RESEARCH ARTICLE

Introduction of a New Suture Method in Repair of Peripheral Nerves Injured with a Sharp Mechanism

Alireza Saied, MD; Majid Asadi Shekaari, PhD; Amirreza Sadeghifar, MD; Ali Karbalaeikhani, MD

Research performed at Kerman University of Medical Sciences, Kerman, Iran

Received: 31 January 2015 *Accepted: 12 July 2015*

Abstract

Background: The standard method for repair of an injured peripheal nerve is epineural repair with separate sutures. Herein we describe a method in which the nerve is sutured with continous sutures. In fact this method has not been utilized for nerve repair previously and our purpose was to compare it to the standard method. If it proved to be successful it would replace the standard method in certain circumstances.

Methods: The proposal of the clinical trial was given a reference number form the ethics comitee. 25 dogs in which the scaitic nerve was cut by a sharp blade under genaeral anesthesia were divided randomly into three groups: control (5 dogs), repair of sciatic nerve with simple sutures (10) and repair with continous sutures (10). In the control group the nerve was not repaired at all. After 6 weeks the dogs were killed and the nerve was studied by light and electronic microscopes. The amount of consumed suture material, time of repair, myelin thickness and axon diiameter were examined. Ultrastructural studies were performed to assess degeneration and regeneration findings.

Results: Time of repair and the amount of consumed suture material were significantly lower in the continous group (P<0.001). No difference was found with regard to light microscopy findings and regeneration was confirmed by electron microscopy in the continous group.

Conclusion: The method described in the present study, provided a result similar to the standard method. Though undobtfully it has some limitations, can replace the standard method in many circumstances.

Key Words: Nerve regeneration, Peripheral nerve injuries, Sutures

Introduction

The first person in the history who tried to suture a severed periphearl nerve was probably Paul of Argina in 600 A.D. and it was Seddon who introduced nerve grafting in situations where direct repair was impossible because of nerve loss (1). With introduction of microscope to the world of surgery the results of nerve repair have been improved. Despite this and though some authors declare that nerve regenration may be complete, in most circumstances this is not true and it seems that microsurgery has reached a plateau in this case (2).

The standard method of repair of peripheral nerves is epineural sutures in which all other methods are compared with. Although no advantage has been shown for epi perineural and perineural methods over epineural sutures, many surgeons prefer the latter (3-7).

All valid references advice repairing nerves with separate sutures. Although we could not find a particular cause for this, in arterial repair separate sutures are avoided because of pursing in the repair region. It should be noted that repair with continuous sutures has some benefits, at least theoretically: The amount of consumed string is reduced and the surgeon is less tired particularly when he /she operates with a microscope

Corresponding Author: Ali Karbalaeikhani, AJA University of Medical Sciences, Emam Reza Hospital , Tehran, Iran
E-mail: Alikhanikhani@gmail.com

AB&JS THE ONLINE VERSION OF THIS ARTICLE ABJS.MUMS.AC.IR

and finally in continous suture the overlap of repaired tissues takes place better so healing time will be reduced significantly. Herein we describe a new method in which continuous sutures are used while avoiding pursing.

