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The Veterinary Journal 171 (2006) 491–499
The Veterinary Journal
www.elsevier.com/locate/tvjl

The effects of free fat graft or cellulose membrane implants on laminectomy membrane formation in dogs

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Accepted 3 December 2004

Abstract

The purpose of this study was to determine the effect of cellulose membrane or free fat grafts (FFG) on laminectomy membrane (LM) formation. Eighteen dogs were randomly divided into three groups of six dogs. All dogs underwent a modified dorsal laminectomy on T_{13}–L_1. The laminectomy defect was left uncovered in the control group but either a FFG or a cellulose membrane implant was provided in the other two groups. The dogs were evaluated through neurological examination, myelography, macroscopic roundness index of spinal cord and histological evaluations of epidural fibrosis and spinal cord.

The results showed a significant difference between the control and the FFG group, with the FFG causing neurological deficits and spinal cord compression as assessed by the roundness index of the spinal cord. Both FFG and cellulose membrane were partially effective in preventing LM formation. The use of FFG was associated with a high rate of significant neurological complications and spinal cord lesions.

Keywords: Laminectomy membrane; Postlaminectomy fibrosis; Epidural scar; Free fat graft; Cellulose membrane

1. Introduction

Laminectomy membrane (LM), epidural fibrosis or postlaminectomy scar are terms used to describe an expected healing consequence after laminectomy in animals and humans. In humans, this extradural fibrotic tissue may extend into the vertebral canal and adhere to the dura mater and nerve roots causing recurrent symptoms including pain (Gill et al., 1985; Robertson, 1996). Laminectomy membrane is assumed to be responsible for 8% of failures of spinal surgery in humans (Burton, 1991). In dogs, the major factor limiting the width and length of laminectomy exposure is the risk of postoperative spinal cord compression caused by fibrous tissue in the thoracolumbar spine.

Few studies have specifically looked at the role of LM on recurrence of back pain or neurological deficits in dogs. In a retrospective study of thoracolumbar disc disease, it was found that LM was responsible for 10.2% of recurrences (Brown et al., 1977). Unfortunately, most dogs with recurrent signs of pain or ataxia postsurgery do not have any diagnostic work up performed, limiting our knowledge in this field (Brown et al., 1977; Brisson et al., 2004).

The control of scar formation has been one of the main concerns in disc surgery and the subject of research for many years. A large number of materials and

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doi:10.1016/j.tvjl.2004.12.011

methods for preventing epidural fibrosis have been studied including free or pedicle fat grafts (Kiviluoto, 1976; Langenskiöld and Kivilvoto, 1976; Keller et al., 1978; Gill et al., 1979, 1985; Van Akkerveeken et al., 1986; Jensen et al., 1996), absorbable gelatin films and sponges (LaRocca and MacNab, 1974; Gill et al., 1979; Jacobs et al., 1980; Pospiech et al., 1995), cellulose mesh (Pospiech et al., 1995), methyl methacrylate (Barbera et al., 1978; Lawson et al., 1991), and local or systemic pharmaceuticals such as methylprednisolone (Jacobs et al., 1980) and dexamethasone (Hinton et al., 1995).

Despite more than 35 different techniques being used, there is currently no single agent widely accepted as consistently reducing epidural fibrosis without side effects in dogs and humans. Free fat grafts (FFG) seem to work better than most materials studied and to date are the most popular material used in spinal surgery of dogs and humans (Trevor et al., 1991; Kanamori et al., 2001). However, there are several reports of fat grafts causing significant complications such as cauda equina syndrome in humans and compressive myelopathy in dogs (Cabezudo et al., 1985; Prusick et al., 1988; Martin-Ferrer, 1989; Mayer and Jacobsen, 1989; Trotter, 1990; Wheeler and Sharp, 1994; Çobanoglu et al., 1995). The efficacy of FFG in preventing epidural fibrosis has also been questioned (Jensen et al., 1996; Görgülü et al., 2004).

The purpose of this investigation was to evaluate the development of LM after a modified dorsal laminectomy and the effectiveness of a cellulose membrane implant and FFG on the prevention of LM formation. To achieve this goal, clinical, myelographic, macroscopic and histological evaluations of the fibrosis and the spinal cord were conducted.

2. Materials and methods

The experiments were conducted with the approval of the Animal Experimentation Ethical Committee of the Federal University of Santa Maria.

Eighteen mixed breed dogs, obtained from the Central Animal Facility, with average body weight of 9 kg (range 6–13 kg) were used. They underwent a complete physical and neurological examination, with complete blood count, biochemistry profile and faecal analysis prior to entry into the study. Dogs were admitted only if the results were normal.

