Maxillary Bone Defect Reconstruction Using Porous Polyethylene Implants

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Purpose: The aim of this study was to evaluate the bone repair process in the maxillary sinus in monkeys treated with high-density porous polyethylene (Medpor).

Methods: Four capuchin monkeys (Cebus apella) were submitted to bilateral horizontal osteotomies in the anterior wall of the maxillary sinus and divided into 2 groups: control group, left side with no implants, and porous polyethylene group, right side with Medpor. After a period of 145 days after implant placement, the maxillae were removed for histologic and histometric analyses.

Results: Bone repair in osteotomized areas took place by connective tissue in 58.5% and 58.7% in the control group and the porous polyethylene group, respectively. In the contact surface with Medpor, bone repair occurred in 41.3%.

Conclusions: Medpor was not reabsorbed within the period of this study and allowed bone repair surrounding it. The porous polyethylene constitutes a feasible alternative for bone defect reconstruction.

Key Words: Polyethylene, polymer, bone matrix, maxilla, biocompatible materials

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H uman tissue replacement is a millenarian procedure and has grown significantly over the last century. During all these years, materials such as metals; ivory; corals; calcium preparations; polymers; polyurethanes; ceramics; silicone; cartilage; dura mater; pericardium; collagen; dentin; autogenous, homogeneous, and heterogeneous bone; dry natural bone; and synthetic bone, among others, have been used to replace human tissues.1–7

Autogenous bone grafting is considered standard for craniofacial reconstructions because it demonstrates osteogenic properties and promotes no antigenic reaction, besides offering no risk of cross-contamination. However, this type of grafting shows as a main limitation the need of 2 surgical procedures, resulting in increased surgical time and morbidity to the donor site.8

In an attempt to supply the limitations of autogenous grafting, alloplastic materials have been widely studied in reconstructive and aesthetic surgeries.7,9 The current study focuses on high-density porous polyethylene, brand name Medpor (Porex Surgical Inc, Newman, GA), which is synthesized from pure porous high-density polyethylene.

Porous polyethylene is a widely used material in contour re-establishment and reconstruction of the ridge and orbital floor. In addition, it is also used for restoration of other regions, such as the mental region, zygomatic arch, mandibular ramus, skull, ear, and nose.10 It is available in several shapes and sizes, and its main physical characteristic is easy handling and molding with heating during the surgical procedure. In addition, porous polyethylene is insoluble in fluid tissues, is nonreabsorbable, and has long-term structural stability.6,11–13

However, the use of this material in maxillary bone defect reconstruction is poorly reported in literature. Thus, the purpose of this study was to analyze the repair process in surgical defects induced in the anterior wall of the maxillary sinus of monkeys treated with porous polyethylene (Medpor).

MATERIALS AND METHODS

Four young adult capuchin monkeys (Cebus apella), weighing approximately 3 kg, were used in the current study. The animals were operated on and kept in individual cages until the end of the experiment on a liquid hypercaloric and hyperprotein diet. This study was approved by the Animal Ethics Committee at the School of Dentistry of Araçatuba, State of São Paulo University (UNESP).

For the surgical procedure, animals were submitted to an initial sedation process through inhalation of sulfuric ether. Next, an anesthetic solution based on sodium thiopental 1 mg/kg body weight and diazepam 0.3 mg/kg body weight was injected intramuscularly. After adequate sedation, local anesthesia in the right and left maxillae was carried out through infiltration of 3 mL of lidocaine solution associated with 1:200,000 adrenaline (Merrell Lepetit Farmacêutica e Industrial Ltda, Rio de Janeiro, Brazil), diluted in 5 mL of distilled water.

The surgeries consisted of intrabuccal access, with incision in the fornix and exposure of the anterior wall of the right and left maxillary sinuses. Both sides underwent horizontal osteotomies using carbide drill number 702 at high rotation speed under abundant irrigation with double-distilled water. The osteotomies were initiated in the canine fossa going up to the tuber maxillary region. The created horizontal defect was approximately 0.5 cm wide and 2 cm long.

After osteotomies, animals in the control group (CG) received no implant in the left maxillary sinus, and animals in the porous polyethylene group received porous polyethylene implants (Porex...
The surgical wounds were sutured by continuous spiral stitches using absorbable polyglactin 910 sutures (Polivircryl; Jonhson & Jonhson Ltda, São Paulo, Brazil). All implants were placed in their receiving beds with no additional fixation, only the natural stabilization along the cavity walls; they showed no movements and were well adapted.

The animals received intravenous cephalexin-based antibiotic therapy during the immediate preoperative and postoperative periods. In addition, the animals received dipyrone and diclofenac potassium during the immediate postoperative period.

After 145 postoperative days, the animals were killed, according to the protocol for intracardiac perfusion with fixative solution. The right and left maxillae were removed, postfixed in 10% formaldehyde solution for 48 hours, rinsed in tap water for 24 hours, decalcified in 20% EDTA for 5 weeks, and then submitted to routine histologic processing. Serial histologic sections of 6-μm thickness were stained in hematoxylin-eosin.

The histologic sections were observed in a light microscope to qualitatively evaluate the repair process that occurred in both groups. For histometric analysis, the histologic sections were evaluated using image analysis software ImageLab 2000 for Windows (MCM Design, Hillerod, Denmark).

