The Effect of Silastic Replacement Following Discectomy in Sheep Temporomandibular Joints

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The effect of Silastic (Dow Corning, Midland, MI) replacement following discectomy was examined in sheep temporomandibular joints (TMJs). Four sheep had disc perforations created bilaterally, and 20 weeks later the right disc was removed and replaced with a Silastic sheet. At 40 weeks following commencement of the study, the sheep were killed and the TMJs examined radiologically and histologically. The TMJs of two unoperated sheep were similarly evaluated to determine normal findings. Radiologic examination showed destructive bony change in all four operated joints. Histologic examination confirmed these bony changes in both the temporal bone and condyle. There were foreign particles with an accompanying foreign-body reaction throughout the fibrous tissue capsule that had formed around the implant.

Replacement of the excised temporomandibular joint (TMJ) disc with an interpositional material has become popular as a possible method of stimulating rebuilding of the soft-tissue cover of the condyle and temporal component and preventing or reducing the postoperative development of fibrous adhesions or ankylosis, structural bony change, crepitus, trismus, or recurrent pain. Initial descriptions of the findings following alloplastic replacement of the TMJ disc report good short-term results using a polyethylene cap over the condyle or a Silastic sheeting (Dow Corning, Midland, MI). Silastic is probably the most commonly implanted silicone rubber and may be used either as a block or as a sheet. Van Noort and Black have suggested that the silicone rubbers are biologically inert in that no adverse tissue response is produced after implantation. On the other hand, silicone has a high coefficient of friction and poor wear characteristics under direct function. For an interpositional implant to be effective, it must become encapsulated by connective tissue. In an arthroscopic study of TMJs in which the disc had been replaced by Dacron-reinforced silicone implants, Eriksson and Westesson found that the condyle articulated directly against the implant, and there was no obvious fibrous capsule. Worsing et al, using rabbit knee joints, showed that particulate Silastic has the potential to induce a reactive synovitis with foreign-body giant cells. It has been suggested that the destructive lesions seen radiographically in both the TMJ and wrist following reconstruction with Silastic are a result of the reactive synovitis initiated by silicone particles abraded from the implant.

The sheep has recently come into use as an animal model for TMJ research. The size and anatomy of the TMJ are similar to that of humans, and this robust animal is widely available, cheap, and has high ethical acceptability. The aim of this study...
was to determine the effect of Silastic replacement following discectomy in sheep TMJs.

**Materials and Method**

Six purebred merino sheep of approximately 70 kg body weight were used and their general management followed our previously described technique. The TMJs of two sheep were not operated on, but were radiographically and histologically evaluated to establish control values. Four sheep were operated bilaterally to produce a perforation in the central part of the disc. The sheep were anesthetized using pentobarbital. Endotracheal intubation was not necessary. The preauricular area was shaved and prepared with aqueous antiseptics. The field was isolated with sterile drapes and the joint exposed via a preauricular incision. The superior joint space was opened by a horizontal incision through the joint capsule. A full-thickness perforation 5 mm in diameter was made in the disc over the central portion of the mandibular condyle. The joint capsule and overlying tissues were then repaired in layers. The procedure was repeated on the contralateral joint. Prophylactic antibiotics were used and the animal returned to field conditions after 3 days of observation in a covered animal house.

At 20 weeks, the perforated disc in the right joint was removed and replaced with Silastic. The joints were exposed in the manner previously described, and discectomy was carried out using fine artery forceps and a scalpel. A piece of 2-mm thickness, nonreinforced, Silastic sheeting was trimmed to fit into the joint cavity so that it would cover all functional areas of the condyle and glenoid fossa. The implant was attached to the temporal surface with resorbable sutures (Fig 1). The postoperative management was the same as that following disc perforation.

