LETTER TO THE EDITOR

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A Novel Craniofacial Multidisciplinary Team Pathway for Functional and Aesthetic Reconstruction

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Disclosures: The authors declared no potential conflicts of interest with respect to the research, authorship, and publication of this article.

Funding: The authors received no financial support for the research, authorship, and publication of this article.

Surgical training has long been considered a vocation under mentorship; learning from the experiences and expertise of senior colleagues, methodically dissecting and studying small parts of each operation before carrying one through to completion under supervision, refining those skills over time and finally mastery.[1] Developing a thorough understanding of an operation has relied on this time consuming, but robust practice. Surgical simulation has demonstrated benefit in reducing learning curves and time to learn novel skills, whilst simultaneously improving confidence and understanding.[2,3] An important end goal of surgical training is to be confident and competent to complete operations in a safe and reliable way, to a high standard, and be able to fully manage any potential risks and complications. In plastic & reconstructive surgery, a huge plethora of surgical options exists that could be employed for each defect; having a detailed understanding is essential for consultation with the patient, with significant amounts of time spent on developing such competence. Profound insights gained into the context of each operative step, particularly in complex and staged reconstructions, helps to manage patient expectations, understandings and frustrations, as well as accelerate the surgical learning curve for trainees. Combining three-dimensional (3D) photography and computer modelling allows for the development of a digital training database which can be used as illustrative examples for patients and as a teaching tool for trainees, thereby providing remote exposure and learning opportunities at a faster pace.[4,5]

In this paper we illustrate the development of a digital database of surgical reconstructions, highlighting various stages of functional facial reconstruction. By establishing a novel craniofacial multidisciplinary team (MDT), we outline a streamlined pathway which involves a clear referral pathway, multidisciplinary joint clinics, integrated 3D photography, custom 3D printing, and computer modelling for planning staged reconstructions. This is a model which can be replicated in other units, and yields benefits for trainees as well as patients. We demonstrate those benefits with a clinical vignette of a patient with nasal atresia who benefitted functionally from a novel patent nasal airway, as well as a staged total nasal reconstruction.

ESTABLISHING A STREAMLINED MDT CLINIC

MDT meetings often involve representatives of multiple specialties from independent teams brought together in order to deliberate management plans for patients. Where there are large volumes of patients, this is an efficient technique. However, combining the expertise of the MDT with an outpatient clinic to review and discuss the options with patients is a far more engaging experience for clinicians and patients. Being able to review 3D scans and 3D models of patients before clinical consultation allows for a more holistic and insightful MDT discussion and preparation before an appropriate management plan is devised.

The front door referral pathway for patients is either directly from primary care to the MDT, or via referral from other outpatient clinics. Often these patients are referred from allied specialties, within our unit or nationally, such as plastic surgery; ear, nose, and throat (otolaryngology); maxillofacial; neurosurgical; as well as speech and language (SALT); paediatrics; psychiatry; and oncology. As clinical cases are discussed, a representative from each of these specialties attends the MDT to provide input, share their experiences, and determine the management plan. Due to the increasing number of patients seen with disfiguring facial defects, we established a novel craniofacial MDT service in our tertiary reconstructive centre. As part of existing subspecialty care we can provide as a hospital, the MDT was a streamlined for efficiency to provide a comprehensive service for patients. Following determination of the final plan, each specialty keeps a record of the patient details and arranges follow up as required.

Initially this required a union of like-minded healthcare professionals who offered their time in a proof-of-concept MDT with patients being internally referred between consultants. As this proved to be useful, a formal clinic room and designated meeting times were established through liaison with divisional directors and hospital managers. The onsite clinical photography department was contracted to provide the necessary 3D imaging with coinciding clinic times. Image viewing and manipulation software was installed on MDT computers, and a 3D printer utilised from our research department.

3D PHOTOGRAPHY AND COMPUTER MODELLED RECONSTRUCTIONS

On attendance to the clinic, and prior to consultation, 3D and 2D photographs of each patient are taken at our clinical photography department, together with standardised speech recordings wherever relevant. Images are then uploaded in real time to our photography servers and made available for viewing by the MDT members. This allows a baseline 3D image to be reviewed by the MDT members prior to the ensuing consultation with the patient. In parallel, 3D computed tomography (CT) renderings can be reviewed and the 3D photographs overlaid to enhance a hard-soft tissue comprehension of each patient's face.

The photographs and computer models are stored with patients' consent on site as an education resource for other patients, and as a teaching adjunct for trainees.[5] In cases where surgical reconstruction is required from an aesthetic or functional perspective, a surgical plan is devised by the MDT. Next, computer modelling of 3D photographs is used to predict surgical end-points in accordance with patient preferences. This allows for greater comprehension of the reconstructive process and what patients can expect their surgical end point to look like. Furthermore, a 3D printout of the hard tissue architecture can be produced with a soft tissue overlay as an adjunct to help plan surgery. This proves particularly useful when functional benefits are a priority, such as an improved airway through bony septum manipulation; information that can be obtained via CT scans rather than 3D photographs.

3D IN-HOUSE PRINTING

Computer-modelling and visualisation of 3D constructs are highly valuable techniques if visualised on a computer screen, but there is benefit to be had in comprehending the full extent of a hard tissue defect by printing a 3D model.[6] We incorporated this process in to our MDT pathway, allowing 3D models to be produced at a low cost and quick turnaround time, thereby minimising surgical delays. These printed adjuncts, which can be sterilised and used intraoperatively for accurate measurements, prove extremely beneficial for explaining surgical steps to patients and trainees (Figure 1).

