Virtual Surgery: Facing the Future!

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Background

In 1979, Hounsfield and Cormack won the Nobel Prize for medicine and physiology for their part in the invention of the CT scanner (Peeters et al, 1979). These images allowed human anatomy to be viewed in 3 dimensions for the first time, revolutionising medicine. Virtual surgical planning was used for the first time in craniofacial surgery during the 1980's (Vannier et al, 1984). With increasing popularity, computer technology now encompasses a number of uses in addition to surgical planning, across a number of specialities such as neurosurgery, cardiothoracics, plastics, ENT and orthopaedics. This report describes the use of a virtual surgical planning in an interesting maxillofacial case.

Presentation of Case

A 42 year old female Nigerian refugee was referred to the maxillofacial department at St James Hospital with a 2 year history of a painless swelling in the anterior of the mandible. She was medically fit and well with no other associated symptoms, and no surgical history. She was a non-smoker and non-drinker.

On clinical examination, she had mild facial asymmetry with swelling around the left symphyseal/parasymphyseal region of the anterior mandible. Intra-orally there was buccal and lingual expansion of the mandible anteriorly (Figure 1) with mild displacement of the teeth. Of note, there was no sensory alteration in the inferior alveolar nerve distribution. All other examinations were normal.

Investigations and Diagnosis

Differential diagnosis for a firm swelling in the anterior mandible includes; an odontogenic (dental origin) tumour, cystic lesion, fibro-osseous lesion, or malignancy. In order to make a definitive diagnosis, the patient underwent a plain film radiograph, CT imaging, and a bone biopsy. The orthopantomogram radiograph (Figure 6A) revealed a lesion extending from the lower left first molar to the lower right premolars in the mandible of mixed radiodensity. The lesion appeared to be circumscribed by corticated bone (seen radiologically as a white line around the lesion) suggestive of slow growth and a benign process. This radiological appearance was most consistent with a fibro-osseous lesion such as ossifying fibroma, fibrous dysplaisa or a giant cell granuloma. However, an odontogenic tumour such as an ameloblastoma could not be ruled out. Histology from the bone biopsy showed cellular fibrous tissue with mineralised components of bone confirming a diagnosis of ossifying fibroma. This is a benign fibro-osseous lesion.

Management

Following a multi-disciplinary meeting, a team decision was made to resect the ossifying fibroma of the anterior mandible, and reconstruct the defect using a vascularised fibula free flap. Due to the long length of bone needed, virtual planning was used to achieve the best aesthetic and functional outcome. In order to do this, DICOM data (Digital Imaging and Communications in Medicine: the standard format for medical images to be exchanged) was uploaded into the virtual planning software (Materialise) and 3-Dimentional reconstructions of the skull and fibula were made (Figure 2).

The ossifying fibroma margins were identified and the osteotomies (surgical cutting of bone) of the mandible planned with a 1cm margin to reduce the recurrence rate (Figure 2). Once the mandible was virtually resected, the reconstruction phase could begin. Approximately 10 cm of bone from the distal portion of the right fibula was chosen, making sure to leave 6

cm of bone distally to maintain the stability of the ankle joint. This 10 cm length of bone would then be segmented into thirds to create a curved neo-mandible as shown in Figure 3.

To translate this virtual plan into the operating theatre, custom-made surgical guides were designed to screw to the mandible and fibula intra-operatively (Figure 2,3). Access to the mandible was made through a visor incision in the skin crease of the neck (Figure 4) which was then reflected upwards so the ossifying fibroma could be fully viewed, resected and the remaining defect assessed. Simultaneously, the pre-planned portion of fibula was then removed from the donor site with a vascular pedicle made up of the fibular artery and 2 accompanying vena comitantes. Once the pedicle was cut, the ischaemic time began (maximum 6 hours) and the fibula was segmented into three, shaped, and attached to the reconstruction plate (2 screws in each segment) and then to the mandible with 4 screws bilaterally. The fibula was placed mid mandible (Figure 5) as a compromise between the best aesthetic and functional outcomes. For best facial contour, the fibula should be set to the level of the inferior border of the mandible, whereas for best functional outcome, the fibula should be set higher up, with the flat aspect of this triangular shaped bone superiorly to facilitate the placement of dental implants 6 weeks post-operatively. The anastomoses of the flap to recipient vessels was performed under an operating microscope using 9/0 sutures. (Figure 5) The fibular artery was joined end to end to the facial artery, and the 2 vena comitantes were joined end to side to the internal jugular and one of its branches. Post-operatively the area of the arterial anastomoses was marked using a superficial suture on the skin so that doppler ultrasound could be used to monitor the free flap. As there was no skin paddle, assessment of colour, capillary refill, temperature, skin turgor or the pin-prick test was not feasible in this case.