Materials and Methods

This clinical trial was approved by the Ethics committee. The study was performed on 25 dogs that were divided into three groups: separate (classic, 10), intervention (continuous, 10) and the witness (control, 5). In each group the animals were anesthetized by injecting Ketamine (50 mg/Kg) and Xylazine (10 mg/kg) by a veterinarian. In aseptic conditions after prep and drape, the mid-thigh was incised in the posterior surface and the sciatic nerve identified. The nerve was cut by the surgeon and then repaired under magnification with 8-0 nylon suture material in the control. In the control group (10 dogs) separate epineural sutures were used, the first two stay sutures were in the 3 and 9 o'clock position, and were used to turn the nerve for repair of the back. The time required to place the stay sutures was recorded as the "time 1" and "time 2" and the time from stating the other sutures to the end of repair was recorded as the "time 3". In the intervention group the new method was used. A 2-needle string was cut from the middle to harvest two strings. The two stay sutures were placed in the 3 and 9 o'clock position, each with one of the strings without cutting the stings and the time was recorded as times 1 and 2 respectively. The nerve was repaired using continuous epineural sutures from the 3 to 9 o'clock position where it was sutured to the shorter end of the other string. Then the nerve was turned around and the procedure was repeated from the 9 to 3 o'clock position with the other string [Figure 1; 2]. So the pursing of the sutured nerve was avoided. This was recorded as "time 3". In the continuous group the surgeon placed the needle of the string exactly at the point that he would have placed his next suture in the separate group, so that the "number" of sutures would be equal. In the witness group the nerve was not repaired. All of the surgeries were performed by a hand surgeon with 6 years of experience in peripheral nerve repair. The dogs were cared for by the veterinary department for 6 weeks and then they were destroyed with an injection of high dose anesthetic. The nerve was explored and 10 mm proximal and distal to the repair site was excised and sent for examination. A 2 cm segment of the normal contralateral sciatic nerve was harvested from 3 dogs. Unfortunately, 4 dogs died of sepsis before the 6 weeks follow up period and new specimens were enrolled.

In the neuroscience lab, at first an expert technician incised each sample and 10 cuts were made from the proximal and distal of each segment. The sciatic nerve was isolated and divided into 2 mm segments. They were fixed immediately with glutaraldehyde solution 2% in 0.1 M Phosphate Buffer Solution (PBS) for 24 hours. The specimens were washed with PBS 3 times and post fixed for 1 hour in 1% tetroxide osmium and dehydrated in a graded concentration of ethanol and finally embedded in epoxy resin. Semithin sections (400 nm) were stained with 1% toluidine blue and examined by light microscopy. Ten fields of transverse sections were morphometrically analyzed by the computerized image analysis system (Motic Images China e-kup Co., Ltd). AD, MFD, and MSD were measured for each section. For ultrastructural study, ultrathin sections (80 nm) were stained with 1% uranyl acetate and 2% lead citrate before viewing in the Philips EM 300 electron microscope (Philips, Eindhoven, Netherlands).

After preparation for microscopic and ultrastructural studies, samples were reviewed for histological studies. Light and electron microscopic examinations were performed by an experienced histologist blinded to the sample type. All of the samples underwent light microscopic examination, but for the electron microscope 3 samples were chosen randomly.

In the light microscope the fiber diameter, the axon diameter and the myelin layer diameter were measured in micrometers after specific staining. In the electron microscope sample group the fiber and myelin