Forty weeks following the initial operation the sheep were killed and the joint areas were removed en bloc with a band saw and fixed in 10% neutral buffered formalin. The joint blocks were then radiographed in the anteroposterior and lateral planes. The following features were assessed for both the condylar and temporal surfaces: erosion, flattening, osteophyte formation, sclerosis, and presence of subcortical cysts. A morphologic rating of 0 for no demonstrable change, 1 for mild, 2 for moderate, and 3 for severe change was used. This was applied to all features and both joint surfaces so a maximum score of 60 could be assigned to a joint. A second assessment was performed at 2 months. This method followed that used by Muir and Goss for human TMJ radiographs.

The blocks were then decalcified and sectioned in the parasagittal plane into lateral, central, and medial specimens. The sections were stained using hematoxylin and eosin. The slides were assessed using a modification of the method used by Hansson et al and Richards et al. By dividing each joint into three blocks and assessing each slide in its anterior, central, and posterior aspects, the joint was thus divided into nine zones. Each zone was assessed both descriptively and also by direct measurement.

Measurements were taken in each region of the thickness of the articular layer, including synovial membrane; thickness of the fibrocartilage layer, including the proliferative area; and thickness of the mineralized cartilage layer. The measurements were done at 100× magnification using a microscopic eyepiece graticule (10 mm = 100 scale lines). Each layer was measured perpendicular to the articular surface and at four separate sites. The average was then determined for each region. A second determination of the histologic findings and measurements was performed at 1 month on a randomly selected 10% of the slides.
Results

The control joints showed no radiographic abnormality. The findings in the left joints, which had been subjected to disc perforation but had not been repaired or replaced, have been reported elsewhere. The four joints in which the disc had been replaced with Silastic showed marked radiographic changes. Bony destruction was seen in all joints (Fig 2), with osteophytes in three and flattening in two (Fig 3). The position of the implanted Silastic was well demonstrated on all radiographs (Figs 2, 3).

Histologically, all four joints operated on exhibited a foreign-body giant-cell reaction. In two joints this was a severe destructive response, with obliteration of the normal anatomy of the condyle and superficial part of the temporal bone. In the other two joints, the response was less severe. In the severe response, the position of the Silastic implant between the condyle and temporal surface was easily detected, with a well-demarcated, smooth capsule of dense fibrous tissue surrounding it. This capsule was lined by several layers of mononuclear cells. Within the fibrous tissue, many foreign-body particles could be seen, mostly within multinucleated giant cells or large macrophages, but also lying free in the intracellular matrix.

In the two joints where a severe response was seen, the cortical bone of both the condyle and temporal bone was covered by a fibrous tissue layer of variable thickness, which could not be differenti-
FIGURE 4. High-magnification photomicrograph showing a severe response in the condyle following Silastic implant placement. Irregular bony destruction and loss of the normal articular surface morphology are evident. Foreign-body particles (arrows) can be seen in the marrow spaces (hematoxylin-eosin stain, original magnification ×50).

FIGURE 5. High-magnification photomicrograph showing a mild response in the condyle following Silastic implant placement. The normal histologic appearance of the condyle has been maintained, although darkly staining foreign-body particles (arrows) can be seen in the outer fibrous layer (hematoxylin-eosin stain, original magnification ×50).

of the articular soft tissues was not possible because of the gross destruction of the condyle. The lateral part of the condyle was also destroyed in the other two specimens. In all scorable specimens, the articular tissue covering both the temporal bone and condyle tended to be thicker than normal (Table 1).

Discussion

This study shows that discectomy followed by Silastic replacement in the sheep TMJ resulted in marked bony destruction with formation of a poor quality fibrous capsule. This was in contradistinction to the unrepaired disc perforation in the contralateral joint. In these, there was only slight flattening and small lateral osteophytes. Histologically, there were proliferative changes in both the condylar and temporal surfaces adjacent to the disc perforation. When these disc perforations were repaired with temporal fascia, there was a reversal of these changes back toward normal articular shape and thickness. Discectomy without replacement also results in proliferative rather than destructive changes.

The English literature contains few animal studies documenting the histologic changes that occur in the periarticular and articular tissues of the TMJ in response to a Silastic interpositioned implant following discectomy. Only Tucker and Burkes, using monkeys, showed the effectiveness of temporary Silastic implantation and reported encouraging results. They used Silastic to induce the formation of a tissue capsule, but removed the implant after 3 months.

