Modern advances in reconstructive oral and maxillofacial surgery

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Abstract

Reconstruction within the head and neck is usually difficult. Wound is anatomically complicated and already be compromised by inflammation, infection, and scarring. Tissue grafts and vascularised flaps (either pedicled or free) lead healthy tissue to a compromised wound for many favourable healing and are the benchmark for the repair of such defects, however disadvantages are their restricted handiness, the issue of shaping the flap to suit the wound and, most significantly, donor website morbidity. The importance of function and aesthetics has direct advances within the preciseness of surgical techniques. Evolution in navigation, three-dimensional imaging, stereolithographic models, and also the use of custom-made implants will aid and upgrade the accuracy of existing constructive ways. Tissue engineering and distraction osteogenesis avoid the necessity for autologous tissue transfer and may thus be noticeable as additional standard ways of reconstruction. Recently, facial allotransplantation has allowed whole anatomical facial units to get replaced with the chance of sensory recovery and reanimation being completed in a very solitary procedure. However, patients who have facial allotransplants are subject to life-long immunological disorder therefore this technique of reconstruction ought to be restricted to chose cases.

Keywords: Reconstructive surgery, Head & Neck.

Introduction[1,2]

Reconstructive oral and maxillofacial surgery is to revive the shape and form of the head and neck region, which can or might not embody aesthetic or cosmectic surgery. It constributes a little however vital compoment of the great care of cancer patients. Reconstructive surgeons employs the conception of reconstructive ladder to manage progressively complicated injuries. These procedures vary from easy techniques like primary closure and dressing to complicated skin grafts, tissue growth and free flaps. We review the published material and have identified the following major advances, which will be discussed in more detail: navigation systems, three-dimensional imaging, stereolithographic models, custom-made fixation prostheses and immediate placement of implants, robotic surgery, tissue stimulate bony growth within a patient to reconstruct defects of the mandible. Similarly, distraction osteogenesis has been used to reconstruct defects of the mandible, negating the need for a donor bone graft. Recently, facial allotransplantation has been described. It permits the replacement of whole facial anatomical units with the possibility of sensory recovery and facial reanimation being completed in a single procedure. However, it is necessary for patients to be on life-long immunosuppression, so this method of reconstruction should be limited to appropriate selected patients.

Navigation systems[1,3,4]

Surgical navigation has been likened to global positioning systems. The localizer, usually an optical system, uses a three-dimensional camera to detect an infrared light source or the surgical instrument containing a passive marker. Neurosurgeons use navigation systems to allow maximal removal of tumors that are distinct on computed tomography (CT) or magnetic resonance imaging (MRI), but are clinically indistinguishable from the surrounding tissue, and they allow the surgeon to see the position of the instruments in relation to the patient’s imaging in real time. We were not able to identify any papers that describe the use of navigation to improve accuracy when removing soft tissue tumors in maxillofacial surgery, but its use in hard tissue surgery is ideal as the anatomy is fixed.

Navigation systems have been described and used to reconstruct complex fractures of the zygoma and orbital floor. Using the software provided with the system the intact orbit is copied digitally, flipped around the sagittal plane, and superimposed over the injured area to create an accurate navigational target. The orbital floor can be repaired using conventional access methods and the defect can be dissected out using well known techniques. Such a system is useful in complex orbital fractures or large defects as it allows for accurate reconstruction of the bony anatomy and orbital volume. Where there is extensive loss of tissue either side of the midline, planning by mirrored templates is not possible. In such cases a virtual template from a matched patient of the same age, sex, and ethnic group can be merged with the patient's CT to create a new dataset. The outcomes are possible with a multidisciplinary approach throughout treatment, but such navigational systems are expensive and there is a learning curve. However, once this is overcome, procedures can be completed rapidly. There is clear evidence of an improvement

in accuracy when navigation is used in neurosurgery and orthopaedics, but it has yet to be seen in maxillofacial surgery.

Stereolithographic models and customised implants[1,5,6]

When using osseous flaps, the size and shape is estimated and formed manually during the operation, which is time consuming and inaccurate. Preoperative computer aided planning and design (CAD) can be used to evaluate the size, shape, and anatomy of the defect. Using three dimensional imaging, stereolithographic models can be constructed, which is useful as they simulate the surgical procedure and allow for the construction of custom-made implants that should fit the defect perfectly, shortening operating time.

One case series described the use of CAD and three dimensional imaging to aid reconstructions of the mandible in five patients. Four previously had resection of mandibular tumors with free flap reconstruction, and one had osteoradionecrosis of the mandible. None had originally been treated using CAD. They were undergoing treatment for severe malocclusions that caused trismus, headache, pain in the temporomandibular joint, and facial asymmetry, and further osseointegrated teeth could not be inserted. Inaccurate placement of the plates used for reconstruction was thought to have caused the malocclusions. In one case osteoradionecrosis had caused the left mandible to fracture and collapse. Using CAD, the right mandible was mirrored around the sagittal plane and used as a reference to locate the left mandible. Where the mandibular defects were larger, a similar sized mandible from another patient was used to form the model of the defect. A three-dimensional model was created by a rapid prototyping machine, which was then used to produce a custom-made reconstruction plate. The plate was fixed to the existing mandible and the bone graft built up to the desired shape to match the computer simulation. After treatment the patients developed good mouth opening, accurate occlusion, and osseointegration of implants.

