Seprafilm superior to Gore-Tex in the prevention of peridural fibrosis

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Object. This is an investigation into the effects of two barrier membranes in the prevention of peridural fibrosis in an animal model.

Methods. Seprafilm or Gore-Tex was applied to a laminectomy defect overlying the dura mater in rats separated into treatment groups. A third group of rats underwent laminectomy only and served as controls. Two months postoperatively a histological study was performed to compare the amount of scar tissue in each group.

The gross dissection demonstrated that both membranes created a controlled dissection plane, facilitated access to the epidural space, and provided a reduction in the amount of tissue adhering to the dura mater. Statistically, Seprafilm was superior to Gore-Tex in preventing peridural fibrosis (p < 0.05).

Conclusions. Seprafilm can prevent peridural fibrosis better than Gore-Tex and can be used in humans in spinal surgery.

KEY WORDS • adhesion • peridural fibrosis • scar • Gore-Tex • Seprafilm

Peridural fibrosis is the leading cause of failed-back syndrome following spinal surgeries. The characteristic tissue of failed-back surgery is the laminectomy membrane, which is a dense fibrous cicatrization tissue that replaces bone removed at the laminectomy site and binds dura mater to overlying muscles. The term “laminectomy membrane” was first used by LaRocca and MacNab. This membrane is a normal physiological tissue response to laminectomy and will always occur, even with the most gentle and precise surgical technique. It may be exaggerated in cases of fibrous organization of hematoma, technical failures, and surgical trauma; in the presence of microscopic fragments of surgical swabs and patters; and allowing for individual variability and the amount of bone removed. Histological studies of experimental adhesion formation have demonstrated the sequence of tissue inflammation, fibrin deposition within inflammatory exudates, and organization of fibrin with fibroblast invasion and collagen formation followed by maturation of collagen to produce mature fibrous tissue. Fibrosis may not be a problem unless it causes adhesions to neural tissue. This pathological process, however, is not inevitable; it may be prevented or reduced both physiologically and therapeutically.

The prevention or limitation of fibroblast migration into the wound site, thus promoting fibrinolysis, reducing the inflammatory response, inhibiting coagulation, or separating injured surfaces, seems to be a key factor affecting scar formation. For the purpose of preventing scarring, pharmacological and other therapeutic methods (steroid medications, octreotide, meclofenamate, antiinflammatory drugs, Ringer lactate, dextran 70, CO2 laser, low-dose radiation treatment, resorbable gels [such as ACON-L], PLAs, carbohydrates, polymer, fibrinolytic agents such as heparin with rtPA, streptokinase, urokinase, and HA as well as the barrier membranes have been investigated. Among the bioreosorbable barrier materials, epidural fat graft, PLA, PLAs plus elastase, poloxamer 407, hemostatic agents such as fibrin glue, collagen gel and film, Avitene, Gel foam, polyglactin 910, CMC (Surgicel), poloxamer 407, PLAs plus elastase, poloxamer 407, and oxycel have all been studied. Interceed (TC7 oxidized regenerated cellulose) has been used in the prevention of tendon adhesion and for carpal tunnel syndrome, but not in spinal surgery. Among the nonbioreosorbable barrier membranes, bone wax, autologous bone, dura mater, silastic sheeting, silicon barrier, polymethylmethacrylate, Teflon–Proplast, Polyactive, polypropylene mesh, and Dacron have been used in intraabdominal surgeries. Of all these membranes, the expanded polytetrafluoroethylene (expanded Teflon polymers in a porous form), Preciclude (also known as Gore-Tex; W. L. Gore & Associates, Inc., Flagstaff, AZ), was the most successful nonresorbable material found to provide an antiadhesive barrier in abdominal and cardiac surgery. It has also been used in the repair of the flexor tendon. This material attracted the attention of neurosurgeons and has been used in spinal surgery.
surgery either as a dural substitute \(^{25,27,47,59,60}\) or an interposition membrane to prevent peridural fibrosis \(^{1,10,19,24,45}\), and has proved to be very effective. We decided to investigate its effects in comparison with Seprafilm (Genzyme Corp., Cambridge, MA).