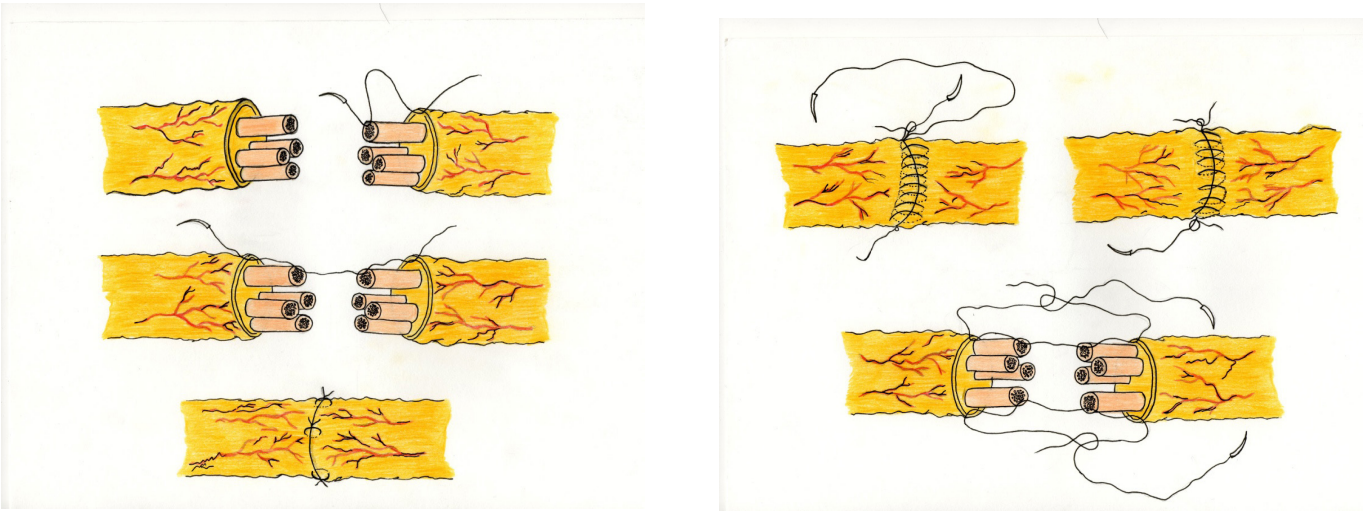

Figure 1. Schematic presentation of nerve repair with classic (left) and proposed method (right).

Table 1. Repair time in the calssic and continous groups

	Time 1	Time 2	Time 3	Total time
Simple	14.02±0.99	5.48±1.03	5.18±0.51	3.35±0.82
Continous	7.94±1.64	2.47±0.79	2.56±0.83	2.90±0.57
P-Value	0.000	0.000	0.000	0.175

sheath and axon growth were assessed qualitatively based on the fiber, myelin sheath and axon growth. Ultrastructural assessment was made qualitatively for Wallerian degeneration and regeneration. Regeneration was confirmed by the presence of Schwann cells and evidence of myelin sheath renovation and the presence of regenerated fibers in the distal fragment.

Results

Twenty-five dogs were followed for 6 weeks and their sciatic nerves were harvested for examination. The time of surgery was compared between the classic and continuous groups. The total tme needed to repair the nerve was significantly less in the continuous (7.94 ±1.64 minutes) then the classic group (14.02±0.99 minutes), (P<0.0001), though the time required for placing the stay sutures was comparable, P=0.175 [Table 1].

The amount of consumed string was significantly less in the continuous group (P=0.003). The light microscopic examination parameters (axon diameter, nerve fiber diameter and the myelin layer diameter in the distal segment) did not show statistically significant difference, while the difference among these groups and the control and witness groups was significant [Table 2].

Ultrastructural findings showed that the degeneration phenomenon was similar in the proximal and distal segments of the classic and intervention groups, with more severe changes in the classic group. Evidence of regeneration was observed in the distal segment of the continuous group only [Figure 2-4].

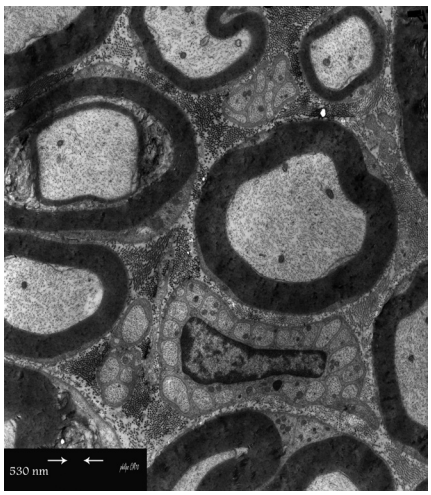

Figure 2. Normal sciatic nerve section iin electron microscopic examination.

Table 2. Light microscopic findings of the study

	Axon diameter (micrometer)	Myelin diameter (micrometer)	Nerve fiber diameter (micrometer)
Classic	6.35	2.88	3.34
Continous	5.95	2.99	3.11
Control	3.53	1.1	2.1
Normak nerve	12.4	4.63	7.77

Discussion

The theory suggesting that probably the repair of a damaged peripheral nerve would not absolutely be undertaken with seprate sutures is the main finding of this study.

In this study we introduced a new and simple method to repair a cut nerve due to acute sharp trauma and the results of this study indicate that this method is probably as effective as epineural repair. If this result is confirmed in larger, human studies, this method could be recommended as an effective and simple method to repair peripheral nerves.