Silicone has a high coefficient of friction and poor wear characteristics under direct function. Therefore, the silicone implant may be abraded during joint function, with dispersion of the silicone particles into the surrounding joint tissues. Silicone rubbers are widely used in all surgical specialties. Overall the results have been satisfactory, with intact, solid implants being well tolerated by the body, usually eliciting only fibrous encapsulation.
and a mild foreign-body reaction within the capsule. On the other hand, silicone particles have the potential to induce a reactive synovitis,11,13 which may extend into underlying cartilage and subchondral bone, causing extensive destruction. Particles of silicone rubber may migrate for considerable distances from an implant. Gordon and Bullough6,14 reported on four cases of failed silicone rubber wrist prostheses where intramedullary silicone rubber particles and a surrounding foreign-body giant-cell reaction were found in bone at a distance from the prosthesis. Following disectomy with silicone rubber replacement in the TMJs of rabbits, Timmis et al15 noted a giant-cell response that varied in severity after 20 weeks, but "which extended into bone, muscle, and adipose tissue at some distance from the implant."

In two joints in our study Silastic particles and an associated foreign-body giant-cell reaction were noted in the cancellous bone of the mandibular condyle a considerable distance from where the implant had originally been placed. This was accompanied by severe bony destruction. The other two joints in which Silastic implants were placed showed a similar foreign body response with fibrous tissue proliferation, but there was no bony involvement. It is suggested that the TMJs in which less marked changes were seen represent an early stage in the progression of a destruction process initiated by abraded Silastic particles during joint function.

Silastic has been one of the disc replacement materials most widely used in the TMJ. Despite the extensive use of Silastic and its apparent inertness,7 there appear to be an increasing number of reports regarding complications associated with its use. When combined with previous investigations, the findings of this study suggest that nonreinforced Silastic sheeting may not be totally inert as previously thought, and that its physical properties are not appropriate for its long-term use in the TMJ. Certainly, if it is used, it should only be used on a short-term basis to induce the formation of a fibrous capsule, although this may be of poor quality and contain multinucleated giant cells.

### References


### Table 1. Condylar Articular Soft-Tissue Thickness of Normal Sheep TMJ and Following Disectomy With Silastic Replacement

<table>
<thead>
<tr>
<th></th>
<th>Anterior (mm)</th>
<th>Central (mm)</th>
<th>Posterior (mm)</th>
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<tbody>
<tr>
<td><strong>Central</strong></td>
<td></td>
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<tr>
<td>Articular layer</td>
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<tr>
<td>Control condyle</td>
<td>.11 (.07-.20)</td>
<td>.15 (.09-.19)</td>
<td>.24 (.14-.32)</td>
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<tr>
<td>Silastic replacement</td>
<td>.21 (.14-.28)</td>
<td>.20 (.11-.28)</td>
<td>.39 (.27-.50)</td>
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<tr>
<td>Fibrocartilage</td>
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<td></td>
<td></td>
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<tr>
<td>Control</td>
<td>Absent</td>
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<td>.32 (.23-.48)</td>
</tr>
<tr>
<td>Silastic replacement</td>
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<td>.06 (.04-.08)</td>
<td>.17 (.13-.21)</td>
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<tr>
<td>Calcified cartilage</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>Absent</td>
<td>.05 (.0-.16)</td>
<td>.07 (.0-.17)</td>
</tr>
<tr>
<td>Silastic replacement</td>
<td>.09 (.0-.17)</td>
<td>.28 (.23-.34)</td>
<td>.25 (.20-.30)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>.11 (.07-.20)</td>
<td>.42 (.26-.47)</td>
<td>.64 (.62-.68)</td>
</tr>
<tr>
<td>Control</td>
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<td>.81 (.68-.93)</td>
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<td>Silastic replacement</td>
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1 Two specimens could not be measured because of marked surface irregularities, hence n = 2 Silastic, n = 4 control.