Seprafilm is a biodegradable translucent membrane composed of USP glycerol and two chemically modified anionic polysaccharides, sodium hyaluronate (HA) and CMC. The USP glycerol was added for the improved flexibility of the material. Seprafilm is currently used in abdominal and gynecological surgery \(^{23,27,31,32,28,47,59}\) and has been found to equal Gore-Tex in the prevention of adhesion. \(^{29}\) Although there have been isolated studies regarding the usefulness of HA acid or CMC in spinal experimental models and follow-up studies, \(^{15}\) there has been no study on the issue of Seprafilm in spinal models or surgery. In the present study, our aim was to compare the effects of these two barrier membranes in the prevention of peridural fibrosis in an adhesion model of rats.

**Materials and Methods**

**Animal Preparation**

Forty-five male Wistar rats, each weighing between 280 and 350 g, were used in this study. All animals received humane care as outlined in the Guide for the Care and Use of Laboratory Animals. \(^{45}\) The animals, which had been fed rat chow, were deprived of food for 24 hours before surgery, but were allowed free intake of water. Each animal received one intramuscular injection of cefazime (100 mg/kg) before the operation. After 400 mg/kg of chloral hydrate had been administered to induce anesthesia, a 4-cm midline incision was made in the lumbar region. With the aid of the operating microscope, the paravertebral muscles were separated and a T8–L3 total laminectomy was performed in all animals. The laminectomy window was created using a 1-mm Kerrison rongeur. Gelfoam soaked in thrombin was used for hemostasis at all sites, but removed before closure. Statistical Analysis

Identification of the type of tissue response, qualitative evaluation of the postoperative scar adhesion, and histological and cytological investigations of the responses of host tissue to the implant materials were performed. Anterior or internal scarring (scar tissue located anterior to the membrane) was evaluated and graded microscopically. To evaluate the extent of tissue adhesion, we investigated six parameters (medulla spinalis retraction, peridural fibrosis, inflammation, foreign-body reaction, dural adhesion, and granulation tissue) and established an ordinal scale in all groups, which was expressed in milligrams per gram of fat-free dry tissue. The number of rats in each group was less than 30; therefore, we performed the Kruskal–Wallis variance analysis. The probability value was less than 0.05 and hence the Mann–Whitney U-test was applied for inter-group comparisons. Total scores of the parameters and hydroxyproline contents in inflammation, a probability value less than 0.03 was considered significant.

**Table 1**

<table>
<thead>
<tr>
<th>Group &amp; Level of Fibrosis</th>
<th>Medulla Spinalis Retraction</th>
<th>Peridural Fibrosis</th>
<th>Inflammation</th>
<th>Foreign-body Reaction</th>
<th>Dural Adhesion</th>
<th>Granulation Tissue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1 (control)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>minimal</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
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<td>0</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>severe</td>
<td>11</td>
<td>10</td>
<td>0</td>
<td>14</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Group 2 (Gore-Tex)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>minimal</td>
<td>0</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>8</td>
<td>4</td>
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<tr>
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<td>4</td>
<td>7</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>severe</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Group 3 (Seprafilm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
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<tr>
<td>severe</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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</tr>
</tbody>
</table>

**Histological Preparation**

Samples were fixed in 10% neutral buffered formalin for 24 hours so that they could be used in the histological studies. Later, they were immersed in decalcification solution containing formic acid, where they remained for 48 hours. Slices were cut horizontally through the spinal cord, providing decalcified tissue samples. After a 13-hour standard follow-up process, the tissue samples were embedded in paraffin blocks and cut into 5-μm-thick sections. In the present study, our aim was to compare the effects of these two barrier membranes in the prevention of peridural fibrosis in an adhesion model of rats.

For the gross anatomical examination of posterior scar tissue, the intermuscular adhesion, the interspinous adhesion, and the intercostal adhesion were assessed with a modified version of the system described by Lunsford et al. \(^{14}\) For statistical analysis, we simplified from the Stuedemann method, which is based on the spectrophotometric determination of hydroxyproline. \(^{15}\) Samples were analyzed by extracting the fat and obtaining the dry weight. Tissues underwent hydrolysis by using hydrochloric acid to determine the level of hydroxyproline, reflecting the total amount of collagen, which was expressed in milligrams per gram of fat-free dry tissue.

