Analgesic Benefit, Functional Outcome, and Patient Satisfaction After Partial Wrist Denervation

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Partial wrist denervation is a useful palliative procedure for chronic wrist pain when reconstructive procedures are not feasible or desirable. We reviewed 19 patients who had 20 isolated anterior and posterior interosseous neurectomies with no previous or concurrent wrist surgery in a 5-year period at our institution. At an average of 2.5 years postoperatively, 80% of patients reported a decrease in pain, 45% reported normal or increased grip strength, and 73% of employed patients had returned to work. Three patients required additional procedures for pain relief (2 arthrodesis, 1 radial styloidectomies). Failure tended to occur in the first postoperative year. Poor preoperative range of motion and workers' compensation status were predictive of failure. Failure also occurred in the single patient with rheumatoid arthropathy. Two patients had subsequent arthrodeses. There were no complications related to the surgery. Overall, 85% of patients reported satisfaction with this procedure; 90% retrospectively would choose the same treatment for their chronic wrist pain. Partial denervation of the wrist via the anterior and posterior interosseous nerves is a technically easy procedure and may provide pain relief sufficient to markedly delay the need for more extensive salvage procedures in patients with wrist arthritis. (J Hand Surg 2002;27A:833–839. Copyright © 2002 by the American Society for Surgery of the Hand.)

Key words: Wrist, denervation, arthritis, outcomes.

Chronic wrist pain presents a therapeutic challenge to both the clinician and patient. Ideally surgical procedures can remove or correct the underlying pathology. Treatment algorithms become more complicated in patients with failed previous repairs and reconstructions, degenerative arthrosis, and secondary gain issues. The traditional salvage procedure, arthrodesis, provides pain relief in most circumstances. The requisite loss of motion, lengthy postoperative immobilization, and potential for complications, however, are not insignificant. In some patients a more conservative procedure for symptom relief may be preferable.

Wilhelm[1] described the use of total wrist denervation for palliation in patients with scaphoid nonunions and Kienböck's disease. The indications have since been expanded, and good results have been reported in 51% to 69% of patients having this procedure for chronic ligamentous injuries, fractures, and arthritis.[1–6] The primary drawbacks to total wrist denervation are the multiple incisions required and the potential for symptom recurrence.

Röstlund et al[7] modified Wilhelm's technique to achieve partial wrist denervation by using fewer incisions. Several anatomic studies have detailed the course of articular nerves to the wrist to identify potential sites and possible results from partial denervation.[1,8–12] Clinical reports have suggested that the analgesia of partial wrist denervation is inconsis-

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tent, transient, and less efficacious than total denervation for chronic wrist pain.[6,11,13]

The current literature on partial wrist denervation is insufficient for clinical decision making. In some studies conclusions were drawn from data on 4 or fewer patients.[6,7,13,14] Other studies with large patient cohorts had great heterogeneity in surgical technique used and nerves selected for neurectomy.[2,3] Few studies have evaluated isolated denervation procedures,[2,3,6,7,15] most have reported the results of adjunctive denervations.[6,13,14] Few studies have addressed patient satisfaction, and none has gathered functional outcome data with a reliable, validated data-collection instrument.

Anecdotal experience at our center suggested that anterior and posterior interosseous neurectomy, performed through a single dorsal incision,[16] could provide many of the benefits of total wrist denervation with negligible morbidity. The aim of this study was to formally assess analgesic response, functional outcome, and patient satisfaction after partial wrist denervation for intractable wrist pain. If proven efficacious, this procedure may delay the need for salvage procedures in patients with severe wrist pain caused by end-stage disease.

Materials and Methods

A retrospective review of surgical dictations identified patients who had a wrist neurectomy at our institution between June 1993 and June 1998. Patients who had combined neurectomy of the anterior interosseous nerve (AIN) and posterior interosseous nerve (PIN) were selected to form the study cohort. Those who had concurrent surgical procedures on the same upper extremity were excluded, as were those who had isolated posterior interosseous neurectomy. Our search identified 144 denervation procedures performed in 140 patients in the 5-year period reviewed. Twenty wrists in 19 patients met the entry criterion of isolated neurectomies of the AIN and PIN.

Demographic and clinical data were extracted from patient records. Average patient age was 52 years (range, 21–71 y; median, 29 y). Fifteen patients (79%) were men and 4 were women. Seventeen patients were right-handed. Fourteen patients had surgery on their right side. Two patients had bilateral neurectomies of the AIN and PIN (1 synchronous and 1 staged). Denervation was performed on the dominant side in 14 cases and the nondominant side in 6 cases. Seven patients (8 cases) were employed as active laborers. Four patients (5 cases) were retired, and the remaining 6 patients (7 cases) held sedentary jobs. Five patients (6 cases) had active workers' compensation claims related to their wrist pain. Demographic data and preoperative diagnoses are detailed in Table 1.

