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Technical Note
Pre-Implant Surgery

Fully guided, flapless zygomatic implants for oncological rehabilitation—a technical note

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Abstract. Midface defects following head and neck cancer surgery present significant functional and aesthetic challenges. While free-tissue transfer is a favoured reconstructive approach, it may be contraindicated in the medically comorbid and failure may be catastrophic, resulting in significant morbidity. In such cases, zygomatic implant-retained prosthetic obturators provide an effective alternative. However, traditional zygomatic implant placement often requires the elevation of large full-thickness mucoperiosteal flaps, risking osteoradionecrosis in irradiated bone following postoperative radiotherapy. This technical note describes a novel method for fully guided, flapless zygomatic implant placement that was applied in a 74-year-old with a Brown Class IId maxillary defect following hemi-maxillectomy of a pT4aN0M0 right maxillary squamous cell carcinoma. Using virtual surgical planning, two zygomatic implants were placed utilizing 3D-printed tissue-borne drill guides based on the patient's obturator. These guides were designed with low tolerance flutes to minimize angular deviation and utilized hard and soft tissue undercuts to ensure stability. By using a flapless technique, trauma to the irradiated tissues was minimized, whilst achieving accurate zygomatic implant placement. This case highlights the importance of a multidisciplinary approach between the surgical, prosthetic, and engineering teams. Further studies are needed to validate the accuracy and predictability of this innovative approach.

Keywords: Maxilla; Zygoma; Dental implants; Dental prosthesis; Osteoradionecrosis; Head and neck neoplasms; Computer-aided design.

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Maxillary and midface defects following head and neck cancer (HNC) surgery have significant functional and aesthetic consequences for patients and their quality of life[1]. The repair of such defects continues to be a complex and controversial area in HNC surgery, where there has been a trend from the traditional prosthetic obturator to free-tissue transfer reconstruction[2]. The management of such patients can be further complicated by age and comorbidity, where the increased surgical complexity associated with free-tissue transfer may be contraindicated. In such cases, oral and maxillofacial rehabilitation with prosthetic obturators remains a viable option that can yield excellent functional and aesthetic results[3]. Following ablative HNC surgery, retention and fixation of these obturators poses a challenge and the use of zygomatic implants (ZIs) for oral and maxillofacial rehabilitation has become increasingly common.

Postoperative radiotherapy (PORT) is a common adjunct in patients with HNC. Implants placed in irradiated bone are at a higher risk of implant failure and the development of osteoradionecrosis due to the hypovascular, hypoxic, and hypocellular tissue changes[4,5]. ZI placement usually involves the reflection of a large mucoperiosteal flap to visualize the zygoma and appropriately orientate the implant trajectory, which can be difficult in irradiated tissues and further compromises tissue vascularity. Advancements in virtual surgical planning (VSP) have allowed the use of minimally invasive techniques such as guided flapless implant placement, which may minimize trauma to the at-risk tissues. The authors present a novel approach to ZI placement that was applied in a HNC patient following PORT.

Technique

The oral and maxillofacial rehabilitation of a 74-year-old male with a right maxillary pT4aN0M0 squamous cell carcinoma treated with a right hemimaxillectomy is described. Adjuvant radiotherapy (60 Gy/45 fractions) was delivered to the primary site and bilateral neck. Due to his extensive comorbidities with an ASA of 4 (American Society of Anesthesiologists physical status), the patient was deemed high risk for major reconstructive surgery and vascularized free-flap reconstruction. The multidisciplinary team recommendation was to limit the surgical procedure to prevent general anaesthetic complications. Post-resection, the patient had a Brown Class IId maxillary defect[2]. An obturator was fabricated by the maxillofacial prosthetic team to facilitate function and healing postoperatively. Definitive oral and maxillofacial rehabilitation with two ZIs was performed with the aid of VSP and a fully guided and flapless technique 6 months following completion of radiotherapy.

Implant planning

Following recovery from the ablative surgery and adjuvant radiotherapy, a stable, well-fitting obturator incorporating hard and soft tissue undercuts was fabricated by the maxillofacial prosthetic team. This included a radio-opaque baseplate and positioning markers. With the obturator fully seated in-situ, a computed tomography (CT) scan of the facial bones was performed using the TruMatch CMF CT scan protocol (DePuy Synthes GmbH, Oberdorf, Switzerland). The obturator was subsequently scanned using a TRIOS 4 intraoral scanner (3Shape A/S, Copenhagen, Denmark).