Outcome and Follow-Up

One month following her surgery, the patient was recovering extremely well. She was independently mobilising and eating a soft minced diet. The pre- and post-operative radiographs (Figure 6) demonstrate the full resection of the ossifying fibroma and the reconstruction with the segmented fibular and reconstruction plate. At 6 weeks post-operation, placement of titanium dental implants into the fibula will allow restoration of the missing teeth.

Discussion

Vannier is praised with being the first to use the three dimensional CT reconstruction images for craniofacial virtual surgical planning (3D planning, computer-aided design) and evaluation in 1984. More recently however, CT images have been utilised for a number of additional uses; construction of 3D stereolithic models, intra-operative navigation, individual implant design and fabrication, and outcome assessment (Zhao et al, 2012). Potential benefits of virtual planning include ease of use, and in comparison to conventional planning, improved surgical accuracy and reduced intra-operating time that may be reflected in a decrease in cost (Rodby et al, 2014). Virtual planning usually consists of 4 phases, namely; planning, modeling, surgical phases and post-operative evaluation (Kirke et al, 2016). One disadvantage therefore is that the planning phase is prolonged usually taking a minimum of 2-4 weeks, which may not be appropriate for some cases. Other disadvantages include increased initial costs, issues with the placement of the surgical guide, and limited literature with regards to cost benefit and specific quantifiable benefits (Rodby et al, 2014). The present case was ideal for the incorporation of virtual technology as a long 10 cm defect was resected from the mandible,

Figures

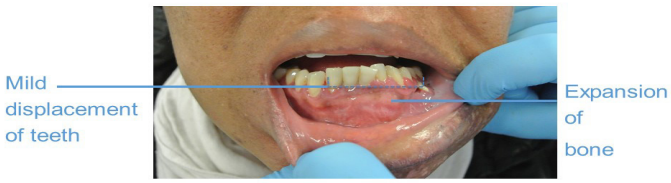

Figure 1. Clinical intra-oral photograph demonstrating bony expansion of ossifying fibroma

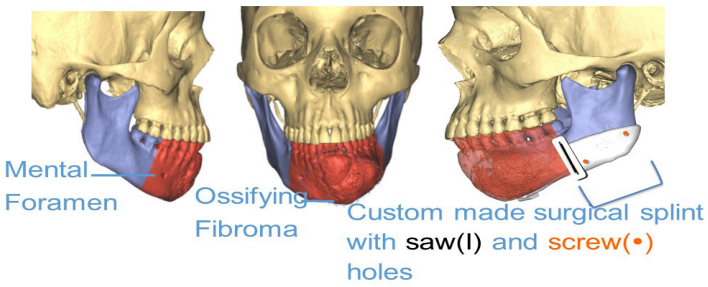

Figure 2. Digital reconstructions of facial skelton. Blue colour indicates mandible. Red colour indicates virtual planning of the proposed margins of the osteotomy.

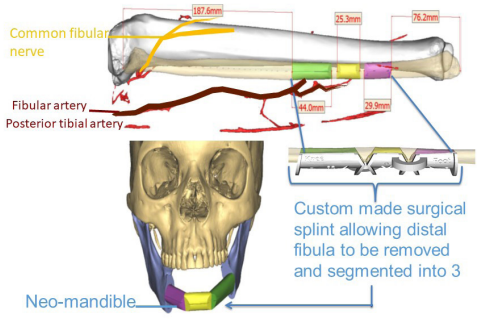

Figure 3. Virtual Planning of the reconstruction of the mandible. A distal portion of the fibula is planned to be cut into 3 segments using a surgical guide to reconstruct the shape of the mandible.

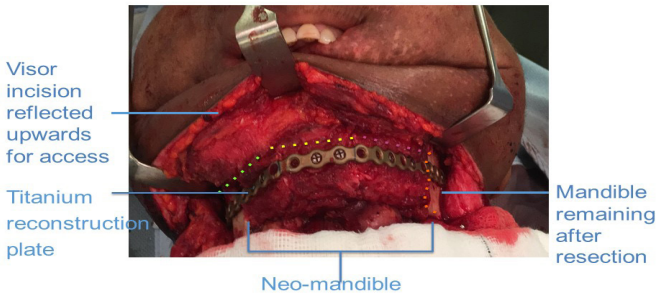

Figure 4. Intra-operative photograph of front view of neomandible fixed using reconstruction plate and screws, to remaining mandible.