TRAINEE COMPREHENSION QUESTIONNAIRES

To test for comprehension and understanding of the various steps involved in a total nasal reconstruction requiring vascularised nasal lining, costal cartilage architecture and a forehead flap, a short survey was administered amongst trainee surgical registrars in our department. The survey was taken by 10 trainees using 2D photographs, and then again using our 3D computer models, with an ordinal rank improvement in global understanding up from 6/10 to total understanding. As our database of patients undergoing facial reconstructive procedures grows, the imaging and modelling is becoming a useful teaching aid in our department.

PATIENT EXPERIENCE AND FACE-Q

Our clinical case illustrates the benefit of this craniofacial pathway with integrated 3D photography and computer modelling in a functional and aesthetic reconstruction for a patient with nasal atresia who had undergone numerous childhood operations resulting in significant midface scarring and a completely blocked nasal air entry (Figure 2). Following 3D photographs, a computer model was built to design a nose that was in accordance with her wishes (Figure 3). As the patient also had airway issues, a CT scan was undertaken and 3D printed, allowing a reconstructive plan to be developed by the MDT. The plan for the first stage of the reconstruction was to harvest costal cartilage (CC) and create a 2D cartilaginous construct for the supportive architecture of the nose. This was then buried underneath a radial forearm fascial flap (RFFF) and left for 4 weeks to vascularise, forming a composite construct of cartilage and forearm fascia which would go on to become the inner lining. A forehead flap was also raised but set back in a delayed procedure to improve subsequent vascularity for the second stage.

In the second stage, the primary objective was to improve the nasal airway. In a combined MDT surgical approach with ENT and maxillofacial surgery, the nasal opening was re-created and all scar tissue and malpositioned hard tissue in the nasopharynx removed using saw and sharp dissection. The RFFF and CC composite construct was raised on the RFFF pedicle and inset in to the defect, over the nasopharynx which was supported using two plastic tubes to maintain nasal airway patency. Anastomosis was to the facial artery and vein with the pedicle tunnelled under the cheek skin. The cartilage was folded in to the desired 3D shape and plated on to the maxilla and glabella. The forehead flap was then raised and inset over. A CT scan was undertaken to show positioning of the plates and improved nasopharynx for breathing, and a soft tissue overlay mask 3D printed to illustrate the final expected outcome (Figure 1).

Subsequent stages are planned using computer modelling software to identify areas which require refinement, thinning or repositioning, novel 3D masks can be printed as required with updated measurements. Performing complex reconstructions in multiple stages allows for improved vascularity, minimises infection risk and flap loss, and allows for the dynamic manipulation of the previous reconstructed stage as scar tissue and swelling change (Figure 4).

The immediate patient feedback was a significant improvement in her breathing, 'like a window has been opened.' Furthermore when asked to read a standardized literature passage, she felt that her phonation had improved significantly. All this translated in to a much improved FACE-Q score.[7] The craniofacial FACE-Q, a validated patient reported outcome measure questionnaire revealed improvements in scoring in nasal appearance (4/100 to 60/100), functional breathing (0/100 to 100/100), health-related quality of life (appearance distress reduction 40/100 to 60/100, and psychological improvement from 40/100 to 70/100). Given that the functional issue has now been corrected, refinement of the nasal construct will take place in subsequent stages to improve the aesthetic appearance.

Facial defects can result from trauma, cancer and/or congenital abnormality. They can be composite, making reconstruction often complex and requiring multiple stages and coordinated input from various specialties and allied healthcare providers. Until now, developing such reconstructive plans is often limited to the imagination and experience of the consultant surgeon, inevitably leaving gaps in understanding for the patient and trainees. Using our streamlined MDT pathway with integrated clinic, 3D photography, computer modelling and 3D printing, many of these issues can be resolved in an efficient manner, yielding improved patient outcomes, satisfaction, and training. On the basis of a clinical case of total nasal reconstruction amongst others, we have demonstrated the feasibility of our approach and quantified improvements using FACE-Q and trainee questionnaires. As our databank of 3D photographs, CTs and computer models grows, these materials will be integral in the future for surgical planning, patient satisfaction and trainee education.

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Figure Legend

Figure 1. Three-dimensional printed models of skull from computed tomography with (A) overlayed soft tissue resin mask, (B) individual printed components including nose adjuncts, and (C) computed tomography skull models before first operation and after opening of nasal aperture and plating of costal cartilage construct to glabella and maxilla.

Figure 2. Baseline images of our patient with nasal atresia.

Figure 3. Three-dimensional photographs (lateral views) of patient at (A) baseline, (B) superimposed computer model of end-point nose, and (C) integrated computer model of reconstructed nose.

Figure 4. Computer modelling during refinement operations.

Figure 1

Figure 2

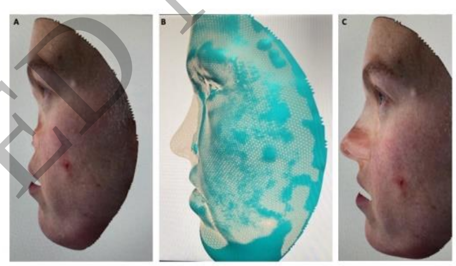

Figure 3

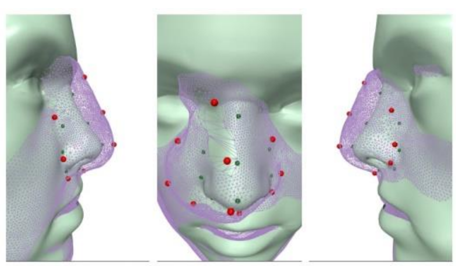

Figure 4