The CT and obturator data were merged, and implant planning was undertaken using VSP software (ProPlan CMF; Materialise NV, Leuven, Belgium) (Fig. 1). The orientation of two ZIs (Southern Implants, Irene, South Africa) was virtually planned to ensure appropriate angulation towards the jugal point in adequate bone stock and away from the peri-orbital soft tissues, with the abutments projecting in the premolar region (Fig. 1A, B). Three implant guides were fabricated for the recommended drill sequence of each implant, as per the Southern Implant system. The baseplate of the original obturator was used as the foundation to these guides, with the addition of a cylinder projecting in-line with the proposed implant trajectory. The height of these cylinders was designed to correspond to the planned drill depth, and their diameters corresponded to the drill bit with an additional 0.1 mm tolerance (Fig. 1C, D). The final guide was designed with a half cylinder to guide implant placement and incorporated a breakaway mechanism to allow for easy removal of the guide and insertion of the implant (Fig. 1E, F).

The guides were trialled prior to surgery to ensure their position was repeatable and stable. The drill bits were also trialled within the cylinders to confirm patency and a single path of insertion, as well as to ensure adequate access with the patient's limited mouth opening and soft tissue interferences (Fig. 2A, B). During this trial it was identified that the right implant trajectory was angled too superficially towards the zygoma. The trajectory was angled deeper in a subsequent VSP session and new drill guides were manufactured.

Implant placement

The procedure was performed under general anaesthesia with nasotracheal intubation. The patient was positioned supine and prepped and draped. Local anaesthetic was administered.

The Southern Implant ZYGEX system drilling sequence was followed for the left side using the fabricated drill guides, without raising a mucoperiosteal flap. Sequential guides were used as planned. The final implant insertion guide was seated and a ZYGEX 3.4 × 55 mm implant was guided into the appropriate trajectory. Once the implant was engaged into bone, the final guide was removed to allow seating of the implant to depth.

The right ZI was then placed using the Southern Implant ONC-55 system. The appropriate drill sequence was followed using the fabricated guides and a 4.1 × 37.5 mm ONC-55 implant was inserted in a similar manner (Fig. 2C, D).

For both implants, the operative time from pilot drill to implant insertion was less than 10 min, and no immediate complications were encountered. The low tolerance of the baseplate allowed for a stable, repeatable seating of the drill guide and re-engagement of the previously drilled holes.

A delayed loading protocol was followed to ensure complete osseointegration of the ZIs in the irradiated bone, and the existing obturator was relieved to accommodate and unload the abutments. Cross-arch stabilization of the ZIs was planned to be completed during the prosthetic phase of rehabilitation.

Discussion

This technical note describes a multidisciplinary approach to ZI rehabilitation of a maxillary defect following ablative HNC surgery. Other novel flapless approaches have been published in the literature, including approaches using dynamic navigation guidance[6] and implant-retained guides[7]; however, these methods are reliant on specialized navigation equipment and existing dental implants, respectively, which may not be readily accessible. The novel approach described here, of a fully tissue-borne guided, flapless ZI placement, relies on technologies that are readily available to most surgeons around the world.

There is conflicting evidence on the accuracy of VSP and guided surgery for ZI placement[7–10]. Inaccuracies between the planned and actual implant

