Available online at www.sciencedirect.com

ScienceDirect

British Journal of Oral and Maxillofacial Surgery 61 (2023) 136–140

BRITISH Journal of Oral and Maxillofacial Surgery

www.bjoms.com

Flapless placement of zygomatic implants using dynamic navigation: an innovative technical note

Ashwini Bhalerao [a], Madhulaxmi Marimuthu [a], Abdul Wahab [a], Ashraf Ayoub [b,*]

[a] *Oral & Maxillofacial Surgery, Saveetha Dental College, Chennai, India*

[b] *Oral & Maxillofacial Surgery, Glasgow University Dental Hospital & School, United Kingdom*

Received 15 February 2022; revised 11 October 2022; accepted in revised form 30 November 2022
Available online 9 December 2022

Abstract

Zygomatic implants are routinely used for the rehabilitation of the midface and edentulous maxilla; the procedure is carried out under general anaesthesia and requires the direct lifting of the Schneiderian membrane. A prefabricated surgical guide is usually used to direct the position of the zygomatic implants during surgery. This proof-of-concept study explored an innovative flapless approach for placement of zygomatic implants guided by dynamic navigation. Under local anaesthesia eight zygomatic implants were placed using a flapless technique. The preplanned position of zygomatic implants was transferred to the operating theatre using dynamic navigation, which guided the sinus lift procedure and the planned osteotomy. Operative complications were recorded, the accuracy of the implant position was measured and postoperative morbidities including pain and swelling were evaluated. Surgical complications were minimal, the Schneiderian membrane was intact in all the cases except one, which required the application of resorbable collagen membrane. Satisfactory accuracy was achieved regarding the precision of implant position and angulation. One of the patients developed maxillary sinusitis three months following surgery. Postoperative pain and swelling were minimal. The dynamic navigation guided flapless placement of zygomatic implants under local anaesthesia is a feasible technique with minimal surgical complications and postoperative morbidities.

Keywords: Navigation; Flapless; Zygomatic; Implant; Dynamic

Introduction

Zygomatic implant has been an effective option in the management of the atrophic edentulous maxilla as well as for maxillectomy defects.[1] The placement of zygomatic implants requires accurate surgical execution due to the proximity of vital anatomical structures. Misalignment of zygomatic implants could cause orbital injury, damage to the maxillary sinus, and a failure of osseointegration if the implant is not fully engaged within the maximum width of the zygomatic bone.

The classic approach to guide the placement of zygomatic implants is printing a surgical guide based on presurgical cone beam computed tomography (CBCT) and the preplanned implant position. These guides are manufactured in such a way that they match the location, and trajectory of the planned implant but do not control the depth of the preparation. Davidson et al,[2] proposed a stereolithographic template guided flapless approach for zygomatic implant. In addition to the cost of the surgical template, the main drawback of their proposed clinical protocol was the difficulty in achieving the correct angulation of the implant. For the anterior-posterior view they reported mean (SD) 8.06 degrees (6.40) angular deviation of the long axis between the planned and placed implants, and 11.20 degrees (9.75) from the caudal-cranial view. They recommended further research to enhance the precision of zygomatic implant placement.

The current surgical technique requires a wide exposure of the maxilla and the buttress part of the zygoma up to the zygomatic arch to ensure the accurate placement of the

* Corresponding author at: Oral & Maxillofacial Surgery, Glasgow Dental Hospital & School, University of Glasgow, 378 Sauchiehall Street, Glasgow G2 3JZ, United Kingdom.

E-mail address: ashraf.ayoub@glasgow.ac.uk (A. Ayoub).

https://doi.org/10.1016/j.bjoms.2022.11.282
0266-4356/

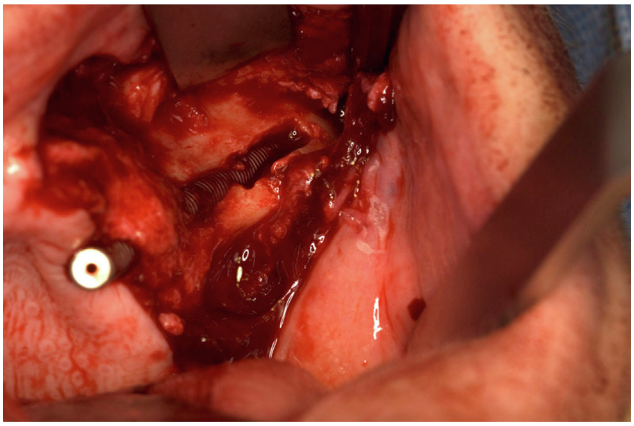

Fig. 1. Clinical image showing the wide exposure required for the insertion of left zygomatic implant.

implant and allow the direct access to visualise and protect the Schneiderian membrane (Fig. 1). Therefore, in most of the cases, the procedure is carried out under general anaesthesia to allow the required access for insertion of the zygomatic implants.

