3D Reconstruction Role in Surgical Treatment of Sinonasal Tumours

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Three-dimensional printing has numerous applications and has gained much interest in the medical world. The constantly improving quality of 3D-printing applications has contributed to their increased use on patients. Nowadays, 3D printing is very well integrated in the surgical practice and research. Also, the field of head and neck reconstructive surgery is constantly evolving because of the three-dimensional printing, a technology which can be widely used in a variety of situations such as reconstruction of tissue defects, surgical planning, medical modeling and prosthesis. By using 3D printing into tissue engineering and materials, it may be possible for otolaryngologists to implant 3D printed functional grafts into patients and will also provide a rapid production of personalized patient-specific devices. Advances in 3D printed implants and future tissue-engineered constructs will bring great progress to the field of otorhinolaryngology.

Key words: sinonasal tumors, 3D printing, reconstruction

Tumours of the nasal cavity and paranasal sinuses represent a wide spectrum of histologies, tissues of origin, and anatomic primary sites. The distinctive difficulty in generalizing treatment approaches is obvious, given the numerous variables associated with the broadly-based term, paranasal sinus malignancy.

Since the first reported maxillectomy by Syme in 1828 [1] the maxillary reconstruction has been a controversial theme and in a constant debate mainly due to the complexity of the maxillary structure and its important diverse functions.

Nowadays, the three-dimensional printing is becoming increasingly important and useful in medicine and especially in the surgical field. The current clinical value of 3D printed surgical guides in resection and reconstruction after surgical treatment of sinonasal tumours is under constant development. The 3D printed surgical guides may significantly improve the postoperative functional and aesthetic results after resection and reconstruction of sinonasal tumours and can reduce the incidence of complications. Furthermore, the 3D printed cranial prosthesis are simple, feasible and represent an useful solution that may significantly improve the cosmetic outcomes. Moreover, it seems that it has the potential to decrease perioperative complications like infections and resorptions, and also, it lowers the morbidity rate.

Three-dimensional printing may allow otorhinolaryngologists to remove the maxillary anterior wall and provide the reconstruction using the 3D print custom cranioplastic prosthesis during the reminder of the intervention [2].

Furthermore, in office virtual surgical planning using 3D, for creating surgical models and guides seems to be an beneficial method and allows for a more cost-effective and less time consuming method. This also improves intraoperative efficiency, surgical precision. Overall, it lowers the cost for different types of craniofacial and reconstructive surgery [3].

After extensive resection, a large defect results which must be covered. There are various methods available such as skin grafts, local or distant flaps or prosthesis. The primary reconstruction of soft tissue should reduce the operative morbidity, re-establish the integrity of the dura mater, and offer the patient an acceptable appearance. Facial reconstructive surgery must aim at a functionally and aesthetically rehabilitated patient. The performance of facial plastic surgery requires an understanding and the application of many important principles.

Usually, the difficulties in facial reconstruction come from the particular unique character of the face and the low availability of local matching tissues. The midface and orbitonasomaxillary complex is an intricate three-dimensional entity with important functional and aesthetic purpose. The principles of aesthetics and function are very important for successful facial cutaneous reconstructive surgery: local flaps must have an appropriate tissue donor sources, the mechanisms and dynamics should be well known, including the effects of tissue movement, and techniques for scar camouflage. These principles may be difficult to apply to particular cases, determing the surgeon to look for new reconstructive options.

The use of different technological devices that allow the creation of three-dimensional models is in constant evolution, allowing a greater application of these technologies in different fields of health sciences and medical training.

The radical resection of the sinonasal tumours extensively invading the skull base appears justified and feasible under certain conditions. If there is the possibility for the patient to obtain a true benefit of this severe mutilation, he must have a reasonable chance of cure, otherwise the postoperative result should at least be compatible with reasonable quality of life. For this reason, immediate reconstruction of the cavity with soft tissue or prosthesis during the first stage of tumour resection is essential.

Reconstruction of the skull base is mandatory if the defect includes bones and dura mater because of the risk of cerebral fluid leakage. Various methods have been described for covering large sinonasal defects. Resurfacing of the wound with skin grafts is often unable to prevent infection.

3D printing represents an important part of the surgical practice and research area and has gained a lot of interest

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in the past few years. It has a wide variety of applications, from anatomical models, which can be used with success in surgical planning, to implants and other surgical features. Although 3D printing has numerous advantages, a cost-effectiveness analysis must be developed in order to establish a balance between the increased intervention costs and the benefits of the applications [4].

