Experimental study on the amputation neuroma

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DOI: 10.12920/jopola.2016.01

Abstract

Purpose. To report anatomopathological and histological changes that follow some common surgical treatments for painful neuroma prevention.
Method. 16 Wistar rats received sciatic nerve section: first group received no treatment; group 2 received bipolar diathermy; group 3 received the terminal-end suture; group 4 received interfascicular suture of proximal stump. After sacrificing the animal at sixth week histological samples received histology staining.
Results. 1st group lesions show pathologic finding of neuroma amputation. 2nd group lesions (bipolar diathermy) in all the cases show a large scar formation from the proximal stump to the distal stump. 3rd group sutures show nerve reparation. 4th group interfascicular suture show a small loop at the suture level with a slight growth of the nerve fibers surrounding by the outer sheath (epineurium).
Conclusions Macroscopic and histological appearance of the nerve lesions treated with the interfascicular suture (group 4) differs greatly from the untreated lesions (group 1-section of the nerve). Compared to untreated neuromas, interfascicular suture show less fibrous tissue production and a less anarchic growth of the nerve fibers, which remain enclosed by epineurium.

Keywords: amputee, neuroma formation, neuroma prevention, painful neuroma, neuroma surgical treatment, rat.

Riassunto

Obbiettivo: Osservare e documentare i cambiamenti anatomopatologici e istologici che seguono la sezione di un nervo dopo alcuni comuni trattamenti chirurgici per la prevenzione del neuroma doloroso.
Materiali e Metodi. Su 16 ratti Wistar, con microscopio chirurgico si esegue la sezione del nervo sciatico (gruppo 1); si praticano la diatermocoagulazione (gruppo 2), la sutura termino-terminale (gruppo 3), la sutura interfascicolare del moncone prossimale (gruppo 4). Dopo sei settimane si sacrifica l'animale e si prelevano campioni istologici per analizzarli con colorazioni della istologia tradizionale.
Risultati: Nel primo gruppo sono state osservati i caratteri anatomopatologici del neuroma d'amputazione. Nel secondo gruppo si è documentata una notevole produzione di tessuto nervoso. Nel terzo ° gruppo è stata osservata una regolare riparazione dei nervi dopo la sutura. Nel quarto gruppo si è osservata la formazione di una piccola ansa a livello della sutura con una crescita contenuta delle fibre nervose all'interno dell'epinevrio.
Conclusioni: L'aspetto macroscopico e istologico delle lesioni nervose trattate con la sutura interfascicolare del moncone prossimale del nervo (gruppo 4) differisce notevolmente dalle lesioni non trattate (gruppo 1) e mostra una ridotta produzione di tessuto fibroso e un limitata crescita delle fibre nervose che rimangono contenute dalla guaina epinevriale.

Parole chiave: amputato, formazione del neuroma, prevenzione del neuroma, neuroma doloroso, trattamento chirurgico del neuroma, ratto.

Introduction

The complete section of a nerve causes an anatomical pathological entity named neuroma. From 20 to 30% of neuromas cause pain 1, 2.
A painful neuroma can severely reduce the ability of an otherwise normal hand 3.
When conservative treatments do not resolve pain, surgery is needed. There are several surgical prevention treatments of painful amputation neuroma, often based on surgeon anecdotal experience rather than on experimental data.
Barberà et al. 4 proposed to anastomize each fasciculus of the nervous stump by microsuture, interposing a perinevral graft (central-central anastomosis). Belcher et al. 3 proposed the suture of the sectional surfaces of two close nerves. Digital amputation neuromas usually come

from a nerve consisting of an even number of nerve fascicles (usually two) similar in diameter, which can be easily anastomosed.
On an animal model, the aim of the present survey is to see the histological and anatomopathological nerve changes after experimental formation of a neuroma followed by some common preventive treatments of the painful neuroma.

Material and Methods

To get the approval by the Ethics Committee of the Ministry of Education University and Research (under to article 3 Legislative Decree 116/92), the "Allegato 4" form was filled out.
All animals underwent anesthetic treatment with Zoletil 100 (tiletamine hydrochloride and zolazepan hydrochloride) at a dose of 0.3 ml each.
16 male Wistar rats weighing 225-250 grams had right sciatic nerve section. The animals were divided into four groups, each of them consisting of four animals:
In the 1st group the right sciatic nerve section was performed.
In the 2nd group the proximal stump of the cut up nerve was treated with bipolar diathermy.
In the 3rd group, right sciatic nerve lesion was treated with end-to-end suture 5.
In the 4th group, the right sciatic nerve lesion was treated with interfascicular anastomosis, which involves the suture (anastomosis) of two fascicles belonging to the same proximal stump.
All animals were sacrificed after six weeks by an anesthetic overdose. By taking the sciatic nerve sample subjected to the different treatments we evaluated the histology of the neuroma and/or the repaired nerve.
Histological samples were prepared with three different staining techniques: Hematoxylin Eosin, Luxol Fast Blue, and Silver Impregnation. High-resolution photographic images reported the histological changes.