Flapless dental implant placement has been proven to have several advantages including preservation of a healthy peri-implant soft tissue contour and blood supply, decreased operating time, increased patient comfort, and shorter recovery time.[3,4] Placing a zygomatic implant without flap elevation however, can be challenging owing to inadequate visibility and accessibility, difficulty in protecting the sinus membrane, the challenge of achieving the preplanned position and the risk of damaging adjacent vital structures. An earlier flapless technique for zygomatic implant placement had been tried on cadavers and with use of a surgical template guide. [5,6]

Recently, the transfer of the preoperative planning of zygomatic implants to the surgical field has been facilitated with the application of dynamic navigation. This provides 3D control on the entry and exit points of dental implants in real time. The method eliminates the need to print the surgical positioning guide, it promises a more accurate anatomical placement of the dental implants that resembles the preoperative planning position. Dynamic surgical navigation has been shown to be accurate in the placement of standard dental implants, but there is a lack of evidence in relation to the clinical feasibility and accuracy of the placement of zygomatic implants using the technique.[7,8]

The study was carried out to assess the feasibility of the flapless insertion of zygomatic implants guided by dynamic navigation. The rationale of the study was to facilitate this procedure that could be carried out safely under local anaesthesia with minimal operative complications and limited postoperative morbidities.

Methodology

Approval was granted from the local ethics committee of the university hospital; an information sheet was given to the patients highlighting the objective of the study and the potential postoperative complications. Institutional ethics clearance was obtained (IHEC/SDC/PhD/OMFS-1611/21/244). Each patient signed an informed consent. The inclusion criteria included edentulous maxilla with extensive bilateral sinus pneumatisation, good oral hygiene, and absence of bone pathology.

Radiographic planning

Under local anaesthesia, four monocortical screws were inserted in the maxilla, two on each side, before the preoperative CBCT scanning (AERB approved Carestream CS 9600 with exposure time 12 s at 15MA and 140kHz power frequency). The radiographic image was loaded on Navident software package (ClaroNav) for the presurgical planning of the position of zygomatic implants. For each case, two zygomatic implants were planned, one on each side to be placed using Navident Dynamic Navigation system (ClaroNav). The Navident planning software guided the surgeon to choose the optimal length, direction, and position of the zygomatic implants according to the thickness of the zygomatic bone, the alveolar height of the remaining bone, and the planned prosthetic rehabilitation. The dynamic navigation software facilitated the design of a generic stock implant, with its ideal diameter and length. The planned position of the zygomatic implants was transferred to the operating theatre using the Navident Dynamic Navigation system (ClaroNav).

Registration and calibration process

A standard protocol was followed to allow the registration of the patient's head in relation to the preoperative CBCT scan. The registration process was carried out to allow the dynamic navigation system to recognise the geometry of the patient tracking array relative to the fiducials (four maxillary screws) and the planned implants. It also included capture of the position of the tracker attached to the patient's nasal bridge in relation to the pair of stereo-cameras of the Navident dynamic navigation system. The same procedure was applied to record the 3D position of the hand piece. The tracker attached to the handpiece was captured. The handpiece was rotated such that the camera could locate and identify the patterns on the handpiece tracker. This was followed by the contra-angle handpiece chuck calibration.

The surgical instruments used in the procedure including the surgical burs, the zygomatic implants and the curette were all calibrated according to the manufacture instructions. The geometry of the tracking arrays relative to the instrument was determined by the tracking system. The tips of the drills were placed in front of the stereo cameras so the software could 'learn' and register their geometry. This was followed by the direct digitisation of the four screws using the manufacturer supplied digitiser to register the patient's maxilla to its position in the preoperative CBCT.

Throughout the course of surgery and whenever the drill was changed a 'system check' was performed to ensure the calibration of the instruments and the accurate registration of the patient to the dynamic navigation system.

Surgical technique (Fig. 2)

All surgical procedures were carried out under local anaesthesia using Xylocaine 2% with adrenaline 1/80000. Guided by the radiographic image on the computer screen of the dynamic navigation system, the position of the implant on the alveolar ridge was identified. The navigation system monitor allowed the viewing of a virtual drill with a clear visualisation of the depth of penetration in tenths of a millimetre and the angular deviation in relation to the planned implant. The colour changed from green to yellow when the drill was 0.5mm from the targeted depth and turned red when reached the planned depth of the osteotomy.