Dorsal wrist pain was present at initial presentation in all patients. The pain was located centrally or radially in 12 of 20 cases (60%). Two patients had ulnar-sided symptoms. In 14 of 20 cases (70%) the pain was of moderate intensity. The pain was constant in 12 of 20 cases (60%) and involved nocturnal awakening in 7 of 20 cases (35%). All patients reported that their wrist pain was exacerbated by activity. The pain was present for more than 5 years in 9 of 20 cases (45%). The majority of cases presented with complaints of wrist weakness (17 of 20 cases; 85%) and wrist stiffness (16 of 20 cases, 80%). More than half of the cases required the use of medication daily to reduce their wrist pain; 2 of 20 cases (10%) were narcotic dependent.

On physical examination all patients had focal tenderness. Most patients (89%) had central or radial-sided tenderness. Two patients had ulnar-sided tenderness. Total active motion in flexion and extension (TAM F/E) averaged 104° on the surgical side and 126° on the nonsurgical side. Total active motion in radial deviation and ulnar deviation averaged 48° on the surgical side and 64° on the nonsurgical side. Grip strength was weaker on the surgical side (28 kg) than on the nonsurgical side (37 kg), as were appositional pinch (6.6 kg vs 8.9 kg) and oppositional pinch (4.8 kg vs 6.8 kg). All patients had anteroposterior and lateral wrist radiographs performed. Static carpal instability was found in 12 patients.

Preoperative diagnostic AIN/PIN blocks were performed according to a previously described technique.[16] A 25-gauge needle was inserted 5 mm below the skin at a site 2 cm proximal to the distal radioulnar joint. Two milliliters of local anesthetic was injected into this region to block the PIN. The needle was then advanced an additional 5 mm, penetrating the interosseous membrane, where 2 mL of anesthetic was injected to block the AIN. Subsequent objective measures of grip strength and subjective measures of pain relief were recorded.

Three surgeons performed the denervations. In 12 cases (60%), the procedure was performed by one of the authors. All patients had resection of the terminal AIN and PIN branches through a single dorsal incision under a regional anesthetic or local anesthesia with parenteral sedation.[16] Briefly this resection was performed as follows. A pneumatic tourniquet was

Table 1. Neurectomies of the Anterior Interosseous Nerve and Posterior Interosseous Nerve Only

Case	*Age (y)*	*Occupation*	*Workers' Compensation*	*Diagnosis*	*Previous Procedures and Comorbidities*
1	71	Retired teacher	No	SLAC 3	Contralateral hemiparesis
2	22	Laborer	Yes	Dorsal wrist pain	
3	45	Executive	No	SLAC 2	Carpal tunnel release
4	46	Data entry	No	Rheumatoid arthropathy	Contralateral wrist arthrodesis
5	61	Food service	No	SLAC 1	
6	45	Landscaper	No	SLAC 3	
7*	61	Trucker	No	SLAC 3	
8†	61	Trucker	No	SLAC 2	
9	60	Farmer	No	SLAC 2	
10	55	Dairy farmer	No	SLAC 2	
11	45	Millwright	No	Posttraumatic radiocarpal degenerative joint disease	Distal radius fracture
12	33	Physical therapist	No	Scaphoid nonunion	
13	67	Retired farmer	No	SL dissociation, ulnar translation of lunate	Girdlestone, crutches for 15 years
14	63	Retired laborer	No	SLAC 4	
15*	68	Retired surgeon	No	SL instability	
16†	68	Retired surgeon	No	SL dissociation	
17	35	Postal clerk	Yes	SLAC 2	Madelung deformity
18	61	Dentist	No	STT degenerative joint disease	
19	47	Farmer	No	SLAC 2	Perilunate injury
20	47	Consultant	No	SLAC 1	

SLAC, scapholunate advanced collapse arthritis; STT, scaphotrapezio-trapezoid.
*Bilateral procedure, dominant hand.
†Bilateral procedure, nondominant hand.

applied to the arm. Beginning distally 2 cm proximal to the ulnar head a 3- to 5-cm longitudinal incision was made dorsally over the interval between the distal radius and ulna (Fig. 1). The deep antebrachial fascia was incised longitudinally, exposing the musculotendinous junction of the digital extensor tendons. The digital extensor tendons were retracted to expose the PIN lying on the dorsal surface of the interosseous membrane. It is typically immediately adjacent to the posterior division of the anterior interosseous artery (Fig. 2). Two centimeters of the PIN was sharply resected. With the artery protected, a 3- to 4-cm longitudinal incision was made in the distal aspect of the interosseous membrane, exposing the insertion of the deep head of the pronator quadratus muscle. Between the interosseous membrane and the pronator quadratus muscle are the anterior interosseous artery and the AIN (Fig. 3). The AIN is typically 2 to 3 times greater in diameter than the PIN. After it was certain that no motor branches were affected, a 2-cm length of the AIN was sharply resected. A layered wound closure was done and a soft, sterile dressing was applied.