By depicting precise personalized anatomy, 3D printing brings important improvement in many fields of surgery, with a large variety of applications such as implants, prostheses and surgical planning. In addition, medical students and young doctors can use this technique for educational learning instead of using conventional cadaver. With numerous trials still ongoing, research is extended for multiple use, such as vascular grafts, ear reconstruction and developing in the area of skin, nerve and vascular graft preparation. However, 3D printing has its limitations consisting in high cost, long processing time and suboptimal accuracy [5].

In the field of otorhinolaryngology, 3D printing has been used for reconstruction procedures, prostheses, grafting and also educational training (provides an opportunity for young doctors to better visualize anomalies and to practice surgical techniques) [6].

A challenge encountered by surgeons is endoscopic sinus surgery, due to complex and variable anatomy [11] and the risk of major complications. This is the reason why there is a need of creating and providing a 3D printed simulator of the nose and paranasal sinuses, in order for the young doctors to practice and assimilate better techniques [7]. The surgeon must be very careful to both function and anatomy when performing bony reconstruction of defects that were caused by resection of malignancy or trauma. Replacement of bone should be done in the functional anatomic position. Some of the principles of a successful facial cutaneous reconstructive surgery include: use of appropriate tissue donor sources, knowledge of the mechanisms and dynamics and the effects of tissue movement.

Moreover, surgery is a must, in the treatment of the majority of epithelial and salivary malignancies [12] and recent studies have underlined the importance of postoperative oncologic applications. Also, non-epithelial malignancies, including the wide variety of sarcomas arising in this region, most commonly require multimodality treatment such as chemotherapy, radiation, surgery. In addition, due to surgical advances, complex tumour removal is now possible, along with an optimal reconstruction and cosmetic outcome. However, there is a need for additional clinical trials in order to properly evaluate the locoregional control and rate survival according to the currently available treatments [8].

Among other available reconstructive options there is also the application of free-tissue transfer flaps, a safe and effective method for repairing large midfacial and cranio-orbito-facial defects[9], osteocutaneous free flaps are useful to restore contour and structural support for massive midfacial defects with insufficient bony support [10]

The aim of this paper is to prove that the 3D printing reconstruction of maxillectomy defects after resection of sinonasal tumour represents a good option with truly expectation of good functional and aesthetic results. Although, due to defect complexity and large number of reconstructive options, this is not yet the perfect solution. The individual assessment of the patient and the defect may provide the best method for the reconstructive planning.

Experimental part

Materials and methods

We discuss the case of a 48 years old male patient, with no important pathology associated, diagnosed with sinonasal cancer, which was treated with radical surgery in July 2017. This case required a multidisciplinary surgical team: ENT and Plastic Surgery.

The tumour was resected within oncologic limits and the anterior wall was replaced by a titanium prosthesis tailored and folded after the 3D printed mold.

Fig.1 Exposing the tumour

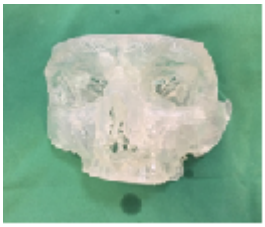

Fig.2 The 3D printed mold used for tailoring the titanium mesh

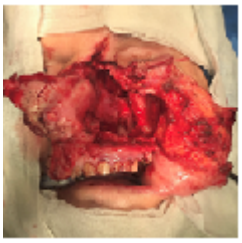

Fig.3 Intraoperative aspect

Fig.4 Placing the titanium mesh

Fig.5 Postoperative reconstruction aspect

In our experience, this procedure was perfectly adapted to the reconstruction of the anterior wall of the left maxillary sinus and inferior orbital wall, providing easier reconstruction using titanium mesh which proved to be safe and effective. This significantly reduced the operative time and improved the aesthetic outcomes of postsurgical reconstruction.

Results and discussions

That model was printed using the preoperative CT scan and reproducing the contralateral side. The wide, external approach allowed a large exposure of the tumour and a complete resection with clear margins. The titanium mesh that was used to replace the anterior wall of the maxillary sinus, was previously folded over the 3D printed reconstructive model. Postoperative functional and aesthetic results were significantly positive. After the surgical treatment, the patient underwent radiotherapy with good preservation of the covering skin graft. There are no signs of recurrence or local and distant complications after 6 months.

Conclusions

Even though there are so many advantages of 3D printing, the additional expensive cost and the time needed to produce devices by current 3D technology still limit its widespread use in hospitals. There is a need for a formal

cost-effectiveness analysis. However, the development of guidelines to improve the reporting of experience with 3D printing in surgery is highly desirable

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Manuscript reeived: 6.02.2018