A mucosal perforation was made using a tissue punch attached to the implant's hand piece and the first cut of bone was achieved using the pilot drill. Following this, a curette was gently used to remove any inadvertent entry of soft tissue into the implant socket. This was followed by the second drill to extend the depth of the bony cut up to the floor of the maxillary sinus. A calibrated surgical curette was delicately applied to allow the in-fracture of the floor of maxillary sinus, carefully retract the Schneiderian membrane upward, and reflection of the lining off the posterior wall of the maxillary sinus, up to the posterior superior corner, exactly where the zygomatic implant was planned to be inserted. This procedure was guided by the dynamic tracking of the position of the edge of the curette (Fig. 2A, B). Inspection of the sinus membrane perforation was achieved by asking the patient to perform the Valsalva manoeuvre. The absence of air bubbles confirmed that the sinus membrane was intact. The standard drilling sequence was followed (Fig. 2C) according to the manufacturer's instructions guided by dynamic navigation, that was constantly monitored, on the computer screen of the dynamic navigation system. The flapless placement of zygomatic implant was achieved using the calibrated handpiece according to the preplanned position guided by real time tracking (Fig. 2D). Fig. 2E shows the final position of the implants.

Postoperative follow up

A five-day course of antibiotics (amoxicillin 500 mg) was prescribed, and paracetamol (650mg) three times daily for three days, normal saline nasal spray, and 0.2% chlorhexidine mouth wash were used. Standard postoperative instructions were given to the patients including oral hygiene measures, refraining from smoking, avoidance of nose blowing, and forceful mouth rinsing for ten days postoperatively. Postoperative CBCT scans were captured on the same day following surgery. The accuracy of the position of the zygomatic implants was assessed by superimposition of the postoperative CBCT scan on the STL 3D image of the preoperative planning. Using the Navident software 'EvaluNav' the angular deviations and positional inaccuracies of zygomatic implants were measured.

Patients were followed up after one week, and monthly to assess postoperative complications.

Results

The study was completed in four patients who received eight zygomatic implants, four on each side. Minimal surgical complications were recorded. Excessive bleeding was noted in one case. Out of eight surgical sites, perforation of the Schneiderian membrane was noted in one, which was confirmed by the positive Valsalva manoeuvre. A moist collagen membrane, after being soaked in saline, was applied at the surgical site and adhered to the Schneiderian membrane (where the calibrated curette had been inserted for the reflection of the Schneiderian membrane). The Valsalva manoeuvre was then repeated, and the negative test confirmed that perforation of the sinus membrane had been adequately sealed, and the implant was inserted. One patient developed the classic symptoms of chronic maxillary sinusitis of the right side three months after surgery despite the fact that the Schneiderian membrane had been intact during surgery. This was managed successfully by a course of antibiotics and nasal decongestant.

Postoperatively, minimal oedema and bruising were noted, and none of the patients developed any alteration in sensation related to the cheek or the nose. Osseointegration was achieved in all cases, and patients proceeded to the prosthetic rehabilitation phase. Based on the linear and angular measurements, satisfactory accuracy was achieved in all cases, and the mean angular accuracy was five degrees and vertical apical deviation was two mm.

Discussion

This feasibility study provided a proof of concept, confirming the safety and reliability of flapless placement of zygomatic implants guided by dynamic navigation. The presented technique also combines indirect sinus lift and guided reflection of the Schneiderian membrane using real time dynamic navigation in addition to zygomatic implant placement. This technique eliminates the need for the standard window technique to identify and protect the sinus membrane. We were able to perform this surgery with only one site identified as having a perforation of the Schneiderian membrane using the well-recognised Valsalva manoeuvre.[9] We acknowledge this test is only suitable for patients who are awake, which was the case in this study. Perforation of the Schneiderian membrane during the insertion of zygomatic implants should be avoided in order to minimise the risk of postoperative sinusitis.[10] The reported incidence of Schneiderian membrane perforation ranged from 7% to 44% in the lateral bony window technique or direct maxillary sinus lift.[9,11] Indirect elevation of the sinus membrane through the extraction socket has been proved successful

