

Comparison of Microsurgical Suture with Fibrin Glue Connection of the Sciatic Nerve in Rabbits

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Summary

The regeneration of the sciatic nerve after microsuture was compared with the connection of transected nerve with a coagulum of autologous blood plasma in 20 rabbits. The epineuroperineural suture was performed in 10 rabbits (group A). The severed nerve was approximated with fibrin glue of autologous blood plasma in 10 rabbits (group B). Their skin sensation margin during a 3-month-period of regeneration was examined, 90 days after surgery the connection was inspected and the nerve conduction velocity was measured across the site of the anastomosis. The microsuture was found to be firm in all 10 animals of group A. On the other hand, in 2 animals of group B, the glue failed to keep the nerve stumps approximated (dehiscence occurred in 20 % of the animals). There were no significant differences found on clinical and electrophysiological testing of regenerated nerves of both groups. The method of autologous fibrin glue in the repair of peripheral nerve transection does not provide a sufficiently firm connection. This procedure with the preparation of the centrifuged plasma is a more time-consuming method in comparison with the microsuture. Epineuroperineural microsuture with maximal effort to adapt the corresponding nerve fibres remains the method of choice for peripheral nerve reconstruction.

Key words

Rabbit – Sciatic nerve – Regeneration – Microsuture – Autologous fibrin glue

Introduction

The fibrin glue connection of the transected peripheral nerve is one of the surgical techniques which were developed for the improvement of the unsatisfactory results of peripheral nerve regeneration. Young and Medawar (1940) were the first who applied fibrin glue for the reconstruction of severed nerves. Seddon and Medawar (1942), Tarlov and Benjamin (1943) and Tarlov and Boernstein (1948) were also the pioneers of this method. In the Czech Republic, Metelka began the work with this method under experimental conditions and then in clinical cases (Metelka *et al.* 1962). Subsequently, a number of other authors applied fibrin glue with different results (Becker *et al.* 1985, Cruz *et al.* 1986, Feldman *et al.* 1987, Herter 1988, Romano *et al.* 1991, Ventura *et al.* 1981).

In the present experimental study, the functional results of this technique of nerve connection

was compared with microsurgical suture. The time-factor and the technical requirements of both methods were also studied.

Methods

Twenty male rabbits of the same age, weighing 3–4 kg, were kept separately in rabbit hutches in a heated room according to the rules of the European Communities Council Directive of November 24, 1986 (86/609/EEC). The rabbits were observed daily by a laboratory assistant.

Before surgery, the rabbits were anaesthetized with a combination of pentobarbital sodium 30 mg/kg, ketamine 30 mg/kg i.m. and atropine sulphate 0.1 mg/kg s.c. The dorsolateral aspect of the right thigh was shaved and disinfected. The surgical field was then infiltrated with 1 % trimecaine.

The rabbits were operated in the prone position. Access to the sciatic nerve was dorsolateral in

the middle part of the right thigh between the semitendinosus muscle and caput pelvium bicipitis femoris muscle (Sameš and Beneš 1995). The nerve was freed from surrounding tissues and transected sharply with microscissors in the middle of the thigh under aseptic conditions.

Twenty animals assigned for surgery were divided into two equal groups – Group A: epineuroperineural repair with four sutures and Group B: autogenous fibrin glue. All nerve connections were performed under an operating microscope at x 8–16 magnification. Suture repair was done with 10/0 Ethilon (Ethicon, Edinburgh). For the repair in which autologous fibrin glue was used the preparation of sedimented plasma was done immediately before surgery (Metelka *et al.* 1962). By means of a silicon needle, 5 ml of blood from the auricular vein was injected into a refrigerated silicon tube which was closed with a plug. The plasma was separated by centrifugation of the blood sample for two minutes at 1000 r.p.m. under continuous cooling at 0 °C. The tube with separate elements and plasma was then put into a vessel filled with crushed ice. The transected nerve was adapted in a small polyvinyl chloride trough and the cooled plasma was applied to the site of the connection. Under the influence of body temperature the plasma becomes warm, coagulates and glues the nerve within several seconds. After ten minutes, the coagulum is firm enough to remove the plastic tube. The skin incision was closed using 4–0 nylon in each animal. Post-operatively, buprenorphine 0.25 mg i.m. was administered for analgesia and sulfopen powder was applied locally to prevent infection.

Clinical examination

The animals were clinically tested weekly during the 3-month period of regeneration. Gentle mechanical stimuli (pin prick) were used from the hip to the ankle to test for functional reinnervation of the skin according to the scheme of Horch *et al.* (1977). The reinnervation range of the cutaneous pain receptors was thus ascertained.

Nerve inspection

The animals were anaesthetized 90 days after the initial surgery and the sciatic nerve was exposed. Attention was focused on the firmness of the nerve connection and to surrounding scarring.

Electrophysiology

Immediately after the inspection, bipolar hooked platinum stimulating and recording electrodes were placed under the sciatic nerve proximal and distal to the site of the nerve anastomosis. The distance between the electrodes was 33 mm. Normal body temperature was maintained with a heating lamp. Current stimulation with a voltage pulse generator, a differential amplifier and a current stimulator

(Neurolog System, Digitimer Ltd.) was performed. The nerve was stimulated with 0.05 ms impulses of 2 mA intensity. The resulting nerve action potential was displayed on an oscilloscope and graphically recorded. The nerve conduction velocity (NCV) was calculated from the time latency of the wave A and the interelectrode distance. Similar studies were performed on 5 normal rabbit sciatic nerves.

Statistical evaluation

The results are mean values \pm S.E.M. of the wave A response. The statistical analysis was carried out by the two-tailed t-test.