**Outcome Measures**

Identification of the type of tissue response, qualitative evaluation of the postoperative scar adhesion, and histological and cytological investigations of the responses of host tissue to the implant materials were performed. Anterior or internal scarring (scar tissue located anterior to the membrane) was evaluated and graded microscopically. To evaluate the extent of tissue adhesion, we investigated six parameters (medulla spinalis retraction, peridural fibrosis, inflammation, foreign-body reaction, dural adhesion, and granulation tissue) and established an ordinal scale in all groups, with the following grades: 0, absent; 1, minimal; 2, moderate; and 3, extensive.

**Statistical Analysis**

In our study, three independent groups were compared. We used a computer software program (SPSS version 9.0; SPSS, Inc., Chi-cago, IL) for statistical analysis. The probability value less than 0.05 and hence the Mann–Whitney U-test was applied for inter-group comparisons. Total scores of the parameters and hydroxyproline contents in inflammation, a probability value less than 0.03 was considered significant.
Effects of Seprafilm and Gore-Tex on peridural fibrosis

Tissue reactions were evaluated microscopically. A thin, organized membranous tissue was observed in the edges of bone that had been nipped using the rongeur. The types of cells present at the laminectomy site included lymphocytes, endothelial cells, and fibroblasts. Interestingly, no foreign-body reaction, which would have consisted of macrophages and foreign-body giant cells, was noted in any group. A minimal chronic inflammatory response, consistent with the presence of lymphocytes and a few neutrophils, was observed adjacent to the barrier film in one rat in which Seprafilm had been used; the inflammation was minimal in four animals in which Gore-Tex had been used and moderate in three animals in the control group. All groups were statistically similar in this regard (p > 0.03). Granulation tissue was composed of young connective tissue, which may or may not progress into complete fibrosis. It was minimal in all four animals and moderate in three animals in the Gore-Tex group, and minimal in four animals and moderate in one animal in the Seprafilm group. Granulation tissue was minimal in four animals and moderate in 11 animals in the control group. Minimal dural adhesion was seen in six animals in the Seprafilm group, in eight animals in the Gore-Tex group, and in no animals in the control group. Fibrosis (moderate or severe) was associated with moderate dural adhesion in two animals with Seprafilm, three animals with Gore-Tex, and one control animal; it was associated with severe dural adhesion in four animals with Gore-Tex and 14 control animals, but no animals in the Seprafilm group. Medulla spinalis retraction was observed only in cases in which dural adhesion and fibrosis were also present in significant amounts. Severe retraction was noted in 11 control animals, but in no other groups. A moderate retraction was only observed in four animals treated with Gore-Tex and a minimal retraction was seen in three control animals and one animal treated with Seprafilm (Table 1 and Figs. 1–3).

The mean scores (± SEM) of medulla spinalis retraction, peridural fibrosis, inflammation, foreign body reaction, dural adhesion, granulation tissue, the mean total scores (± SEM) of these parameters, and the probability values of the

FIG. 1. Photomicrograph showing a specimen from the control laminectomy group. Severe fibrosis (f and ft), dural adhesion, and spinal cord (sc) retraction (arrows) are delineated. Masson trichrome, original magnification × 40.

Results

For the gross anatomical examination of posterior scarring, the intermuscular scar was observed as binding the paraspinal muscles together in the plane of dissection. The ease with which the paraspinal muscle could be separated in the same plane as the initial surgery varied with some animals having no scar or only a few adhesions and others having thick and tenacious scar tissue. The next layer of posterior scarring was the middle scar, which lay just beneath the layer of muscle and above the laminectomy site. This layer of scarring was encountered at the margins of the laminectomy site; it was attached to the dorsal aspect of the remaining laminar bone, but did not extend into the bone defect. Beneath was the deep scar, which lay within the laminectomy defect and extended into the space previously occupied by the ligamentum flavum and epidural fat. Anterior scarring with or without dural adhesion was the only scarring found anterior to the membrane; the dural adhesions consisted of connective tissue attachments between the anterior or deep scar and the dura mater within the spinal canal.15