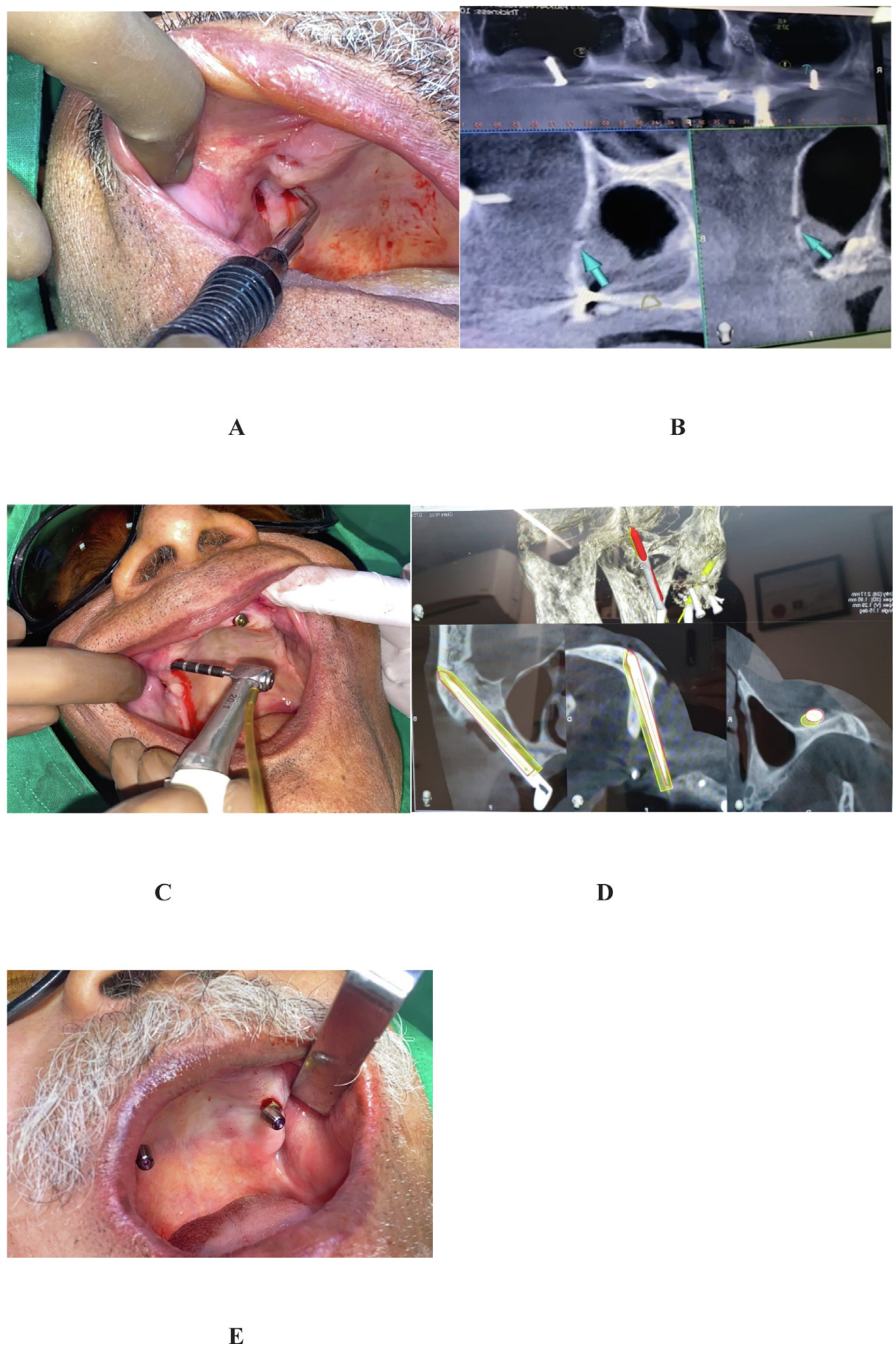

Fig. 2. The surgical steps of the flapless insertion of zygomatic implant; A, the flapless application of calibrated and tracked curette for the reflection of the sinus lining. B. The dynamic navigation monitor showing the position of the curette in relation to the floor and lateral wall of the maxillary sinus. C. Dynamic navigation guided drilling for the implant. D. Real time tracking to guide the placement of the zygomatic implant in relation to the preplanned position. E. The final position of the flapless zygomatic implant.

for conventional endosseous implants.[12,13] The incidence of Schneiderian membrane perforation was significantly less with the transcrestal maxillary sinus floor elevation technique.[14] Our results were similar or, indeed, lower than that reported in others studies for other methods of sinus membrane elevation.