Stereolithographic models have also been used to aid reconstruction of the maxilla.

The authors state that early reconstruction is important because it counteracts the contraction of tissue and scarring, and ensures adequate mouth opening. The patient is rehabilitated faster, pain is reduced considerably, and from an economic point of view, the duration of hospital stay is reduced.

Robotic surgery[1,7]

During the 1990s NASA, along with the Stanford Research Institute, hoped to establish a programme to enable surgeons to do complex operations on wounded soldiers from a remote

location. Intuitive Surgical produced the da Vinci® Surgical System (Sunnyvale, California, USA), which consists of a command console at which the surgeon sits and operates from a remote site, It controls a robotic surgical cart that houses an endoscope and three robotic arms with interchangeable instruments. The robotic arms work in a similar way to laparoscopic instruments used in abdominal surgery but are more intuitive, and the EndoWrist® (Intuitive

Surgical, Inc.) instruments allow seven degrees of motion, which is ideal for minimally invasive complex surgery in confined areas. For this reason the system has been established in numerous surgical specialties and recently has been developed for the resection of tumors in the oropharynx without the need for mandibulotomy by transoral robotic surgery (TORS).

A case series of five patients who had resection of oropharyngeal tumours, reconstruction, and microvascular anastomosis with the da Vinci® robot would have required mandibulotomy if conventional surgical techniques had been used. All procedures were successful and there were no intraoperative complications. The author concluded that TORS is an effective way to preserve the mandible; it allows superior visualisation, access, and precision in areas that are normally very challenging technically. Certain smaller tumors within the head and neck are preferentially treated with chemoradiotherapy to avoid invasive operations, but the da Vinci® robotic system offers the efficacy of open surgery with a minimally invasive approach. The US Food and Drug Administration Board currently have cleared the da Vinci® surgical system for transoral head and neck operations restricted to benign and malignant tumors classified as T1 and T2. The robot eliminates tremor completely and has a motion scaling of 5:1, which makes it ideal for microvascular anastomosis in confined areas. Although the robot does not modify the method of reconstruction, it does allow resection and reconstruction to be done without mandibulotomy. Certain obstacles such as cost and the time required to establishrobotic programmes prevent its rapid adoption on a wide scale.

Tissue engineering[1,8,9]

Tissue engineering has been defined as "the application of the principles and methods of engineering and the life sciences toward the fundamental understanding of structure–function relationships in normal and pathologic mammalian tissues and the development of biologic substitutes that restore, maintain, or improve tissue function." Until recently autologous grafting or prosthetic materials were the only options, but with autologous grafting there is considerable donor site morbidity, and prosthetic materials can fail to integrate and perform when used .With stem cell therapy and tissue engineering there is the possibility that tissues can be repaired, replaced, or regenerated for specific purposes that would respond to needs that cannot be met by donation or prostheses.

The osteogenic potential of bone morphogenetic proteins (BMP) to induce bone to form by their actions on stem cells in extra skeletal, intramuscular sites in rats was first described by Urist in 1965 and then by Reddi and Huggins in 1972. Much of the published material has discussed its osteogenic potential in vitro or in animal studies.

First case describes a 60-year-old man who had previously been treated for squamous cell carcinoma (SCC) and had the tongue, mouth, jaws, and neck tissue resected. He had no mandible left of the midline and there was soft tissue filling in the space. Previous surgery and radiotherapy had prevented the mandible being reconstructed with a microvascular free flap. Three hydroxyapatite (HA) blocks were linked together to form an L-shape similar to the defect in the mandible. HA is a calcium phosphate salt that forms the inorganic component within bony matrix. BMP-7, also known as osteogenic protein 1 (OP1), was smeared over the block, which was then placed under the left pectoralis major muscle. Three months later, skeletal scintigraphy showed that bone had formed within the HA/OP1 composite implant, and four months later the graft of HA/OP1 was raised with a pectoralis major flap pedicled on the thoracoacromial artery. It was secured with an external fixator. The pedicle was covered by a split skin graft from the thigh. Four weeks later the flap was divided by staged clamping of the pedicle over 48 h, which showed good established peripheral vascularisation. The external fixator was removed at this stage. Clinically, the neomandible and the patient's mandible had fused in the midline and ossification was noted between the individual HA blocks. Histological analysis showed 17% bone, 37% HA, and 46% fibrovascular tissue. The patient was able to open and close his mouth and claimed that he had spatial awareness of his new mandible. However, five months later the graft had to be removed because of an MRSA infection. The failure of the graft was attributed to the need for well vascularised soft tissue cover, the loss of tissue from previous operations, previous radiation, and the fact that the new flap needed to be tunnelled under tight, inelastic skin.