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The mean scores (± SEM) of medulla spinalis retraction, peridural fibrosis, inflammation, foreign body reaction, dural adhesion, granulation tissue, the mean total scores (± SEM) of these parameters, and the probability values of the
intergroup comparisons are represented in Table 2 and the results are represented in box-plot graphs (Fig. 4). There were statistically significant differences between Groups 1 and 2, between Groups 1 and 3, and between Groups 2 and 3 in all parameters ($p < 0.03$), except for inflammation and foreign body reaction in all Group 1–Group 2, Group 1–Group 3, and Group 2–Group 3 intergroup comparisons ($p > 0.03$), and for Group 2–Group 3 comparisons of medulla spinalis retraction ($p = 0.1$) and granulation tissue ($p = 0.3$). There were also significant differences in the Group 1–Group 2, Group 1–Group 3, and Group 2–Group 3 intergroup comparisons of total scores ($p = 0.000$, $p = 0.000$, and $p = 0.002$, respectively). The mean hydroxyproline levels were $3.3 \pm 0$ mg/g tissue in Group 1, $2.3 \pm 0$ mg/g tissue in Group 2, and $1.3 \pm 0$ mg/g tissue in Group 3. There were significant differences between groups ($p = 0.000$ for each) (Fig. 4). The correlation analysis proved that the hydroxyproline contents correlated with total scores of tissue reaction ($r = 0.9$, $p = 0.00$).

**Discussion**

Early attempts in the prevention of peridural fibrosis were made using solid and bioresorbable materials, including the epidural fat graft, with discrepant results. LaRocca and MacNab used Gelfoam in dogs and provided a histological evaluation of the result. Barbera and colleagues used oxicel, silastic, Dacron, methylmethacrylate, and Kiel bone graft in dogs and performed myelography, a radiographic calculation of the tissue densities, and a histological evaluation; they concluded that a solid barrier is necessary to prevent formation of laminectomy membrane. Mikawa and associates used elastase alone and elastase plus PLA in rabbits and performed a histological evaluation. Songer and coworkers investigated the effects of sodium hyaluronate (1.9% solution) in dogs. These authors examined areas of fibrosis and their tenacity and applied histological grades (none, easily broken, disrupted, and cut); they claimed that Gelfoam and a fat graft had little effect and only on posterior scarring. Nussbaum and colleagues investigated the use of Vycril (poliglactin 910) mesh in dogs and applied a numerical grading system, whereas Kitano, et al. studied the use of viscous CMC in rabbits, and Lawson, et al. studied CMC in solid form. In a study involving rats Hadani and associates claimed that a silicon envelope prevented epidural root adhesions after they performed neurological and histological evaluations. Using carbohydrate polymer (GT1587) in rabbits, Robertson, et al. identified new bone growth, dural adhesion, a deep scar, a middle scar, and an intermuscular scar after gross microdissection and a histological analysis of the density and area of the scar. Cook and coworkers studied the use of a polyactive membrane sheet in dogs, using numerical grading, computerized tomography and magnetic resonance imaging, and gross dissection. Zide, et al. tried Medpor in humans, whereas Colak and associates used a CO$_2$ laser in guinea pigs, evaluating clinical status, performing light microscopy studies, and determining hydroxyproline content. Einhaus, et al. investigated ADCON-L in dogs, and based their evaluation on their application of a numerical grading system as well as their determination of the amount and tenacity of fibrosis. In cats Maynard and colleagues used a thick sheet of Teflon film positioned between an implanted microelectrode array and the dura mater. Massie and associates tried antifibrotic gel-thick film in rats, and Welch and coworkers studied PLA in dogs; these authors relied on histological grading, scar volume, and tenacity, and hydroxyproline levels.

**Fig. 2.** Photomicrograph showing a specimen from the Gore-Tex group. Fibrotic tissue (F), moderate granulation tissue, minimal dural adhesion, and minimal spinal cord retraction (arrow) are observed. Masson trichrome, original magnification $\times 40$.

