ncm (Figure 6).

Discussion

In this technical note, we have presented an approach to integrating an external cooling irrigation system into a surgical guide. The surgical guide used during the implant placement was modified, and an additional irrigation system was implemented using computer-aided design/computer-aided manufacturing. Before modifying the surgical guide with additional features, we ensured that these features did not influence the stability of the guide and the accuracy of implant placement. Implementing additional cooling ports into the upper side of the guide did not affect the fitting of the guide. Connecting the cooling pipe to the surgical guide through a tip allowed cooling through the internal irrigation channels of the surgical guide.

Clinically, more irrigation solution reached the drill during the implant bed preparation.

Overheating of the bone during drilling and implant placement negatively affects on osseointegration and the long-term survival rate of dental implants. Therefore, sufficient irrigation must be ensured. Applying a sufficient irrigation system is important when performing guided implant surgery.



Figures 4–6. Figure 4. The designed guide was 3-dimensionally printed and the guided sleeves added. **Figure 5.** The cooling tube was connected safely with the surgical guide. Irrigation solution flowed through the constructed internal channels. **Figure 6.** Implant bed preparation using an internally cooled drill guided by internal irrigation channels.

Guided flapless surgery leads to less postoperative pain, bleeding, and discomfort; shorter surgery time; more accurate implant placement; and reduced healing time.[3,20,21] All in all, guided surgery is safer and more efficient than conventional freehand surgery, but guide sleeves block external irrigation and result in higher temperatures on the bone.[6] According to several studies, guided surgery is a technique that makes bone temperature control more difficult and causes greater overheating of the bone than the conventional freehand method.[6,22] In contrast, Jeong et al[3] concluded that guided flapless surgery did not generate overheating. This inconsistency may have resulted from different preparation procedures. In the study of Jeong et al, [3] the drill was moved up and down during preparation, enabling more cooling solution to reach the drill and bone.

Taking the current literature into account, Liu et al[6] concluded that using surgical guides with irrigation channels achieves 1.95 times more cooling than conventional cooling. Using drills with internal cooling achieves 3.6 times more cooling than external cooling.[6] Internal cooling is more efficient in reducing temperature, but cortical bone can clog the internal cooling ports, especially in the anterior region of the atrophic mandible.[11] Further, internal cooling drills are not fully sterilizable and thus entail higher costs.

Unfortunately, no method for totally eliminating the heating of the burr has been described in the current literature yet. In studies investigating methods counteracting burr overheating, internal irrigation performed best (1.34°C, 1.48°C).[11,23] However, regarding the crucial temperature of 47°C for bone necrosis, combined external/internal irrigation should provide a suitable method to prevent overheating at that level.[2]

Conclusion

Guided surgery enables accurate implant placement and results in less postoperative discomfort. However, external irrigation is not sufficient as the surgical guide sleeve blocks the irrigation, which might result in overheating of the local bone. The use of computer-aided design/computer-aided manufacturing, as described in this technical note, improves the cooling irrigation during guided implantation with no additional costs and without affecting the workflow. However, systematic clinical studies are needed to confirm the observations of the presented technique.

Clinical Relevance

To avoid bone overheating, the following suggestions are found in literature[3,4,6,7]:

- Use sufficient irrigation (internal cooled guide or drills).
- Withdraw the drill or use an up-and-down motion.
- Use a low drill speed.
- Ensure low drill wear.
- Use sequential drilling.
- Increase the depth drilled for internally cooled drills.

Note

We declare that all authors have read the guidelines on ethical considerations. We have not received any funding for this study. We declare that there are no conflicts of interest.

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