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How to do an outside-in/outside-in microsuture for nerve repair

Peripheral nerve injuries are common and debilitating. Epineural repair with microsutures remains the gold standard of management for severe axonotmesis and neurotmesis injuries, with the goal to allow reinnervation of target organs by guiding regenerating sensory, motor and autonomic axons into the environment of the distal nerve with minimal axonal loss at the suture line.[1] These same principles are critical for the success of nerve transfers, which have revolutionized the management of central and peripheral nerve injuries. Technically, microsutures need to be tension-free and avoid engagement with neural tissue, facilitating precise apposition of nerve ends in a well vascularized bed to allow regeneration of as great a proportion of injured axons as possible.

In particular, external sprouting of fascicles must be avoided, and the neurorrhaphy should be covered by epineural tissue with no interposition into the repair itself. This can be difficult to achieve, particularly in small diameter nerves that have been traumatized. Animal studies have shown that a snug tubular enclosure [via nerve tubes] reduces extra-fascicular axonal escape during nerve repair.[2] Thus, it stands to reason that circumferential draping of well-opposed neural elements via an everted epineural sheet will similarly prevent fascicular protrusion and promote axonal regeneration at the suture line. Here, we describe a modification of standard microsuturing which allows superior epineural eversion and fascicular coaptation.

The technique for an eversion suture is as follows. Both nerve ends are identified and visualized – although the nerve can be mobilized at either end to aid opposition, extensive mesoneurial stripping should be avoided.[3] The nerve ends are prepared by progressively cutting back 2 mm segments with micro-scissors until spouting fascicles are visualized. Correct orientation is achieved by aligning blood vessels and other epineural markings, and matching the arrangement of fascicular bundles.[3] Nerve repairs must be tension free to succeed – if a neurorrhaphy is performed for nerve transfer, adequate length can be achieved by nuerotomies performed via the 'donor distal and recipient proximal' principle.

In a standard microsurgical suture for nerve repair, the needle is passed through the epineurium in an out-to-in direction on one nerve end, with care taken to not penetrate the fascicles. The needle is then inserted in an in-to-out direction on the opposing nerve end, before the knot is tied.[4]

In this modification, the needle is passed through the epineurium in an out-to-in direction on one nerve end, before being passed in the same direction on the opposing nerve end (Fig. 1). This results

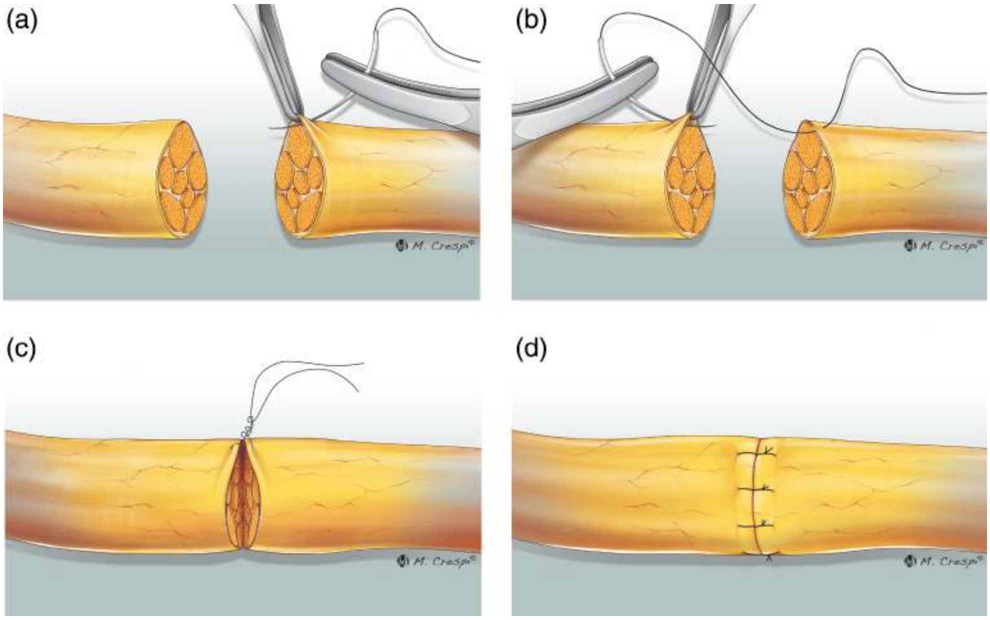

Fig. 1. Needle passed in out-to-in direction through both ends, resulting in figure-of-8 construct when viewed from sagittal aspect, allowing tension-free coaptation without fascicular protrusion or epineural interposition.

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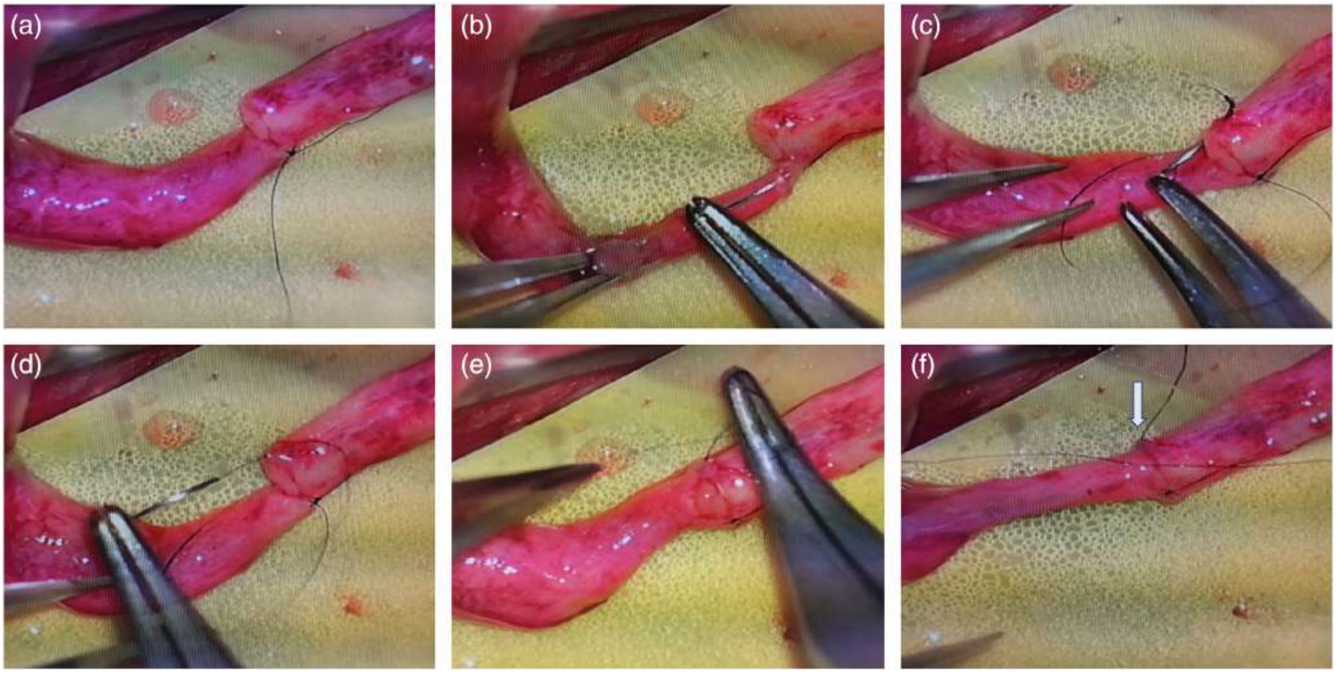

Fig. 2. Clinical demonstration of outside-in/outside-in microsuture for nerve coaptation.

in a figure-of-8 suture when viewed from the sagittal profile. The configuration of this suture facilitates epineural eversion whilst preventing fascicular protrusion through the repair site. The knot is tensioned by pulling the suture ends in line with the site of neurorrhaphy – care is taken to ensure adequate fascicular approximation without a gap, whilst avoiding bunching, twisting or protrusion of the fascicles. Similar eversion sutures placed around the nerve's circumference afford a tension-free coaptation and circumferential epineural coverage without fascicular protrusion, whilst avoiding epineural interposition between neural elements. The number of sutures required vary according to the size of the nerve – three to four sutures are usually sufficient for neurorrhaphy of a digital nerve, whilst repair of a larger nerve trunk may necessitate more (Fig. 2).

The outside-in/outside-in suture enables eversion by design, with each epineural end gliding along the monofilament suture which passes from deep to superficial as the knot is tensioned, preventing epineural interposition within the repair. We believe that utilization of this suture theoretically aids in achieving maximal nerve recovery following repair. Although a possible disadvantage may be increased risk of scarring due to greater interposition of suture material within the epineurium, we have not noticed any anecdotal difference in nerve recovery or function. Further *in-vitro* comparison of this suture to standard microsurgical repairs would be useful.

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Author contributions

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