The animals were randomly divided into three groups of six dogs: control, cellulose membrane and FFG. The dogs were pre-medicated with acepromazine (0.1 mg/kg) and anaesthesia was induced with thiopental sodium (10 mg/kg), both given intravenously (IV). Fluid therapy was constant at rate of 10–15 mL/kg/h throughout the surgical procedure. After anaesthetic induction, sodium oxacillin (20 mg/kg) was given IV. The dogs were intubated and anaesthesia was maintained with halothane. Monitoring was performed with continuous pulse oximeter and electrocardiogram. Body temperature was also monitored.

A modified thoracolumbar laminectomy (Trotter, 1990), involving the complete excision of the dorsal lamina and caudal articular processes with preservation of the cranial articular processes and excavation of the medial aspect of the pedicles, was performed at T_{13}–L_1 with a high-speed drill with constant flushing of the surgical field. The dura mater was not invaded. The surgeries were performed by the same investigator (RCD). In the control group, the laminectomy defect was left uncovered. In another group, a biosynthetic cellulose membrane, 50-μm thick, resembling paper film with a smooth surface (Fibrocell Produtos Biotecnologicos), was placed over the surgical defect resting on bone that demarcated the edge of the laminectomy. In the FFG group, fat was harvested from the subcutaneous tissue adjacent the incision. All efforts were made to trim the fat to a thickness of approximately 5 mm and of a sufficient width and length to cover the laminectomy defect. A three-layer closure was performed in all dogs.

Care was taken when closing the incision to ensure that neither the fat graft, nor the cellulose membrane compressed the spinal cord. The epaxial fascia was closed using monofilament nylon suture in a simple interrupted pattern. The subcutaneous tissue was closed using Poliglactin 910 sutures in a continuous pattern, and the skin was stitched using monofilament nylon suture in a simple interrupted pattern.

Postoperative analgesia was maintained with epidural preservative-free morphine given at the lumbosacral junction on induction at a dose of 0.1 mg/kg. Physical and neurological examinations were performed daily. All dogs had their gait monitored hourly from about 4 to 12 h postsurgery and then once daily. A blinded evaluation of motor function was undertaken based on a scale of paresis and ataxia (Trotter et al., 1975), as follows: grade 5: normal; grade 4: animal walked with minimal paresis–ataxia; grade 3: animal walked but frequently stumbled, moderate paresis–ataxia; grade 2: animal walked with assistance, stumbled and fell; grade 1: animal could not walk, slight movement when supported by tail; grade 0: absence of purposeful movements.

Two dogs from each group were euthanased at two, four and eight weeks, respectively. A lumbar myelogram at L_5–L_6 or L_4–L_5 was performed immediately prior to euthanasia using a 22 gauge (0.73 mm), 6.35 cm spinal needle and 0.3 mL/kg of iopamidol (Iopamiron, Schering). Radiographs were taken immediately after contrast injection. Myelographic abnormalities were graded as follows: grade 4: marked attenuation: spinal cord compression evident; grade 3: moderate attenuation; loss of the dorsal contrast column without spinal cord com-

pression; grade 2: slight attenuation; thin narrowing of the contrast in the dorsal subarachnoid space, and grade 1: normal – neither narrowing nor spinal cord compression evident.

At necropsy, the vertebral column was removed from T_{10} through L_4 and fixed in 10% formalin solution. The spinal cord was left in situ in the vertebral canal. Transverse sections of the spinal column were made using a slab saw through the centres of the T_{12}, T_{13}, L_1, and L_2 vertebrae and through T_{12}–T_{13}, T_{13}–L_1, L_1–L_2 and L_2–L_3 intervertebral discs. This resulted in seven sections, which were photographed from their cranial aspect. The vertical and horizontal diameters of the spinal cord within the vertebral canal were measured from the photographs. A roundness index (RI) was calculated for each section as the ratio of vertical (V) and horizontal (H) diameters. The non-operated sections (T_{12}, T_{12}–T_{13}, L_1–L_2 and L_2) served as RI controls for the operated area (T_{13}, T_{13}–L_1 and L_1). The average of the operated and non-operated regions of each dog was used for analysis (Trotter et al., 1988).

