Long-Term Follow-Up Evaluation of Denervation of the Wrist

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Purpose: To evaluate the indications and results of complete wrist denervation and to focus on the correlation between results and length of follow-up evaluation.

Methods: A retrospective review was performed of 71 complete denervations of the wrist joint in 70 patients with an average follow-up period of 9.6 years (range, 1–23 y) using the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire. The denervations were performed according to the description by Wilhelm. All patients were asked to provide a DASH score. The indications for surgery were degenerative changes caused by scaphoid nonunions (25), distal radius fracture (11), Kienböck's disease (11), primary degenerative arthritis (9), scapholunate dissociation (8), and others (7).

Results: The average DASH score was 26 (range, 0–88). Thirty-nine patients (40 wrists) reported considerable improvement, 8 reported little improvement, and 10 reported temporary improvement after surgery. Seven experienced no change and 6 experienced worsening after surgery. Twenty-two patients were completely free of pain and 13 (14 wrists) had little, 20 had moderate, 11 had considerable, and 4 had severe pain. Forty-eight patients (49 wrists) stated that they would repeat the denervation and 61 (62 wrists) were able to keep their former occupations. There was a trend toward lower (improved) DASH scores in patients with longer follow-up periods but this did not reach statistical significance. The best results were achieved in patients with scapholunate dissociations and the worst results occurred in old distal radius fractures. Patient age did not influence the results. Nine patients with unsatisfactory results needed a second procedure.

Conclusions: Complete wrist denervation resulted in subjective long-term improvement in two thirds and in a complete or marked pain relief in half of the patients. Patients with longer postoperative time and younger age did not affect the results adversely. This procedure is simple and fast, does not decrease range of motion, and leaves all other surgical options open. (J Hand Surg 2006;31A:559–564. Copyright © 2006 by the American Society for Surgery of the Hand.)

Type of study/level of evidence: Therapeutic, Level IV.

Key words: Denervation, wrist, complete.

The treatment of chronic wrist pain due to degenerative or inflammatory changes of different origins still presents a therapeutic challenge[1–4] and often involves a variety of partial or even complete wrist fusion.[5–7] Loss of wrist mobility, the relatively long duration until osseous consolidation, and possible complications represent the main drawbacks of these procedures, particularly in younger patients.

In 1966 Wilhelm[8] described the technique of a complete wrist denervation. Since then many reports have been published, with the success rates ranging between 24% and 90%.[2,4,9–20] The procedure was modified by various investigators and a success rate of up to 90% has been reported after only partial wrist denervation.[2] Wilhelm's[8] indications for wrist denervation were for scaphoid nonunions and Kienböck's disease. Later these indications were expanded to include arthropathies, fractures, ligament injuries, and chondrocalcinosis.[15,21,22]

