Received: 29 April 2024 | Revised: 18 July 2024 | Accepted: 26 July 2024

DOI: 10.1002/ccr3.9271

Clinical Case Reports Open Access WILEY

CASE REPORT

Three-dimensional printed model reconstruction in intraoperative use for glass penetrating facial tissue removal

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Funding information
Regional Hospital Liberec, Grant/Award Number: VR 230306

Key Clinical Message

In the anatomically complex terrain of the head and neck, the use of 3D intraoperative models serves as an effective verification tool, determining the size, shape, and number of foreign bodies. This allows the main operator to maximize their capacities for careful wound revision and receive real-time information about the remaining content of the sought-after bodies.

Abstract

Penetrating foreign bodies of various origins in the head and neck are uncommon, but potentially hazardous injuries. Complete removal of foreign bodies from soft tissues is essential for optimal healing, minimizing complications, and significantly reducing the risk of the need for reoperation. Despite various technological systems and safeguards available, unintentionally retained surgically placed foreign bodies remain difficult to eliminate completely. A 34-year-old female patient with a cut on the right side of her face who was initially treated with sutures at a general surgical clinic presented for a follow-up examination. A foreign body was verified subcutaneously on the anterior–posterior x-ray image on the right side. Computed tomography confirmed a total of 7 foreign bodies with a density corresponding to dental enamel, distributed subcutaneously, subfascially, and intramuscularly in the right temporal region. As part of the preoperative preparation and analysis, the bone segment of the right temporal fossa with the zygomatic bone and the glass fragments were segmented from the CT data and printed on an SLA printer. The physical 3D models were autoclave sterilized and present during surgery. The position, shape, and number of each individual glass fragment was compared with 3D-printed one. The benefits of producing 3D models of foreign bodies are undeniable, particularly in their perioperative comparison with the removed foreign bodies from wounds.

KEYWORDS

3D print, facial surgery, foreign body, glass particles, inspections

1 | INTRODUCTION

Penetrating foreign bodies of various origins in the head and neck are uncommon, but potentially hazardous injuries. The metal, wood, or glass residues might complicate the treatment due to their wrong detection during primary care and subsequent surgery. The risk of infections is high, and it often results into chronic wound healing disorders. Wounds are likely to be contaminated and must be separated from serious wounds produced by impalement, gunshots, stabbings, and explosions.[1] Most foreign bodies are metal, plastic, or glass, which are easily find by standard x-rays in 2D projections. However, because wooden foreign bodies are uncommon and difficult to detect in standard x-ray pictures, their diagnosis is frequently ignored or delayed. When foreign bodies are suspected, a CT scan is routinely conducted. Nevertheless, it is widely recognized that a wooden foreign body first emerges on a CT scan with a low-density signal, which resembles air bubbles.[2,3] Despite various systems and safeguards available, unintentionally retained surgically placed foreign bodies remain difficult to eliminate completely. Developing a standardized approach to the request, "intraoperative film, rule out foreign body," is essential to reduce the adverse outcomes associated with this problem.[4,5] Several soft-tissue foreign bodies, such as wood and plastic, are not radiopaque and may remain undetected on radiography; however, all foreign bodies are hyperechoic on sonography. Sonographic artifacts deep in relation to soft-tissue foreign bodies are related to the surface attributes rather than the composition of the foreign body and aid in their identification.[6] In this report, our objective is to discuss 3D printing as a tool for foreign bodies inspection in facial traumatology in the case of glass foreign bodies.

2 | CASE HISTORY/EXAMINATION

A 34-year-old female patient with a cut on the right side of her face that was initially treated with sutures at a general surgical clinic presented for a follow-up examination at the Department of Oral and Maxillofacial Surgery, Regional Hospital in Liberec, Czech Republic. Ten days after the initial treatment, the wound had healed by primary intention, but with persistent reactive swelling. The treating oral and maxillofacial surgeon removed the sutures and palpated the swelling, detecting crepitus. The patient described the mechanism and cause of the injury as a fall while intoxicated onto a glass. A glass foreign body was verified subcutaneously on the anterior–posterior x-ray image on the right side (Figure 1). Computed tomography confirmed a total of seven foreign bodies with a density corresponding to dental enamel, distributed subcutaneously, subfascially, and intramuscularly in the right temporal region. Given the location and number of fragments, we indicated revision and removal of the foreign bodies under general anesthesia.

3 | METHODS

As part of the preoperative preparation and analysis, the bone segment of the right temporal fossa with the zygomatic bone and the glass fragments were segmented from the CT data (CT Somaton Edge, Germany). The virtual reconstruction was provided in 3DSlicer software[7] in which virtual models were developed (Figure 2). A SLA printer (Nexa 3D, ITSCZ, Czech Republic) was used for printing the separated foreign bodies. The printing time was 55 minutes and KeyGuide resin was used for printing. The

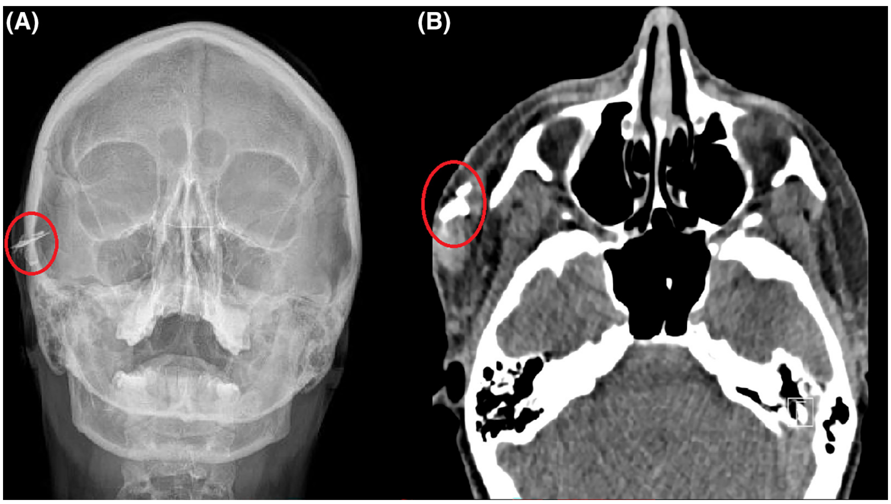

FIGURE 1 Anterior-posterior X-ray image with foreign body localization (A), axial CT slice with part of foreign body localization (B).

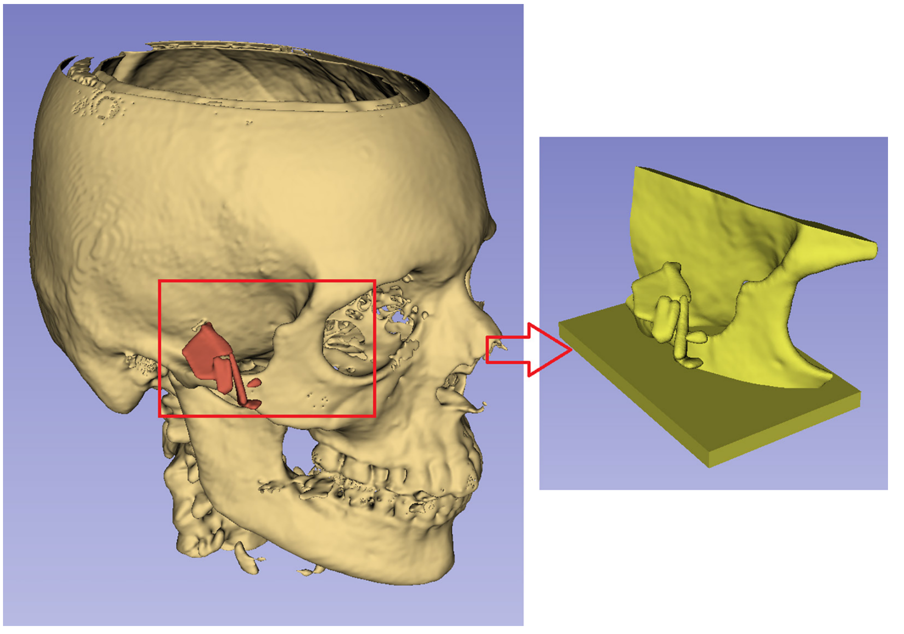

FIGURE 2 Virtual reconstruction of bone and foreign bodies in anatomical position.