The vertebral sections were decalcified in 5% nitric acid. Thin sections were prepared for histological examination. The sections were stained with haematoxylin–eosin and Masson's trichrome. The histological classification of fibrosis was based on the quantity of fibrous tissue and dural adhesions observed. A scale from 0 to 3 was used. A blind evaluation was performed by one of the authors (D.L.G). Grade 3 was used when dural adhesions and increased thickness associated with extensive fibrosis were observed; grade 2 when moderate fibrosis and extensive adhesions were apparent; grade 1 was applied when few areas of fibrosis and some adhesions were evident and grade 0 when mild or no fibrosis was present and there were no dural adhesions (Nussbaum et al., 1990; Lawson et al., 1991; Hinton et al., 1995; Mohsenipour et al., 1998).

The microscopic spinal cord abnormalities were blindly evaluated and classified into six groups based on the number of lesions: grade 6: severe diffuse demyelination, moderate diffuse digestion chamber and moderate diffuse axonal swelling; grade 5: severe diffuse demyelination in white and/or grey matter, mild diffuse or localised axonal swelling and few localised digestion chambers; grade 4: moderate to severe diffuse demyelination in white and/or grey matter and slight diffuse or localised axonal swelling with or without some localised digestion chambers; grade 3: moderate diffuse or localised demyelination in white and/or grey matter and mild to moderate localised axonal swelling, with or without few disseminated digestion chambers; grade 2: mild diffuse or localised demyelination in white and/or grey matter, with or without mild localised axonal swelling and grade 1: normal to mild localised or diffuse axonal swelling.

For the statistical analyses, a two-factor design was used, with the first factor, treatment, having three levels: control, FFG and cellulose membrane, and the second factor, time, having three levels: two, four, and eight weeks. Analyses were performed using the SAS Statistical Software (SAS Institute, 1999). Roundness index of the spinal cord was analysed by analysis of variance using PROC GLM. The myelogram, fibrosis, and microscopy of the spinal cord were analysed using PROC CATMOD with the response function being the marginal probabilities of treatment and time levels, which recognizes the categorical nature of these observations.

Motor function was analysed by analysis of variance of mean of the daily scores during the observation period (two, four or eight weeks) and also as a categorical trait, assuming four categories (2, 3, 4 and 5) given by the mean daily scores rounded to the nearest integer value. Using the mean values of motor scores, it was assumed that motor function scores could be considered as an interval variable, that is, the distance between the scores represents well the actual differences in motor function. Due to the low number of observations, the six original scores for histology of the spinal cord were transformed into three scores as follows: grades 1 and 2 = 1; grades 3 and 4 = 2, and grades 5 and 6 = 3, and the new scores were analysed. For categorical analyses (motor function, myelogram, fibrosis and histology of the spinal cord), comparisons were always made between the treatments (cellulose and FFG) and the control group. For the traits analysed as continuous variables (motor function), comparisons among all groups were made using Scheffe's test for multiple comparisons. For all analyses the minimum significance level was established at 5% probability.

3. Results

The mean of daily motor function scores during the observation periods showed that the control group was normal (5.00), the cellulose group scored 4.45, and the FFG 3.15 (Table 1). The period showing the worst results was at two weeks, although no significant difference was seen amongst the three observation periods. A significant difference ($P = 0.0003$) was observed between the control and the FFG group for all periods (two, four, and eight weeks), the latter showing the poorer results. The neurological abnormalities of the FFG group started 6–12 h after surgery in dogs that had appropriate motor function up to six hours following recovery from anaesthesia. The neurological deficits progressively decreased in severity over 3–10 days in all but one dog, in which moderate deficits persisted during the eight-week period of evaluation. However, mild deficits persisted in four out of five dogs in which the

Table 1
Effects of the treatments on motor function and spinal cord roundness index

Treatment	*n*	Motor function (SAP)[c]		Macroscopy of spinal cord (RI)[d]	
		Mean[e]	SE	Mean[e]	SE
Control	6	5.00[a]	0.25	0.79[a]	0.05
Cellulose	6	4.45[a]	0.25	0.74[ab]	0.07
Free fat graft	6	3.15[b]	0.25	0.71[b]	0.06

[c] Scale of ataxia and paresis (SAP), graded from 5 to 0: 5, meaning normal locomotion and 0, paraplegia.

[d] Roundness index (RI) of the spinal cord calculated from the vertical and horizontal diameters of the spinal cord.

[e] Means followed by different letters indicate significant difference by Scheffe's test ($P < 0.05$).

