Original Article

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Steriolithography (Rapid Prototype): An Useful Tool in Mandible and Maxilla Reconstruction

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Abstract

Purpose: To study the effectiveness of Steriolithogrphy rapid prototype model in Mandible and maxilla reconstruction.

Methods and Materials: We present here our case series of 6 patients having maxilla or mandible reconstruction. These patients are reconstructed with free fibula graft which has been moulded at the

donor site itself.

Results: Reconstruction of these bones with free fibula is quite effective. The amount of graft required could be determined preoperatively. The operative time was reduced significantly.

Conclusion: Simulation of surgery using rapid prototype model helps to predetermine the amount of graft required, reduces the operative time and also preoperatively determines the shape of reconstructed bone.

Keywords: Steriolithography; Mandible and maxilla reconstruction; Free fibula.

Introduction

Reconstructions of complex mandibular & maxillary defects have been achieved with autografts[1,2,3] or prosthetic maxillary obturators[4] and reconstruction plates in case of mandible. A prosthetic maxillary obturator is an alternative for maxillary defect reconstruction. Although acceptable results can eventually be achieved in many cases, patients may become dissatisfied, because the removable prosthesis lacks sufficient retentiveness for adequate speech, swallowing, and acceptable esthetic appearance. Bone grafts have become the common method used in maxillofacial Surgery and are the more retentive structure for replacement. But use of a bone graft increases length of surgery as the defect is estimated perop and the moulding of the graft is done peroperatively.[5] Conventional CT and MRI scans are standardized and are important diagnostic tools for assessing the extent of tumour resection.[6,7] The reconstructed 3D data from the CT can be transferred in the operating room to accurately determine the resection margins of the tumour, simplifying the surgical procedure[8] however, tumour resection or defect reconstruction based on 3D imaging modalities presents difficulties in defining the resection plane with sufficient accuracy. On the other hand, stereolithographic models are more concrete, allowing the surgeon to actually simulate the surgical procedure or even to generate patient-specific templates that can be used in the surgery of the tumour, simplifying the surgical procedure.[9] As the result of the development of modern design and manufacturing technology, a customized surgical resection template that matches skeletal anatomy can now be accurately designed.[10,11,12] Using a CAD technique the physical model of the individual template or skull replica can be produced through rapid prototyping (RP), rapid tooling (RT), and

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computer aided manufacturing/computer numerical control (CAM/CNC) processes.[13,14] The RP model facilitates surgical simulation and planning.[15] Such surgical simulation helps us to drastically reduce the operative time as the defect and the amount of bone graft required is determined and is given shape even before the actual surgery starts. We present here few of our cases where the RP model was a useful tool in planning and execution of reconstruction of maxilla and mandible.

Materials and Methods

Case 1

This young lady was operated previously for ameloblastoma of the right hemimandible. Patient was planned for secondary reconstruction using free fibula graft. 3D CT scan was done and based on that RP model prepared. Preoperatively the exact requirement of the graft could be made out. The implant for fixation was mould even before the surgery started. So, the surgery consisted of harvesting the graft and fitting it in place. This RP model helped us to reduce the surgical time. (Fig 1, 2, 3,)

Case 2

In this case the preop RP model helped us

Figure 1: Preop-OPG showing right hemimandibular defect

Figure 2: Pre op preparation of the Steriolithogrphy model of the deficient mandible

to simulate operation, the exact site of excision of the lesion could be predetermining precise requirement of the graft and shaping of the graft were other advantages.

Case 3

This 11 yr old boy was suffering from histiocytosis X, resorption of both mandible and maxilla occurred leaving a thin strip of cortical bone, patient was planned for reconstruction using free fibula graft now and Osseo integrated implant at a later date. The RP model was use to preoperatively determine the exact site of osteotomy, the amount of graft required and preop moulding of the implant.

Discussion

Figure 3: Moulding of the Fibular graft preoperatively at the donor site

The maxilla and mandible serve as the functional and aesthetic keystones of the mid and lower face. Defects in the palatomaxillary complex can lead to devastating functional and cosmetic consequences.[16] Multiple reconstructive techniques, such as autologous tissue transfers and alloplastic materials, have been available for many years, but reconstruction of extensive defects with the use of alloplastic materials, such as reconstruction plates, has several risks, including plate exposure, plate and screw fracture, screw loosening, infection, and limited aesthetic and functional restoration. Until now most implants have been manually shaped intraoperatively on the surgical site. Intraoperative adaptation of the implant is a difficult task, however, due to lack of visualization of the facial anatomy, with the result that an undesirable shape can be obtained when use of complex 3D contouring is required.[17] Furthermore, intraoperative modelling is time-consuming and reduces accuracy, often leading to more invasive surgery, and impairing aesthetic results. The use of a CAD/CAM system is an adequate method for the design and manufacture of very complex 3D models or shapes that are difficult, but not impossible. As the majority of tumour-related maxilla and mandible deformities are unilateral, CAD using RP technologies is an effective technique for generating a precise shape for re-establishing symmetry and an individual template for tumour resection. Creating the 3D model of bone structures extracted from CT image data allows not only for prosthesis design, but also provides very good visualization of the defect for preoperative surgical evaluation and planning. The preoperative preparation, symmetry, and precise fit implant evaluation can be performed much more easily on the physical model generated by RP. As a consequence, the operating time is reduced, and potential intraoperative errors can be modified preoperatively and thus avoided during the actual surgery. The cases presented demonstrate the efficacy and accuracy of using combined technologies of 3D-CT data and a Stereolitho-graphy-produced model for tumour resection guidance and defect reconstruction. One drawback of this approach is that it depends on preoperative CT imaging and, therefore exposés the patient to high radiation exposure, [9] and high expenses incurred for the preparation of the model.

Conclusion

We can conclude that CT imaging, RP, and computer modelling have improved the surgical planning and help achieving efficient immediate reconstruction. In our clinical cases, a computer generated model preoperatively represents the anatomic defect, which is helpful in determining the accurate requirement of graft before harvesting. The plate for fixation can also be mould preoperatively. The use of these techniques leads to reduced operating time, fewer surgical errors, more precise fit, and high stability after screw fixation. Other advantages include simplification of the surgical procedure; the method also permits testing the bone graft fit before the actual surgery, and determination of accurate positioning of the graft. So, the actual surgery consists only of defining the defect and placement and fixation of the bone graft. But the use of such models is limited due to the high costs involved in preparation.

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