Combining Use of Resin Models With External Fixation in Mandibular Reconstruction

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Objective: To obtain accurate occlusion in mandibular reconstruction when the tumor is exophytic, which makes prebending the plate impossible.

Design and Setting: Use of computed tomography–based resin models and external fixation devices is combined in a tertiary academic center. The exophytic part of the tumor on the model is burried off, and the reconstruction plate is bent on the model before surgery. Temporary external fixation is applied before resection, and a precontoured plate is applied following segmental resection before the release of external fixation.

Results: Six patients underwent mandibular reconstruction by using this technique, and all of the patients retained a class 1 occlusal relationship without need for additional intraoperative plate contouring.

Conclusion: Computer-generated resin models of the mandible combined with intraoperative temporary external fixation allow the maintenance of preoperative occlusal status.

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Reconstruction of segmental mandibular defects necessitates maintaining a proper contour and occlusal relationship. This is especially true when the tumor involves the outer cortex of the mandible, where the classic method of reconstruction involving prebending a plate before osteotomies is not possible. One of the most commonly used surgical techniques in this clinical scenario entails using external fixation devices to maintain a correct occlusal relationship. Although maintaining a correct intraoperative occlusal relationship is possible by placing external fixation devices before osteotomies, the patient may experience postoperative malocclusion because of contour deformities as a result of imperfections in bending the reconstruction plate bridging the segmental defect.

Stereolithography is a relatively new technology involving fabrication of resin skeletal models based on the data acquired by computed tomography. This technology has been successfully used in reconstructive head and neck surgery, especially for prefabricating custom-made implants to repair certain skeletal deformities of the skull and face. Resin models have also been used for contouring the reconstruction plates in the management of segmental mandibulectomy defects.

We describe a technique of reconstructing segmental mandibulectomy defects by combining use of stereolithographic resin models with external fixation devices to maintain a class 1 occlusal relationship and the natural contour of the native mandible in cases in which the outer mandibular cortex was involved by tumor or the mandibular continuity was disrupted by a pathological fracture, with the loss of correct contour and/or the occlusal relationship. Shortcomings of other techniques used in maintaining correct occlusion and/or contour in the reconstruction of segmental mandibular defects are discussed.

METHODS

The following technique was used in patients who had tumor involvement of their outer mandibular cortex between November 1, 2004, and January 31, 2006 (institutional review board rules were not applicable to the described technique). A stereolithographic resin model of the mandible is manufactured preoperatively (Protommed Inc, Arvada, Colo) from standard 0.5- to 1.0-mm-thick axial computed tomographic images mailed to the company on a compact disc. No special training, expertise, or equipment was needed to obtain these models. The exophytic part of the tumor on the model is cut or burried off until the exophytic portion becomes flush with the adjacent uninvolved outer cortex. The reconstruction plate is cut and then bent appropriately before sur-
surgery using the resin model, and is attached to the model by using screw fixation (Figure 1). The screws are then removed and eliminated, and the plate is sterilized for use during the actual surgery. The model is also sterilized to allow the surgeons to handle it in the sterile environment when necessary. At surgery, the mandible is exposed and an external fixation device is applied temporarily, proximal and distal to the proposed osteotomy lines. This eliminates the use of intraoral temporary maxillomandibular fixation (MMF) techniques, such as arch bars or Ivy loops. Segmental mandibulectomy is performed in the presence of an external fixation device, because the device does not obscure the surgical field (Figure 2). Following osteotomies, a previously shaped reconstruction plate is then applied to the patient's mandible by using screw fixation in the exact location where it rested on the model based on the guidance of screw holes drilled on the resin model. The external fixation devices are then removed, and vascularized bone in the form of fibula-free tissue transfer is added to maintain continuity of the mandible (Figure 3).

**RESULTS**

We used this combination of procedures in 6 patients. The age of these patients was between 29 and 79 years (mean, 48.6 years). Of these 6 patients, 5 were women. Three patients underwent segmental mandibular resection for removal of ameloblastoma, 1 for mucoepidermoid carcinoma, 1 for squamous cell carcinoma, and 1 for pathological fracture due to osteoradionecrosis facilitated by osteointegrated dental implantation as a result of a previously given postoperative radiation treatment for squamous cell carcinoma of the oral tongue. All
preoperative plate contouring was accurate when applied to the actual patient. No additional contouring of the reconstruction plate was required. A class 1 occlusal relationship and satisfactory mandibular contour were obtained in all patients (Figure 4). None of the patients complained about pain or limitation of mouth opening at the end of 14.8 months of mean follow-up, varying between 6 and 20 months. None of the patients required additional orthodontic intervention. Although none of the patients in this series underwent replacement in their dentition because of financial reasons, all were able to maintain their chewing function without difficulties with their remaining teeth without any change in their occlusal status.

