THE NERVE GAP: SUTURE UNDER TENSION VS. GRAFT

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The ultimate goal of any nerve repair is maximum sensory and motor recovery of the distal denervated part. A controversy exists about how to do the surgical repair of peripheral nerve injuries when a large defect is present between the severed nerve ends. Should one mobilize extensively and stretch the nerve to bridge the gap, thereby achieving end-to-end repair with a single anastomosis? Or, should one eliminate the tension by bridging with a nerve graft, leaving the regenerating axons to find their way through two anastomoses?

The use of nerve grafts is favored by some investigators while other authors consider nerve grafting inferior to end-to-end suture.

Our object was to use electrophysiological recordings of peripheral nerves to study and compare the suture of nerve injuries under tension with similar repairs done by using nerve grafts.

MATERIALS AND METHODS

We used 50 albino rats divided into two groups for this study.

Group A comprised 30 animals in which the right sciatic nerve was cut and a segment of nerve (2, 4, or 6 mm long) was resected to create a nerve gap. End-to-end suture was then done under varying degrees of tension: mild (2 mm), moderate (4 mm) or severe (6 mm). The left sciatic nerve was also cut and it was repaired by end-to-end anastomosis; this served as the control.

Group B comprised 20 animals in which the right sciatic nerve was transected. The created gap served as the recipient site for varying lengths of nerve grafts. Half of these nerve transplants were properly tailored for the gap, while the other half were made 10 mm in excess of the required length. The left sciatic nerve in each animal served as the donor site.

The animals were anesthetized with intraperitoneal Nembutal and their hindquarters were shaved. The nerve repairs were done under the OPMI 6 Zeiss operating microscope, using microsurgical techniques: 10-0 Ethilon sutures on ST-6 and BV-5 needles were used for the actual anastomoses.

No postoperative immobilization was used. Infections or wound dehiscence were not encountered. Five animals died from the anesthesia; these were replaced.

Both groups were allowed to survive between 6 and 10 weeks. At that time, the animals were anesthetized and intubated with an endotracheal cannula, the femoral artery was catheterized for blood pressure determinations, and the femoral vein was cannulated for rapid administration of anesthetic. The animal was then placed on a thermal blanket, and the head and hind limbs were immobilized.

The repair sites were re-exposed and fine platinum recording electrodes were lowered onto the proximal part of the sciatic nerve. Under high magnification (40 to 80x), using a Nikon dissecting microscope, single fascicles were isolated and placed onto the recording electrode. The larger bipolar platinum stimulating electrode was then lowered to contact the distal part of the nerve at the various sites. These sites were located as shown in Figure 1. The impulses elicited were amplified 1,000 times by a Textronix 122 preamplifier, then fed to a Textronix 565 oscilloscope. A deflection, in the form of a compound action poten-
rye was transplanted as the re-lengths of nerve transplants served as the gap. The made 10 mm length. The animal served

done under the microscope, using miniature monofil suture on was used for the action.

were not allowed to survive before that time, the animals were intubated with the femoral artery cannulated for later analysis of latencies, amplitudes, and conduction velocities.

After all the recordings were completed, the nerve was excised and placed in formalin for histological examination (eosin, van Gieson, Bodian, LBF-PAS).

RESULTS

The resulting conduction velocities and the percentages of decrease in amplitudes at the various sites are shown in Figure 2.

Conduction velocity is determined from the following equation.

\[ V = \frac{D}{T} \]

where \( V \) is the velocity of the action potential, \( D \) is the distance between the stimulating and recording electrodes, and \( T \) is the time elapsing between the stimulus artifact and the beginning of the action potential (latency). The conduction velocity is expressed in meters per second (m/sec).

The amplitude of the evoked response reflects the number and size of the fibers contributing to the response. When a supramaximal stimulus is delivered to the proximal stump (site 2), the distance from the baseline to the highest point of the deflection represents the amplitude of that response. If this is taken to be 100 percent for the normal nerve, then any decrease of this parameter—as the nerve is stimulated past the suture lines and onto the distal stump—would represent the diminution in the number and size of the axons at the various sites. On these graphs each point represents the mean value.

On the basis of electrophysiological conduction studies, the following observations were made.

1. Axonal regeneration was optimal in the control side of Group A animals, where end-to-end suture was done without tension. This was demonstrated by the faster conduction velocities and the smaller reduction in amplitude across the anastomosis.

2. Regeneration through mildly stretched repair sites was equivalent to that obtained after applying a properly tailored graft.

3. Poor results were obtained from either excessively long grafts, or moderately stretched repair sites.

4. Severely stretched nerves exhibited minimal functional recovery.

Sustained plantar ulceration was a good indicator of poor regeneration throughout the series. In some animals, the initial ulceration disappeared subsequently as regenerating fibers reached
the distal stump. On re-exposure of the repair sites prior to recording, scar tissue formation around the anastomosis was most pronounced in the moderate and severely stretched nerves.

**DISCUSSION**

The problem is the surgical management of the nerve gap. Is nerve grafting a better approach for restoring function than suturing nerves under tension?

**Nerve Graft**

The object of a bridging nerve graft is to provide a scaffolding that will assist regenerating fibers in finding their way to the distal part—to thus restore the original pattern of innervation. However, there are many obstacles that a regenerating axon has to overcome on its way to the proper terminal. A crucial factor in determining the success of a nerve autograft is the relative orientation of the fascicles in the graft and the fascicles in the recipient nerve-stumps. Axons may be wasted at both the proximal and distal suture line by growing into the perifascicular and epineurial connective tissue. Those that do enter the intrafascicular tubes of the autograft are subject to more redistribution, due to the various branches and plexi within the graft. Furthermore, even if successful in crossing the nerve graft, regenerating fibers risk entering unrelated Schwann cell tubules in the distal stump and terminating in foreign end organs.

**Suture under Tension**

Tension at the suture line invites connective tissue proliferation. This tis-
The success of a relative orientation of the graft to the recipient nerve should be wasted at the distal suture line. Those that are invaded by scar tissue will shrink and constrict nerve fibers. Regenerating axons reaching the distal stump under these conditions may fail to mature and attain proper myelination. Furthermore, it has been shown that there is a direct relationship between the amount of tension in a sutured nerve and connective tissue proliferation.

Our studies support previous histological and clinical observations. The conduction velocity—which reflects the excitability of the neural elements, the size of the nerve fibers and thus their myelinated status—was fastest and exhibited less drop-off across the single suture line of the control group (without tension). In the severely stretched repairs, the conduction velocity showed the greatest decline. In addition, the percentage decrease in amplitude, as compared to the normal nerve, was least in the control animals and greatest in those with severely stretched repairs. Grafted animals fell somewhere in between.

These electrophysiological findings confirm those of previous histological work. No assumptions can be made, however, of the caliber of the final innervation pattern distal to the injury.

The electrical parameters of regenerating axons were optimal in end-to-end suture without tension, and worst in severely stretched repairs. Nerve grafts provided an alternative means of bridging nerve defects, with results ranging from satisfactory to poor. It seems evident that the alternatives that exist today in handling large nerve defects—suture under tension or nerve grafts—are unsatisfactory. A continued and intensified search for other means to solve this problem is needed, for better results.

SUMMARY

Conduction velocities and amplitudes of evoked responses were used in experimental models to compare reinnervation through nerve gaps sutured under tension or bridged with nerve grafts. The best results were obtained when end-to-end suture was done without tension. Regeneration through mildly stretched nerve repairs was equivalent to applying a properly tailored graft. Minimal axonal activity was exhibited by severely stretched repair sites.

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REFERENCES