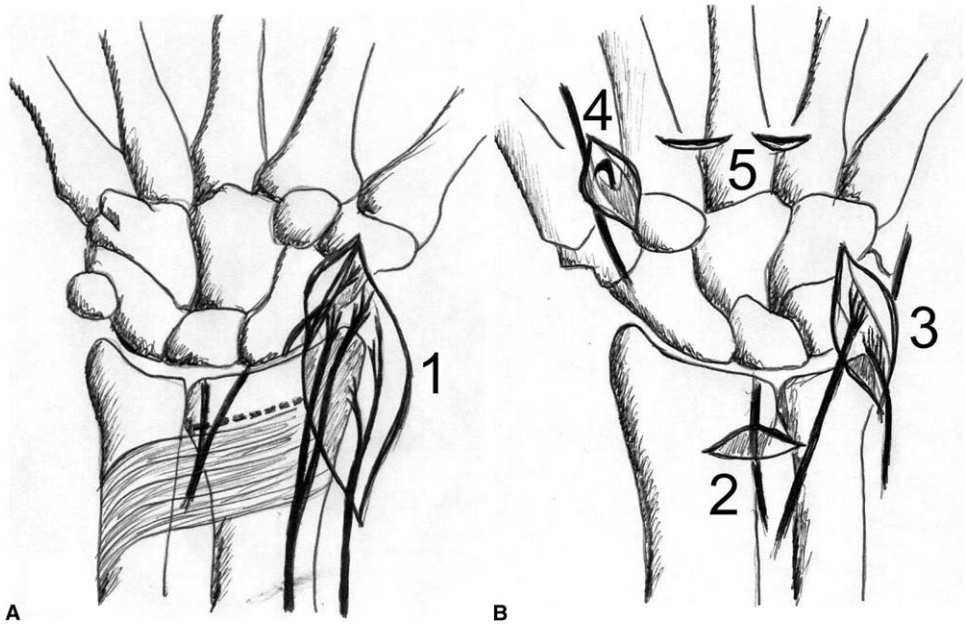

Figure 1. Technique of wrist denervation with the 5 incisions indicated (see text for more detail) with (A) palmar and (B) dorsal views. (A) Incision 1 was made on the radiopalmar side over the radius styloid between the brachioradialis and the first extensor compartment to expose the anterior interosseous nerve and the superficial branch of the radial nerve. (B) Incision 2 was made over Lister's tubercle to expose the posterior interosseous nerve. Incision 3 was made over the ulnar border of the wrist over the ulnar head to expose the dorsal branch of the ulnar nerve. Incision 4 was made dorsally at the base of the first interosseous space to expose the recurrent branch from the dorsoradial nerve of the index finger. Incision 5 was made over the base of the index–middle interosseous spaces to expose the corresponding recurrent branches.

At our institution complete wrist denervation has been performed since 1981. This study evaluated the results of complete denervation of the wrist. We focused on the correlation between the results and the postoperative time that had passed to detect the long-term effects of the procedure by analyzing follow-up evaluations from 1 to 23 years (mean, 9.6 y). We further searched for correlations between the results and initial diagnosis. Buck-Gramcko[16] published a study with a mean follow-up period of 6.7 years (longest follow-up period, 18.3 y); however, wrist denervations were mixed in with other surgical procedures. The longest follow-up study of complete and isolated wrist denervation that we found was 5 years.[20]

Materials and Methods

A retrospective review at our institution showed that 109 patients had 111 complete wrist denervations between 1981 and 2003. Ninety patients with 92 denervations were contacted by a mailed questionnaire. No mailing address could be found for 19 patients. We received and evaluated 71 DASH forms from 70 patients who had filled out the forms completely. Three patients had died and 17 patients had moved and could not be located.

There were 52 men (53 wrists) and 18 women (18 wrists). The 1 patient who had surgery on both wrists was treated as 2 cases in our evaluation. The dominant hand was involved in 30 patients. The average age at the time of the surgery was 45 years (range, 19–80 y; SD, 14 y) and the age at time of the follow-up control by questionnaire was 55 years (range, 30–84 y; SD, 13 y). The average follow-up period was 9.6 years (range, 1.0–23.0 y; SD, 5.9 y). The diagnoses for the surgery were degenerative changes caused by scaphoid nonunion advanced collapse wrist in 24 patients (25 wrists), distal radius fracture in 11 patients, Kienböck's disease in 11 patients, primary degenerative arthritis in 9 patients, scapholunate advanced collapse (SLAC) wrist in 8 patients, distal radioulnar joint and triangular fibrocartilage complex disorders in 3 patients, neurogenic disorders in 3 patients, and lupus erythematosus in 1 case.

Technique

In all patients the denervation was performed according to the description by Wilhelm[8] without a concomitant surgical procedure. The surgery was performed using axillary block anesthesia with a tourniquet. The first incision (Fig. 1A, incision 1)