**COMMENT**

Reconstruction of extensive defects of the mandible can be extremely challenging because of the need to maintain proper contour and an occlusal relationship between the upper and lower jaw. Apparently, the exact rate of malocclusion following segmental mandibulectomies with free tissue transfer is unknown, because most of the series published regarding this particular patient group were concerned with other outcome measures, such as quality of life or success rate of the chosen reconstructive modality. To maintain preoperative occlusal status and the contour, a well-accepted method entails bending the reconstruction plate over the mandibular cortex and providing temporary screw fixation of the plate before the osteotomies. This technique may provide an excellent occlusal relationship and correct mandibular contour, even in the absence of temporary MMF, as long as the reconstruction plate is shaped in a perfect fashion. However, when the tumor involves the outer cortex of the mandible and becomes exophytic, intraoperative plate contouring cannot be performed before the segmental resection.

Applying temporary MMF by using arch bars or Ivy loops is a potential solution in such cases. However, performing segmental mandibular resection can be technically difficult when temporary MMF is in place. Furthermore, the patient’s partial dentition status may not allow the surgeon to apply adequate temporary MMF. Another solution for this problem is to use either external fixation devices in the mandible or plates acting like external fixation devices by temporarily connecting the maxilla-zygoma complex to the mandible before the osteotomies. In this case, a reconstruction plate is contoured by bridging the gap following segmental mandibulectomy, while the external fixation devices are still in place. Although maintaining a correct intraoperative occlusal relationship is possible, the final mandibular contour may not match with the native mandibular contour using this technique, because the segment of the plate corresponding to the gap in the mandible is shaped in the absence of an underlying intact cortex. This is especially true when the segmental mandibular defect is located in a significantly arched anterior portion of the mandible. Also, minor imperfections in bending the plate in the absence of an underlying segment of the mandible may cause a less than optimal occlusal relationship in the postoperative period, probably because of minor changes in the spatial orientation of the remaining mandibular segments after release of external fixation devices. Occlusion is not a concern in an edentulous patient; however, maximum effort should be given in providing correct contour rather than simply bridging the segmental gap. The patients may experience chronic temporomandibular joint–related pain in the absence of correct contour, probably because of the strain on 1 or both of the joints regardless of the dentition status.

Although applying an external fixation device in the technique described in this article may seem to be a step that can be omitted, it may still play a significant role in maintaining the optimal occlusal status and the native contour of the mandible for the following reasons. There are 2 important factors in bridging a segmental mandibular defect with a reconstruction plate. The first one is the shape of the plate, which is addressed by contouring the plate over the mandible before resection in cases in which the outer cortex is not involved, and by con-
The technique of mandibular reconstruction by computer-generated resin models was described in this article. The described technique (B) provides correct contour and occlusal relationship, even in the presence of mandibular discontinuity due to pathological fracture, as seen in osteoradionecrosis or tumor invasion. Although native occlusion is already lost in these cases, the surgeon may apply temporary intraoperative MMF to restore the native occlusion. After obtaining satisfactory occlusion, external fixation devices can be placed, temporary MMF can be released, and segmental resection can be performed. The surgeon can still prebend the reconstruction plate in an appropriate fashion on the resin model by simply ordering the model to be made based on the mirror image of the unaffected side. Because the deformed side of the mandible is replaced on the model with the mirror image of the opposite side, the final contour of the plate would match the native contour of the mandible before pathological fracture occurred (Figure 5). The only clinical scenario in which this technique could not be as useful is one in which the patient has a pathological fracture at the symphyseal region, where no mirror image is available. Another disadvantage of using this technique might be the cost of obtaining computed tomography–generated resin models, which was about $1100 per model when this article was prepared. However, we believe maintaining class 1 occlusion in all cases by using mandibular models may justify their cost, because orthodontic treatments for the correction of malocclusion may cost about $6000, with an average of 26 clinic visits in cases in which malocclusion occurred.

In conclusion, the use of computer-generated resin models of the mandible combined with intraoperative temporary external fixation seems to be a viable alternative to more traditional techniques, to maintain correct occlusal status and mandibular contour in cases in which the tumor involvement of the outer cortex of the mandible makes prebending a reconstruction plate impossible.

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REFERENCES


**Correction**

Typographic Errors in Genotype Terms. In the Original Article titled “The Influence of Mutations in the SLC26A4 Gene on the Temporal Bone in a Population With Enlarged Vestibular Aqueduct,” published in the February issue of the Archives (2007;133:162-168), 5 typographic errors were published in the genotype terms in the first paragraph of the “Laboratory Findings” subsection of the “Results” section. The correct terms appear in bold in the following paragraph: