Torps and Porps:*
A transmission and scanning electron microscopic study

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Introduction
Since Shea (1976) introduced Plasti-pore\textsuperscript{M} total ossicular replacement prostheses (TORPs), these prostheses, as well as the partial replacement ones (PORPs) are used extensively by otologists in middle-ear surgery. Despite reports of extrusion of the head of some of these prostheses through the tympanic membrane in percentages varying from 2.2 (Smyth \textit{et al.}, 1978) to 9.3 (Hicks \textit{et al.}, 1978), the recent clinical performance of the prostheses is promising (Brackmann and Sheehy, 1979).

In an attempt to know the fate of Plasti-pore\textsuperscript{M} prostheses in the human middle ear, we have used both transmission and scanning electron microscopy in studying four TORPs and seven PORPs implanted in the middle ear for periods varying from seven to 34 months.

Materials and Methods
Four TORPs and seven PORPs were removed during revision tympanoplasty procedures. Revision surgery was performed because of unsatisfactory auditory gain in six cases, and in five cases because of partial extrusion of the prosthesis from the middle-ear space. The transplanted PORPs and TORPs remained in the middle ear from seven to 34 months. Clinical and surgical data of patients are summarized in Table I. Two unused prostheses—one TORP and one PORP—were used as controls.

All removed prostheses were immediately fixed in Karnovsky’s solution containing 2 per cent glutaraldehyde, 2 per cent paraformaldehyde, and 0.1 M cacodylate buffer. Most of the prostheses were prepared for scanning electron microscopy (SEM). Parts of two PORPs and of two TORPs were postfixed in 1 per cent osmic acid, dehydrated in graded alcohol solutions, embedded in epon araldite, and then examined with light and transmission electron microscopy (TEM).

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## TABLE

**TORPs AND PORPs**

<table>
<thead>
<tr>
<th>Case</th>
<th>Age</th>
<th>Sex</th>
<th>Ear</th>
<th>Prosthesis</th>
<th>Months in middle ear</th>
<th>Pre-operative air-bone gap</th>
<th>Cause of revision tympanoplasty</th>
<th>Tympanic membrane</th>
<th>Middle ear cleft</th>
<th>Gross examination of prosthesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8</td>
<td>M</td>
<td>Rt</td>
<td>PORP</td>
<td>10</td>
<td>43 db</td>
<td>Partial extrusion of prosthesis</td>
<td>—</td>
<td>Atelectasis</td>
<td>Pulled off stapes head; no resorption or adhesions</td>
</tr>
<tr>
<td>2</td>
<td>21</td>
<td>M</td>
<td>Lt</td>
<td>PORP</td>
<td>7</td>
<td>6 db</td>
<td>Partial extrusion of prosthesis</td>
<td>Attic perforation</td>
<td>Residual cholesteatoma in attic, inflammatory reaction</td>
<td>On head of stapes; no resorption or adhesions</td>
</tr>
<tr>
<td>3</td>
<td>56</td>
<td>D</td>
<td>Rt</td>
<td>PORP</td>
<td>18</td>
<td>7 db</td>
<td>Partial extrusion of prosthesis</td>
<td>Central perforation</td>
<td>Squamous epithelium over stapes</td>
<td>Displaced; no resorption or adhesions</td>
</tr>
<tr>
<td>4</td>
<td>36</td>
<td>F</td>
<td>Lt</td>
<td>PORP</td>
<td>7</td>
<td>18 db</td>
<td>Unsatisfactory functional result</td>
<td>—</td>
<td>Mucous membrane disease</td>
<td>Good position; resorbed crura of the stapes</td>
</tr>
<tr>
<td>5</td>
<td>19</td>
<td>F</td>
<td>Rt</td>
<td>TORP</td>
<td>8</td>
<td>35 db</td>
<td>Partial extrusion of prosthesis</td>
<td>—</td>
<td>Atelectasis</td>
<td>Good position; no resorption or adhesions</td>
</tr>
<tr>
<td>6</td>
<td>35</td>
<td>M</td>
<td>Lt</td>
<td>TORP</td>
<td>11</td>
<td>15 db</td>
<td>Unsatisfactory functional result</td>
<td>—</td>
<td>Well healed</td>
<td>Displaced from oval window; mild adhesions in oval window; no resorption</td>
</tr>
<tr>
<td>7</td>
<td>54</td>
<td>M</td>
<td>Lt</td>
<td>TORP</td>
<td>24</td>
<td>46 db</td>
<td>Partial extrusion of prosthesis</td>
<td>Thin with central perforation</td>
<td>Well healed</td>
<td>Displaced; no resorption or adhesions</td>
</tr>
<tr>
<td>8</td>
<td>53</td>
<td>F</td>
<td>Lt</td>
<td>PORP</td>
<td>19</td>
<td>26 db</td>
<td>Unsatisfactory functional result</td>
<td>Central perforation</td>
<td>Scar tissue</td>
<td>Displaced by scar tissue</td>
</tr>
<tr>
<td>9</td>
<td>22</td>
<td>F</td>
<td>Rt</td>
<td>PORP</td>
<td>12</td>
<td>31 db</td>
<td>Unsatisfactory functional result</td>
<td>Well healed</td>
<td>Well healed</td>
<td>Pulled away from stapes</td>
</tr>
<tr>
<td>10</td>
<td>34</td>
<td>M</td>
<td>Rt</td>
<td>TORP</td>
<td>34</td>
<td>22 db</td>
<td>Unsatisfactory functional result</td>
<td>Well healed</td>
<td>Adhesions around oval window niche</td>
<td>Immobilized by scar tissue in oval window</td>
</tr>
<tr>
<td>11</td>
<td>42</td>
<td>M</td>
<td>Rt</td>
<td>PORP</td>
<td>19</td>
<td>40 db</td>
<td>Unsatisfactory functional result</td>
<td>Retraction pocket</td>
<td>Fluid</td>
<td>Good position; no resorption or adhesions</td>
</tr>
</tbody>
</table>
Findings

SEM examination showed fibrous tissue growth on the outside of the TORPs, and on the outside as well as the inside of the PORPs. There was no evidence of any changes in the physical characteristics of the prostheses. The general shape of all prostheses was preserved (Fig. 1).

Under higher powers of magnification, fibrous tissue strands invaded the prosthesis between its micromolecules. No gross evidence of erosion or disintegration of the prostheses was seen (Fig. 2).

Light microscopic examination of these prostheses showed invasion of fibrous tissue strands throughout the Plasti-poreM. The fibrous tissue was infiltrated in all specimens by multiple macrophages and giant cells. In many instances, there was a particulate dust-like pigment in these cells (Fig. 3).

TEM examination showed diffuse infiltration of the substance of the prostheses with macrophages and multinucleated giant cells dispersed among collagen fibers and fibroblasts (Fig. 4). The giant cells showed abundant electron-dense bodies in their cytoplasm (Fig. 5).

Discussion

The assessment of tissue responses to Plasti-poreM in vivo is difficult and the final assessment can only be made from autopsy findings under experimental conditions, and in patients who had implants inserted into their middle ears during their lifetime.

![Fig. 1](https://www.cambridge.org/core/core)  
Scanning electron micrograph of a PORP removed from the middle ear during revision surgery 18 months after its insertion (Case 3). The prosthesis showed no change in its gross physical characteristics and there was a local fibrous tissue reaction on the surface of the prosthesis. Original magnification x20.
FIG. 2
Scanning electron micrograph of the same specimen as shown in Figure 1. There was growth of fibrous tissue into the micropores of the prosthesis. Original magnification ×500.

FIG. 3
Light microscopic section of a TORP removed from the middle ear during revision surgery 24 months after its insertion (Case 7). The fibrous tissue infiltrating the substance of the prosthesis showed multinucleated giant cells with particulate-like matter in their cytoplasm (P). Toluidine Blue stain, original magnification ×40.
Transmission electron micrograph of a TORP removed 34 months after its insertion in the middle ear (Case 10). There was infiltration of the prosthesis material by collagen fibers, multinucleated giant cells and macrophages. Original magnification × 1900.