Transport disc distraction osteogenesis[1,10,11,12]

Codivilla first described distraction osteogenesis in 1904, and the technique was later developed and popularized by Ilizarov in 1951. Distraction osteogenesis is a three-step process. The first is the latency phase that allows callus to form after osteotomy, the second is the transport phase where the osteotomised bony edges are moved apart (distracted) with the aid of a mechanical device, and the third is the consolidation phase where remodelling and calcification of the bone occurs. It has been used to correct craniofacial deformities and is particularly useful in congenital problems of the mandible. Snyder et al. described distraction osteogenesis in a canine mandible in 1973, and McCarthy et al. first described the procedure in humans in 1992. In the mandible a transport disc distraction osteogenesis (TDDO) is used. A piece of bone is cut adjacent to the defect and moved across to the other end of the defect with a mechanical device. The piece of bone being moved is the disc. Costantino et al. in 1990 used an extraoral device for distraction in a canine. The regenerated bone was of similar size and the inferior alveolar artery and vein had tunnelled through the new bone. Since then several cases have been described in human patients. Initially, external devices were used but they caused facial scarring, and since then internal plate-guided distraction devices have been developed.

A case series describes five patients who had previously had free flap reconstruction for mandibular defects after tumour resection and who went on to have TDDO because poor alignment from scar tissue and inadequate length of the bone had caused poor functional outcomes. After distraction an average gain of 11 mm was achieved, which improved function. The largest case series to date published in 2010 documents the outcome of 28 patients treated with distraction osteogenesis of the mandible after tumor surgery. The authors reported that it was successful in 22/28 patients. It is useful where the bone is straight, but it is difficult to recreate curves, and it is unreliable after radiotherapy, and requires expensive equipment and the compliance of patients.

Facial transplantation[1,13,14]

Current conventional techniques to repair head, neck, and facial defects have failed to restore simultaneously the aesthetic and functional activity of the face. Facial allotransplantation can potentially resolve this. To date there have been 13 such cases but not all have yet been fully reported. So far the overall results have been encouraging with regard to functional and aesthetic outcomes. The first case in 2005 was a 38-year-old woman who had been bitten by a dog, which had resulted in her distal nose, upper and lower lips, chin, and adjacent parts of her right and left cheeks being completely amputated. The surgeons opted to do a single procedure because they thought that conventional autologous tissue reconstruction would require many operations and would result in poor aesthetic and functional outcomes. The donor was a brain dead woman aged 46 who had died after irreversible cerebral ischaemia. The flap was contoured precisely with a rigid metallic pattern, which was made to match the facial deficit. The donor's nose–lip–chin triangle was reconstructed on a custom-made silicone mask from the recipient's face. A radial forearm flap was taken from the donor and anastomosed to the recipient's axillary vessels to act as a sentinel graft for indirect monitoring of the immunological behaviour of the graft, avoiding the need for repeated biopsy examination of the transplant. The total ischaemic time of the flap was 230 min. The initial postoperative course was uneventful. At 18 days and 214 days there was evidence of acute rejection, which resolved with increased doses of immunosuppressants.

Extracorporeal photochemo therapy was started two months after the second episode of acute rejection, and at 18 months. The patient was able to eat and drink by the end of the first week; fluids leaked from the mouth, but this resolved at 12 months. Touch sensation returned to the whole graft after 14 weeks, and heat and cold sensation returned after six months. The patient could move the upper mouth at 14 weeks; at six months she had complete movement of the lower lip, and labial contact was possible. It took 18 months to recover the ability to smile. Psychologically the transplant was well tolerated and the patient faced the outside world for the first time at 12 weeks. Two infectious complications occurred: on day 185, herpes simplex virus 1, which was treated effectively with valaciclovir; and after the second episode of acuterejection, molluscum contagiosum, which was treated by curettage. Quality of life studies in head and neck oncology patients have identified specific functions and aesthetics that are important factors in the rehabilitation of patients, and reconstructive techniques should aim to restore these functions.

Conclusion

This review confirms that the ideal system for reconstruction within the head and neck is yet to be identified. Navigation can be used to aid accurate repair of facial fractures without affecting the method in which the repair is done. There is clear evidence that it improves accuracy and functional outcomes in orthopaedics and neurosurgery, but this has yet to be shown in oral and maxillofacial surgery. The techniques used in navigation with the use of three dimensional imaging and mirroring templates can be used to construct stereolithographic models, which allow for surgical planning and simulation. The models can also be used to construct custom-made implants that enable reconstruction to be more rapid and accurate. Robotic surgery, like navigation, does not actually alter existing reconstructive methods, but it does allow certain oncological procedures to be carried out in a minimally invasive way. TORS enables tumours of the oropharynx to be resected and free flaps inserted without the need for mandibulotomy. TDDO and tissue engineering can be used to reconstruct the mandible while obviating the need for a donor graft. Evidence for the use of tissue engineering to aid reconstruction in the head and neck is still limited. Much of the research is still at laboratory and animal stages, and it will be a long time before it will become routine practice in reconstruction. The first few facial allotransplantations have had promising results. Whole facial anatomical units can be replaced with the potential for sensory recovery and reanimation in a single procedure, but patients will require long-term immunosuppression, and the procedure should be considered only in carefully selected cases.

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Conflict of Interest

None.

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