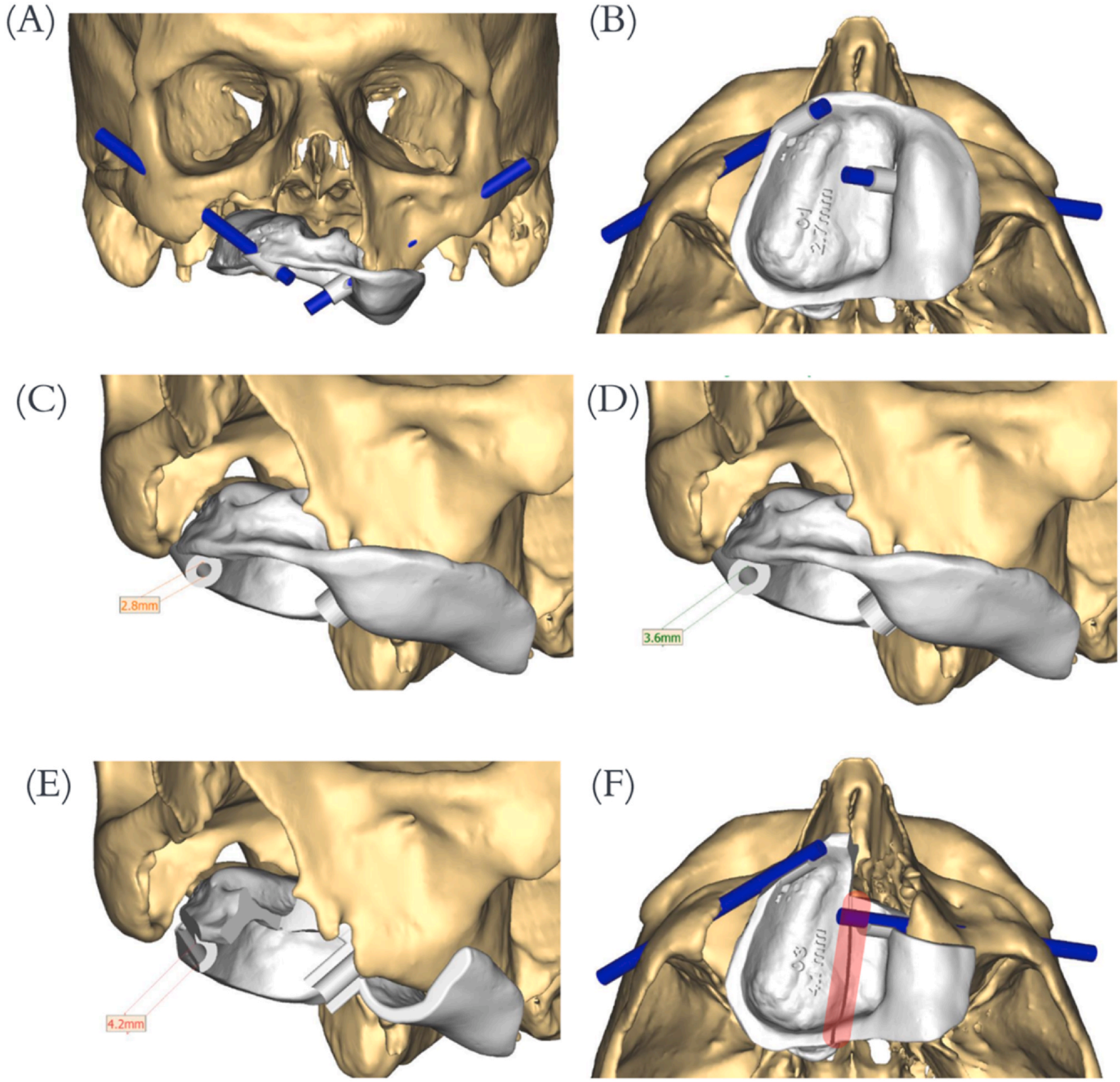

Fig. 1. Screen captures of the virtual surgical planning, demonstrating the planned trajectory of the zygomatic implants and the surgical guide design in ProPlan CMF (Materialise NV, Leuven, Belgium). (A, B) Coronal and axial view of the surgical guide and planned orientation of two zygomatic implants. (C, D) Cylindrical design of the subsequent drill guides. (E) Half-cylinder design of the implant insertion guide. (F) Axial view of the final implant insertion guide with perforated breakaway mechanism (highlighted in red) for easy removal.

positions have been found to be due to unstable surgical guides, high tolerance in drill chute diameter, and the largest error being introduced by the unguided nature of the ZI insertion[8]. In this case, the design process of the surgical guides was instrumental to minimizing these sources of error.

In the context of PORT, exposure of bone must be avoided; however, tissue-borne guides are prone to instability and errors in implant angulation. To address this issue, the maxillofacial prosthetist utilized the baseplate of the patient's well-fitting obturator as the template on which the surgical guides were fabricated (Fig. 1A, B).

The stability of the obturator and drill guides is essential in the success of this technique, as any mobility at the insertion point may result in significant deviation from the planned ZI trajectory. This highlights the importance of patient selection and presents a limitation of this technique, as it relies on the availability of soft tissue undercuts and bony landmarks to ensure stability of the guides. Following postoperative analysis, the left ZI placement was more accurate compared to the right (Fig. 2E, F). This was due to soft tissue and the lack of bony landmarks on the right causing instability of the surgical guides. This method of placing ZIs may not be suitable for patients without such anatomical features, as it may introduce errors in ZI angulation.