was made on the radiopalmar side over the radius styloid between the brachioradialis and the first extensor compartment. After subcutaneous dissection the radial artery was identified and denuded. The venae comitantes were resected for at least 1 cm to cut accompanying radial nerve fibers. The palmar fascia was split radial to the flexor carpi radialis tendon, and the pronator quadratus muscle was exposed. The periosteum of the radius then was cauterized transversally distal to the pronator quadratus muscle up to the distal radioulnar joint to cut the anterior interosseous nerve. Deep subcutaneous and epifascial spreading dorsoradially allowed all small nerve branches that came off the superficial radial branch to be cut. A second incision (Fig. 1B, incision 2) was made over Lister's tubercle. The posterior interosseous nerve was exposed through the fourth extensor compartment and resected over a length of 2 cm. The subcutaneous tissue again was undermined to cut all the small nerve branches from the superficial branch of the radial nerve and the dorsal branch of the ulnar nerve. A third incision (Fig. 1B, incision 3) was made over the ulnar border of the wrist over the ulnar head. The dorsal branch of the ulnar nerve was undermined and the subcutaneous tissue was freed from the fascia to join the second incision to cut all the small diverging nerve branches that immerse to the wrist joint. The fourth incision (Fig. 1B, incision 4) was made dorsally at the base of the first interosseous space to cut the recurrent branch from the dorsoradial nerve of the index finger. Finally the fifth incision (Fig. 1B, incision 5) was made over the base of the index–middle interosseous space to cut the corresponding recurrent branches. This also can be performed with 2 small incisions.

The Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire mailed to the patients included the extended German version of the DASH score.[23,24] The following data from the DASH score were evaluated separately: restriction of occupational and daily activities according to question 23 (Restriction due to hand, shoulder, or arm problems? Possible responses: no restriction, little, noticeable, considerable, severe) and evaluation of pain according to question 24 (Pain in shoulder, arm, or hand? Possible responses: none, little, moderate, considerable, severe). In addition to the DASH score patients were asked about the postoperative improvement of pain, whether it was considerable and long-lasting (until the most recent follow-up evaluation), little and long-lasting, only temporary, none, or worse. They were asked whether they were able to return to their occupations after the procedure or whether they had to change occupations. The patients also were asked whether they had had additional surgical procedures in other hospitals (what type of procedure, when, and why) and whether they would have a wrist denervation again (there also was an option for *unsure*). The results according to the DASH scores and the patients' ages were analyzed to find any correlation between these parameters and postoperative follow-up time. The results also were analyzed for differences (correlation) concerning the preoperative diagnosis. Statistical analysis was performed with the Student *t* test for parametric data, the Mann-Whitney *U* test for nonparametric data, and the Pearson test to evaluate any correlation between 2 parameters (SPSS for Windows, Version 10.0, Chicago, IL). Differences were defined as significant if the p value was less than .05.

Results

The average DASH score of all patients at the follow-up examination was 26.0 (range, 0–88; SD, 21). The following important parameters were obtained from the DASH score questionnaire: 22 patients were completely free of pain, 13 (14 wrists) had little, 20 had moderate, 11 had considerable, and 4 had severe pain. Thirty-nine patients (40 wrists) reported considerable, 8 reported little, and 10 reported temporary improvement of pain after surgery; in 7 patients there was no change and 6 felt a worsening of pain after the surgery. Twenty-four patients (25 wrists) experienced no restrictions during daily activities (including occupation); 14 experienced little, 19 experienced noticeable, 8 experienced considerable, and 5 experienced severe restrictions.

Forty-eight patients (49 wrists) stated that they would repeat the surgery, 19 would not do it again, and 3 were undecided. Sixty-one patients were able to return to their former occupations; however, 9 had to change their occupations. Ten patients needed a second surgery. Four patients had a proximal row carpectomy and 6 had a complete wrist arthrodesis. The secondary procedures all were performed between 5 months and 6 years after the denervation.

Patient age and follow-up time, which might have affected the results (DASH score), were investigated. There was a trend toward lower DASH scores with length of follow-up evaluation (better results for longer follow-up periods) (Fig. 2); however, it did not reach statistical significance ($p = .095$). Neither age at the time of surgery ($p = .85$) nor age at the time of the follow-up examination ($p = .68$) influ-

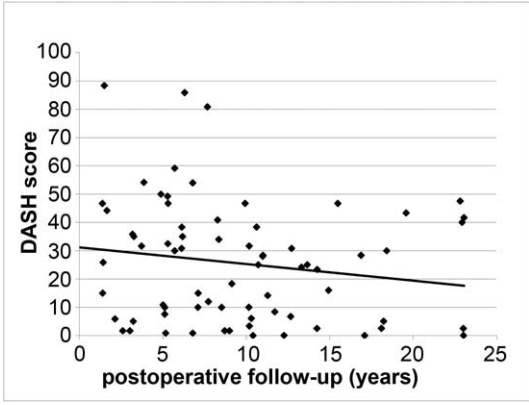

Figure 2. Correlation of the DASH score with postoperative follow-up time with linear trendline.

