Surgical Technique to Reduce Scar Discomfort After Carpal Tunnel Surgery

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A total of 379 patients (416 hands) with clinically diagnosed and electromyographically confirmed carpal tunnel syndrome were enrolled in a prospective study to determine the influence of a modified open decompression technique on postoperative scar discomfort. The new technique used in 184 patients (200 hands) is presented. Special attention was focused on identification and preservation of macroscopically detectable subcutaneous nerves. After using this method, which permits complete visualization of the entire transverse carpal ligament, the incidence of postoperative scar discomfort was 2.5%. This was significantly lower compared with the group of 195 patients (216 hands) treated by standard open decompression technique, without preservation of subcutaneous nerves. Primary results regarding relieving symptoms were comparable in both groups. Five anatomic variations of subcutaneous innervation, at the site of the incision in the line with the radial border of the ring finger, are described. The etiology of scar discomfort is discussed. (J Hand Surg 2002;27A: 821–827. Copyright © 2002 by the American Society for Surgery of the Hand.)

Key words: Modified surgical technique, palmar cutaneous branch of the median nerve, nerve injury, painful scar, etiology.

To reduce postoperative morbidity after surgical treatment of carpal tunnel syndrome numerous studies have been done and new surgical techniques introduced. After open carpal tunnel release (OCTR) patients are often troubled by nonuniform conditions—scar tenderness, tingling, burning pain, deep pain, pillar pain, dysesthesias, and hypesthesias around the scar—which can be gathered under a more general description: scar discomfort (SD). The incidence of scar tenderness ranges from 19% to 61% and its cause is not yet fully understood.1,2 Some investigators have attributed it to the injury of the palmar cutaneous branch of the median nerve (PCBMN) and/or palmar cutaneous branch of the ulnar nerve, with subsequent neuroma formation.3–6 Several anatomic studies detailed the cutaneous innervation of the palmar triangle and new favorable sites for the placement of the incision were proposed.7–10 Martin et al11 suggested that there is no true internervous plane in the palm and that by using the open technique damage to cutaneous nerves is unavoidable.

A successful attempt to avoid painful scars was made with the introduction of the endoscopic technique, but the frequency of major complications and incomplete transections of the carpal ligament was significantly higher compared with the open release.2,12,13 As an alternative some investigators suggested transection of the ligament through a short
incision in the palm, with the use of specially designed instruments or a conventional knife. Even with modifications these techniques do not permit satisfactory exploration of the carpal tunnel in all patients and put numerous major structures at risk.

During the standard open decompression technique (SODT), the nerve branches that were routinely cut were often detected in the subcutaneous tissue. We assumed that regenerating sprouts of sensory and vegetative fibers of the transected cutaneous nerve branches entrapped in the scar tissue could be the main cause of SD, after standard surgical approach to the carpal tunnel. Therefore a prospective clinical study was launched (1) to compare the incidence of postoperative SD in patients treated with SODT and modified open decompression technique (MODT), with preservation of subcutaneous innervation; and (2) to identify subcutaneous innervation.

Materials and Methods

Patients

The study was approved by the National Committee for Medical Ethics. A total of 195 patients (216 hands) treated with SODT (without preservation of subcutaneous innervation) in the years 1998 and 1999 represented the first group. They were on average 57 years old (range, 32–83 y). One hundred fifty-three were women and 42 were men. One hundred fourteen surgeries were on the right hand, 68 on the left hand, and 17 were bilateral. Two patients had recurrent carpal tunnel syndrome after standard open and 3 after endoscopic carpal tunnel release. Five dialyzed patients had artificial arteriovenous fistulas on the forearms of the operated extremities. A total of 184 patients (200 hands) treated with MODT in the years 2000 and 2001 were enrolled in the second group. The average age of patients was 56 years (range, 30–86 y). One hundred forty-one were women and 43 were men. One hundred five surgeries were on the right hand, 63 on the left hand, and 16 were bilateral. Four patients had recurrent carpal tunnel syndrome after standard and 3 after endoscopic carpal tunnel release. Two patients had artificial arteriovenous fistulas on the forearms of the operated extremities.

