Chapter 10

10 Nerve Reconstruction by Means of Tubulization

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10.1 Clinical Background

Injuries of peripheral nerves are regularly seen in trauma and hand surgery. The impact of the loss of motion and sensitivity often puts the treatment of nerve injury at the center of interest. Incomplete nerve regeneration could lead to permanent severe impairment of hand function. This and the microsurgical techniques needed for reconstruction place high demands on the attending surgeon.

Direct, tensionless suture is the method of choice for the treatment of partially or completely disrupted nerves. However, if tensionless approximation of both nerve stumps cannot be achieved, direct suture is not acceptable because tension on the suture line severely impairs nerve regeneration [19]. Nerve gaps can originate either from trauma, from nerve retraction at the time of secondary reconstruction or from nerve resection. The gold standard for the reconstruction of peripheral nerve gaps is the nerve autograft. Usually, sensitive skin nerves such as the sural nerve or the medial cutaneous nerve of the forearm are used for grafting.

However, nerve harvesting inevitably leads to donor site morbidity, which can include loss of sensitivity, scarring and neuroma formation.

In injuries of small, solely sensitive nerves such as the digital nerves, the risks and benefits of nerve grafting have to be considered thoroughly. Artificial nerve tubes could help avoid donor site morbidity. The tubes are inserted between the proximal and distal nerve stump and act as a growth chamber for the regenerating nerve. The longitudinal direction of growth is determined and scarring from the surrounding tissue can be eliminated from the lumen.

Nerve reconstruction by means of tubulization was first mentioned in the late 19th century. Since then, numerous materials in various shapes have been tested for efficiency [8, 12, 17]. Experiments on animals have increasingly concentrated on the use of growth factors, modifications of the intrinsic framework and the incorporation of living cells [9, 13].

Simple, mostly hollow tubes have already crossed the barrier into clinical practice [14, 15]. Today, several conduits made of synthetic, biodegradable materials are approved for clinical application. Various results on the effectiveness of these conduits have been published by different studies in the literature [1, 2, 4, 6, 7, 10, 11, 15, 21, 24, 28].

10.2 Tubulization as an Alternative to Nerve Grafting

Since nerve grafting is limited in terms of donor site morbidity and the available amount of donor nerves, the search for alternatives continues [17].

The underlying idea of tubulization is to secure a growth chamber where neurotropic and neurotrophic substances of both nerve stumps can promote and direct nerve regeneration [14, 28]. The use of hollow conduits is limited to gap lengths of up to 30 mm in humans. The aim of animal and clinical research is the improvement of the growth-promoting abilities of the artificial nerve graft [8, 17].

Synthetic tubes help to avoid donor site morbidity and are available in random amounts at the primary surgery. Non-resorbable tubes show the drawback of secondary nerve compression and frequently have to be removed in a second operation [14]. Thus, biodegradable materials such as collagen or polyglactin have become accepted in clinical practice.

The use of conduits of biologic origin is still controversial. Muscle grafts and vein conduits have been used in the first instance [5, 22, 27]. Results are partly promising, but the methods also require donor sites. In addition, hollow vein conduits could collapse and thus fail to secure an open lumen.

Commercially available conduits made of synthetic
polymers or collagen seemed to yield comparable results, but a direct comparison has not yet been performed. Several authors have gained good results by reconstructing nerve gaps of up to 30 mm by means of tubulization [2, 6, 11, 15, 21, 28]. Individual cases of successfully bridged distances of 40 mm have also been reported [1, 4, 10]. On the European market, nerve tubes up to 40 mm in length can be purchased. Their use should be limited to gaps of less than 30 mm. The internal diameter ranges from 1.5 to 10 mm.

10.3 Surgical Procedure

Surgery on the peripheral nerve requires microsurgical techniques. Following debridement and neurolysis if applicable, the nerve stumps are located with one or two suture of 10/0 nylon and inserted into the moistened tube with an overlap of 2–3 mm. Tubulization has to be performed after release of the tourniquet to prevent bleeding into the conduit. After finishing each coaptation, the lumen has to be rinsed with normal saline or electrolyte solution using a small cannula to remove any remaining blood clots.

Antibiotic treatment is partially described in the literature [28]. We chose the single shot intravenous treatment with 1.5 g cefuroxime. Immobilization of the adjacent joints is advisable for at least 14 days. Massaging the scar should be avoided due to the risk of dislocation of the tube in the first weeks following the operation.

10.4 Clinical Experience

Tubulization seems equally appropriate for primary and secondary nerve reconstructions, as well as for reconstruction after neuroma resection [1, 10, 11]. Although the capacity for nerve regeneration diminishes in the elderly [16], good results are possible in patients older than 65 years [1, 2, 28]. Increasing the length of defect diminishes the prognosis of regeneration. Crushing or avulsion injury can have the same impact on outcome, compared to a clean cut of the nerve [28]. Cases of rejection or allergic responses have not been reported so far. However, scar sensitivity or palpability of the conduit has been mentioned in some trials [24]. In general, nerve reconstruction even with an excellent surgical technique could lead to significant failure in nerve regeneration. After direct suture or nerve grafting, a detectable 2-point discrimination was achieved only in about 80% of cases [16, 23, 26]. It is likely that favorable results following tubulization are also highly dependent on the experience of the surgeons in carrying out end-to-end nerve repair [16, 18].

In our clinical experience of 13 reconstructed digital and palmar nerves using collagen conduits (Fig. 10.1),