All patients were mailed a 2-part survey. The first part contained questions about current wrist pain, grip, range of motion, return to work, satisfaction with the surgery, and need for additional wrist procedures. The second part was the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire. Patients who did not respond were contacted by telephone to complete the survey. All patients were invited back for additional clinical assessment and radiographs. Consent to participate in the investigation was obtained from all patients. The Institutional Review Board of our institution approved this study.

Statistical analysis was performed by using SAS version 6.12 (SAS Institute, Cary, NC), assuming a level of $p = .05$ for significance. Multiple outcome measures were tested against the results of the diagnostic block by using rank sum tests and Spearman correlation coefficients. Chi-square tests were used to evaluate factors prognostic of treatment failure. Preoperative and postoperative ranges of motion were compared by using paired *t*-tests; patients who had had arthrodesis in the interim were excluded from this analysis.

Results

Preoperative diagnostic nerve blocks were performed in all cases. Grip strength was recorded be-

Figure 1. Landmarks for the skin incision used for partial denervation of the wrist. (From Berger RA. Partial denervation of the wrist: a new approach. Tech Hand Upper Extrem Surg 1998;2:25-35. By permission of Mayo Foundation for Medical Education and Research.)

fore and after block. The average improvement in grip strength was 34% (range, 0% to 128%; median, 15%). Pain relief was calibrated on a scale from 0% to 100%, with 100% signifying complete relief. The average reported relief was 83% (range, 0% to 100%; median, 95%). Analgesic response after block correlated poorly with ultimate pain frequency ($p = .50$) and severity ($p = .13$) determined at follow-up evaluation. Pain relief after block and grip improvement were not correlated with DASH scores at follow-up evaluation ($p = .67$ and $p = .20$, respectively).

In the early postoperative period (10–14 d) complete pain relief was reported by 6 of 20 cases (30%) and some relief was noted in 12 of 20 cases (60%). One patient reported no pain relief and one was worse after the procedure. Early postoperative pain relief did not correlate with ultimate pain frequency ($p = .23$) or severity ($p = .44$) as recorded at follow-up evaluation.

Questionnaire data were available for all cases at an average of 31 months postoperatively. Most patients reported residual wrist pain, but on a case basis 16 of 20 cases (80%) reported it as less severe than preoperatively. Twelve of 20 cases (60%) now reported the pain as rare or occasional instead of constant. Nine of 20 cases (45%) believed that their grip strength had improved or was now normal, and 5 believed that it was equal to the preoperative state. Six cases (30%) indicated that their grip strength was weaker. Among the 15 employed patients with follow-up data, 11 (73%) had returned to work.

Three patients required additional procedures for pain relief. One patient with scapholunate instability had a radial styloidectomy 5 months after the denervation. The single rheumatoid patient in the cohort required a total wrist fusion 1 year after the dener-

Figure 2. Posterior surgical exposure of the posterior interosseous nerve (PIN). It lies on the interosseous membrane (IOM) between the radius (R) and ulna (U) with the posterior division of the anterior interosseous artery (AIAp). Care is taken to avoid entering the distal radioulnar joint (DRUJ) at the distal extent of the wound. A 2-cm length of the PIN is sharply resected, as marked. (From Berger RA. Partial denervation of the wrist: a new approach. Tech Hand Upper Extrem Surg 1998;2:25-35. By permission of Mayo Foundation for Medical Education and Research.)

Figure 3. Exposure of the anterior interosseous nerve (AIN) and artery (AIA) after longitudinal division of the thin interosseous membrane (IOM). The AIN and AIA are posterior to the deep head of the pronator quadratus muscle (PQ). A 2-cm length of the AIN is sharply resected, as marked. (From Berger RA. Partial denervation of the wrist: a new approach. Tech Hand Upper Extrem Surg 1998;2:25-35. By permission of Mayo Foundation for Medical Education and Research.)

vation. One patient had a limited intercarpal arthrodesis 4 months after the denervation. Neuropathic changes were not observed on serial radiographs.