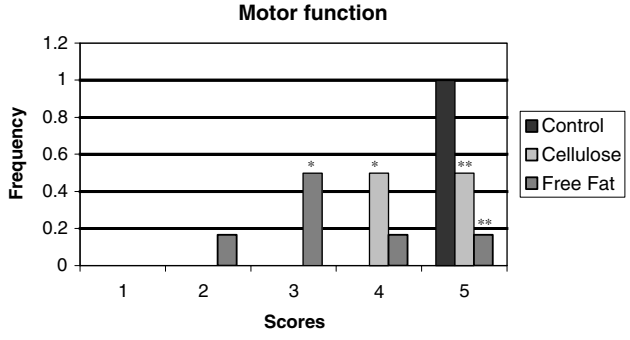


Fig. 1. Distribution of all dogs in the five motor scores: 5, means normal gait and 1, non-ambulatory paraparesis (*, P <0.05; **, $P < 0.01$).

neurological status improved. The distribution of dogs according to the motor status classification is shown in Fig. 1.

The lumbar myelograms showed great variation between dogs of the same group. The control group had one dog with a normal myelogram (grade 1), four dogs with a grade 2 myelogram (slight attenuation) and one dog with a grade 3 (moderate attenuation). Two dogs

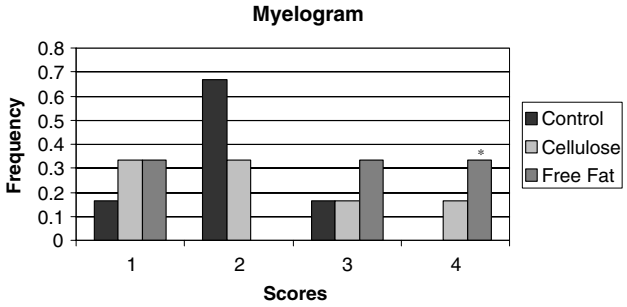


Fig. 3. Distribution of all dogs in the four myelographic categories: 1 represents a normal myelogram and 4 a marked attenuation of the contrast column with spinal cord compression (*, $P < 0.05$; **, $P < 0.01$).

of the free fat graft group were graded as 4 (marked attenuation), two dogs as grade 3 and two as grade 1. There was significant difference ($P = 0.04$) between the free fat graft and the control group in the grade 4 myelograms (marked attenuation category). The cellulose group had a higher probability of scores 1 and 2 (two dogs on each), but also one dog on grade 3 and 4. There was no difference between the cellulose and control group. Fig. 2 shows a myelogram of a dog from the free fat graft group. The frequency of distribution of all dogs to each category is shown in Fig. 3.

The least squares means of the macroscopic spinal cord roundness index was 0.79, 0.74, and 0.71 for control, cellulose, and fat graft, respectively (Table 1). A significant difference between the control and the FFG group was seen ($P = 0.048$), the latter having the poorer results. As expected there was no significant effect of the treatments on the non-operated regions. Additionally, there were no significant effects of time ($P > 0.90$) on the roundness index of the spinal cord. Fig. 4 shows two transverse sections of a dog from the FFG group, comparing an operated and a non-operated region.