Results

There were no complications during anaesthesia and surgical procedures. The healing of the wounds took place without infection. Two weeks postoperatively all 20 rabbits performed autotomy (Wall *et al.* 1979) of the nails or toes on the operated anaesthetic leg.

Clinical examination

At the end of the first month, an equal reaction to the pain stimulus at the knee-joint region was recorded in both groups. Towards the end of the 3-month period of regeneration, the animals responded to the pain stimulus 1–2 cm below the talus. Spreading of the skin pain sensation margin on the limb was the same in both groups (except for two animals in group B, where no symptoms of regeneration were recorded) and corresponded to the speed of axonal growth of 1–1.3 mm per day.

Nerve inspection

All 10 sutures in group A were anatomically intact after 90 days of regeneration (100 % success). Two dehiscences of the fibrin glue connection occurred in group B, eight fibrin glue connections were anatomically intact (80 % success). There was soft bulbous bulging at the site of connection in both groups. Scarring in the vicinity to the sutured and glued nerves was minimal in both groups.

Table 1. Nerve conduction velocity (m/s) in normal rabbit sciatic nerve (Control), and 3 month after epineuroperineural microsuture (Group A) or after fibrin glue connection (Group B).

Control	Group A	Group B
50.3 \pm 3.8 (n=5)	0.7 \pm 3.6 (n=10)	10.6 \pm 2.7 (n=8)

Mean values of wave A response \pm S.E.M.

Electrophysiology

The nerve conduction velocity of the normal rabbit sciatic nerve was 50.3 ± 3.8 m/s. In group A, the nerve conduction velocity in 10 animals was 10.7 ± 3.6 m/s and 10.6 ± 2.7 m/s in 8 animals after the fibrin glue connection (Table 1). There were no statistical differences between groups A and B ($p > 0.05$).

Discussion

The technique of nerve repair with fibrin glue of autologous plasma was published in detail by several authors (Cruz *et al.* 1986, Metelka *et al.* 1962, Seddon 1972, Zvěřina and Stejskal 1979). To prevent partial coagulation of the plasma and for maximal adhesive capability of the plasma it is necessary to keep the temperature at 0 °C during the preparation. The quality of the plasma declines with the presence of erythrocytes, by centrifugation at frequencies higher than 1000 rpm, or when the centrifugation takes longer than two minutes. Simple sedimentation is the ideal preparation of the plasma; however, it is a time consuming procedure. The fibrin glue nerve repair itself is very fast, the only difficult manoeuvre is to remove the polyvinyl chloride tube without damaging the nerve connection.

Traditional methods of assessing nerve recovery, including histomorphometry and measurements of axonal transport, do not necessarily correlate with the return of motor and sensory function. Recent efforts have focused on the assessment of functional recovery following nerve injury. De Medinaceli *et al.* (1982) described a method of walking track analysis to assess sciatic nerve motor function. However, section of the sciatic nerve trunk produced complete anaesthesia of the foot leading to autophagia (Wall *et al.* 1979). In our study all 20 rabbits of both groups performed autotomy of the nails or toes and thus became excluded from the walking track, toe spread and toe twitch examinations (De Medinaceli *et al.* 1982). During the 90-day postoperative period, minimal improvement was observed in walking and there was no EMG evidence of reinnervation distal to the transection of sutured or glued nerves. Kline *et al.* (1972) reported the same results after transection of the sciatic nerve. Recovery of motor function returns somewhat more slowly than sensory functions (De Medinaceli *et al.* 1982), so we therefore decided to test for functional reinnervation of the skin according to the scheme of Horch *et al.* (1977).

For electrophysiological assessment we used the standard recordings across the injured nerve segment with electrodes placed proximally and distally to the area of reconstruction (Bridge *et al.* 1994,

Fischer *et al.* 1985, Huang *et al.* 1992, Kline *et al.* 1972). Two dehiscences of connection in group B were found during macroscopic inspection of the nerves. The other nerves in group B and ten nerves in group A did not differ when viewed through the surgical microscope. No significant differences were found neither on clinical examination, or when the values of the nerve conduction velocity were compared. Averaged nerve conduction velocities for both sutured and glued nerves were 20 % of pre-injury values 3 months after injury. This result corresponds closely to other studies (Kline *et al.* 1972, Terzis and Smith 1987).

The two cases of dehiscence of the connection of glued nerves have confirmed that the coagulum is not sufficiently stretch-resistant when tension is present at the suture site (Cruz *et al.* 1986, Metelka *et al.* 1962). The tension in the present study might not have been caused by movements of the animal, because sciatic nerve transection produced complete paresis of the leg. However, the operated lower limb of the animal was wrapped securely with cotton wool and adhesive tape for the first two weeks to prevent trophic ulceration. According to Metelka *et al.* (1962) the force sufficient to break the glued nerve is half that needed to disrupt the sutured nerve. Herter (1989) mentioned the influence of fibrinolysis on the stability of the connection with the coagulum. He treated the animals with antifibrinolytics, however, he did observe fibrosis of the connection.

This work was designed to compare the two methods with regard to surgical techniques and surgical time requirements. In comparison with nerve microsuture, fibrin glue nerve repair with the autologous plasma is a time-consuming procedure. With blood sampling and preparation of plasma, this procedure requires on the average twice as long as the time needed for the microsuture. The technical requirements of the fibrin glue connection are not simpler than suturing the nerve. The electrophysiological assessment in this study reports very rarely published values of nerve conduction velocity of the normal rabbit nerve and also values for nerve conduction velocity 3 months after microsuture and glue connection.

In conclusion, fibrin glue nerve repair remains only an alternative method to the usual microsuture. Fibrin glue should be reserved for minor nerves such as the facial nerve without tension between the stumps or for tensionless nerve grafts, combined with sutures.

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