Neural injuries are common and well known in traumatology. It is reported that 5% of all trauma cases include peripheral nerves and approximately 100,000 patients every year in the USA and Europe undergo surgery for such injuries (8). After a peripheral nerve is severed the only way to achieve function (sensory or motor) is end-to-end repair. Many factors affect the final outcome such as: severity of the primary injury, injury location, time of repair, patient factors and of course surgical techniques (9).

In this study we tried to choose similar groups in the interventions. It should be noted that peripheral nerve repair is not cellular surgery, rather a connective tissue surgery with the aim of apposition of two healthy distal and proximal stamps. We can divide repair methods of a

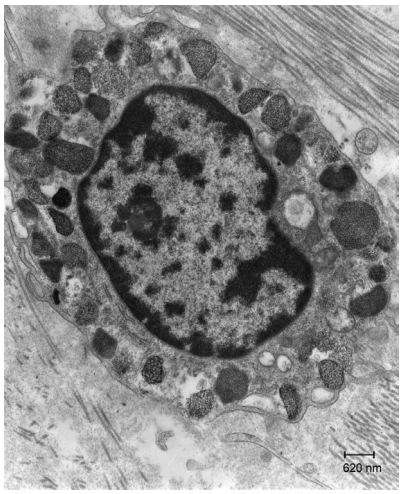

Figure 3. A macrophage containing phagocytized nerve fragments (degeneration).

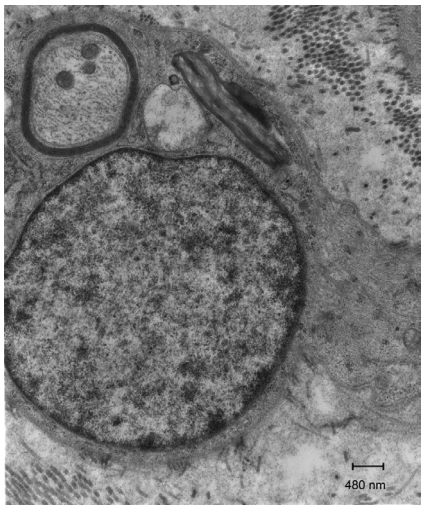

Figure 4. Regneration, a large schwan cell with big nucleus and myelin sheeth.

cut nerve into two groups: direct repair and neural grafts. The direct repair is done when there is no anatomical defect and many methods have been suggested for it such as epineural repair, group fascicular, epineural and epiperineural. Each of these methods has its own benefits and disadvantages. Overall, the epineural method is the standard method (6). Although fascicular repair may afford more accurate anatomical apposition, studies have not proven its superiority in practice (10-13). In theory, scar formation is more severe in this method, so that placement of smaller number of sutures has been advised at times (14, 15). All of the studies in this field are relatively old and to the best of our knowledge no studies have been performed on the topic in recent years.

Separate suture utilization is the standard method in vascular and microsurgery and other methods have been compared with it (16); the main reason is the theoretical disadvantage of suture site pursing (17). But in these operations usage of continuous sutures has been examined and its efficacy proved (18-21), although complications such as string rupture and knot entrapment in vascular clips have been reported (22). We could not find any study or report about nerve repair with continuous sutures; however, we can assume that the most important challenge with this method is similar to what was mentioned in vascular surgery: fear of pursing and pressure on the nerve. The suggested method prevents this difficulty and is as effective as the standard method.

The most important advantage of the continuous repair method in vascular surgery has been mentioned to be significant decrease in operation time (23). Again we think the most important advantage of the suggested method in nerve repair surgery would be significant decrease in surgey time, lowered by half as was observed. On the other hand, the amount of consumed material would decrease significantly and theoretically coverage of repair site would take place better.

We used light microscopic examination to assess regeneration and an electron microscopy to confirm our results (24, 25). Another method that we could have used was electrodiagnostic studies (26). Lack of their usage in this present study, surely a limitation, was due to the fact that our follow up was too short for the electrodiagnostic findings to be of value. The short follow up, in turn was because of some animal loss due to sepsis, which induced the fear of more losses with a longer follow up. In fact, sepsis would kill the animal in less than 24 hours, and so we decided to end the study before other animals would show signs and symptoms of sepsis.