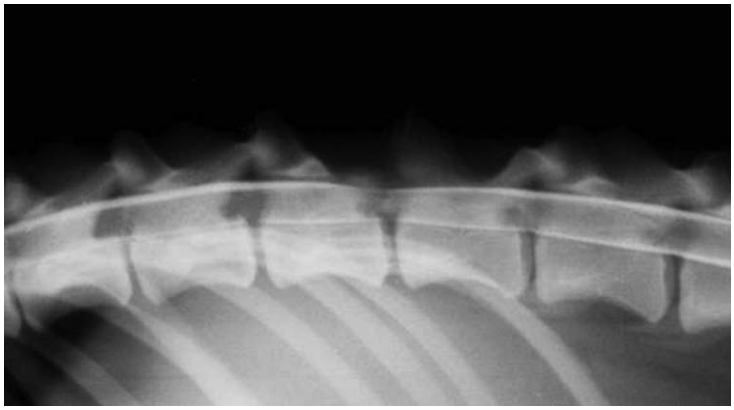
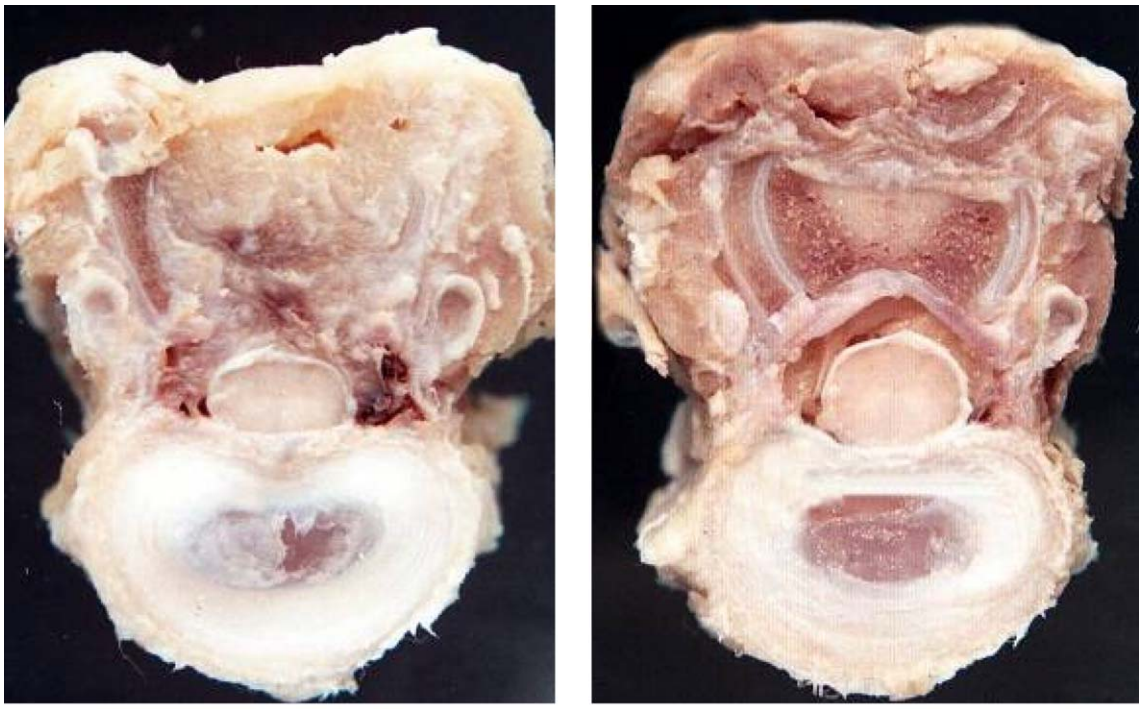


Fig. 2. Myelogram from a dog that had a dorsal laminectomy and free fat graft two weeks earlier. Note a thinning of the dorsal contrast column with spinal cord compression at the T_{13}–L_1 area. Scored as grade 4 (marked attenuation).



(a) (b)

Fig. 4. Macroscopic transverse section of the spinal cord from a dog that had dorsal laminectomy and free fat graft two weeks earlier. Fig. 4a corresponds to the T_{13}–L_1 location (operated region). Fig. 4b represents the disc caudal adjacent to the operated region (L_1–L_2 disc – non-operated area). Compare the flattening of the spinal cord on the operated region against the spinal cord on the non-operated area.

The histological features of epidural fibrosis were similar in all groups. At two weeks, early granulation tissue was seen with large vessels in the myxoid matrix. Maturation of granulation tissue was seen at four weeks, with longitudinal and transverse bands of fibrous tissue centrally and cartilaginous metaplasia peripherally. At eight weeks, there was additional fibrosis with cartilage and associated bone formation. The cartilaginous metaplasia formed earliest and in the greatest quantity in the cellulose membrane group. A lymphocytic plasmocytic infiltrate was seen in the cellulose membrane group, but there was no indication of a foreign body reaction. In three cases, the cellulose membrane became unwoven causing a local increase in inflammatory cells. The membrane was observed as a homogeneous band, separating the fibrous tissue from the dura and bone, usually with small adhesions between the membrane and these structures (Fig. 5).

At two and four weeks, the FFG remained viable and was revascularized. In three cases, the fat graft kept the dura apart from the fibrous connective tissue (Fig. 6), two of these cases were classified as grade 1 (few areas of fibrosis) and one as grade 2 (moderate fibrosis). In the other three cases, the fat graft was infiltrated with fibrous connective tissue, reaching the dura (grade 3).

Four dogs of the cellulose membrane group were classified as having few areas of fibrosis (grade 1). The other two dogs were classified as grade 2 (one dog) and 3 (one dog). The control group had four dogs with moderate fibrosis (grade 2) and two with marked fibrosis (grade 3). There was a significant difference between the control and FFG ($P = 0.046$) and cellulose ($P < 0.0001$) groups relative to the grade 1 classification of fibrosis. No significant effects of time were observed amongst the groups. The distribution of all dogs according to their classification of fibrosis is presented in the Fig. 7.

