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Scapular tip free flap reconstruction of complex midface defects using electromagnetic navigation

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Abstract

PROBLEM: The virtues of the scapular tip free flap for reconstruction of complex midface oncologic defects have been claimed by many. In order to obtain optimal functional and aesthetic results, the precise positioning of the free flap used for reconstruction is paramount.

METHODS: We hereby present four cases illustrating our approach to midface reconstruction with angular branch-based scapular tip flaps. A standard surgical navigation device (*Fusion ENT Navigation System*, Medtronics) is used both to plan bone cuts for the oncologic resection and to optimize the positioning of the flap.

RESULTS: Case #1 illustrates the usefulness of navigation for reconstruction of total palato-septectomy defects, using an horizontally positioned flap. Optimal neo-palate height, alignment of the anterior nasal spine and nasal projection were obtained. For cases #2 to 4, vertical inset of the flap yielded optimal midface projection and orbital floor position.

CONCLUSION: Surgical navigation systems are useful adjuncts for midface reconstruction.

Keywords

Free Tissue Flaps; Scapula; Reconstructive Surgical Procedures; Surgical Oncology; Surgery, Computer-Assisted, Surgical Navigation Systems

Introduction

Composite midface oncologic defects are among the most challenging reconstructive cases, as optimal aesthetic and functional results strongly rely on the precision of the reconstruction. For ideal results, two conditions must be met: the substrate used for reconstruction must be adequate and positioning of the substrate must be extremely precise.

Regarding selection of the optimal substrate, the virtues of the angular branch-based scapular tip free flap have been claimed by many. Specifically, its long pedicle, its anatomic similarity with the hard palate and the rapid reepithelialisation of its muscular surface are definite advantages [1]. Moreover, the possibility of dental implantation has been demonstrated for this flap [2], and it is possible to proceed to a greenstick-osteotomies to use different angulations of bone for different components, as published by Haring *et al*. [3].

As for optimizing positioning of the free flap, surgical navigation devices are a subject of particular interest. Use of intraoperative electromagnetic or infrared image guidance is well established for sinus surgery [4]. In head and neck surgery, it has been particularly used for intraoperative control of resection margins for advanced tumors [5] and to guide craniofacial approaches for anterior skull base oncologic surgeries [6]. In reconstructive surgery, a growing literature supports its use for guiding complex reconstructions. While the existing literature is mostly centered on its use for orbital floor reconstructions and the preparation of osteotomies, some authors have used navigation specifically for refining the positioning of peroneal [7] and latissimus dorsi [8] free flaps for midface reconstructions.

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We developed an approach for reconstruction of complex midface defects combining angular branch-based scapular tip free flaps and electromagnetic navigation in an innovative way. We believe that this method yields optimal aesthetic and functional outcomes. We hereby present a summary of our approach, illustrated by four clinical cases.

Material and methods

Participants

Patients operated at the CIUSSS de l'Estrie – CHUS for midface malignancies using the combination of a surgical navigation device and an angular branch-based scapular tip free flap reconstruction were seen at regular follow-up according to the National Comprehensive Cancer Network (NCCN) guidelines. They were contacted for consent and their files were retrospectively studied to collect the data presented in this series.

Materials

A conventional electromagnetic surgical navigation system was used for every case (*Fusion ENT Navigation System*, Medtronics, Minneapolis). To enable mobility of the head during surgery without restricting the surgical access, a reference system, consisting of a *Cranial Dynamic Fixation Frame* (Medtronics, Minneapolis) was fixed to the patient's skull. This system, although more expansive than the standard surface sticker registration, is more precise and more versatile, as it can be installed anywhere on the calvarium and thus does not interfere with craniofacial resections.

Surgical Technique

For every case, a preoperative CT scan and MRI of the facial bones with navigation protocol sequences, as for computer-assisted sinus surgery, was obtained and downloaded in the electromagnetic navigation device (figure 1).

At the beginning of the surgery, the electromagnetic device is draped and positioned freely at the head of the patient, for easy access throughout the case. The

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reference device is installed and calibration is undertaken according to the manufacturer's protocol (figure 2).

During the resection, the navigation device may be used in establishing appropriate cuts in remote bony margins, notably at the level of the pterygoid plates.