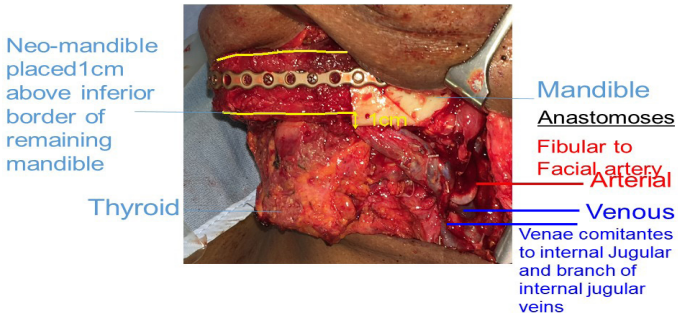

Figure 5. Intra-operative photograph. Side view of right side of the neomandible attached to remaining mandible posteriorly, and anastomoses.

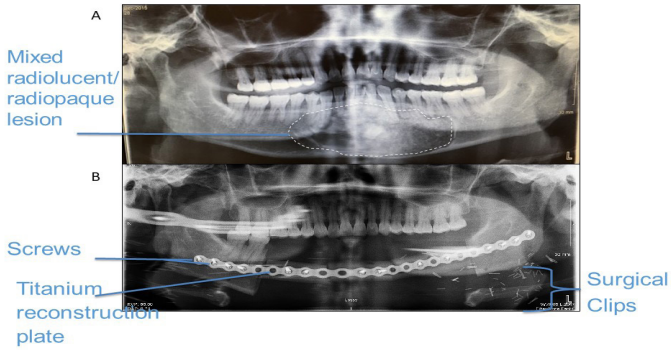

Figure 6. Pre and post operative plain film orthopantograms showing ossifying fibroma completely resected and reconstruction.

Table 1. Postive-negative analysis of free flap options. Adapted from information from Yilmaz et al, 2008.

Free flap	Pros	Cons
Fibula	Up to 25-30cm bone, excellent for dental implants Can include muscle bulk and skin paddle Allows 2 teams working simultaneously	Straight bone requires osteotomies for curvature Potential vascular compromise to the foot, foot drop (injury to common fibular nerve) and altered gait, and instability of ankle joint (avoided by keeping 6cm bone at distal end of fibula). Long scar along leg, possible need for skin graft
Iliac Crest	Natural curvature contoured for ipsilateral reconstruction Good vertical and horizontal height for dental implants Allows 2 teams working simultaneously	More difficult dissection Potential secondary hernias, pelvic pain, pelvic fracture or instability

including the symphasis (anterior region), which is a challenging defect to restore to a high standard using conventional methods. Expansion of the bone due to the OF meant that the mandible could not be used as a guide to pre-bend the reconstruction plate. Virtual technology allowed the expanded bone of the OF in the mandible to be virtually "shaved" by the surgeon to the desired shape, which could then be used to make 3D models and pre-bend the plate.

Ossifying fibromas (OF)

These are benign, well demarcated lesions composed of fibrocellular tissue and mineralised components such bone or cementum. They occur most frequently in females between the 2nd and 4th decades, although they can occur at any age. The mandible is more commonly involved than the maxilla (Slootweg and El-Mofty, 2005). Rarely, OFs may be found in the frontal, ethmoid, sphenoid, temporal bones, orbit and anterior cranial fossa (MacDonald-Jankowski 2014). Clinically, they present as slow expansion of the jaw bone which is often painless, as in the present case of the conventional OF. More aggressive subtypes, such as juvenile aggressive ossifying fibromas, also exist. Diagnosis is using a combination of orthopantogram plain X-ray demonstrating a lesion with ground glass appearance (Figure 6), CT imaging, and biopsy. OFs originate from the periodontal ligament of teeth and histopathology may aid in the distinction between OF and other fibro-osseous lesions. For example, fibrous dysplasia tends to have a more classical "Chinese lettering" appearance of the mineralised components, and merge more with its surroundings in contrast to the well demarcated/ encapsulated OF (Slootweg and El-Mofty, 2005).

Treatment options

OF is a benign process, and consequently the treatment options are curettage and enucleation, or resection. In the present case, the dimensions of the OF were so large that such an attempt at curettage and enucleation would most likely lead to instability of the anterior mandible and fracture. The anterior mandible is important for facial contour, aesthetics and function, as it contains teeth. It is the insertion point for the mylohyoid, genioglossus, geniohyoid and anterior belly of the digastric muscles. These muscles are important for airway stability, speech, deglutition, and mastication and consequently, any fracture could lead to serious

morbidity. The MDT decision was therefore to resect the anterior mandible.

There are a number of vascularised free flaps that have been used for reconstruction of mandibular defects in maxillofacial surgery. Bone and soft tissue may be included. Two types are summarised in Table 1 (Yilmaz et al, 2008). The fibula free flap was considered the best option in this case due to the length and quality of bone needed for restoration with dental implants 6 weeks post-operatively.