Result

In the 1st group (nerve section), all the cases showed pathological and histological features of neuroma amputation such as lively proliferation of nerve ending, disorganized proliferation of nerve fascicles Schwann cells, and fibroblasts surrounded by scar tissue (fig. 1). It was not possible to find the distal stump probably completely degenerated. One case had a self-mutilation.
In the 2nd group (treatment of the proximal stump with bipolar diathermy) a large scar formation from the proximal stump to the distal stump occurred in all animals (fig 2).
In the 3rd group (end-to-end suture), excluding a case of death before six weeks, sutures show nerve reparation with slight nerve volume increase. Stumps connections show fibrous tissue development in the central portion of the nerve Fig. 3).
In the 4th group (proximal fascicles anastomosis) sutures show a small loop with a slight growth of the nerve fibers just inside the outer sheath (epineurium). Compared to untreated neuromas, nerve cuts show less fibrous tissue production and a less anarchic growth of the nerve fibers, which remain enclosed by epineurium (Fig. 4).

Discussion

Merle et al. 6 defined painful neuroma a painful nerve ending because of undue nociception. According to the gate control theory of Melzack and Wall 7, the A beta fibers belonging to the tactile sensory path exert a control on the slow-conducting fibers A delta and C matching to the path of thermal nociceptive sensitivity. In essence, the neuroma would cause a lowering of the pain threshold activating A delta and C fibers, thus leaving the passage to the painful impulses that would escape the control.
Excluding small neuromas, which usually respond to desensitization by physiotherapy, (such as ultrasound, transcutaneous electrical neurostimulation), surgery is the most chosen presidios to treat painful neuromas 8, 9, 10, 11, 12. The presence of several proposed techniques highlights a general difficulty in gaining pain relief. Unexpectedly in literature, there are few experimental works with sometimes conflicting conclusions.
Belcher et al. 3 clinical experience encourage direct suture of proximal stumps for neuroma prevention. Other authors 4, 13, 14 support the need of an interposing graft between section surfaces.
The nerve of the rat has a remarkable regenerative ability due to high metabolism and small expected distance from the experimental lesion to neuronal cell body 15,.
Nerve section neuromas in the first group show typical macroscopic and histological features of section neuromas (anarchic proliferation of axons, fibroblasts, Swann cells and newly formed capillaries). The neuromas, in fact, appear as a bulky mass with vegetation that protrude in all directions towards the surrounding tissues. There are dense number of Swann cell nuclei and fibroblasts mixed with disordered myelin clusters.
The subjects treated with the bipolar diathermy show a large scar formation from the proximal stump to the distal stump.

The end-to-end sutures, which show slight nerve volume increase nearby the lesion, histologically show fibrous tissue development in the central portion of the nerve, which appears moderately destructing the axons arrangement.

Proximal stumps anastomosis (group 4), show an expansion at the loop nearby the suture. Histologically, there is a neurofibril fascicles disorder in the central area; this area match to the meeting point of the fibers coming from the junction. A dense fibrous tissue is visible in this location. In some microscopic fields, fibrils fascicles are physiologically wavy, in other areas they overlap.
An analysis of the preparations with 6 microns microtome cuts would be needed to center the exact plane of the nerve fibers meeting, and to note the axons arrangement within the proximal interfascicular suture loop.
Our experience allows to note some observations, which should be considered in painful neuroma investigations.

