Combining an External Fixator and an Artificial Nerve-Guide for the Treatment of a Complex Digital Injury

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Abstract A complex digital injury, with tendon, nerve and bone losses, may pose the problem of which structure deserves the highest priority. Authors were able to treat tendon, nerve and bone lesions with the same level of priority thanks to the combined use of an external fixator and a nerve-guide.

Keywords External fixator · Finger · Nerve-guide · Trauma

Introduction

A complex digital injury, with tendon, nerve and bone losses, may pose the problem of which structure should deserve the highest priority for treatment and which may be, if needed, sacrificed.

In the literature there are reports about the application of the so-called “mini-fixators” in fractures of the phalanx or in post-traumatic rigidity of fingers or in Dupuytren’s contracture [1–3]. Mini-fixators are often scaled-down versions of standard external fixators used for long bones of the limbs and may arguably present the same advantages when applied in open and contaminated lesions (little invasiveness) and the same disadvantages in regard to mechanical performance (little control of bending and torsion).

Artificial nerve guides (or conduits) have been introduced into clinical practice since about 20 years as a reliable alternative to nerve autograft; they are basically cylindrical conduits inside which a regenerating nerve stump may find

protection and guidance [4–7]. Their application in digital nerve injuries offers a good alternative for those patients which refuse the morbidity associated with the donor site or do not accept the simple excision of the nerve stumps with the associated loss in local sensitivity.

In the case reported, Authors were able to treat tendon, nerve and bone lesions with the same level of priority thanks to the combined use of an external fixators, a nerve-guide and a standard tendon repair; they propose this association for similar cases of complex digital injuries.

Case Report

A 25 old Caucasian male suffered an exposed fracture of the middle phalanx of the index finger of the left hand while using a motorized circular saw. The middle third of the phalanx was avulsed in a distal-proximal oblique fashion but the ulnar neuro-vascular bundle was spared. The bone of the middle third of the phalanx was lost; the extensor tendon was severed and there was a partial lesion of the radial side of the deep flexor tendon close to its bony insertion; the radial neurovascular bundle was torn away.

The sudden impact of the circular blade produce a dorsal dislocation of the distal stump at 180°; this, probably, triggered a reflex spasm in the preserved ulnar vascular bundle that made the patient reaching the emergency department with a severe cyanosis of the distal stump. Reduction and stabilization was attempted in the Emergency which resulted in the reinstate of the vascular supply. The patient was referred to immediate surgery in the specialized Hand Surgery Unit.

We decided to preserve bone length and distal inter-phalangeal (DIP) and proximal inter-phalangeal (PIP) joints mobility by applying an external fixator to the fractured bone

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ends of the phalanx (Laki, Plustec, Milan, Italy). Not-threaded pins were inserted carefully, caring to obtain the desired position during the first attempt. This was done to avoid a successive re-positioning which would likely compromise the mechanical grip of the pin. A “Brunelli” pull-out button-suture was used to treat the extensor tendon injury (also referred as the “Mantero” procedure). A simple suture was deemed enough for the partial lesion of the deep flexor tendon.

While exploring the complete avulsion of the radial neurovascular bundle, we discovered a still recognizable distal nerve stump. We implanted a treated-collagen nerve-guide, a bioresorbable cylindrical conduit with a 2 mm lumen which bridged the gap between the stumps (Neuragen, Integra, Plainsborough NJ, USA). A not-degradable Prolene 7-0 suture was used to secure the guide in place, using only one knot for each stump. We pierced the epineurium about 2 mm far from the trimmed end of each stump.

Active DIP and PIP joints motion was allowed immediately after surgery (Fig. 1). The fixator was in place for 73 days; then consolidation of the fracture was judged adequate for removal (on the basis of radiological findings). Successive x-ray films showed the progressive filling-up and remodelling of the post-traumatic bone defect. After 96 days a second-look at the nerve-guide was attempted; “roof-opening” of the guide revealed a regenerated nerve tissue. It was possible to slip apart the guide and remove most of it. From the clinical point of view, the patient never experienced any painful neuroma

sensation. Sensory recovery occurred gradually, covering the area of pertinence of the affected branch; it was judged clinically adequate in about 6 months.

The patient returned to full working activities after 111 days. A deficit of about 15° remained to reach a full DIP joint extension but the patient did not complain for that (Fig. 2).