**Fig. 3.** Effects of Seprafilm and Gore-Tex. A greater fibrosis (f), no dural or spinal cord (sc) adhesion and no spinal cord retraction served. Masson trichrome, original magnification $\times 40$. On the other hand, Gordon repair in rabbits by Hanft, repair in humans by Ohata, and their colleagues; and in rats by Park and Teval evaluated the material's performance and performing a histological evaluation (inflammation and foreign body response). Gore-Tex used as a barrier membrane in humans by Llado,
On the other hand, Gore-Tex was used for flexor tendon repair in rabbits by Hanff and Hagberg; for duraplasty in humans by Ohata, Vinas, Tekkok, and Yamagata; and in rats by Park and Tator, who evaluated the material’s usefulness by studying neurological performance and performing a histological evaluation (inflammation and foreign body response). Gore-Tex was used as a barrier membrane in humans by Llado, Aliredjo, Inoue, and DiFazio and their associates in tethered cord or other spinal surgeries.

Many studies have been performed using Seprafilm; however, no study has focused solely on the use of Seprafilm in neurosurgery, although in some studies it has been examined as a component of therapy. We compared the effects of Seprafilm with those of Gore-Tex. There is no doubt that Seprafilm continued to be present for at least 2
months, which was proved by an examination of histological slices. The biocompatibility of Seprafilm and Gore-Tex has been reported in several previous studies. In our study we found that no foreign body reaction was observed with either barrier. Only a slight inflammation was observed, which was more exaggerated in the control group, and the difference was not significant in intergroup comparisons. Both barrier films appeared to be effective in reducing the amount of scarring on the anterior side adjacent to the epidural space through a mechanism of organized tissue encapsulation and a controlled dissection plane. A numerical rating system was developed by Einhaus, et al.,20 to assess the relative amount and tenacity of the anterior scar tissue in Group 3. The difference between groups was significant in all animals in the control and Gore-Tex groups, but in only nine rats in the Seprafilm group. As to the extent of fibrosis, there were significant differences among the control, Gore-Tex, and Seprafilm groups. We concluded that fibrosis existed substantially in the Gore-Tex group, but not as much as in the control group. In addition, this fibrosis was associated with dural adhesion in all animals in the control and Gore-Tex groups, but in only eight animals in the Seprafilm group. Although dural adhesion was present in all animals in the Gore-Tex group, the difference between this group and the control group was significant as was the difference between it and the Seprafilm group. The most striking finding was found in the medulla spinalis retraction, which developed in the presence of extensive fibrosis plus dural adhesion. It was severe in 11 of 15 animals in the control group and, naturally, was very different in the other groups. In four animals in the Gore-Tex group and one in the Seprafilm group, the difference was not significant. We summed the scores of all parameters for each group and performed the statistical analysis. The result was consistent with previous findings. Seprafilm was superior to Gore-Tex and to the absence of barrier material (control group) and Gore-Tex was superior to the absence of barrier material. In this study, more sophisticated surface area calculations16,21,40 could have been made to make the data more objective, but the authors did not believe this was necessary. A qualitative assessment of the scar scoring system (tenacity),20,59 was not performed in this study.

Lee and Alexander26 advocated that the amount of collagen is related to the amount of scar tissue.26 Because the best biochemical method for determining fibroid degeneration in tissue (that is, the amount of collagen) is the hydroxyproline index, we investigated these levels as well. The mean hydroxyproline level in the control group was almost three times that in the Seprafilm group (3.3 ± 0 mg/g tissue in Group 1, 2.3 ± 0 mg/g tissue in Group 2, and 1.3 ± 0 mg/g tissue in Group 3). The differences between groups were significant. The hydroxyproline levels were consistent with the amount of fibrotic tissue, according to the correlation analysis, and these correspond to the pathological observations.

Different authors have used different time intervals to evaluate the scar formation after laminectomy and have expressed their observations as mean ± standard error of the mean. Differences in technique and patient selection may account for wide variation in results. The authors have no financial interest in the materials under discussion.