Histopathology of the spinal cords varied from normal to demyelination in the grey and white matter, axonal swelling, and digestion chambers in the white matter. Although the histological changes were classified in six groups, for the purposes of statistical analysis three classes were created indicating minimal, moderate and severe spinal cord changes (grades 1, 2 and 3, respectively). The control group had three dogs in grade 1, one in grade 2 and two in grade 3. The cellulose membrane had dogs only in the minimal and moderate grades (two in the minimal and four in the moderate). The FFG group had four dogs graded as 3 (marked cord changes), one as moderate and other as minimal. The FFG was statistically different from the control group, demonstrating the worst scores. No significant effects of time were seen. The distribution of all dogs in the three statistical categories is shown on Fig. 8.

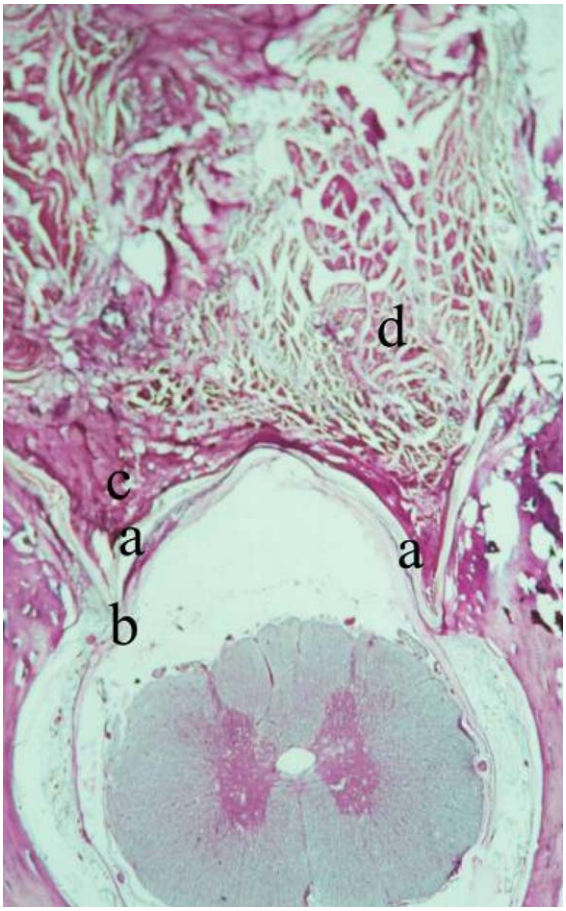


Fig. 5. Histological section of a dog that had a dorsal laminectomy and cellulose membrane implant four weeks earlier. The spinal cord is at the bottom of the picture. Cellulose membrane (a) separates the dura (b) from a restricted area of epidural fibrosis over the membrane and at the left (c). The epaxial muscles (d) are located dorsally on the right side. Graded 1 based on the epidural fibrosis classification. H&E × 3.

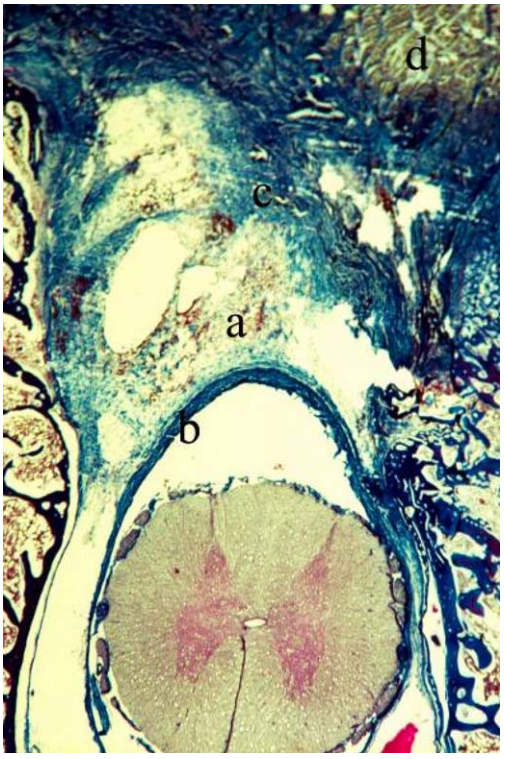


Fig. 6. Histological section of a dog that had a dorsal laminectomy and free fat graft four weeks earlier. The spinal cord is at the bottom of the picture. Free fat graft (a) separates the thickened dura (b) from the extensive epidural fibrosis (c). The epaxial muscles (d) are located dorsally on the right side. Graded as 2 based on the epidural fibrosis classification. Masson's trichrome × 3.