Potential complications

At the recipient site, flap failure, fixation failure or infection of the reconstruction plate, and injury to nearby structures were all potential complications. The patient was aware pre-operatively that both the left and right mental nerves (terminal branches of the mandibular branch of the trigeminal nerve) would be sacrificed as they were involved with the OF. During the consent process therefore the patient was fully aware she would have a numb lip and chin post-operatively. Also at risk, was the marginal mandibular division of the facial nerve that partially supplies the chin muscle mentalis, and is important for depressing the corners of the mouth.

A CT Angiogram of the lower limbs is performed pre-operatively to ensure 3-vessel run off to the foot (anterior, posterior tibial and fibular arteries) and ensure no vascular compromise is likely following flap harvesting. The common fibular nerve is preserved by leaving 6 cm of fibula proximally to avoid foot drop. Similarly 6cm of distal fibular is preserved, however this is to maintain the stability of the ankle.

Airway Management

In the case of head and neck surgery, the surgeon and anesthetist will often share the upper airway. In such cases a nasotrachel tube may be used, where an endotracheal tube or laryngeal mask airway would have otherwise been an option. In complex head and neck cases, it would be common to provide a tracheostomy surgical airway which is indicated where there is failure, or anticipated failure, to secure the airway in any other manor. In the present case, only the anterior mandible was removed, with no soft tissue resection or lymph node dissection; both potential causes of swelling and oedema that may threaten the airway. Therefore, the airway would be patent throughout the procedure, and the patient could be extubated the following morning. This allowed use of a nasotracheal tube, minimising the more morbid complications associated with a tracheostomy such as scarring, higher potential for bleeding, damage to the recurrent laryngeal nerves, pneumothorax, surgical emphysema and fistula formation.

Recovery

Recipient site:
The patient is fed by NG tube initially until the speech and language team are satisfied the swallow is intact (day 2 in the present case). The patient starts with sips of water and then is allowed a soft minced diet that must be maintained for 6 weeks until the placement of the dental implants is permitted.

Donor site:
At the donor site, the leg is kept elevated for the first 48 hours, after which the patient may ambulate with the use of a stroller. An orthopedic non-weight bearing splint is placed for 4-5 days, and removed at 5-7days at which point the patient is generally independently mobilising.

Conclusion

In conclusion, this case report describes the management of a 42 year old Nigerian lady diagnosed with an ossifying fibroma of the anterior mandible, and the use of virtual surgical planning for resection and reconstruction using a fibular free flap. The patient achieved an excellent surgical result and post-operative recovery was uneventful. In the future she will have her dentition restored with dental implants. This case demonstrates the use of virtual planning in a complex maxillofacial case, and reveals an insightful glimpse in to the direction of surgery in the future.

References

Kirke, D. N., Owen, R. P., Carrao, V., Miles, B. A., & Kass, J. I. (2016). Using 3D computer planning for complex reconstruction of mandibular defects. Cancers of the Head & Neck, 1(1), 17.

MacDonald-Jankowski, D. S. (2014). Ossifying fibroma: a systematic review. Dentomaxillofacial radiology.

Peeters, F.; Verbeeten Jr, B.; Venema, H. W. (1979). Nobel Prize for medicine and physiology 1979 for A.M. Cormack and G.N. Hounsfield. Nederlands tijdschrift voor geneeskunde. 123 (51): 2192.

Rodby, K. A., Turin, S., Jacobs, R. J., Cruz, J. F., Hassid, V. J., Kolokythas, A., & Antony, A. K. (2014). Advances in oncologic head and neck reconstruction: systematic review and future considerations of virtual surgical planning and computer aided design/computer aided modeling. Journal of Plastic, Reconstructive & Aesthetic Surgery, 67(9), 1171-1185.

Slootweg, P. J., & El Mofty, S. K. (2005). Ossifying fibroma. WHO classification of tumours. pathology and genetics of tumours of the head and neck. Lyon: International Agency for Research on Cancer, 319.

Vannier, M. W., Marsh, J. L., & Warren, J. O. (1984). Three dimensional CT reconstruction images for craniofacial surgical planning and evaluation. Radiology, 150(1), 179-184.

Yilmaz, M., Vayvada, H., Menderes, A., Demirdover, C., & Kizilkaya, A. (2008). A comparison of vascularized fibular flap and iliac crest flap for mandibular reconstruction. Journal of Craniofacial Surgery, 19(1), 227-234.

Zhao, L., Patel, P. K., & Cohen, M. (2012). Application of virtual surgical planning with computer assisted design and manufacturing technology to cranio-maxillofacial surgery. Archives of plastic surgery, 39(4), 309-316.

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