A new peripheral nerve suture technique with a novel biodegradable poly-lactide film with honeycomb-patterned structure

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ABSTRACT

Peripheral nerve repair with microsutures is the gold standard. A highly sophisticated and precise operation technique is required for good results. There is possibility of inflicting damage to nerve axons by the needle if it inserted deep to the epineurium. Fibrosis around the site of repair increases with the number of sutures used even if these have been confined to the epineurium. Many different technical improvements have been aimed at achieving better coaptation in peripheral nerve repair, but none of them proved to be superior over conventional epineural suture technique. The clinical application of these neurorrhaphy has been limited by the risk of dehiscence in the postoperative period. First, the procedure must result in a sufficient acute tensile strength.

Fukuhira et al. have developed a novel biodegradable polylactide (PLA) film (honeycomb film) with a honeycomb-patterned structure on one side. The honeycomb structure provides useful adhesion properties. In our previous experimental study, the honeycomb film prevented nerve adhesion and enhanced functional recovery after extensive neurolysis (in press).

The purpose of this experimental study was to investigate effects of the honeycomb film for neurorrhaphy in a rat model.

MATERIALS AND METHODS

Experiment 1 for biomechanical evaluation: For strength test of neurorrhaphy, twenty male Lewis rats were used for the experiment. Under aseptic conditions, the sciatic nerves were exposed through a dorso-lateral incision and dissected free from the surrounding tissues. The nerves were transected approximately 1 cm proximal to its bifurcation of the tibial and peroneal nerves using microscissors and then repaired with two epineural sutures (10-0 nylon). The procedures were performed bilaterally. After this step, The 40 limbs were randomly assigned to five groups (n=8). The control group (Group C2), no additional surgery was performed which means that the nerve was repaired with only two epineural sutures. The second control group (Group C4), two additional epineural sutures were performed which means that the nerve was repaired with four epineural sutures in total. The honeycomb film of 7-μm thickness group (Group H7), the sutured nerve was wrapped with a 1-cm² piece of honeycomb film of 7-μm thickness. The honeycomb film of 10-μm thickness group (Group H10), the same procedure as in Group H7 was performed with the honeycomb film of 10-μm thickness. The cast film group (Group CA), the same procedure as in Group H7 and H10 was performed with the cast film of 7-μm thickness. Two days after surgery, biomechanical testing to assess ultimate breaking strength using a published method was performed.

Experiment 2 for functional and histological evaluation. Fifteen male Lewis rats were used. The same operations as in Experiment 1 were performed. The 30 limbs were randomly assigned to five groups (n=6); Group C2, neurorrhaphy with two epineural sutures as a control group; Group CA, application of the cast film; Group H7, application of the honeycomb film of 7-μm thickness; and Group N: sham operation. Wet weights of tibialis anterior and gastrocnemius muscles were subsequently measured. Tibialis anterior and gastrocnemius muscle weight data were calculated as percentage of total body weight. For histological analysis, the sciatic nerves with surrounding tissue were harvested and stained with Neurofilament staining.

All data are expressed as mean ± standard deviation (SD). Tukey-Kramer test was used to compare breaking strengths, MCV and wet muscle weight. Values of p<0.05 were considered statistically significant.

RESULTS

Breaking strength was higher in the order of Group C4, Group H10, Group H7, Group C and Group CA. There were significantly higher for Group C4 and H10 than for Group C2 or CA. No significant difference in breaking strength was seen between Group C4 and H10 (Fig. 1).

DISCUSSION

Our results demonstrate that the honeycomb film has the potential to reinforce site of suture in peripheral nerve repair. The honeycomb film is very soft PLA film because it is very thin with porous structures. Therefore it can adhere firmly to the nerve. Thinner film has better adhesion property to patterned indented surface than thicker one.

The biological fact that the tubular guide made from impermeable material could not supply enough nutrients and oxygen from the outside to the regenerating nerve tissue. However our results showed no negative effect in the functional evaluation. We considered that positive effects were due to diffusion-barrier function and adhesion-prevention function which had the honeycomb film.

Taking the characteristics of materials such as adhesiveness, absorbability, and easy-handling into consideration, we believe honeycomb film assist surgeons with neurorrhaphy.

The honeycomb film has the useful property as a reinforcing material for neurorrhaphy, and prevents adhesion between the nerve and neural bed. It might have positive effects for functional recovery but had influences after nerve surgery.

DISCLOSURES

None of the authors have received any financial benefits as a result of this work.

Figure 1: Breaking strength of suture site

Macrophscopic findings at 6 weeks postoperatively, there were no specimens which the suture was broken. The honeycomb film remained in situ, and no adhesions were seen between the film and surrounding tissues in Group H7 and H10. In contrast, sciatic nerves showed adhesion to the neural bed at the suture site in Group C2. In Group CA, the cast film did not remain fixed in place in most specimens.

Histological analysis At 6 week postoperatively, loose connective tissue was present around the nerve, with no adhesions or inflammation between the film and surrounding tissues in Group H7 and H10. Furthermore, the nerve fibers were formed a line regularly at the suture site (Fig.2A arrow). In contrast, nerves showed severe adhesion to the neural bed with some straying nerve fiber at the suture site in Group C2 (Fig. 2B).

Figure 2: Longitudinal section of the suture site at 6 week postoperatively (Neurofilament stain, ×100) A; Group H7, B; Group C2

Mean percentage wet tibialis anterior and gastrocnemius muscle weight was significantly higher in Group N than in Group C2, CA, H7 and H10 at 6 weeks. Group H7 was significant higher than Group C2, although no significant differences were apparent between C2 and H10.