4. Discussion

This study was conducted to investigate whether a cellulose membrane could effectively reduce LM formation compared with the free fat graft. Surprisingly, the FFG caused severe neurological deficits in all dogs; they had normal motor function up to six hours after surgery but then began to show neurological deficits varying from proprioceptive ataxia to paraplegia, starting from 6 to 12 h after surgery. It is very unlikely that all of these dogs had a compression caused by the FFG during its placement over the spinal cord during surgery as extreme care was taken and all animals were able to walk adequately up to six hours postsurgery. Trevor et al. (1991) also observed severe neurological deficits with the use of free and pedicle fat grafts, but the neurological deficits in that investigation were more prolonged than in ours since all dogs euthanased at two and four weeks were non-ambulatory. It is likely that the differences in results reflects the fact that in the study by Trevor et al. (1991), two laminectomies were performed on each dog and the free fat grafts were thicker (5–7 mm) than in our study.

It is important to note that the epidural morphine had no effect on motor function (Jones, 2001) and all dogs were walking reasonably well four hours postsurgery. The neurological abnormalities markedly improved within 3–10 days in all but one dog. Possible explanations for these deficits include a mass effect caused by the fat graft being pushed against the spinal cord by the epaxial muscles (Cabezudo et al., 1985), excessive size, haematoma formation, graft migration

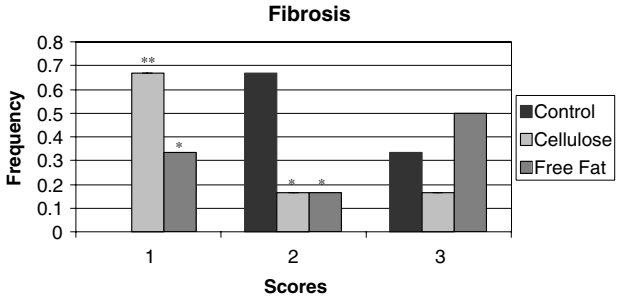


Fig. 7. Distribution of all dogs in the three categories of epidural fibrosis. Graded from 0 to 3: 0, mild or no fibrosis and no dural adhesions and 3, extensive fibrosis, dural thickening and adhesions (*, $P < 0.05$; **, $P < 0.01$).

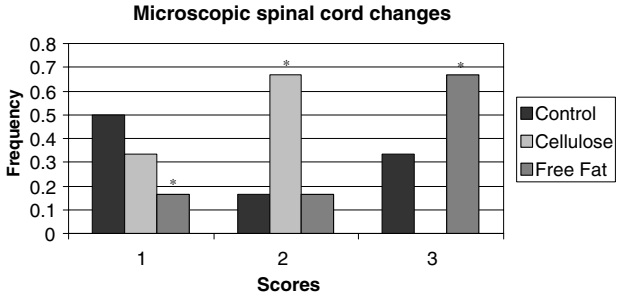


Fig. 8. Distribution of all dogs in the three categories of spinal cord histological changes: 1, none to mild changes and 3, severe spinal cord changes (*, $P < 0.05$; **, $P < 0.01$).

into the epidural space (Prusick et al., 1988; Mayer and Jacobsen, 1989), aseptic necrosis of the graft (Wheeler and Sharp, 1994), or fat inflammation (Trevor et al., 1991). Of these possible causes, graft migration into the vertebral canal with or without surrounding inflammation would seem to be most likely.

The gradual resolution of the neurological deficits, without any anti-inflammatory therapy, after 3–10 days might have been related to graft remodelling and atrophy, and self-resolution of inflammation. Kanamori et al. (2001) demonstrated that grafted fat reduced to 90%, 70%, and 57% of its size 7, 21 and 42 days postsurgery, respectively. They also demonstrated that the fat graft moulds itself around the dura, with self-resolution of dural compression in all patients in six weeks (Kanamori et al., 2001).

Particular care was taken to use a 5-mm thick fat graft in our study, as recommended by others (Van Akkerveeken et al., 1986; Prusick et al., 1988; Trevor et al., 1991). The ideal thickness of the FFG is not well established, although a 5 mm measurement seems to be the most consistently used (Bryant et al., 1983; Van Akkerveeken et al., 1986; Prusick et al., 1988; Kanamori et al., 2001). Kanamori et al. (2001) demonstrated by sequential magnetic resonance imaging studies that fat grafts are reduced to 33% of their thickness within approximately one year. Measuring the thickness of a friable tissue such as fat is not easy and a 5 mm graft may initially appear large. Nevertheless 50% of dogs in the FFG group developed adhesions to the dura and dural thickening, which is a higher percentage than was previously reported in one study (Jensen et al., 1996) but lower than in another (Nussbaum et al., 1990).