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C. Topsalak, et al.

| TABLE 2 |
| Parameter scores and intergroup comparisons of scores |
| Parameter | Mean ± SEM | p Value |
| medulla spinalis retraction | Group 1: 24 ± 0.3, Group 2: 0.5 ± 0.2, Group 3: 0.0 ± 0.0 | Group 1–Group 2: 0.000, Group 1–Group 3: 0.000, Group 2–Group 3: 0.100 |
| epidural fibrosis | Group 1: 2.7 ± 0.1, Group 2: 2.0 ± 0.2, Group 3: 0.6 ± 0.1 | Group 1–Group 2: 0.012, Group 1–Group 3: 0.000, Group 2–Group 3: 0.000 |
| inflammation | Group 1: 0.4 ± 0.2, Group 2: 0.3 ± 0.1, Group 3: 0.6 ± 0.0 | Group 1–Group 2: 0.9, Group 1–Group 3: 0.3, Group 2–Group 3: 0.1 |
| foreign body reaction | Group 1: 0.0 ± 0.0, Group 2: 0.0 ± 0.0, Group 3: 0.0 ± 0.0 | Group 1–Group 2: 1.0, Group 1–Group 3: 1.0, Group 2–Group 3: 0.0 |
| dural adhesion | Group 1: 2.9 ± 0.0, Group 2: 1.7 ± 0.2, Group 3: 0.7 ± 0.2 | Group 1–Group 2: 0.000, Group 1–Group 3: 0.000, Group 2–Group 3: 0.002 |
| granulation tissue | Group 1: 1.7 ± 0.1, Group 2: 0.7 ± 0.2, Group 3: 0.4 ± 0.2 | Group 1–Group 2: 0.001, Group 1–Group 3: 0.000, Group 2–Group 3: 0.000 |
| total score | Group 1: 10.9 ± 0.5, Group 2: 5.1 ± 0.8, Group 3: 1.9 ± 0.5 | Group 1–Group 2: 0.000, Group 1–Group 3: 0.000, Group 2–Group 3: 0.002 |
| hydroxyproline (mg/g tissue) | Group 1: 3.3 ± 0.0, Group 2: 2.3 ± 0.0, Group 3: 1.3 ± 0.0 | Group 1–Group 2: 0.000, Group 1–Group 3: 0.000, Group 2–Group 3: 0.000 |

Fig. 4. Box-plot graph depicting the mean amount of hydroxyproline (mg/g dry tissue) and the total scores of each group (G).
Effects of Seprafilm and Gore-Tex on peridural fibrosis

analysis, and these quantitative values correlated with general observations made during careful dissections.

Different authors have used different time periods in their evaluations of peridural fibrosis or scar tissue. These intervals include 2, 6, 11, 25, 34, 41, 46, 51, 54, 59, 62, 16, 24, 26, 36, 41, 54, 59, 62, 16, 24, 26, and 36 weeks. In our study we evaluated scar tissue at the end of 8 weeks because we believed that control (nonimplanted) defect sites would demonstrate moderate-to-severe scar formation in the dura as early as 2 weeks postimplantation. Nevertheless, whether the scar formation might be enhanced once the material had been implanted longer intervals. Özveren, et al., who evaluated scar tissue at 12, 24, and 36 weeks, claimed that as time elapsed, the amount of scar tissue increased, whereas the ability of the barrier membrane to prevent scar formation was decreased and, thus there would be no difference between scar amounts at the end of 9 months. Surprisingly, despite the fact that Seprafilm is a biodegradable implant, it did not disappear as quickly as expected; Seprafilm was found intact without any sign of fragmentation at the end of 2 months and will probably remain that way for a longer period. This may not be the case for other so-called biodegradable materials, however, and each needs to be evaluated despite the technical problems involved in keeping rats alive for long-term periods. Whether the documented statistical differences between the control and the barrier-implanted groups decrease over longer time periods requires further investigation.

Conclusions

Both Gore-Tex and Seprafilm were successful in creating a controlled dissection plane and providing access to the epidural space and a reduction in tissue adherence to the dura mater with a minimal host response. Both the histological scores and hydroxyproline contents correlated with each other in all groups. Considering the results of the histopathological evaluation and collagen quantitative analysis, however, Seprafilm was superior to Gore-Tex and may therefore be used as safely as Gore-Tex in spinal procedures.

Disclosure

The authors have no financial interest in the materials under discussion.

References


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C. Topsakal, et al.

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