The indications for surgery were pain at rest, persistent sensory symptoms, Phalen’s sign at wrist, failure of conservative treatment, and positive result of the electromyography. All surgeries were performed on an outpatient basis by the first author (U.A.) and the same incisions were used to expose the transverse carpal ligament. Patients with bilateral carpal tunnel syndrome had surgeries performed at separate sessions.

Surgical Technique

Modified open decompression technique was performed by using ×2.8 loupe magnification and local infiltrative anesthesia. The arm was exsanguinated and pneumatic tourniquet was applied. The hand was placed in fully supinated and slightly extended position. The skin was cut with a longitudinal, 2- to 3-cm long incision in the axis of the radial border of the ring finger, originating from the distal wrist crease (Fig. 1). No incision crossed the distal wrist crease. Scissors and forceps were used carefully to identify and separate the nerve branches from subcutaneous tissue and palmar aponeurosis. With the use of retractors the subcutaneous tissue was separated and the incision was deepened until the transverse carpal ligament was reached. Special attention was focused on the placement and straining of retractors to prevent injury to the identified nerve twigs that crossed the path of the incision. With longitudinal incision, the central portion of the transverse carpal ligament was dissected and the median nerve was exposed. Retractors were placed in the distal end of the incision and pulled upward to enable better visualization of the distal edge of the transverse carpal ligament and the motor branch of the median nerve, which is easily seen and protected during the ligament division. The same procedure was used to loosen the proximal end of the carpal tunnel. By direct visualization the level of compression of the median nerve was assessed. Epineuromy of the median nerve on the palmar side was done if epineurium was thickened. Any pathologic features were looked for. After the exploration the tourniquet was deflated and hemostasis obtained. To leave the identified nerves intact, bleeding from the subcutaneous tissue was stopped carefully by bipolar electrocoagulation, especially near the point of emergence of the crossing nerves. The skin was closed with interrupted monofilament sutures placed in such a way that identified cutaneous nerves were not damaged. Soft dressing with a splint was applied. Immobilization in slight extension was removed after 4 days. The sutures were removed after 12 days. The mean time of tourniquet was 15 minutes (3–4 min of which were owing to identification and separation of nerve branches from the subcutaneous tissue).

Standard open decompression technique was per-
formed similarly; the only difference was the incision, which ran directly through subcutaneous fat without identification and preservation of subcutaneous nerves.

Postoperative Evaluations

All patients were examined 7 days and 1, 3, and 6 months after the surgery. For the evaluation of postoperative results our own questionnaire was used. With the first part the symptoms that undoubtedly point to the major cutaneous nerve transection were evaluated. Patients were asked about sensory loss in the palmar triangle and were tested for Tinel’s sign at the site of the incision. Then the patients’ other complaints (tingling, burning discomfort, deep pain, superficial hypersensitivity at rest and with use, radiating pain on palpation) regarding the scar area were assessed. Patients were classified as having scar discomfort if they presented in the first 6 months after the surgery with symptoms from the first group and/or one or more of the symptoms from the second group if these symptoms delayed the patient’s return to work and/or changed the usual course of postoperative rehabilitation and measures to lessen the SD were required (analgesics, massage, desensitization therapy, application of ultrasound). All patients in both groups got the same postoperative rehabilitation. The effectiveness of the new technique was evaluated by comparing the incidence of SD in the 2 groups of patients. The results were analyzed statistically by using the chi-square test and values of p < .05 were determined as statistically significant.

Anatomy

In 200 hands treated with MODT, subcutaneous nerve distribution was examined by using ×2.8 loupe magnification. The number, size, and the branching pattern of the nerves that would definitely be cut if the incision ran directly through the subcutaneous fat and palmar aponeurosis was determined. The diameter of the subcutaneous nerves at the proximal end of the incision was measured and classified into 3 groups according to their diameter (<1 mm, 1–2 mm, >2 mm). The distance between the distal wrist crease and the nearest identified subcutaneous nerve was measured.

Results

Postoperative Evaluations

In the second group (treated with MODT) SD presented in 5 of 200 (3%) cases during the first 6 months after the surgery. In the first group (treated by method without preservation of the subcutaneous innervation), however, we identified 11% of such cases (23 of 216). This numeric difference is statistically significant at the p < .001 level. Two of 5 patients in the second and 6 of 23 in the first group had reasons to remain symptomatic because they received workers compensation. Scar discomfort presented as deep ache and/or burning discomfort and/or superficial hypersensitivity.

