X-ray follow up of end-to-end nerve repair site: A new technique, Nerve Repair Site Marking (NRSM)

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ABSTRACT

Objective: An end-to-end nerve repair site always has the risk of rupture and nerve healing failure. In observing the nerve healing site and nerve anastomosis after surgery, here, a new simple and cost-effective technique, “Nerve Repair Site Marking” (NRSM), is defined.

Methods: During primary or secondary nerve repair, to see the continuity of the repair site, a new technique was employed - NRSM. After coaptation of the nerve at any site of the body and when repairing under tension, 1 cm proximal and 1 cm distal of the suture site, the epineurium was marked with a titanium hemoclip. During the first 6 weeks post-surgery, X-rays of the repair site were taken every week and the distance between the hemoclips was measured.

Results: Since 2006, in 23 patients, 25 nerves underwent end-to-end repair (brachial plexus and peripheral nerves), was conducted under tension and if there was the risk of rupture of the repair site, NRSM was employed. All patients were followed up with X-ray of the repair site every week, especially during the first 4 weeks and at the end of 6 weeks. If the patients lived far away from the clinic, they sent their repair site X-rays. Only one patient had rupture of the repair site, and it was just after surgery and repaired immediately.

Conclusion: To get the best results following end-to-end nerve repair, nerve continuity must continued, though there is always the risk of rupture at the repair site. As ultrasonography and MRI can be utilized to examine the repair site, they are not helpful in brachial plexus repairs, are expensive and can be time-consuming when employed with peripheral nerves. NRSM is an easy, objective, and cheap follow-up technique after nerve repair and provides a chance for early re-repair.

Key words: Nerve repair, nerve repair site marking, nerve repair follow-up

Introduction

End-to-end nerve repair is the best choice of treatment in the case of nerve injuries [1-4]. After trimming the nerve ends, or neuroma excisions, a certain amount of gaps are present. Maintenance of coaptation can be possible by joint positioning, nerve rerouting and transposition or bone shortening [1-4]. Primary or secondary late nerve end-to-end repairs are sometimes performed under tension. It is still not known if there is a safe gap tension for primary nerve suture, however it is understood that end nerve repair always yields better results than other techniques [1,3]. During nerve repair follow-up, one is able to test continuity with Tinel's sign and ultrasonography when the nerve is superficial [1,4-8].
It is difficult to test continuity at certain areas, like the brachial plexus or when the nerves are deeply located. When looking for the best results after nerve repair, time is limited. One must take notice as soon as possible when the repair site deviates from continuity [4].

Method

Between 2006 and 2015, 23 patients (25 nerves) were end-to-end repaired under tension. All nerves were repaired between one week and one year secondarily. 16 patients were male and 7 were female. The age of the patients was between 3 months to 54 years (mean age: 20.1 years). 9 brachial plexus, three sciatic, one tibialis posterior behind knee, two peroneal (near knee joint), one musculocutaneous, three radial, one femoral, two median, two ulnar and one digital nerve were secondarily repaired. After trimming the nerve ends till to point at which healthy nerve axons were observed, nerve end-to-end repair was conducted under moderate tension. If the gap did not allow coaptation, joint positioning, nerve rerouting and transpositions were performed but no bone shortening technique was used. If there still a gap between the nerve ends, nerve grafting was carried out, but severe tension was not acceptable. This method was not used when there was no tension at the nerve ends during nerve repair. When it was believed that there was risk of repair site rupture, markings were utilized. For testing nerve tension, one 8-0 suture was used. If this suture held the nerve ends together, end-to-end suturing was performed and it was believed that it was safe when considering the risk of rupture.

The epineural suture technique was used during nerve repair. After coaptation of the nerve under moderate tension, in general, 1 cm proximal and 1 cm distal of the suture site, the epineurium was marked with a titanium hemoclip without touching the axons, and the distance between the clips were noted in the surgery report because, occasionally, the markings were made more closely but not more near than 0.5 cm to the repair site. The 0.5 cm distance was limiting as it could cause foreing body reaction and fibrosis near the repair site (Figures 1A and 1B, Figures 2A and 2B). In the first 6 weeks post-surgically, X-ray review of the repair site was undertaken and the distance between the hemoclips was measured.

Results

All patients were followed up by X-ray of the repair site every week, especially during the first 4 weeks and at the end of 6 weeks. If the patients lived far away from the author’s clinic, they sent their repair site X-rays. X-rays measuring the distance between the markings were taken. No patients had re-rupturing of the
repair site excepting one. That patient, who had siatic nerve total rupture after knife injury 5cm distal to ischium bone, was operated on previously in another hospital. The patient was seen one year after the injury and had no signs of healing. MR tractography showed a 5 cm defect of the siatic nerve. The patient was operated on after neuroma excision and nerve mobilization end-to-end repair was possible, and to increase success, the nerve grafting option was not selected. Large hemoclips were put on to the nerve epineurium proximally and distally 1 cm from the repair site. Long leg cast splints were applied and the knee was at 70 degrees flexion. After taking the patient to the bed, the nerve coaptation area was screened under fluoroscopy and it was seen that one marking was missed. The patient was immediately operated again, and after repairing the nerve for the second time, a body cast was created such that the hip was immobilized at extension and the knee at 70 degrees flexion. Each week, a hip anteroposterior X-ray was taken and the distance between the markers was measured for 6 weeks (Figures 3A and 3B).

