Use of Porous Space Maintainers in Staged Mandibular Reconstruction

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KEYWORDS

• Mandibular reconstruction • Polymethylmethacrylate space maintainer • Implant fabrication

KEY POINTS

- The success of mandibular reconstructions depends not only on restoring the form and function of lost bone but also on the preservation of the overlying soft tissue layer.
- In this case study, 5 porous polymethylmethacrylate space maintainers fabricated via patient-specific molds were implanted initially to maintain the vitality of the overlying oral mucosa during staged mandibular reconstructions. Three of the 5 patients healed well, whereas the other 2 patients developed dehiscences, most likely due to a thin layer of soft tissue overlying the implant.
- The results presented provide evidence that a larger investigation of space maintainers fabricated using this method is warranted.

INTRODUCTION

Continuity defects of the mandible can be the result of tumor resection or trauma. In cases involving high-velocity projectiles, blast injuries, or locally aggressive tumors, bone loss is often associated with loss or compromise of the overlying soft tissue.[1,2] The goals of reconstruction must therefore include not only strategies for the replacement of bone but also methods to restore or preserve the overlying soft tissue.

CLINICAL CHALLENGE

Several techniques are available for the reconstruction of osseous defects of the mandible, with the gold standard remaining autologous bone transplantation.[3,4] When nonvascularized bone grafts are used, definitive reconstruction is often delayed until a clean wound environment without oral communication is present.[5] Without this delay to allow the soft tissue envelope to heal, an increased incidence of wound dehiscence and graft infection has been reported.[6,7] During healing of the oral tissues, the soft tissue adjacent to the bony defect prolapses into the area filling the space between the bony segments. When secondary reconstruction is attempted several months later, this tissue must be dissected or excised to re-create the defect to be filled with bone. Nerves, nerve grafts, and blood vessels contained within this interspersed soft tissue may be injured during dissection. The concept of space maintenance was developed to assist these staged reconstructive procedures by preserving the soft tissue envelope surrounding the bone defect, creating a pocket for the insertion of a bone graft.

Space maintenance involves the temporary implantation of an alloplastic material into a defect

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to prevent wound contracture into the space normally occupied by bone.[5] Currently, the most widely used alloplastic material for craniofacial reconstruction is polymethylmethacrylate (PMMA) bone cement, an acrylic-based resin.[8] PMMA has also been used in skeletal space maintenance applications[5,6,9] and specifically within the craniofacial complex.[10] PMMA is strong, nondegradable, easily moldable, inert, and simple to mix intraoperatively, making it an ideal material for temporary placement into irregularly shaped defects.[5] Unfortunately, complications such as wound dehiscence and implant exposure are not infrequent and result from compromised soft tissue healing over an implant.[5–7] Once an implant is exposed in the oral cavity, secondary contamination with saliva and oral organisms occurs very quickly, and inflammation, infection, and secondary fibrosis can compromise the wound bed if the implants are not removed immediately.

In addition, intraoperative formation of PMMA space maintainers has been associated with local thermal or chemical necrosis as a result of high curing temperatures and leaching of residual monomer (methylmethacrylate, MMA).[11,12] These concerns are addressed with several innovations and the authors' early experiences with optimized spacer technology are presented.

TECHNICAL INNOVATIONS

Recent innovations in craniofacial surgery as well as research into biomaterial-tissue interfaces have identified several technologies capable of improving the performance and biocompatibility of space maintainers. First, advances in computer-aided modeling techniques allow the development of accurate and affordable surgical models.[13–15] From these models, an anatomically correct template can be fabricated for a space maintainer to fit the proposed defect accurately before surgery. In addition, investigations into material surfaces properties have focused on the creation of porosity within implants to improve retention and soft tissue integration.[16–18] A porous structure allows fibrovascular tissue ingrowth, which improves wound healing and the formation of a stable interface. In the work described here, low porosity was introduced into PMMA implants to facilitate the attachment of the overlying soft tissue layer through mechanical interlocking while minimizing hard and soft tissue ingrowth. Combining this technique with computer-aided modeling allowed for the fabrication of porous PMMA implants customized to fit into a bony resection defect produced during the treatment of benign mandibular pathologic abnormality.

Fabrication of space maintainers preoperatively using molds produced from patient-specific 3-dimensional (3D) models provides several advantages over in situ fabricated implants. The device dimensions approximate the defect dimensions very closely, reducing the time it takes to mix, mold, and trim implants produced intraoperatively. Also, by fabricating a spacer ex vivo, problems associated with intraoperative molding of PMMA such as local tissue damage injury through thermal or chemical injury can be avoided. The polymerization of PMMA is highly exothermic and temperatures reaching 110°C on polymerization have been reported.[19] By fabricating implants outside the surgical defect, tissue necrosis associated with temperature rise is eliminated. Second, MMA monomer released from PMMA during polymerization is toxic to cells, but previous studies have found that toxicity is reduced to negligible levels after 48 hours of polymerization with solid PMMA samples.[11,20] Studies on the actual formulation of porous PMMA used in patients (30 wt% carboxymethylcellulose [CMC]) demonstrated minimal release of MMA after 3 days.[21]

One potential problem of using prefabricated implants relates to the ability to predict surgical margins accurately on 3D models. Although radiographic data are usually accurate, final margins are not confirmed until surgery. In view of this, it has been found prudent to fashion larger spacers that can be trimmed after the resection has been completed.

ADVANTAGES OF POROUS SPACE MAINTAINERS

The use of porous PMMA in this study has many advantages over conventional solid PMMA space maintainers. Past clinical studies have shown that porosity can play an important role in implant attachment to the surrounding soft tissue[11,17,18,22] because the pores of a space maintainer provide "anchorage points" for healing tissue to infiltrate, thereby achieving mechanical attachment over the entire surface of a flap and not just at the incision margins where sutures are placed. This enhanced mechanical support for the flap is thought to reduce the incidence of dehiscence. This hypothesis was tested by in vivo studies demonstrating that porous space maintainers were associated with fewer dehiscences compared with nonporous space maintainers when implanted in segmental rabbit mandibular defects.[23,24] In one study, it was postulated that porous PMMA samples with reduced porosity (30 vs 40 wt%) performed better because they had less of an inflammatory response. Implants