All patients improved symptomatically and electrodagnostically after surgery. There was no risk for limited exposure and none of the important structures
was damaged during the surgery. Relief of preoperative symptoms was the same for MODT and SODT.

Distribution of Subcutaneous Innervation at the Incision Site

Subcutaneous nerve branches at the site of the incision were detected in 146 of 200 cases (73%). In all 7 recidivants surgeries, scar tissue formation prevented the exploration of the subcutaneous tissue. Identified nerves were preserved in 131 of 146 cases (90%). In 13 cases the identified nerves did not sustain the traction that was necessarily applied by retractors. These nerves measured less than 1 mm in diameter. In 2 cases of un preserved nerves pneumatic tourniquet was not used because of arteriovenous fistulas in the forearm and nerve branches were cut to obtain better visualization.

Five different anatomic variations of the subcutaneous nerve distribution were detected at the site of the incision (Figs. 2, 3). Type A, solitary branch that ran transversely from the radial to the ulnar side of the incision. Type B, solitary branch that originated at the radial side, branched in Y-fashion, and ended as 2 smaller twigs at the ulnar side. Type C, solitary branch that emerged from the proximal radial end of the incision branched in T-fashion and ended in radial and another in the ulnar side. Type D, branch that originated from the proximal radial end of the incision branching in numerous twigs with different patterns. Also 2 or more branches that crossed the incision in radial to ulnar direction were included in this group. Type E, subcutaneous innervation was not detected at the site of the incision.

All identified subcutaneous nerves were superficial to or passed through the superficial layer of palmar aponeurosis. At the site of the incision we have not identified any macroscopic branches originating from the ulnar side. Eighteen (12%) of detected nerves measured less than 1 mm in diameter. One hundred fifteen (79%) nerves ranged from 1 to 2 mm

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Figure 2. Frequencies and schematic presentation of different types of subcutaneous nerve distribution at the site of the incision. DWC, distal wrist crease; TH, thenar; HTH, hypothenar.

Figure 3. Anatomic variations of subcutaneous innervation at the site of the incision (clinical cases). DWC, distal wrist crease; TH, thenar; HTH, hypothenar.
in diameter. Thirteen (9%) were wider than 2 mm. The mean distance between the distal wrist crease and the nearest detected subcutaneous nerve was 9.6 mm (range, 3–25 mm).

Discussion

Open carpal tunnel release is still a widely used procedure suitable for all patients. It remains the only choice of treatment for patients with carpal tunnel syndrome caused by inflammatory conditions, post-traumatic derangements, metabolic disorders, and for patients who have had prior carpal tunnel surgery.21,22 Scar discomfort delays patients’ return to work and presents a major disadvantage of standard open techniques compared with endoscopic techniques. When using the SODT the subcutaneous innervation is usually transected, which may leave negative postoperative effects. In the present prospective clinical study, we found decreased SD after MODT with identification and preservation of subcutaneous innervation as compared with SODT. This result corroborates our hypothesis that the main cause of SD after OCTR is incisional trauma to subcutaneous innervation.

An obvious candidate for the development of SD after peripheral nerve injury is the site of nerve injury itself. Electrophysiologic recordings of injured axons have shown their ongoing activity and abnormal sensitivity to physical, chemical, and metabolic stimuli.23,24 The source of ectopic discharges are end-bulbs of regenerating axon sprouts that may grow toward its target tissue, or they remain trapped in scar tissue or neuroma.24 When a larger nerve trunk is divided by using SODT, end-neuroma, which presents with distally radiating pain on palpation and positive Tinel’s sign, may be formed.3,25 The concept of neuroma formation after the incision that followed the thenar crease was documented by Louis et al.,26 who detected neuromas of the PCBMN in 14 of 25 patients with complications after carpal tunnel surgery. Hulsizer et al.,27 however, did not find any neuromas in the revision surgeries after OCTR and neither did we. In our patients SD presented as deep ache, burning discomfort, or superficial hypersensitivity without any symptoms or signs typical of painful neuroma formation (radiating pain on palpation, Tinel’s sign, tingling). Therefore we believe that postoperative scar tenderness derives from entrapment of sprouts of regenerating nerve endings within fibrous tissue of the scar. This is supported by the findings that scar tenderness was most pronounced during the first 6 weeks after the surgery with little or no disability after 9 months28 and favorable effect of ultrasound, which softens the scar, on scar tenderness.