The authors were able to design an implant insertion guide with a half-

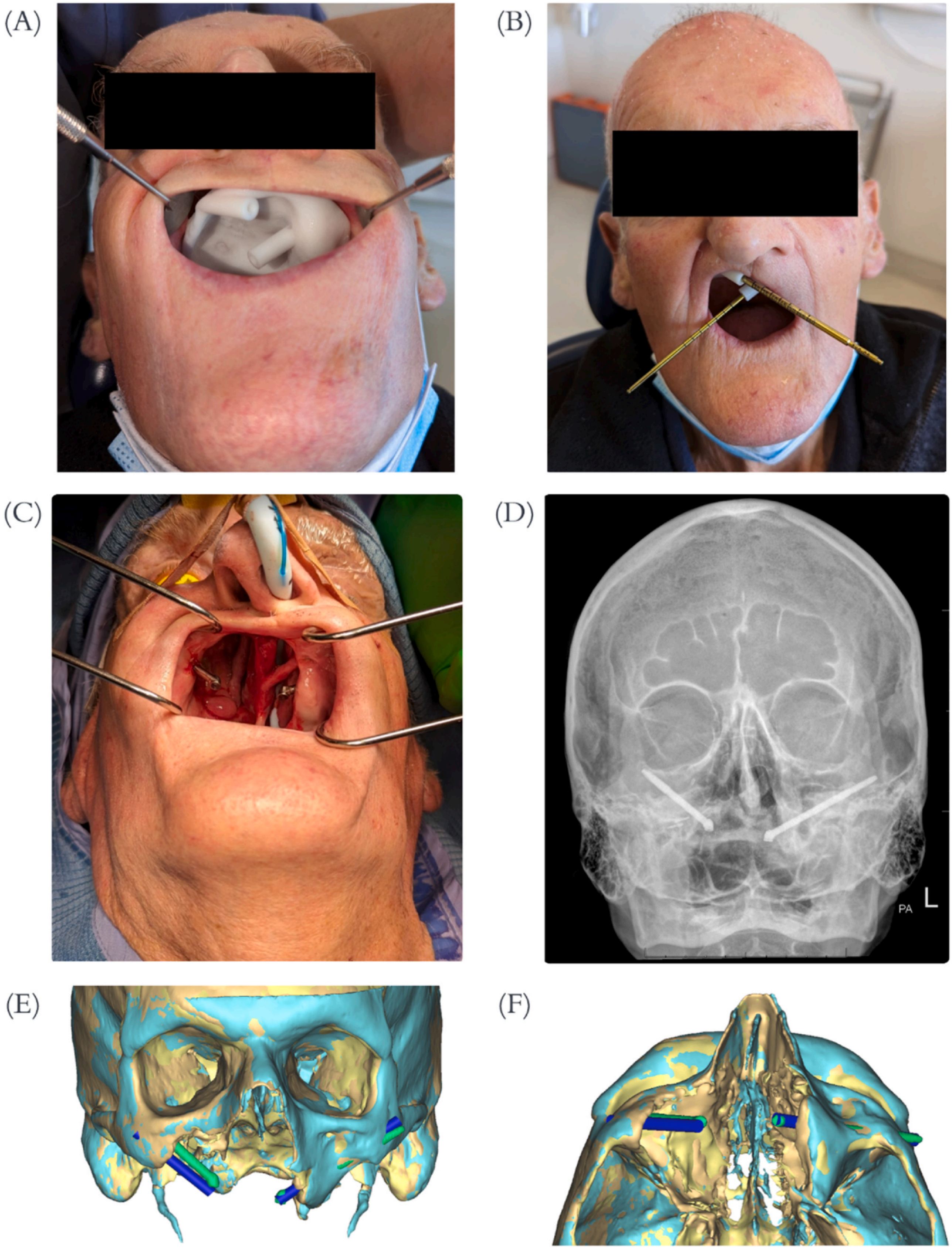

Fig. 2. (A, B) Clinical photographs of the surgical guides trialled prior to surgery, identifying the right implant angled too superficially. (C) Perioperative clinical photograph of the inserted zygomatic implants with the change in trajectory of the right implant. (D) Occipitomental radiograph with 15-degree tilt (OM15) showing successful placement of the zygomatic implants. (E, F) Postoperative analysis of accuracy, showing the planned (blue cylinders) and actual (green cylinders) zygomatic implant placement.

cylinder design and a breakaway mechanism that could easily be removed once the implant was sufficiently inserted (Fig. 1F). This, along with the low 0.1 mm tolerance drill guides, minimized the potential for errors in angular deviation (Fig. 1C, D). These guides were 3D-printed and trialled prior to surgery, which allowed confirmation of guide stability and repeatability, and ensured access was feasible especially in the context of trismus in PORT (Fig. 2A, B). Furthermore, this presurgical trial enabled reassessment and confirmation of the implant trajectory, allowing the authors to identify that the right implant was angled too superficially. As a result, a subsequent VSP was organized to deepen the angulation of the implant trajectory (Fig. 2C).

The placement of ZIs is a complex and technique-sensitive procedure due to the inherent difficulty in the angulation of the drilling sequence and the length of the ZI. Further obstacles arise when bony landmarks are lost due to oncological ablative surgery, and full-thickness flaps are contraindicated in irradiated bone. Using this method, the authors were able to control the entry point, trajectory, and exit point of the sequential drill bits and ZIs, with greater accuracy in areas with more bony landmarks. Success using this method is strongly dependant on appropriate patient selection and a multidisciplinary team approach between the maxillofacial surgeons, a prosthetist, and the clinical engineers involved in the VSP. Further studies are needed to validate the predictability of this novel method of ZI placement.

Ethical approval

Not required.

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Competing interests

None.

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Patient consent

Obtained.

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