Discussion

Nerve repair time is important and classified as primary repair (0-7 days) immediately (0-48 hr), delayed (3-7 days) or secondary repair (after 1 week), early (1-3 week), late (after 3 week) [2-4]. In every stage end to
End repair is sometimes possible. (Figures 4A and 4B). End-to-end nerve repairs always yield the best results [1-4]. Surgeons did not have any routine practice and objective technique to follow up the continuity of the end to end repair site of peripheral nerves after surgery. There is always the risk of the repair site re-rupturing (Figure 5). Imaging of the nerves is difficult but possible. Ultrasonography is a solid choice for superficial peripheral nerves, while MRI or MRI tractography is also helpful for most other nerves, except digital nerves [5-7].

For robust visualization, the ultrasonography device needs high-resolution broadband transducers, real-time spatial compound ultrasonography imaging and artifact reduction software processing [6]. These features tremendously increase image quality and permit evaluation of the normal anatomy and disorders of the peripheral nerves [6]. Since the extremity is immobilized with casting or splinting after nerve repair, ultrasonography is impossible to be done without removing the immobilization device and painful because the operation site is new.

Ultrasonography can demonstrate the loss of continuity of the nerve bundle with or without gap and neuroma formation [6]. Ultrasonography can also provide valuable information about a repaired nerve postoperatively, but visualization of the site of nerve coaptation may be problematic as a consequence of extensive scar tissue in a number of cases [6]. The quality of nerve repair can also be assessed by ultrasonography [6].

Nerve ultrasonography must be conducted in the axial position because the longitudinal plane may cause confusion of the nerve with the tendons. With this, MRI is an expensive technique. When the continuity of the nerve is totally disturbed, both ultrasonography and MRI are beneficial [5]. That said innovations in MRI technology have resulted in improved visualization of nerves [6].

Based on the fact that end-to-end nerve repair results are always better than with other techniques, even secondary nerve repair must be performed end-to-end under moderate tension and limited nerve mobilization if possible [1-4]. Retraction of the nerve stump (elastic recoil) and neuroma formation increases the
gap after trimming the nerve ends [1]. Dissection of the nerve from the surrounding tissue over 2 cm increases scar formation and over 3 cm causes dissection that decreases blood flow to the nerve. To maintain the coaptation of the nerve ends, joint positioning, nerve re-routing and transpositions along with bone shortening techniques can be used. With these procedures, ulnar and radial nerve gaps can be closed up to 3 cm [1]. When the nerve is repaired under moderate tension, most commonly, joint positioning is employed. Follow-up of the repaired nerve should include testing with Tinel’s sign, ultrasonography or MRI, but these techniques are not utilized routinely [1,2,5-8]. Re-rupture of the nerve can occur in the first 3-6 weeks after surgery and that is why immobilization after repair is advised [1,3,4,8].

Pain after surgery at the site of nerve repair is a sign of neuroma formation because of partial or total rupture of the sutured nerve (Figure 5) [7]. Various authors believe that 3 weeks of immobilization is enough for end-to-end repair [8], however, a number of them continue immobilization for six weeks [1,3,4] and describe Tinel’s sign as not being helpful during this period. Ultrasonography and MRI are both time-consuming, expensive and require experience. When the NRSM technique is made use of with a one plane X-ray, it proves to be an easy, cheap, practical and objective technique for observing continuity of the repair site. During surgery, the distance between the epineurial hemoclips is known and after taking an X-ray, it is also very easy to measure the distance between the markings. NRSM can be used in any nerve repair, even after digital nerve repairs, by using minihemoclips (Figure 6). The author did not notice any side effects from using titanium hemoclips. They can be easily affixed to the epineurium of every nerve. The important factor to consider during surgery is that hemoclips of the same size are also used for bleeding control in the nerve repair area and cannot be followed up with because of mixing. Bleeding can be controlled by vessel ligation or NRSM hemoclips of different sizes (Figure 7).

**Conclusion**

With End-to-end nerve repairs, especially when performed secondarily, there is always at least moder-
pairs, they are deemed expensive and time-consuming. The NRSM technique is a simple method to follow-up the nerve repair site easily, objectively and cost-effectively. This technique has no known morbidity or side effects.

Conflict of interest statement
The authors have no conflicts of interest to declare.

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