Discussion

Circular saw injuries often require immediate treatment for the involvement of vascular structure. They also produce severe bone loss and/or fracture which require the correction of the shortening and/or of the deformity of the segment involved. Severity of tendon and nerve lesions is determined by the avulsion mechanism of the injury; in our opinion this is particularly worrying for the nerve, where the extent of the avulsion damage is sometimes difficult to assess in the emergency.

We examined several possible options for the bone and for the nerve injuries. Bone grafting and internal fixation of the complex fracture was discarded because of the high risk of infection in a contaminated wound and the associated morbidity of the bone donor site. Percutaneous cross-pins fixation of the middle phalanx seemed unfeasible due to the vast loss of bone and, also, it was likely to be unable to assure a stable alignment and length. Shortening of the phalanx and internal fixation could associate the risk of infection with the

Fig. 1 Complete bone loss of the middle third of the phalanx in an oblique distal-proximal fashion (a). Intraoperative pinning of the exposed lesion (b). A nerve-guide (between arrows) bridging the nerve stumps (c). Extension (d) and flexion (e) of the DIP and PIP joints which is allowed by the external fixator in place

Fig. 2 “Roof-opening” and slipping upwards the nerve-guide (arrows) revealed a regenerated tissue (dotted lines) after 3 months (a); the removed portion of the guide was only mildly degraded (b). After 7 months antero-posterior (c) and latero-lateral (d) x-rays films show regeneration and remodelling at the site of bone loss, with proper length and alignment of the phalanx. A deficit of about 15° remained to reach a full DIP joint extension (e), however the patient returned to full working activities after 111 days from trauma (f)

tendon imbalance eventually resulting in a permanent loss of proper length and range of motion (a great limitation for the role of the Index finger). Percutaneous transfixation all along the three phalanx was a simple option but would have prevented early mobilization of the PIP and DIP, becoming detrimental for the possible recovery of joint motion and for the prevention of tendinous adhesions. Treatment of tendon lesions has established protocols and there is wide acceptance that preserving an early active motion is of extreme importance to promote a good functional outcome [8, 9].

The reasons for choosing the external fixator were: (a)-the low invasiveness which is desirable in an open and contaminated fracture; (b)-the early mobilization allowed for the PIP and DIP joints; (c)-the possibility to suture the tendons at their physiological length; (d)-the possibility to eventually adapt for a phalanx length shortening in case it would have been required in a successive stage. Early active motion was among the biggest advantage for the patient, in our opinion.

One-side digital nerve lesions are generally considered of little importance because, often, a good degree of compensation in sensation may come from an intact contralateral nerve ramus. However, permanent or diminished loss of sensation is experienced as an inhabilitating condition by most patients. In our case, a direct end-to-end suture would have been unfeasible due to the gap produced, further increased by the trimming of the stumps. Reverting the treatment plan to a phalanx shortening was not justifiable, in our opinion, on the basis of the nerve repair alone. The nerve guide was applied to bridge the nerve gap and protect a possible regeneration in a movable finger; if

restoration of sensation would not occurred, a second goal would have been to avoid a painful neuroma.

Our preference for collagen nerve-guides is related to their longer degradation time in respect with poly-Glycolic-acid guides and their easier implantation technique (in our experience) in comparison with poly-Lactic-acid guide.

In our protocol for nerve-guide implantation, we propose a successive operation to explore and eventually roof-open (or remove), with the consent of the patient, the implant. That is done even if the device is degradable and the rationale relies on the fact that “degradation” of an artifact should not be considered in terms of actual time needed for the in-vitro or in-vivo processes to occur but should be correlated with the duration of the healing process with which it interacts. As the regenerating nerve continues to increase its cross-section, a conflict may arise. An oscillatory process may ensue, with a degrading guide too slowly adapting to an expanding nerve on one side and, on the other side, a regenerating nerve having its growth impaired because of the obstacle of a not-yet fully degraded guide. So, it may be useful to remove a “degradable” after the healing process of the nerve has, likely, completed [10].

The combination of external fixation and artificial nerve-guides can be fruitful in other districts and in even more complex cases. A possible limit can be discussed regarding the higher financial cost that this approach presents in comparison with more traditional techniques. It is the opinion of the Authors that a wider application of both methods will necessarily bring along a reduction in cost for the devices.

Conclusion

Combining an external fixator and an artificial nerve-guide for the treatment of a complex digital injury, where tendon, nerve and bone were involved, made the Authors able to treat all the lesions with the same level of priority. They obtained a good end-result in all the structures and avoided the preventive sacrifice of any of them. Despite the limited experience of just a single case, Authors judge this approach worth to be applied in their forthcoming similar cases.

Conflict of interest None.

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