It must be emphasized that the lack of visualization of the regeneration phenomenon in the standard method group does not mean that this method is not effective. In fact regeneration phenomenon visualization is a strong evidence for its occurrence, but lack of visualization is completely accidental and most probably due to the fact that we prepared few electron microscopic samples because of high costs. However, the electron microscopic examination for the purpose is completely valid (27-30).

The proposed method does have some disadvantages: It is only suitable for sharp and fresh traumatic nerve injuries and where the nerve ends reach easily and without tension, the nerve should have a considerable diameter and for example in a neonate with digital nerve injury there is no place for it, it is not applicable to cases in which group fascicular repair is indicated (e.g. ulnar nerve at wrist) and finally the possibility of suture failure after repair.

The most important limitation of the present study is the relatively short follow up period, so that we could not prove the efficacy of the suggested method in practice and with observing the return of function. This was because of unpredicted loss of animals despite our best efforts. Again, the fact that we did not perform an electron microscopic examination on all of the specimens because of cost certainly is a limitation.

According to the results of the present study, we feel that separate suture placement is not a necessity in the repair of a severely injured peripheral nerve and the described method, though surely accompanied with some flaws can replace the standard method in certain situations.

Alireza Saied MD
Majid Asadi Shekaari PhD
Amirreza Sadeghifar MD
Kerman Neuroscience Research Center, Dr Bahonar Hospital, Kerman University of Medical Sciences, Kerman, Iran

Ali Karbalaeikhani MD
Veterinary Medicine Department, Kerman University of Medical Sciences, Kerman, Iran