enced the DASH score. Patients who had a scaphoid nonunion advanced collapse ($p = .049$, statistically significant) or SLAC ($p = .95$) wrist had lower DASH scores compared with the remaining patients. In contrast patients with arthritis caused by a distal radius fracture ($p < .001$, statistically significant) or degenerative arthritis ($p = .37$) had the highest DASH scores (Table 1).

Discussion

Chronic wrist pain is multifactorial in origin. The ideal therapeutic goal besides reduction of pain is to preserve and restore anatomy and function. In patients in whom advanced degenerative changes are apparent this goal may not be achievable and other options such as partial or complete wrist arthrodesis may be necessary, causing a loss of function. There are, however, patients in whom pain predominates and function still is good. The dilemma of decreasing pain and simultaneously preserving motion resulted in the idea of denervation as described by Wilhelm.[8]

When patients present to our institution with a painful wrist caused by degenerative changes and when reconstructive procedures are not likely to be successful we offer the choice of wrist denervation in addition to other procedures such as partial or complete wrist arthrodesis or proximal row carpectomy. All patients are informed that wrist denervation might not be a definitive procedure and that wrist arthrodesis may become necessary later. In this study preoperative test anesthesia has not been used since 1998 because Foucher et al[15,21] reported no differences in outcome by selecting patients using test anesthesia. Weinstein and Berger[4] reported later that preoperative test anesthesia correlated poorly with postoperative pain occurrence and DASH score. In addition it is likely that surgical denervation does not eliminate all sensory fibers and patients may have too high an expectation after a successful test anesthesia. In selected patients it is possible to anesthetize only the anterior interosseous and posterior interosseous nerves in a predictive manner as shown by Grutter et al[25] and to perform a partial denervation of exactly the same nerves that were anesthetized. In this manner Weinstein et al[4] obtained 85% satisfaction in patients. According to their results[4] it may be sufficient to cut only the anterior interosseous and posterior interosseous nerves instead of performing a complete denervation of the wrist; however, whether a partial denervation is equal or superior to a complete denervation has yet to be shown.

This study consisted of 71 wrists (70 patients) who had complete wrist denervation without a concomitant procedure. The follow-up time ranged from 1 to 23 years (mean, 9.6 y). The follow-up evaluation consisted of an extended DASH questionnaire only. There was no physical or radiologic examination.

Table 1. Preoperative Diagnosis DASH Scores Compared With the Remaining Group of Patients

Diagnosis	Number of Patients	Mean DASH score (SD)	Mean DASH Score Compared With Remaining Patients	p Value
Scaphoid nonunion advanced collapse wrist	25	22.3 (15.7)	27.3	.049
SLAC wrist	8	20.3 (20.0)	26.1	.950
Degenerative arthritis	9	30.4 (27.6)	24.8	.370
Kienböck's disease	11	25.9 (16.3)	25.4	.220
Old distal radius fracture	11	32.9 (30.4)	23.8	<.001
Distal radioulnar joint disorders and triangular fibrocartilage complex disorders	3	33.3 (26.3)	21.2	.940
Other disorders	4	17.5 (25.4)	26.0	.381

