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ORIGINAL ARTICLE

Patient satisfaction and outcomes of partial wrist denervation in inflammatory arthritis

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Abstract

Introduction Inflammatory arthritis frequently affects the wrist, resulting in pain and disability. This study aims to investigate the long-term outcome of patients who underwent posterior interosseous nerve (PIN) denervation for inflammatory arthritis of the wrist.

Method xForty consecutive wrists (36 patients) treated with PIN denervation were identified (mean follow-up 47 months; mean age 62.6 years, 77.5% female). Pain and function scores were objectively measured using the patient-rated wrist-evaluation (PRWE) questionnaires. Data was compared for pre-operation and post-operation (early and long term). The Student's *t* test was used to compare differences between groups for continuous data, whilst the sign test was utilised for pairwise comparisons. The *p* value was set at 0.05 for all comparisons.

Results Three patients died during the course of this study from causes unrelated to wrist surgery, resulting in 93% follow-up. PRWE questionnaires demonstrated a significant improvement following PIN denervation (median pain pre-op 42 vs post-op 16 ($p < 0.001$); median function pre-op 82 vs post-op 41 ($p < 0.001$), respectively). There were no differences identified between early and long-term post-operative scores. Four cases (10%) had persistent, ulnar-based pain and required secondary salvage wrist arthrodesis. However, 95% of patients remained "very satisfied" or "satisfied" after surgery.

Conclusions This study highlights the effectiveness of PIN denervation as a simple alternative to wrist arthrodesis due to long-term improvement in pain and preservation of function. We recommend this procedure in the presence of a positive diagnostic PIN infiltration test to avoid wrist arthrodesis for as long as possible. In patients with predominantly ulnar-based wrist pain, the outcome is less predictable and this subgroup of patients should be counselled about the possibility of subsequent salvage wrist fusion.

Key Points

- *One of the largest study cohorts which report on the outcome of the wrist PIN denervation procedure with over 2-year follow-up*
- *Clinical outcomes of success are enhanced with the use of validated, objective patient-reported outcome measures relating to overall satisfaction, pain relief and function.*
- *Long-term outcomes are compared to pre-operative and immediate post-operative outcome scores, demonstrating the benefits of PIN denervation and the longevity it provides.*

Keywords Denervation · Posterior interosseous nerve · Psoriatic arthritis · Rheumatoid arthritis · Wrist

Introduction

The wrist joint can be affected in up to 50% of patients with rheumatoid arthritis (RA), often resulting in clinically relevant pain and disability [1–3]. Medical management has improved with the introduction of biologic therapies in addition to disease-modifying treatments. However, many patients still advance to the point where surgical intervention may become necessary to manage pain, functional disability and deformity [4].

Posterior interosseous nerve (PIN) denervation is a surgical technique used to manage wrist pain. Wrist denervation was first described by Wilhelm but has since been widely modified [5]. Isolated PIN denervation involves a single incision and is

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associated with a quick recovery time [6]. So far, the literature has focused on its use in pain syndromes and non-inflammatory degenerative arthritis.

As a partial wrist denervation procedure, PIN denervation has the potential to rapidly alleviate wrist pain without sacrificing residual wrist mobility, which is critical in the patient with ipsilateral shoulder, elbow and/or hand involvement. As such, a role for PIN denervation in the management of inflammatory arthritis has emerged with similar outcome reported compared to wrist arthrodesis [6].

The literature describing outcomes of isolated PIN denervation procedures in patients with chronic wrist pain is sparse. Recent studies investigating outcomes such as pain relief and function have found overall satisfactory results [7]. A 2017 systematic review included 6 studies involving a total of 135 patients, but mainly with non-inflammatory conditions with an 88% improvement rate at 51 months but 25.5% of patients experienced pain recurrence on average 1 year after surgery [7].

Although it appears that PIN denervation is a worthy option to treat chronic wrist pain, there is limited evidence in the literature regarding patient-reported outcome measures (PROMs) following this procedure. Furthermore, there is little evidence to validate PIN denervation in patients with wrist pain secondary to established inflammatory arthritis.