The host response to the placement of Plasti-poreM implants in the middle ear can be evaluated by examination of the host tissues, and by studying the effect of implantation on the prosthesis itself.

**Host Tissues**

While Plasti-poreM encouraged fibrous tissue growth along the prosthesis, this reaction was a local one. In no cases was there any gross fibrous reaction in the middle ear.

The surgical findings summarized in Table I show the presence of an atelectatic middle ear in three cases. Inflammatory reaction was manifest in only one case.

Since prostheses in the middle ear are considered to be extra-mucosal, the main host response should be expected to occur at the point of juxtaposition of the prosthesis to the tympanic membrane, oval window or head of the stapes. Because the prosthesis was covered by cartilage in all the cases used in the present series, histologic evidence of foreign body reaction, macrophage activity or fibrous tissue reaction in the tympanic membrane could not be found in the examined specimens. In all cases, the junction between the prosthesis and the overlying tragal cartilage was
fibrous. Partial extrusion of the prosthesis was evident in five cases (3 PORPs and 2 TORPs) and perforation of the drum was found in two. The oval window showed mild adhesions in two out of four cases in which a TORP has been used. The crura of the stapes were resorbed in one case out of four in which a PORP was used.

**Plasti-pore® Prostheses**

The chemical interaction between the prosthesis and the endogenous physiological substances may change the structure of the implants. In the present study, an evaluation was made of the physical properties, and the surface and microscopic structure, of the prosthesis.

In none of the cases was a bad functional result due to changes in the physical characters of the prosthesis.

The surface structure of the implants was thoroughly studied by the SEM. There was a moderate fibrous tissue reaction on the surface of the prosthesis. Fibrous tissue invaded the prosthesis between its micromolecules. No gross evidence of erosion or disintegration of the prosthesis was seen.

Microscopic examination of the prosthesis showed that there is a consistent local foreign body reaction, as evidenced by the abundance of
giant cells and macrophages detected in the substance of the prosthesis, and by the presence of particulate matter inside some of these cells. The significance of this particulate matter is as yet unknown. Kerr (1980) found doubly refractile particles inside giant cells infiltrating Plasti-pore\textsuperscript{M} prostheses under polarized light. He suggested that the most likely explanation for these particles is that the prostheses are attacked by the giant cells with microscopic disintegration. On the other hand, Gamoletti (1980) found that these particles were P.A.S.—positive and were not birefringent under polarized light. He concluded that the Plasti-pore\textsuperscript{M} particles are not phagocytosed by the giant cells.

It is evident from the present work that Plasti-pore\textsuperscript{M} is a relatively inert material based on the clinical performance of these prostheses when placed by experienced otologists, with absence of gross fibrous reaction in the middle ear, and the unchanged physical characteristics of the prosthesis. However, owing to the consistent foreign body reaction against these prosthesis, the final word about their long-term tolerance remains to be said.

**Summary**

TEM and SEM were used to evaluate the fate of eleven Plasti-pore\textsuperscript{M} prostheses left in the human middle ear for periods varying from seven to 34 months. It was evident that Plasti-pore\textsuperscript{M} is a relatively inert material based on its clinical performance, absence of gross fibrous tissue reaction from the middle ear, and the unchanged physical characteristics of the prosthesis. Micro-disintegration of the TORPs and PORPs was suggested by the consistent foreign body reaction invading their structure, and the presence of particulate-like matter inside the giant cells. However, micro-disintegration did not affect the physical characteristics of the prosthesis and seem to have little bearing on their clinical performance.

The question of the long-term performance of Plasti-pore\textsuperscript{M} remains to be answered.

**REFERENCES**


Hicks, G. W., Wright J. W., Jr., and Wright J. W., III (1978) *The Laryngoscope, 88*, 1024.


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