References

1. Seddon HJ. The use of autogenous grafts for the repair of large gaps in peripheral nerves. Br J Surg. 1947;35(138):151-67.
2. Zeev-Brann AB, Lazarov-Spiegler O, Brenner T, Schwartz M. Differential effects of central and peripheral nerves on macrophages and microglia. Glia. 1998; 23(3):181-90.
3. Tupper JW, Crick JC, Matteck LR. Fascicular nerve repairs. A comparative study of epineurial and fascicular (perineurial) techniques. Orthop Clin North Am. 1988; 19(1):57-69.
4. Hurst LC, Badalamente MA, Ellstein J, Stracher A. Inhibition of neural and muscle degeneration after epineural neurorrhaphy. J Hand Surg Am. 1984; 9(4):564-72.
5. Boedts D. A comparative experimental study on nerve repair. Arch Otorhinolaryngol. 1987; 244(1):1-6.
6. Birch R. Nerve Repair. In: Wolfe SW, Pederson WC, Hotchkiss RN, Kozin SH (editors). Green's operative hand surgery. 6th ed. philadelphia: Elsevier, Churchil Livingstone. 2010; Chapter 32.
7. Schlechter B, Guyuron B. A comparison of different suture techniques for microvascular anastomosis. Ann Plast Surg. 1994; 33(1):28-31.
8. Noble J, Munro CA, Prasad VS, Midha R. Analysis of upper and lower extremity peripheral nerve injuries in a population of patients with multiple injuries. J Trauma. 1998; 45(1):116-22.
9. Jobe MT, Martinez SF. Peripheral nerve injuries. In: Canale ST, Beaty JH (editors). Campbell'soperative orthopedics. 11th ed. Philadelphia: Pensylvania. 2008; p.3651–2.
10. Hudson AR, Hunter D, Kline DG, Bratton BR. Histological studies of experimental interfascicular graft repairs. J Neurosurg. 1979; 51(3):333-40.
11. Bratton BR, Kline DG, Coleman W, Hudson AR. Experimental interfascicular nerve grafting. J Neurosurg. 1979; 51(3):323-32.
12. Lundborg G, Rosén B, Dahlin L, Danielsen N, Holmberg J. Tubular versus conventional repair of median and ulnar nerves in the human forearm: early results from a prospective, randomized, clinical study. J Hand Surg Am. 1997; 22(1):99-106.
13. Levinthal R, Brown WJ, Rand RW. Comparison of fascicular, interfascicular and epineural suture techniques in the repair of simple nerve lacerations. J Neurosurg. 1977; 47(5):744-50.
14. Brushart TM, Tarlov EC, Mesulam MM. Specificity of muscle reinnervation after epineurial and individual fascicular suture of the rat sciatic nerve. J Hand Surg Am. 1983, 8(3):248–53.
15. Ogata K, Naito M. Blood flow of peripheral nerve effects of dissection, stretching and compression. J Hand Surg Br. 1986, 11(1):10–4.
16. Butler PE, Sims CD, Randolph MA, Menkes D, Onorato J, Lee WP. A comparative study of nerve healing in adult, neonatal, and fetal rabbits. Plast Reconstr Surg. 1999; 104(5):1386-92.
17. Schlechter B, Guyuron B. A comparison of different suture techniques for microvascular anastomosis. Ann Plast Surg.1994; 33(1):28-31.
18. Lee BY, Thoden WR, Brancato RF, Kavner D, Shaw W, Madden JL. Comparison of continuous and interrupted suture techniques in microvascular anastomosis. Surg Gynecol Obstet. 1982; 155(3):353-7.
19. Wheatley MJ, Mathes SJ, Hassett C. Comparison of continuous and interrupted suture techniques in microvascular end-to-side anastomosis. J Reconstr Microsurg. 1986; 2(2):93-6.
20. Peerless SJ, Gamache FW Jr, Hunter IG. Continuous suture method for microvascular anastomosis: technical note. Neurosurgery. 1981; 8(6):695-8.
21. Firsching R, Terhaag PD, Muller W, Frowein RA. Continuous and interrupted suture technique in microsurgical end-to-end anastomosis. Microsurgery. 1984; 5(2):80-4.
22. Hamilton RB, O'Brien BM. An experimental study of microvascular patency using a continuous suture technique. Br J Plast Surg. 1979; 32(3):153-4.
23. Chen L, Chiu DT. Spiral interrupted suturing technique for microvascular anastomosis: a comparative study. Microsurgery. 1986; 7(2):72-8.
24. Canpolat L, Kunkner A, Canpolat I, Ozan E. Ultrastructural and morphometric analysis of peripheral nerve regeneration within silicone tubes. Tur J Med Sci. 1999; 29(2):203-10.
25. Goel RK, Suri V, Suri A, Sarkar C, Mohanty S, Sharma MC, et al. Effect of bone marrow-derived mononuclear cells on nerve regeneration in the transection model of the rat sciatic nerve. J Clin Neurosci. 2009; 16(9):1211-7.
26. Navarro X, Udina E. Chapter 6: Methods and protocols in peripheral nerve regeneration experimental research: part III-electrophysiological evaluation. Int Rev Neurobiol. 2009; 87(23):105-26.
27. Goel Rk, Suri V, Suri A, Sarkar C, Mohanty S, Sharma MC, et al. Effect of bone marrow-derived mononuclear cells on nerve regeneration in the transection

model of the rat sciatic nerve. J Clin Neurosci. 2009; 16(9):1211–7.

28. Canpolat L, Kunkner A, Canpolat I, Ozan E. Ultrastructural and morphometric analysis of peripheral nerve regeneration within silicone tubes. Tur J Med Sci. 1999; 29(2):203-10.
29. Silva-Neto JC, Vavsconcelos BC, Silva-Júnior VA, Beder-Ribeiro CM. Functional histopathological and morphometric study of the use of gangliosides in nerve regeneration in rats after axonotmesis. Int J Oral Maxillofac Surg. 2009; 38(6):682–8.
30. Ding T, Luo ZJ, Zheng Y, Hu XY, Ye ZX. Rapid repair and regeneration of damaged rabbit sciatic nerves by tissue-engineered scaffold made from nano-silver and collagen type I. Injury. 2010; 41(5):522–7.