To locate the safest incision, the origin, course, termination, and branching patterns of the PCBMN and palmar cutaneous branch of the ulnar nerve were assessed, but variable anatomy of this region has led to different results. It was concluded that branches of PCBMN do not extend ulnar to the axial line of the ring finger7 or are too small to be identified at this site by using ×3.5 magnification.5 Nevertheless, PCBMN or its terminal ulnar subbranches had been detected at the site of the incision in the line with the axis of the ring finger in 12% to 64% of cases.5,10,11 Furthermore, injury to the branches of the ulnar nerve may occur as frequently as or more frequently than injuries to the PCBMN when using the fourth ray approach.4,11 Recent studies agreed that subcutaneous nerves are put at risk by all standard open approaches,8–11 especially smaller nerve fibers that are grossly indistinguishable from fibers of the palmar fascia.5 All of the identified subcutaneous nerves in our series crossed the path of the incision in radial to ulnar direction. One or more of these nerves that innervate the skin over hypothenar eminence were detected in 146 of 200 cases. A total of 79% of ulnar subbranches measure more than 1 mm in diameter and 9% were wider than 2 mm. Furthermore, we found 5 different anatomic variations of the ulnar subbranches of PCBMN. These cutaneous nerves innervate an area of approximately 3 to 35 cm² in the proximal part of the palm (U. Ahćan, unpublished data, May 2001).

Unpublished anatomic and histologic (electromicroscopic) studies on fresh human cadavers showed that ulnar subbranches of PCBMN consist of 500 to 900 myelinated and approximately 3 times more unmyelinated axons (F. Bajrović, P. Zorman, U. Ahćan, unpublished data, January 2002). Therefore in more than 70% of patients treated by SODT, subcutaneous innervation is transected and in the first 24 hours after injury regeneration takes place. The axon sprouts multiply the proximal single nerve by at least 10-fold.29 This can lead to up to 10,000 (sensory and vegetative) nerve sprouts being entrapped into scar tissue at the line of the incision. Additional damage done by electrocoagulation and suturing prevents topographically correct orientation of regenerating sprouts and blocks reinnervation. Based on our observations, injury to the ulnarly based cutaneous innervation has a minor contribution to the develop-
ment of SD because we have not identified any macroscopically detectable nerve branches originating from the ulnar side of the incision. The point of high nerve density where most subcutaneous nerves were identified (on average, 9.6 mm from the distal wrist crease), may explain observations of Biyani et al. regarding why the scar is most frequently tender in the proximal half. We inferred that postoperative SD correlates with the total number of axons transected because none of the patients in whom subcutaneous innervation was too weak to be preserved or was not identified at all experienced scar problems. Scar discomfort in 3 patients after MODT could be explained by entrapment of preserved subcutaneous innervation in the scarring tissue. We assume these troubles would resolve if the scar became softer. It has become clear in recent years that, in addition to peripheral mechanisms, in pain related to the nerve injury central mechanisms might be involved as well. After peripheral nerve injury pain signals originate first from the site of axonal lesion owing to sensitization of nociceptors or damaged axons, but over time, other parts of the afflicted primary sensory dorsal root ganglion neuron and even the postsynaptic dorsal horn and higher-order neurons up to the cortical level will contribute to persistent pain.

Variable anatomy is the reason why placing the incision anywhere above the carpal tunnel puts subcutaneous innervation at risk. The safest incision for OCTR does not directly penetrate the subcutaneous fat and allows identification and preservation of subcutaneous nerve branches. With MODT we were able to preserve all the benefits of the open technique as well as to avoid its major drawbacks. Our prediction that painful scars can be avoided by preservation of macroscopically detectable subcutaneous innervation was confirmed.

References