The aim of this project is to measure the clinical and functional outcome of patients undergoing isolated PIN denervation for pain relief in inflammatory arthritis. We assumed a null hypothesis that there would be no significant change between the pre-operative and post-operative PROMs scores of patients treated with PIN denervation for inflammatory wrist pain.

Materials and methods

A prospective study was performed at a university teaching hospital. Approval for the study was obtained from the NHS Lothian audit department and research ethics service. Participation in the study was voluntary, and informed consent was obtained from all patients.

Study inclusion criteria

All patients who had undergone PIN denervation of the wrist were identified from a prospective single-surgeon series during the period 2009–2018. The current address and medical notes of all patients were obtained using the hospital's electronic TRAK Care™ (InterSystems Corp, Cambridge, MA, USA) system.

Study exclusion criteria

Subjects were considered lost to follow-up if they were uncontactable or declined to participate in the study. All of the remaining patients were contacted via postal questionnaire or telephone.

The long-term outcomes of patients who required further surgery, such as a wrist arthrodesis, post PIN denervation were excluded from the main group, but analysed separately. The pre-operative and early post-operative scores for these patients were retained.

Treatment protocol

Patients were selected for this procedure in a non-randomised fashion after attending a tertiary referral orthopaedic clinic specialising in rheumatoid conditions. All patients had been diagnosed with inflammatory arthritis and experienced severe wrist pain secondary to the disease, which was not controlled by medical therapies.

Plain radiographs for each patient were reviewed by using the hospital's Carestream Picture Archiving and Communication System (PACS) (Kodak Carestream Health, Rochester, NY, USA). Degree of radiographic severity was measured using Larsen's [8], Simmen's and Wrightington's classification [9] from the radiograph closest to time of surgery.

Patients were considered suitable for PIN denervation surgery if they had all of the following:

1) Severe wrist pain and residual wrist mobility
2) Confirmed diagnosis of inflammatory arthritis which had failed to respond to medical therapy
3) Plain-radiograph evidence of joint destruction
4) Complete or main pain relief of wrist pain following a diagnostic local anaesthetic PIN infiltration test (> 80% of subjective patient estimate) performed in clinic

Surgical technique

PIN denervation involves a 4–5-cm incision on the dorsal aspect of the distal forearm, just proximal to the radio ulnar joint. After the fascia is split, the PIN can be identified at the floor of the fourth compartment and ulnar border of the extensor pollicis longus (Fig. 1). A 1-cm section of the PIN is removed. In contrast to Wilhelm's original procedure, no other nerves were divided [5]. Local protocol dictated that weekly DMARDs were stopped 1 week before and then restarted 1 week post-procedure. Daily DMARDS were withheld 2 days prior and restarted 2 days post-procedure respectively [6].