In our experiment, a 5 mm FFG was partially effective in avoiding LM formation but caused spinal cord dysfunction as assessed by the changes in the dog's motor status. Thinner grafts might avoid the neurological deficits but they could then be reabsorbed and so have no benefit in regard to LM prevention (Bryant et al., 1983; Van Akkerveeken et al., 1986). Thicker grafts might result in reduced LM formation but would increase the chances of spinal cord compression.

All fat grafts revascularized, as has been previously observed (Kiviluoto, 1976; Langenskiöld and Kiviluoto, 1976; Keller et al., 1978). Interestingly, many human and veterinary spinal surgeons have been using FFG without many complications. The authors question whether short term complications may go unrecognised in the large group of dogs that are paraplegic before surgery, since it would be difficult to determine any worsening in the motor function in a paraplegic patient.

We elected to use the modified dorsal laminectomy technique to maintain consistency with previous investigations (Trotter et al., 1988; Trevor et al., 1991). Using the technique in the thoracolumbar region, lack of preventive measures, as in the control group, led to an innocuous healing pattern, with minimal spinal cord involvement and no visible neurological deficits during the observation period.

We performed the dorsal laminectomies at only one intervertebral site, namely that usually performed in clinical circumstances, whereas other researchers have used more than one site (Kiviluoto, 1976; Keller et al., 1978; Jacobs et al., 1980; Gill et al., 1985; Nussbaum et al., 1990; Pospiech et al., 1995), or even up to four or five sites in each dog (Kuivila et al., 1988; Lawson et al., 1991). Multiple dorsal laminectomies may cause vertebral column instability, which may in turn cause spinal cord compression with neurological deficits, and make comparisons difficult between different spinal areas (Horne et al., 1977; Swain and Vandevelde, 1977). Nevertheless, performing several laminectomies on the same dog avoids individual variations in scar formation (Nussbaum et al., 1990).

The cellulose membrane used in our study has been used to guide tissue regeneration in periodontal surgery (Novaes Junior et al., 1993) and as a dural substitute after brain surgery in dogs (Mello et al., 1997), where it has been shown to reduce epidural scarring and to have anti-fibrotic properties. The biosynthetic cellulose membrane, however, had not been used previously in spinal surgery. Cellulose mesh has been studied but the results were unsatisfactory (Pospiech et al., 1995). The neurological deficits in the cellulose implant group were not as severe as those with the fat graft and may have been caused by a compressive haematoma or slippage of the membrane into the epidural space due to insufficient extralaminar contact. Such slippage might be avoided in procedures that involve less extensive laminectomy. The cellulose membrane did isolate the dura from the fibrosis in most cases and had twice as many dogs in the category with minimal fibrosis but we did not see the anti-fibrotic property previously reported by Mello et al. (1997).

Although the results of the myelogram studies showed a great variation between dogs of the same group, there was a significant difference between the control and free fat group in the marked attenuation

category, correlating with the poor motor scores of the FFG animals. Few researchers have used myelography in similar studies and none has discussed a correlation between clinical and myelographic findings (Funkquist and Schantz, 1962; Barbera et al., 1978; Trevor et al., 1991; Akdemir et al., 1993).

The evolution of the epidural fibrosis followed the same pattern observed in other investigations, differing only in the presence of cartilaginous and bone tissue that were observed earlier at four weeks (Gill et al., 1979; Jacobs et al., 1980; Trotter et al., 1988). The FFG did not impair the metaplasia from fibrous connective tissue to cartilage and bone, as previously observed (Gill et al., 1979).

It is important that the results observed in this study should only be considered with the modified dorsal laminectomy technique. Whether the FFG would have a similar effect on spinal cord function with other laminectomy techniques is unknown.

5. Conclusion

We conclude that the use of FFG to cover laminectomy defects was partially effective in the prevention of laminectomy membrane formation, but was associated with a higher rate of neurological deficits and spinal cord changes. Cellulose membrane coverage of the defects appears to be superior to FFG in regard to laminectomy membrane prophylaxis but was also associated with mild neurological deficits. It is therefore recommended that FFG or cellulose membrane implants are avoided when performing modified dorsal laminectomy in the thoracolumbar area in the dog. More research is needed to explain further the mechanisms involved in the complications associated with FFG, and to determine if these also occur in other decompressive techniques with less spinal cord exposure.

Acknowledgements

This research was partially supported by the CNPq – Conselho Nacional de Desenvolvimento Científico e Tecnológico, Brazil. The authors thank Drs. David Holmberg, Joane Parent and Daniel Smeak for reviewing this article, Dr. Édison L. Farias for the valuable suggestions, and Dr. F. Schenkel and Professor José H.S. da Silva for assistance with statistical analyses.

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