While the use of a static drilling guide has been shown to be improve accuracy in the placement of zygomatic implants compared with free-hand surgery, this technique also has its drawbacks The use of surgical guides provides a stabilisation of bony drilling by restricting the degrees of freedom of the drill trajectory and depth. The guide provides access to the entry point of the zygomatic body which, theoretically, should control the direction of the drills up to the vicinity of the exit point to avoid the complications associated with angular deviation. However, there are inaccuracies associated with the printing of the guide, and the complexity of stabilising the guides limit their clinical application. Their application in the placement of zygomatic implants is limited, because a significant error can be induced at the tip of the implant with the slight deviation in the direction of the drill path.[12]

Dynamic navigation offers several advantages over the static guide for insertion of dental implant including the possibility of a flapless technique that permits 'direct vision' of the surgical site through the computer screen in addition to its reduced morbidity, complications, and costs. There is also the possibility of verifying the position of the implant intraoperatively and alteration of the surgical plan during surgery, which cannot be achieved with static guiding devices.

To our knowledge, this is the first report on the flapless clinical placement of zygomatic implants guided by dynamic navigation. The flapless protocol in placement of zygomatic implants has been tried in cadavers, which would not provide clear evaluation of the intactness of the Schneiderian membrane nor the clinical feasibility of the technique.[4]

We acknowledge the limitations of the study due to small sample size and the lack of comparison with the standard protocol for guiding the insertion of the zygomatic implant. The authors recommend a prospective randomised trial to compare flapless placement of zygomatic implants with the standard surgical approach to test for a reduction in surgical complications and improved postoperative recovery.

Conclusion

The dynamic navigation guided flapless placement of zygomatic implants under local anaesthesia is a feasible technique with minimal surgical complications and postoperative morbidities. Further research should be carried out to confirm this in a larger cohort of subjects.

Ethics statement/confirmation of patient permission

Local approval for this study was obtained. No patient identifiable information was used.

Conflict of interest

We have no conflicts of interest.

References

1. Gracher A, de Moura M, Peres P, et al. Full arch rehabilitation in patients with atrophic upper jaws with zygomatic implants: a systematic review. *Int J Implant Dent* 2021;**7**:17.
2. Chrcanovic BR, Oliveira DR, Custódio AL. Accuracy evaluation of computed tomography–derived stereolithographic surgical guides in zygomatic implant placement in human cadavers. *J Oral Implantol* 2010;**36**:345–355.
3. Sclar AG. Guidelines for flapless surgery. *J Oral Maxillofac Surg* 2007;**65**(7 Suppl 1):20–32.
4. Pisoni L, Ordesi P, Siervo P, et al. Flapless versus traditional dental implant surgery: long-term evaluation of crestal bone resorption. *J Oral Maxillofac Surg* 2016;**74**:1354–1359.
5. Schiroli G, Angiero F, Zangerl A, et al. Accuracy of a flapless protocol for computer-guided zygomatic implant placement in human cadavers: expectations and reality. *Int J Med Robot* 2016;**12**:102–108.
6. Schiroli G, Angiero F, Silvestrini-Biavati A, et al. Zygomatic implant placement with flapless computer-guided surgery: a proposed clinical protocol. *J Oral Maxillofac Surg* 2011;**69**:2979–2989.
7. Stefanelli LV, DeGroot BS, Lipton DI, et al. Accuracy of a dynamic dental implant navigation system in a private practice. *Int J Oral Maxillofac Implants* 2019;**34**:205–213.
8. Kuo PJ, Lin CY, Hung TF, et al. A novel application of dynamic guided navigation system in immediate implant placement. *J Dent Sci* 2022;**17**:354–360.
9. Jensen OT, Shulman LB, Block MS, et al. Report of the Sinus Consensus Conference of 1996. *Int J Oral Maxillofac Implant* 1998;**13**(suppl):11–45.
10. Summers RB. A new concept in maxillary implant surgery: the osteotome technique. *Compendium* 1994;**15**:152–158.
11. Jordi C, Mukaddam K, Lambrecht JT, et al. Membrane perforation rate in lateral maxillary sinus floor augmentation using conventional rotating instruments and piezoelectric device - a meta-analysis. *Int J Implant Dent* 2018;**29**(4):3.
12. Abduo J, Lau D. Effect of manufacturing technique on the accuracy of surgical guides for static computer-aided implant surgery. *Int J Oral Maxillofac Implants* 2020;**35**:931–938.
13. Trombelli L, Franceschetti G, Trisi P, et al. Incremental, transcrestal sinus floor elevation with a minimally invasive technique in the rehabilitation of severe maxillary atrophy. Clinical and histological findings from a proof-of-concept case series. *J Oral Maxillofac Surg* 2015;**73**:861–888.
14. Gargallo-Albiol J, Tattan M, Sinjab KH, et al. Schneiderian membrane perforation via transcrestal sinus floor elevation: a randomized ex vivo study with endoscopic validation. *Clin Oral Implant Res* 2019;**30**:11–19.