To harvest the angular branch based-scapular tip free flap, a triangular cushion is positioned under the lateral thorax before draping of the donor site side, thus exposing the scapula upon tilting of the table. The muscular triangle delimited by the teres major (TM), teres minor and triceps is palpated, and a curvilinear incision is made from the triangle inferiorly to incorporate the tip of the scapula. Exposition and inferior retraction of the latissimus dorsi muscle (LD) shows the intermuscular septum between the LD and TM. Further dissection enables identification of the thoracodorsal artery after dividing the TM, giving off the angular artery, which is followed to its entry point at the tip of the scapula on its lateral aspect. The appropriate amount of bone is resected, and the vascular pedicle is followed all the way to the origin of the subscapular artery. Figure 3 demonstrates a typical flap once harvested.

During the inset of the flap, surgical navigation is used to match the position of the flap with pre-existent anatomic bony landmarks (figure 4).

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Results and Analysis

Table 1 describes the cases and the utility of neuronavigation for each one of the four cases.

Figure 5 depicts postoperative results for patient #1.

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Discussion

As described by Santamaria [9], maxillectomy defects present three specific reconstructive challenges: (1) restoration of an adequate orbital support; (2) restoration of the oronasal separation and of the functional aspects of both elements; and (3) reestablishment of the facial contour. The four cases presented in this article reflect all these challenges.

Angular branch-based scapula tip free flaps are both reliable and versatile for midface reconstruction [1]. Its versatility allows for optimal adaptation to the deficit, with both vertical and horizontal positioning being possible, depending on the architecture of the osteotomies. No complications specifically related to the flap have been encountered in this series.

As suggested by Feinchtinger *et al*. [5], navigation is helpful in assessing the bony margins of resection, which are often challenging for midface. In all–these cases, navigation also allowed optimal positioning of the scapular tip free flaps. We believe this tool has been particularly useful for securing the height of the reconstructed palate and the alignment of the nasal spine, evaluating nasal and malar projection, and assessing orbital floor position for reconstruction of total maxillectomy defects. A typical pitfall is to base the appreciation of a reconstruction on the appearance of overlying soft tissues. As most head and neck cancer patients will undergo adjuvant postoperative radiotherapy, it is predictable that significant modifications and resorption of the soft tissues will occur. Such a situation may often lead to good immediate postoperative aesthetic results, which will however decline on the longer term. Navigation-assisted

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bony reconstruction of midface defects allows for precise free flap positioning and compensation for the expected post-radiation soft tissue volume variations.

Previously published studies concerning the use of surgical navigation to guide various reconstructions have come to similar conclusions. Harbinson *et al*. have compared mandibular alignment following segmental mandibulectomy on cadavers using surgical navigation, surgical templates, and freehand techniques [10]. Surgical navigation proved to be similar to template-guided reconstruction, but with the added benefit of permitting real-time adjustment independently of the initial resection and reconstruction plans, and was superior to freehand reconstruction.

The use of computer assisted design (CAD), with preoperative 3D printing has gained popularity in the recent decades. However, CAD requires additional time for preoperative virtual planning and involves a long learning curve for the surgeon [11]. Furthermore, CAD incurs costs exceeding up to $10,000 and models cannot be adjusted if cutting guides are incorrectly positioned or if resection margins need updating [10]. In our hospital, current prices are between 3 300 and 3 700$ CAD per case for 3D planning, whereases the neuronavigation equipment cost approximately 790$ CAD per case (*Instrument Tracker* (wire) - Navigation-Fusion: 150$; C*ranial Navigation Tracker* (screw) - Navigation-Fusion: 640$).

Since navigation-assisted functional endoscopic sinus surgery has become standard of care in many situations [4], navigation equipment is often readily available for the reconstructive surgeon. In our experience, the few minutes spent calibrating the machine are more than made up by the expedited flap positioning. We have found that the use of a stand for the electromagnetic device, such as in functional sinus surgery, is

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not practical and have thus elected to drape it in a sterile fashion and move it near the midface whenever a reading is needed.

The principal caveat that has been encountered in our experience is the tendency for the navigation device to decalibrate throughout surgery. The causes of these decalibrations have been discussed by Dario *et al*. [12], and include metal and ferromagnetic sources in the operating theater, such as nearby cellphones. This remains, however, unusual. Calibration of the instruments should be verified periodically throughout the case using reliable anatomical landmarks in proximity to the resection site, such as the glabella and lateral orbit, and recalibrated if required.

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Conclusion

Judging from our practice, optimal results in complex midface reconstruction can be obtained by combining the intrinsic advantages of the angular branch-based scapular tip free flap with the use of a surgical navigation system. In our opinion, the minimal additional operative time and low cost justify its integration to assist in reconstruction of complex craniofacial defects.