RESULTS

Histologic Analysis

Control Group

After 145 postoperative days, the area with surgical defects was mostly filled with intense connective tissue proliferation and remodeling of the bone walls. The connective tissue presented great quantity of fibroblastic cells in different maturation levels and numerous collagen fibers at a regular disposition. No presence of inflammatory cells was observed.

The bone walls exhibited well-defined bone trabeculae with haversian system present and narrow medullary spaces, besides active remodeling in their periphery. Regeneration of the sinus mucosa was complete in the histologic sections of all animals (Fig. 2).

Although the occurrence of connective tissue could be frequently observed in the CG, in 48.5% of the studied area, there was a thick and well-defined trabecular bone neoformation with few medullary spaces. In some areas, this bone neoformation filled the entire surgical defect created in the maxilla, thus occurring total tissue repair of the sinus mucosa (Fig. 3).

Porous Polyethylene Group

In the Medpor implant group, the implants remained in their receiving beds with no exposure to the buccal environment or signs of buccal or sinus infection. The presence of Medpor did not prevent tissue proliferation in the interior of its pores. No resorption process was observed up to the 145-day period after surgery (Fig. 4).

The intense connective proliferation that occupied most periimplantar spaces showed no inflammatory cells and a great number of collagen fibers and fibroblast cells at the final maturation stage.

The bone tissue involving the porous polyethylene implant was characterized by well-defined trabecular bone with well-defined medullary spaces. Tissue repair of the sinus mucosa was also observed.

Histometric and Statistical Analyses

The perimeters for the interface implant/bone tissue and implant/connective tissue were obtained in millimeters (Fig. 5 and Table 1). In addition, the areas occupied by connective tissue
and bone neoformation were also quantified in the CG (Fig. 3 and Table 2).

**DISCUSSION**

The methodology and animal model used in this study were important because they simulated real clinical situations, and the operated area showed close similarity to the human maxilla. Le Fort I fractures, osteotomies for maxillary access, and maxillofacial surgeries are clinical situations that can be associated with this study.9,14–16

Recently, autogenous bone grafts have been used by surgeons because of their biocompatibility, absence of immunologic response, and no risk of cross-contamination. However, this grafting option increases surgical time and needs a donor site.7,8

Along with new techniques, especially for guided tissue regeneration in periodontics and implantology, in which small quantities of particulate bone materiel are needed, the interest for alloplastic, homogeneous, and heterogeneous materials has increased. These materials are used under local anesthesia.1 Among these options, the porous polyethylene has stood out because it is a biodegradable alloplastic material, permits the development of blood vessels in its interior, derives from polyethylene, is high-density porous, and is available in sterile shapes.13,17,18

The polyethylene implant has been successfully used in oral and maxillofacial surgery, mostly in posttraumatic reconstructions with favorable results since 1985.10 Over the last years, it has been mainly used as onlay grafting in reconstructions of the facial skeleton and repair of the mental region, mandibular angle, orbital floor, nose, and ear.16,20

Frequently used as onlay implants for craniofacial contours, the porous polyethylene is easily incorporated by the connective and bone tissues, with no absorption or remodeling process.11,21 This histologic aspect was also verified in this study, with connective prevalence in the interface porous polyethylene, which is considered a positive result for bone contour repairs.10,22

Because porous polyethylene presents prevalence of connective adherance, it would not bear bone movement conditions, and this instability would possibly lead to implant loss. In this study, porous polyethylene was implanted under some pressure to the receiving bed, and it stabilized greatly with no need of rigid or semirigid fixations. Penetration of the blood clot inside the pores of the porous polyethylene is a vital condition for incorporation of the material by ingrowing tissues. This fact was observed in this study, where all spaces were filled with bone or connective tissue, there was no presence of chronic inflammatory infiltrate, and there was mature bone tissue in some areas of close contact, confirming its good acceptance by the organism, an aspect that for Nakamura et al12 can be reference for the study of other implants.

Thus, pure porous high-density polyethylene (Medpor) is highly accepted for craniofacial reconstructions. Furthermore, Park et al,24 through a retrospective study, suggest that, when performed properly after appropriate evaluation, genioplasty using Medpor is a method that should provide satisfactory results for both patients and surgeons. In the current study, it was possible to identify that, for bone contour repairs, this material is highly recommended. However, longitudinal studies and clinical trials must be carried out to analyze the durability of this material.

Based on the methodology studied, it can be concluded that high-density porous polyethylene was not reabsorbed within this study period and allowed bone repair extending up to 41.5% of its periphery. Because of the adequate biologic behavior, it constitutes a viable alternative for bone defect reconstructions in contact with the maxillary sinus.

**REFERENCES**


**TABLE 1.** Quantification of CG Areas

<table>
<thead>
<tr>
<th>Studied Area</th>
<th>Connective Tissue</th>
<th>Bone Tissue</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.450 mm²</td>
<td>3.1882 mm² (58.5%)</td>
<td>2.2617 mm² (41.5%)</td>
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</tbody>
</table>

**TABLE 2.** Perimeters of Interfaces Analyzed in Implanted Group

<table>
<thead>
<tr>
<th>Perimeter Studied (750 mm)</th>
<th>Connective Tissue</th>
<th>Bone Tissue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medpor</td>
<td>440.2 mm (58.69%)</td>
<td>309.8 mm (41.31%)</td>
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