Sensory Recovery 1 Year After Bridging Digital Nerve Defects With Collagen Tubes

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Purpose To investigate digital nerve regeneration following implantation of collagen tubes in a prospective study.

Methods Forty-five digital nerve defects (≤ 2.6 cm) in the hand were reconstructed in 35 patients (6 female, 29 male; mean age, 47 y). Nerve regeneration was evaluated at 3, 6, and 12 months after surgery by applying a sum score comprising static 2-point discrimination, sensory threshold with Semmes-Weinstein monofilament mechanical stimuli, warm/cold sensation, vibration sense, sharp/dull recognition, recognition of numbers, and subjective estimation of the patient. Electroneurography and ultrasound were also performed.

Results In the distribution of 60% of the operated nerves, very good or good recovery was found. In contrast to basic sensory function, the more complex static 2-point discrimination was more frequently impaired after 1 year. After 6 months, the sum score correlated with electroneurography. The type of injury altered the final sensory nerve function. Circular saw and iatrogenic injuries showed a negative correlation with final sensory nerve function. Complications (infection) were observed in 2 patients.

Conclusions Owing to the good functional outcome in the majority of cases, the use of collagen tubes is useful to span digital nerve defects up to 2.6 cm. *(J Hand Surg 2013;38A:90–97.*

Type of study/level of evidence Therapeutic IV.

Key words Bioabsorbable conduit, collagen tube, nerve injury, reinnervation, sensory tests.

Bunnell[1] expressed the view that a hand without sensibility is blind, which illustrates the importance of intact sensation for the normal functioning of the hand.

In the last few decades, researchers have been trying to find alternative techniques for bridging peripheral nerve gaps. The main motivations for this are to avoid a donor site and to obtain function at least comparable to that obtained by standard nerve repair techniques. A collagen tube acting as a nerve conduit or nerve guide may fulfill these objectives.

A nerve conduit directs regenerating nerve fibers toward the distal nerve stump, prevents ingrowth of scar tissue, and contains within its lumen several growth factors derived from the distal nerve stump. *Neurotropic* (necessary for the direction of the growth of the regenerating axons), and *neurotrophic* (necessary for the survival and growth of the damaged axons) factors, which are produced by the distal nerve stump, can accumulate within the nerve conduit.[2]

After the nerve fibers have bridged the gap and the nerve matures, the nerve conduit has fulfilled its purpose. The ideal nerve conduit should, therefore, be resorbed or incorporated after it has completed its function.

Nerve conduits are composed of several materials. Non-resorbable nerve guides (eg, silicone) remain *in*

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Received for publication May 21, 2012; accepted in revised form October 11, 2012.

The authors are grateful to Bernd Schicke for performing statistical analysis and Fred Schreuder and Marcel Meek for carefully reading the manuscript.

This study was done with financial support from the Helios Research Center.

No benefits in any form have been received or will be received related directly or indirectly to the subject of this article.

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0363-5023/13/38A01-0016$36.00/0
http://dx.doi.org/10.1016/j.jhsa.2012.10.017

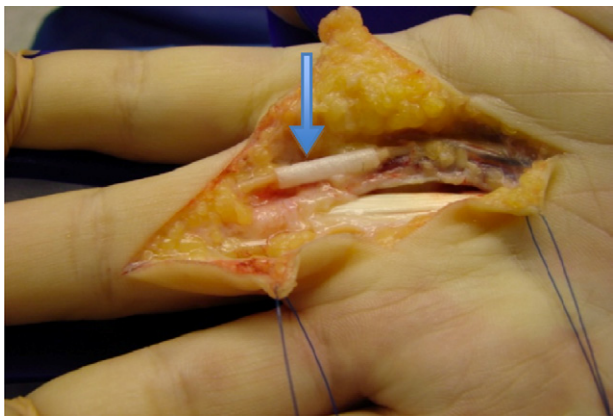

FIGURE 1: View of a collagen nerve guide (arrow) used to span a gap in the radial digital nerve of the right middle finger.

situ after completing their function and may have a negative influence on the regenerated nerve fibers.[3] Several conduits have been used for human peripheral nerve repair, including those of biological origin (vein, artery, muscle)[4,5] and those of synthetic origin (both biodurable and biodegradable).[6–9] Six studies have been published on the evaluation of collagen nerve guides for digital nerve repair.[10–15] Here, we present the 12-month follow-up results of a prospective study of 45 resorbable collagen nerve guides for digital nerve repairs in 35 patients.

MATERIALS AND METHODS

Patients

Before the start of the clinical study, the research protocol and the informed consent forms for the patients were approved by our ethical review board. From January 2007 to September 2009, 35 patients with 45 digital nerve transections of the hand were included in this study. Patients gave their written consent to participate in this study after reading the subject information.

Inclusion and exclusion criteria

The patient population consisted of patients with a complete transection or a neuroma of 1 or more proper digital nerves or common digital nerves in the hand. Nerve guides were used if the preoperative defects were between 5 and 26 mm. Patient age or type of injury were not limiting factors.

Surgery

Implantations of guiding nerve tubes (see Fig. 1) were performed by 8 skilled hand surgeons. No preoperative standard dose of antibiotics was given, except in cases of exposed bone and strong contamination. Tourniquet control was used in all cases. After debridement and mobilization, both nerve stumps were put into the tube. Care was taken to avoid tension on the stumps. The length of the nerve defect was measured with all joints in an extended position. Nerve defects with a maximum length of 26 mm were included in the study. In all cases, resorbable nerve guides (NeuraGen; Integra GmbH, Ratingen, Germany) were used, and a proper internal diameter was selected. The selected nerve guide was then cut to the appropriate length so that it was a few millimeters longer than the nerve gap in order to facilitate positioning of both nerve stumps inside the nerve conduit.

Both nerve ends were pulled 3 to 5 mm into the nerve guide by a horizontal U-stitch with 8-0 nylon. The nerve guide was filled with saline.

Any other injuries were repaired at the same time. Finally, the wound was closed, and the hand was splinted with a plaster splint as appropriate for the overall hand surgery. In cases without accompanying tendon injury, a protective dorsal plaster splint was applied for 2 weeks in order to prevent full extension, whereas flexion of the fingers was possible.

Follow-up and outcome measurements

The degree of sensory recovery and incidence of adverse events were recorded at 3, 6, and 12 months by 1 investigator (A.H.) using a formal protocol. In 6 patients, later amputation after replantation had to be performed. One of the patients died as a result of alcohol disease. In 5 patients, follow-up evaluation was not possible because they did not return to the clinic. As a result, the 12-month follow-up was performed in 35 patients with 45 nerve repairs.

A standardized sensory re-education program was not provided because hand therapy following surgical treatment was performed by different physical and occupational therapists close to the patient's residence and not in the hospital.

Sensory testing was performed using a test battery investigating different qualities including basic and more complex sensory functions. These comprised sensation of sharp and dull mechanical stimuli (1), warm/cold sensation (2) (1 and 2 are considered to be protopathic sensation), vibration sense, measurements of sensory threshold with Semmes-Weinstein monofilaments (3) and static 2-point discrimination (s2-PD) (4) (3 and 4 are considered to be epicritic sensation),[16] and recognition of numbers. Scoring was according to the values in Table 1.

Furthermore, the subjective estimation of sensory dysfunction by the patient was noted, specifically ask-