Failure, defined as the need for subsequent procedures for pain relief, was independently associated with workers' compensation claims ($p < .01$) and preoperative TAM F/E of 80° ($p < .01$). Failure was not associated with chronicity of symptoms ($p = .46$), age ($p = .24$), occupation ($p = .18$), or previous wrist procedures ($p = .23$).

The average DASH score was 31 (range, 6–58; median, 32; SD, 13.1). DASH scores were not predicted by workers' compensation status ($p = .31$), age ($p = .94$), or occupation ($p = .87$).

Fourteen of 20 cases were somewhat or very satisfied with the results of the denervation and 18 of 20 cases (90%) would retrospectively choose the same treatment for management of their chronic wrist pain.

Discussion

Chronic pain is common in a variety of wrist conditions. Repair and reconstruction are often the procedures of choice. Previous investigators have discussed the role of adjunctive partial wrist denervation in patients with chronic pain.[7,13,14] Of the 144 partial wrist denervations at our institution during the study period, 107 were performed in concert with a larger procedure. To assess the outcome of denervation without introducing confounding variables, we chose to evaluate only patients who had isolated AIN/PIN neurectomy.

The patient cohort we studied was a reasonable representation of the chronic wrist pain population, although a large number of denervations were done on individuals who had previously had a surgical procedure on the affected wrists, excluding them from this study. Six of the 20 cases had pending workers' compensation claims. In several cases, systemic comorbid conditions (contralateral hemiparesis, wrist arthrodesis, and requirement of upper-extremity weight bearing) made arthrodesis a less desirable option. All patients reported focal, activity-related pain. Most had secondary weakness and restricted motion. Most patients were routinely using nonsteroidal anti-inflammatory medications, and a few required narcotics for pain control. At their preoperative clinic visit patients were offered the choice of arthrodesis, palliative neurectomy, or other wrist reconstructive procedures as appropriate. Most chose partial wrist denervation with the understanding that arthrodesis might become necessary later.

Diagnostic AIN/PIN blocks were conducted preoperatively to guide patient selection for partial wrist denervation. Patient-reported pain relief after injection was substantial. Average reported relief was 83% (median, 95%) on a scale of 0% to 100%. Objective measurement of improved grip strength yielded less dramatic results. Average improvement in grip strength was 34% (median, 15%). Results of the diagnostic AIN/PIN blocks correlated poorly with ultimate postoperative pain frequency, severity, and DASH score. Enthusiasm may lead patients with chronic pain and disability to overestimate the analgesic effect of the diagnostic block. Aware of potential false-positive results, in our practice we have recently begun to use serial preoperative blocks with long-acting local anesthetic agents. Having patients test the block effect in the workplace or at home may facilitate realistic estimates of pain relief before a denervation procedure is considered.

Previous investigators[15,17] have commented on the transient nature of pain relief after both total and partial wrist denervation. In this series, sustained pain relief was evident at the time of questionnaire follow-up in most cases. Eighty percent of patients described their pain as less severe, 67% noted it less frequently, and 44% did not require medication for it. Most patients had some residual pain but it had receded to an acceptable level. These findings are to be expected because AIN/PIN neurectomy does not alter the underlying disease process or completely denervate the wrist.

Functional outcome assessment was performed with the DASH questionnaire. The average score was relatively high (31), and the SD was large (13.1). In general, responses indicated greater levels of disability with higher-demand tasks (heavy household chores, carrying objects heavier than 4.5 kgf) and wrist-loading activities (opening a tight jar). DASH scores were not predicted by workers' compensation status, patient age, or occupation. As shown in Table 2, correlations between DASH scores and overall satisfaction are imprecise at best. In this patient population, serial DASH testing may be useful.

Three patients required additional procedures for pain relief. Most procedures were performed within 1 year of denervation. Failure was independently associated with poor preoperative TAM F/E and workers' compensation status (both $p < .01$; Figs. 4, 5). The single patient with rheumatoid arthropathy required arthrodesis. Failure was not associated with chronicity of symptoms, previous wrist surgery, patient age, or occupation. One patient had a radial styloidectomy and one had a successful limited intercarpal arthrodesis. As expected for partial denervation, neuropathic changes were not observed on the serial radiographs.

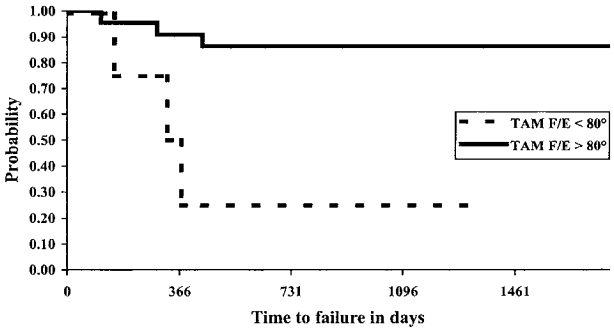

Figure 4. Cumulative probability of avoiding additional procedures according to preoperative total active motion in flexion and extension (TAM F/E).