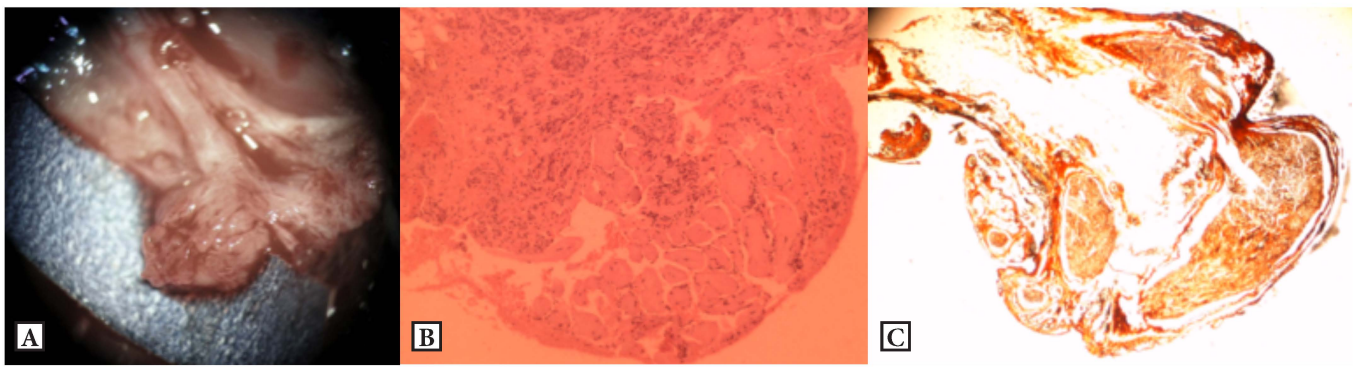

Fig. 1 nerve section:
A) six-week after treatment (25X magnification).
B) Histological preparation (Hematoxylin Eosin. 200X magnification) and C) (Silver impregnation 200X magnification).

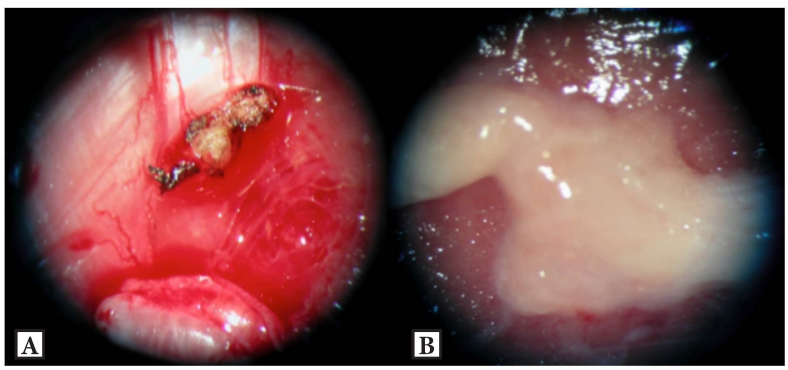

Fig. 2 nerve section followed by proximal stump diathermy:
A) intraoperative image (25X magnification);
B) six weeks after treatment (25X magnification);

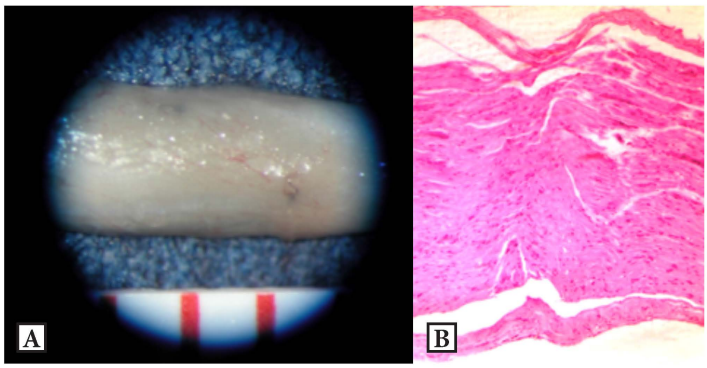

Fig. 3 nerve section followed by end-to-end suture:
A) loupe magnification photograph (25X magnification)
B) Histological preparation (Hematoxylin Eosin. 200X magnification);

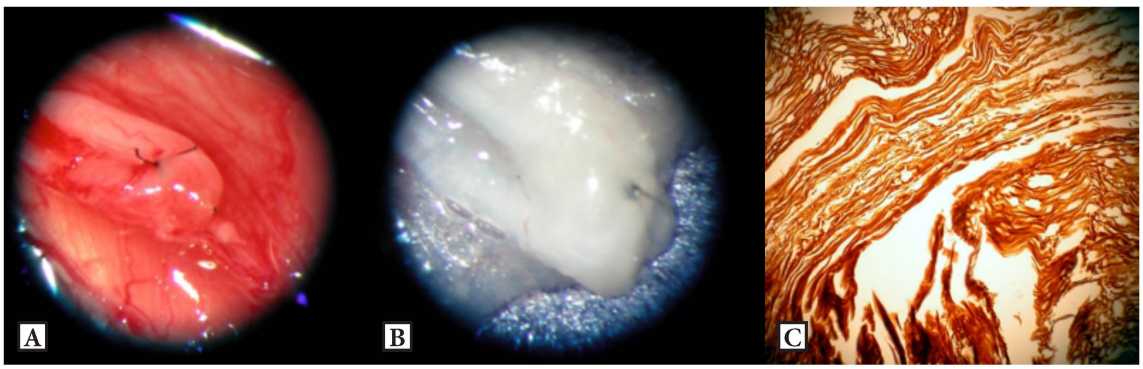

Fig. 4 nerve section followed by interfascicular suture:
A) intraoperative image (25X magnification);
B) six-week after treatment (25X magnification).
C) Histological preparation (Silver impregnation 200X magnification).

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