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Tables

Table I. Summary of our case series of complex midface reconstruction with scapular tip free flaps and surgical navigation device.

Identification	Pathology	Defect	Positioning of the flap	Utility of the navigation system
PATIENT #1: ♀, 66 y.-o.	Nasal septum squamous cell carcinoma with sphenoethmoidal extension and hard palate erosion ($T_{4a}N_0M_0$; Figure 1)	Total palato-septectomy with anterior ethmoidectomy	Horizontal (Figure 3)	Assessment of bony margins of resection Positioning of the reconstructed nasal spine and neo-palate (Figure 5)
PATIENT #2: ♂, 63 y.o.	Recurrent polymorphous adenocarcinoma of the oral cavity with extension to maxillary sinus and pterygoids ($T_{4b}N_0M_0$)	Subtotal maxillectomy	Vertical; provides support to the titanium orbital floor reconstruction mesh. Placement of the thicker lateral scapula border inferiorly to recreate the maxillary crest, the thinner portion extending medially towards the piriform aperture.	Precise positioning of the flap according to the preoperative location of the bony edges of the nasal spine, the cheek, and the inferior orbital rim
PATIENT #3: ♂, 73 y.-o.	Left cheek squamous cell carcinoma with zygomatic extension ($T_3N_{2b}M_0$)	Subtotal maxillectomy, with orbital floor and zygomatic resection	Same as patient #2	Same as patient #2
PATIENT #4: ♀, 57 y.o.	High grade conventional osteoblastic and chondroblastic osteosarcoma of the left maxillary sinus, with extension to the skin anteriorly, pterygoid musculature posteriorly, anterior fossa superiorly, and orbit medially	Total maxillectomy with resection of anterior fossa skull base	Same as patient #2	Assessment of optimal cheek projection and neo-alveolar ridge positioning

Bullet Point Summary

- Scapular tip flaps provide versatility and reliable tissue for complex midface defects.
- Surgical navigation facilitates accurate positioning of free flaps, with real-time adjustments accommodating variations in patient anatomy, thus optimizing aesthetic and functional outcomes.
- Proper calibration and verification of navigation systems is essential to optimize accuracy throughout surgery.
- Neuronavigation minimizes additional costs compared to other advanced imaging and planning technologies, making it a cost-effective option in complex midface reconstruction.

Figure 1:

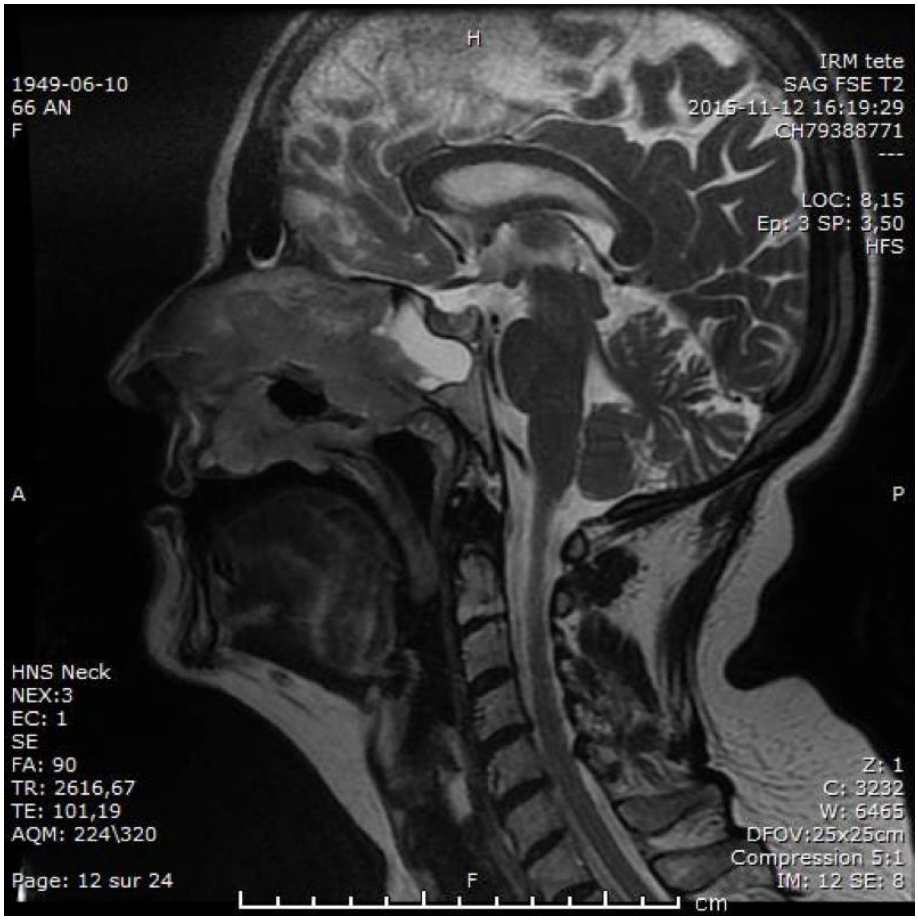

Figure 2:

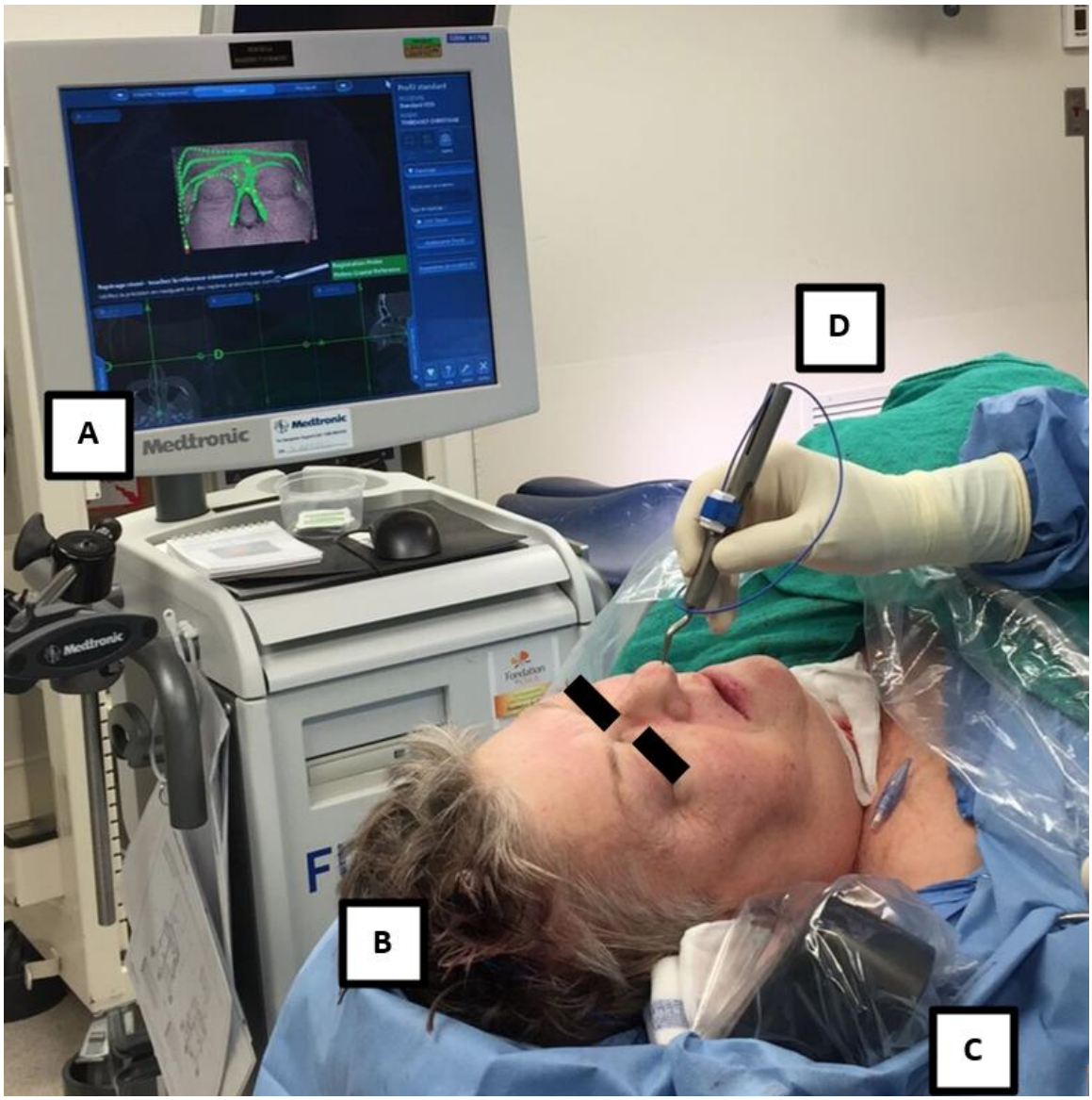

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Figure 3:

Figure 4:

Figure 5:

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