FIGURE 3 Removed glass bodies (left) and printed 3D models of glass bodies (right) with corresponding numbers of each individual fragment.

sterilization of printed models was done by autoclave according to datasheet of the material.

The patient's wound was loosened under general anesthesia, and the glass fragments were gradually removed with stepwise preparation respecting the course and branching of the facial nerve and vascular supply of the area, which were counted intraoperatively and compared with the preparation model. After disinfection and wound debridement, the wound was sutured in layers, healing by primary intention without alteration of facial motor innervation. The number and size of each individual glass body was compared to 3D-printed modes, so that no remaining artifacts were forgotten (Figure 3).

4 | CONCLUSION AND RESULTS

Foreign glass bodies were missed on initial evaluation during the first surgery. During the second inspection the 3D reconstruction of foreign bodies indicated the precise position and number of glass particles in the facial part of the patient. Consequently, the simulation for foreign body extraction was then performed. The 3D model improved our clinical workflow, gave us the advantage precise planning and communication with patient. Three months after the surgery, the patient is without any signs of nerve lesion and complications.

5 | DISCUSSION

The use of 3D printing in oral and maxillofacial surgery has enormously increased in the last decades due to the economical availability of this technology. It was many times shown that 3D-printed models allow better preoperative planning, training for the procedures and for pre-shaping of plates. The other use of 3D printing is patient-specific implants (PSI), which are much more demanding, but their manufacturing remains mostly in the hands of the industry.[8] It is obvious that 3D-printed devices will play an important role in healthcare, but more rigorous and long-term assessments are needed to determine if 3D-printed devices are clinically relevant before they become part of standard clinical practice.[9–11] Identification and removal of a foreign body in a wound can be difficult, depending on the type and location of the wound and the timing and mechanism of injury. Thus, having a standardized tool showing to the surgery the size, shape and position of foreign body in a wound would be with a great benefit. In our case the 3D-printed model helped to illustrate the number, shape, and position of glass particles in the body. The use of 3D model in maxillo-facial surgery brought many benefits, including pre-operative planning and saving the time. It may give the surgeon direct observation of the object and location of the lesion. The close conclusions were achieved previous studies when they have applied the 3D models for wooden penetrating brain injury and simulate grasping of bronchial foreign body.[12,13]

The benefits of producing 3D models of foreign bodies are undeniable, particularly in their perioperative comparison with the removed foreign bodies from wounds. In the anatomically complex terrain of the head and neck, this method serves as an effective verification tool, determining the size, shape, and number of foreign bodies. Not only does it objectively save surgical time, but it also distributes the complexity of the procedure between the assistant (who can gradually assemble and complement the removed foreign bodies in correlation with the 3D model) and the main operator. This allows the main operator to maximize their capacities for careful wound revision and receive real-time information about the remaining content of the sought-after bodies. The low-cost production of 3D models of foreign bodies itself has the potential to become a standard, thanks to the widespread availability of FDM printers in oral and maxillofacial surgery workplaces. Hospitals with departments specializing in 3D printing have a tremendous advantage, as they can prepare models of foreign bodies within hours.

AUTHOR CONTRIBUTIONS

Filip Basovsky: Conceptualization; data curation; formal analysis; funding acquisition; investigation; methodology; project administration; resources; software; visualization; writing – original draft. **Lukas Capek:** Conceptualization; data curation; formal analysis; investigation; methodology; project administration; software; supervision; validation; visualization; writing – original draft; writing – review and editing. **Ivo Kucera:** Conceptualization; data curation; methodology; software; validation; writing – original draft. **Frantisek Ptacek:** Conceptualization; formal analysis; funding acquisition; project administration; resources; supervision; writing – review and editing. **Jakub Kriz:** Data curation; investigation; methodology; validation; visualization; writing – original draft.

ACKNOWLEDGMENTS

This study was financed by the internal grant (VR 230306) of the Regional hospital in Liberec Czech Republic.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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How to cite this article: Basovsky F, Capek L, Kucera I, Ptacek F, Kriz J. Three-dimensional printed model reconstruction in intraoperative use for glass penetrating facial tissue removal. *Clin Case Rep*. 2024;12:e9271. doi:10.1002/ccr3.9271