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Original article

Reduction of neural scarring after peripheral nerve suture: An experimental study about collagen membrane and autologous vein wrapping

Réduction de la fibrose nerveuse après suture des nerfs périphériques: étude expérimentale d'une membrane d'interposition en collagène et du manchonnage veineux autologue

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Abstract

The effects of a collagen membrane and a technique of autologous vein wrapping on scar formation after peripheral nerve suture are investigated. Forty-eight sciatic nerves from Wistar rats were transected and repaired, then allocated to a control group C ($n = 16$) and two experimental groups: in group A ($n = 16$) the repair line was covered by the collagen membrane, and in group B ($n = 16$) the repair line was wrapped by an external jugular venous graft. Three months later, it was observed that adhesions in the surrounding tissues were significantly less in groups A and B compared to group C, and significantly less in group A than in the group B. Histological analysis revealed no significant reduction of extraneural or intraneural scar tissue in groups A or B compared to group C. However intraneural fibrosis was significantly less in the group A than in the group B. It was concluded that the collagen membrane was effective in reducing neural scar formation after peripheral nerve suture. Autologous vein wrapping also showed a favorable effect in this indication despite less successful histological outcomes.

Keywords: Scar inhibition; Peripheral nerve; Regeneration; Collagen polymer; Vein graft

Résumé

Cette étude évalue l'effet d'une membrane d'interposition en collagène et d'un manchonnage veineux autologue sur la formation de fibrose après suture nerveuse périphérique. Quarante-huit nerfs sciatiques issus de rats Wistar ont été sectionnés, réparés, puis répartis en un groupe témoin C ($n = 16$) et deux groupes expérimentaux: un groupe A ($n = 16$) dans lequel la suture a été entourée par une membrane en collagène, et un groupe B ($n = 16$) dans lequel la suture a été manchonnée par un greffon de veine jugulaire externe. Trois mois plus tard, les adhérences aux tissus environnants étaient significativement moins importantes dans les groupes A et B, ainsi que dans le groupe A par rapport au groupe B. L'analyse histologique n'a pas montré de réduction significative de la fibrose extra- ou intraneurale dans les groupes A ou B. La fibrose intraneurale était en revanche significativement plus faible dans le groupe A par rapport au groupe B. L'utilisation d'une membrane d'interposition en collagène apparaît comme un moyen efficace pour réduire les adhérences après suture des nerfs périphériques. La technique de manchonnage veineux utilisée dans cette étude semble également efficace, malgré des résultats histologiques moins favorables.

Mots clés : Fibrose ; Nerfs périphériques ; Régénération ; Polymère de collagène ; Greffon veineux

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1. Introduction

The result of peripheral nerve suture depends on the time available before the repair, the patient's age, type of nerve affected, level of injury, trauma mechanism, but also trophic and mechanical factors related to the inevitable development of cicatricial fibrosis [1]. Intraneural fibrosis affects nerve regeneration by preventing the passage of axons from the proximal segment to the distal segment. Extraneural fibrosis, which limits the physiological movement nerves during limb movement, is a source of irritation pain syndromes and of functional limitations [2]. The reduction of intraneural and perineural fibrosis should therefore improve the outcome of peripheral nerve suture, but also reduce complications during iterative surgeries by facilitating the dissection of nerves [3].

Different biosynthetic materials designed to limit post-operative adhesions have been experimentally studied in the field of abdominal, gynaecological or spinal surgery [4–7]. These materials were then tested to limit scarring after peripheral nerve surgery, often with conclusive results [1,2,8,9]. Collagen polymers are currently used as conduits for nerve regeneration [10,11], but no studies were specifically dedicated to their anti-adherent characteristics.

The use of autologous venous sleeves is a technique used for the treatment of recurrent entrapment syndromes [12,13]. After repetitive neurolysis, this can be used to limit the extraneural adhesions and maintain a slip plane between the nerve and surrounding tissue. In the context of peripheral nerve suture, the method could be an alternative to non-stick materials, which are expensive and not always available.

The purpose of this study was to evaluate the effects of membrane tissue regeneration using purified type I collagen derived from porcine (Cova™ ORTHO, Biom'Up® SAS, Lyon, France) and autologous venous sleeves on the reduction of scarring after sciatic nerve suture in the rat.

2. Material and methods

This experimental study was conducted in the laboratory of microsurgery of the School of Surgery in Paris, after approval from the experiments committee. Twenty-five female Wistar rats, weighing between 275 and 340 grams were used. Twenty-four rats were operated bilaterally, that is, 48 sutured sciatic nerves, and one rat was used as a control for the histological study. All procedures were performed by the same operator.

2.1. Surgical procedure

The rats were anesthetised with a gas mixture of isoflurane and oxygen in an inhalation cage and subsequent maintenance with a mask. After shaving, rats were mounted prone on a heated work surface. A skin incision was made along the femur to the posterior thigh, and then the deep fascia was incised to expose the sciatic nerve between the gluteal muscles and femoral biceps.

The sciatic nerve was then sectioned midway between its emergence from the pelvic ring and its division into tibial nerve and common peroneal nerve. Microsurgical nerve repair was immediately performed using an end-to-end suture with four periepineural stitches of 10-0 nylon thread (Ethilon® 10-0, Ethicon). Three groups of 16 sciatic nerves were defined after randomisation. In group A, the nerve suture was wrapped in the Cova™ ORTHO collagen membrane. This membrane was cut to size, passed under the nerve and sutured to itself by five stitches of 9-0 nylon thread (Ethilon® 9-0, Ethicon), to form a non-constrictive sliding sleeve around the nerve (Fig. 1). In group B, the nerve suture was surrounded by a venous graft taken from external jugular vein previous extracted from the

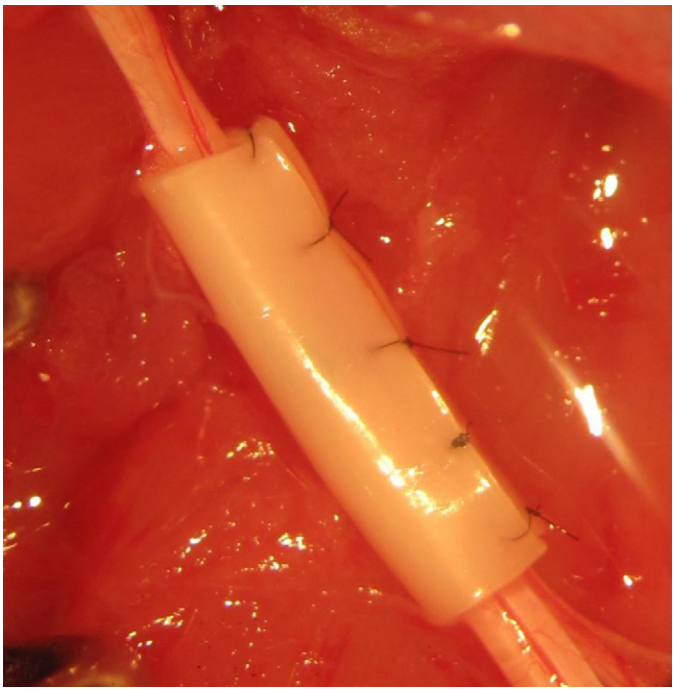

Fig. 1. Application of collagen membrane around the nerve suture.

Fig. 2. Autologous vein graft protecting nerve suture.