Table 2. Summary of the Results in the Current Literature Review

Study	Number	Additional Procedures*	Follow-Up Period, mo	Results
Wilhelm,[8] 1966	21 partial	19%	16	80% success rate
Geldmacher et al,[9] 1972	24 complete, 8 partial	75%	No data	84% success rate
Buck-Gramcko,[10] 1974	5 complete, 26 partial	35%	28	13% no pain, 55% slight pain
Buck-Gramcko,[11] 1977	30 complete, 165 partial	No data	48	26% complete, 43% partial pain relief
Helmke et al,[29] 1977	54 complete	28%	37	83% positive
Stegemann et al,[28] 1980	26 complete	88%	≈30	81% positive
Rostlund et al,[12] 1980	9 complete	None	24	89% improvement
Martini et al,[13] 1983	33 complete/partial	54%	24	84% success rate
Ekerot et al,[14] 1983	48 complete/partial	None	28	56% pain relief
Dellon,[2] 1985	29 partial	None	35	90% improvement
Foucher et al,[15] 1992	50 complete	40%	48	72% improvement
Buck-Gramcko,[16] 1993	61 complete/partial	77%	74	76% very or remarkably satisfied
Ishida et al,[17] 1993	17 complete, 12 partial	41%	51	24% satisfied
Ferreres et al,[18] 1995	22 complete, 30 partial	None	65	Complete better than partial
Grechenig et al,[19] 1998	22 complete	27%	50	77% satisfied
Foucher et al,[20] 1998	50 complete	None	60	74% pain relief
Weinstein and Berger,[4] 2002	19 partial	None	30	80% pain relief, 85% satisfied
	761 (sum), 24 (mean)		45 (mean)	75% improvement (mean)
Present study, 2004	71 complete		113	67% improvement

*Additional procedures consisted of, eg, partial or complete arthrodesis, arthroplasty, scaphoid reconstruction, radius shortening osteotomy, proximal row carpectomy.

The average DASH score was relatively high (26) with a wide range (SD, 21) and is comparable with the results of Weinstein and Berger[4] (mean, 31; SD, 13). Patients showed greater levels of disability (higher DASH score) when performing heavier manual tasks and when carrying objects that weighed more than 10 kg and often reported loss of strength. Forty-eight patients (49 wrists) stated that they would again choose the denervation. The best results were achieved in patients with SLAC wrists and the worst results occurred in patients with old distal radius fractures. These results are in accordance with other outcome studies.[15,25,26]

Different variations of wrist denervation (complete, partial) have been performed and many investigators mixed denervations only with combined procedures in their studies.[9,10,13,15–17,19] Of the studies[2,4,14,18,20] reporting wrist denervation as an isolated procedure only 2[12,20] performed a complete wrist denervation. Foucher et al[20] reported 74% pain relief in 50 patients and Rostlund et al[12] reported 89% improvement in 9 patients. A recent study conducted by Weinstein and Berger[4] using partial denervation as a single procedure reported an 85% satisfaction rate in their patients with this procedure. Eighty percent had pain relief and 90% would choose the same treatment again (n = 19; mean follow-up time, 30 mo). With respect to pain, satisfaction, and willingness to repeat the procedure, their results were better than ours. In contrast the average DASH score in the study by Weinstein and Berger[4] was slightly worse (31) than the DASH score of 26 in our study.

Among all studies successful results ranged from 24% to 90% (mean, 75%).[2,4,8–17,19,20,27–29] In these series between 9 and 195 patients were included (mean, 45 patients), for a total of 761 patients in 17 studies. The mean follow-up time was much shorter than in our study, ranging from 16 to 74 months (mean, 46 mo) compared with 12 to 276 months (mean, 113 mo) (Table 2). Although our results are comparable (69% improvement) and in accordance with the average results (75% improvement) of all studies cited earlier (Table 2), an exact comparison among these studies[2,4,8–17,19,20,27–29] is difficult because of the different outcome evaluation.

One might have expected that over time degener-

ative changes would increase and pain and functional loss would become more pronounced. This assumption, however, was not confirmed in the present study. There was a trend for improved DASH scores with longer follow-up evaluations, although this did not reach statistical significance ($p = .095$). This may support the observation[11] that denervation does not cause a further neurogenic destruction leading to a Charcot joint. Foucher et al[20] observed radiologic deterioration in 23% of their patients after a mean follow-up period of 4 years and Buck-Gramcko[11] observed radiologic deterioration in 17% after a mean follow-up period of 3.5 years; however, the reason why patients with longer follow-up times show slightly better results remains unclear. A certain adaptation of pain perception and an avoidance of painful movements or activities during the course of chronic joint pain may serve as a possible valid explanation.

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