Despite occasional pain and functional limitations, 14 of 20 cases reported satisfaction with partial wrist denervation. As shown in Table 2, this included all 3

Table 2. Outcome of Neurectomies of the Anterior Interosseous Nerve and Posterior Interosseous Nerve

Case	*Follow-Up (mo)*	*Subsequent Procedures (Months After Neurectomy)*	*DASH Score*	*Satisfaction*	*Retrospectively Choose Same Treatment?*
1	10	None	22	Very satisfied	Definitely yes
2	46	None	18	Neither	Probably not
3*	13	None	46	Somewhat satisfied	Probably yes
4	30	Total wrist fusion (12)	30	Somewhat satisfied	Probably yes
5	32	None	58	Very satisfied	Definitely yes
6	16	None	24	Very satisfied	Definitely yes
7†	32	None	44	Neither	Probably not
8*	33	None	42	Somewhat dissatisfied	Probably yes
9	15	None	44	Very satisfied	Definitely yes
10	20	None	30	Neither	Definitely yes
11	28	None	40	Somewhat satisfied	Probably yes
12	18	None	12	Very satisfied	Definitely yes
13	57	Four-corner fusion (4)	42	Very satisfied	Definitely yes
14	44	None	32	Very satisfied	Definitely yes
15*	58	None	20	Very satisfied	Definitely yes
16†	41	None	31	Somewhat satisfied	Definitely yes
17	12	Styloidectomy (5)	24	Very satisfied	Definitely yes
18	48	None	36	Neither	Probably yes
19	32	None	6	Neither	Probably yes
20	16	None	18	Very satisfied	Definitely yes

*Bilateral procedure, nondominant hand.
†Bilateral procedure, dominant hand.

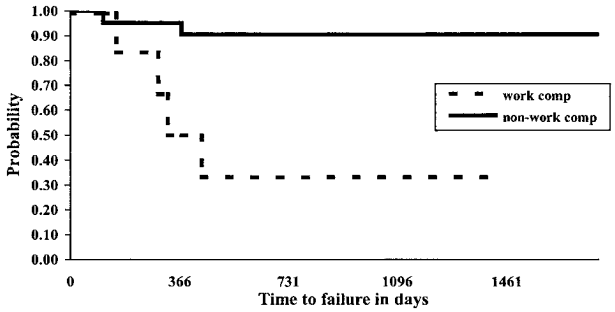

Figure 5. Cumulative probability of avoiding additional procedures according to workers' compensation status (work comp).

patients who required additional surgical procedures. Retrospectively, 18 of 20 cases, or 18 of 19 patients (95%) would have selected partial wrist denervation instead of arthrodesis or other procedures for management of their chronic wrist pain.

Several questions regarding the safety of denervation are continuously raised. First, there is a concern that denervation of a joint, partial or total, will lead to Charcot changes in the joint. In the present study, no patients exhibited any radiographic changes that could not be attributed to the progressive nature of their arthritic condition without the denervation procedure. Second, there is concern about what effect on normal joint mechanics resection of the nerve will produce. There may be some role that the AIN and PIN play in the neurologic monitoring of the wrist under normal circumstances; however, no direct evidence exists to support this. No patient in this series complained that his or her sense of joint position was negatively altered. Resection of these nerves under normal circumstances would not be warranted and may indeed produce some measurable deficit in mechanoreception. In patients with pain caused by a permanent condition such as arthritis, resection of these nerves as a means of palliating the patient's pain should offset any perceived alteration of proprioception. Independent work in our laboratory is currently underway to determine the normal and pathologic roles of these nerves as they relate to wrist joint mechanics. It will be interesting to determine if proprioception in patients with arthritis is a naturally occurring comorbidity of the arthritic process. The third and final concern with this specific denervation procedure is that resection of the AIN will denervate the pronator quadratus muscle. As with the original description of the procedure[16] the AIN is resected distal to the majority of motor fibers supplying the pronator quadratus muscle.

The efficacy of partial denervation of the wrist through the AIN and PIN as an adjunct to other procedures (radial styloidectomy, limited intercarpal fusions, additional denervation, and so forth) was not addressed in the current study. It would seem logical that when warranted, combinations of procedures would increase the overall efficacy of the procedures, which should be studied in the future.

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