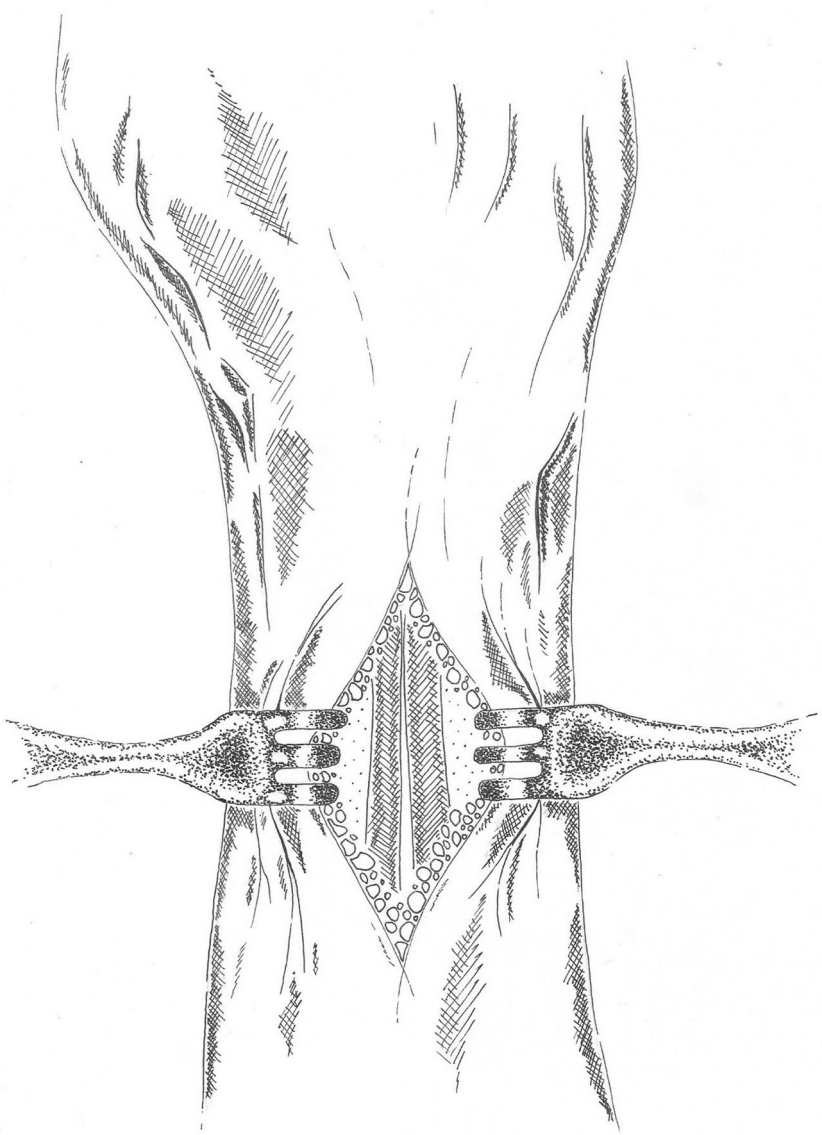

Fig. 1 Diagram depicting dorsal surgical approach utilised in PIN denervation of the wrist

Patient-reported outcome measures

The primary outcomes were analysed using a validated patient-rated wrist-evaluation (PRWE) questionnaire and satisfaction questions. Data was collected pre-operatively, early post-operatively (6 to 8 weeks) and long-term post-operatively (over 1 year).

The PRWE questionnaire assesses pain and functional impact of wrist pain in daily activities. Pain is rated on a scale of 0–10 where 0 is described as no pain and 10 as worst pain imaginable. Pain is assessed in 5 categories with a maximum total score of 50. Function is rated on a scale of 0–10 where 0 is described as no difficulty and 10 unable to do. There are 10 categories with a maximum total score of 100 [10]. Additionally, using a Likert scale, patients were asked at the long-term post-operative follow-up whether they were satisfied with the surgery, if they would recommend it to someone else and if they would have the procedure again [11].

Data analysis

Data analysis was completed using IBM SPSS Statistics software version 24. The change in scores of the questionnaire subcategories was analysed using paired Student's *t* tests. Total pain and function scores were compared between the three groups (pre-operative, early post-operative and long-term post-operative). Friedrich test assessed for a change across the groups with time, whilst Sign tests were selected for pairwise comparisons. *p* values were adjusted using Bonferroni correction to account for chance giving a statistically significant result. An independent *t* test was used to compare the mean long-term postoperative scores between

PIN denervation and the four cases of wrist arthrodesis. The level of statistical significance was set at a p value of < 0.05.

Kaplan–Meier survival curves with 95% confidence intervals were plotted to analyse success of PIN denervation. An event was defined as the patient requiring wrist arthrodesis due to failure of PIN denervation. Data was censored for loss to follow-up and/or death.

Results

Study population

Forty consecutive cases of PIN denervation on 36 patients were identified (four bilateral cases) during the period 2009–2018. Three cases were lost to follow-up in the long-term post-operative group due to patient death (unrelated to wrist surgery).

A total of 92.5% of patients had RA, with the remainder diagnosed with psoriatic arthritis. All patients reported disease affecting other joints, most commonly the knees and small joints of the hand. Radiographic classification showed severe erosion (Larsen grade 4, Wrightington's grade 4), mutilating changes (Larsen grade 5) and ankylosis (Simmen's grade 1). The most commonly prescribed DMARD was methotrexate. Average age at surgery was 62.6 years (26–82) and 77.5% of patients were female. Over half of surgeries were on the right wrist, the dominant hand of 92.5% patients. The mean follow-up time was 47 months (24–111 months). Patient demographics are summarised in Table 1.

Satisfaction

Ninety-five percent of patients were satisfied or very satisfied, the latter being 70%. Two patients were dissatisfied as they experienced no pain relief from the procedure. All patients (100%) would undergo the surgery again or recommend it to a friend.

Patient rated wrist evaluation—pain and function outcomes

PROMs demonstrated a significant decrease, therefore improvement, in median pain and function scores following PIN denervation of the wrist (< 0.001) (Table 2) with no decline over time (Figs. 2 and 3). Pairwise comparison of the pre-operative and post-operative 1 group showed a highly significant decrease ($p < 0.001$) in pain and function scores post-procedure. This was further confirmed ($p < 0.001$) when comparing the preoperative pain and function scores to the post-operative 2 scores.

To investigate pain recurrence, the early post-operative pain and function scores were compared to long-term post-operative scores. Median pain and function scores did not change (Table 2) with p values of 0.049 (Bonferroni adjusted to 0.147) and 1.000 (deemed unnecessary to adjust) respectively. This showed no statistically significant change suggesting that pain and function do not change over the post-operative time period analysed in this study.

Patient rated wrist evaluation—specific pain and function components

Prior to surgery, a proportion of patients reported significant pain rendering their wrist function of little use. This correlated with a total pre-operative function score of above 80. Twenty-four (60%) of patient scores fell into this severely disabling category. Moreover, 54% of those patients' X-rays were classified as Larsen grade 5; the severe mutilating joint changes likely underpin the observed disability. At the end of follow-up, 10 of those patients (42%) reported a dramatic improvement in function and thereby independence, correlating to a total function score below 40.

PIN denervation improved mean total pain scores by 52.3% and function scores by 41.4% when comparing pre-operative to early post-operative scores ($p < 0.001$) (Table 3). Specific activities such as turning a doorknob (62.8% improvement) and personal care (65.3% improvement) suggest recovery of function (Table 3). Pain at rest improved the most (68.3% improvement). However, patients should be aware of residual difficulties with carrying heavy objects (22.8% improvement) and recreational activities (26.4% improvement) (Table 3).

Adverse reaction, revision surgery and survival analysis

The recorded post-operative complications are shown in Table 1. In six cases, PIN denervation did not completely alleviate pain. Four out of these six patients subsequently opted for a wrist arthrodesis (10% of cohort). In all 4 patients, the radial wrist pain was resolved by PIN denervation, but wrist fusion was then carried out due to persistent ulnar-based pain (either DRUJ or ulnar impingement pain). Wrist fusions took place at an average of 12.3 months (4–30) after initial PIN denervation, indicating that "failures" are identified early, whilst successful outcome persists over time. Mean estimate survival time was 100 months (Confidence Interval 90–111) and 9-year survival time was 88% (Fig. 4).

In an attempt to compare the outcome of PIN denervation and wrist arthrodesis (within this cohort), the mean pain and function scores of the four patients who underwent wrist arthrodesis were compared to the mean long-term post-operative scores. No significant difference between pain ($p = 0.922$) or function scores ($p = 0.459$) was found. This suggests that PIN denervation and wrist arthrodesis, if successful, have very

Table 1 Summary of study group demographics

Demographics		Number (%)
Female gender (%)		77.5
Age (years); mean (SD)		62.6 (12.6)
Procedure on dominant hand (%)		55
Duration of diseases (years): mean (SD)		11.6 (5.1)
Follow-up (months); mean (SD)		47.4 (30.3)
Disease modifying anti-rheumatic drugs, *n* (%)	Any	37 (92.5)
	Methotrexate	23 (57.5)
	Hydroxychloroquine	4 (10)
	Leflunomide	3 (8.1)
	Prednisolone	3 (7.5)
	Sulfasalazine	3 (7.5)
	Analgesia alone	3 (7.5)
Biologic drugs, *n* (%)	Any	8 (20)
	Certolizumab	2 (5)
	Tocilizumab	2 (5)
	Etanercept	2 (5)
	Rituximab	1 (2.5)
	Adalimumab	1 (2.5)
Polyarticular disease (%)		100
Other joints affected	Knee	24 (60)
	Hand	20 (50)
	Foot and ankle	16 (40)
	Shoulder	11 (27.5)
	Hip	9 (22.5)
	Elbow	5 (12.5)
Larsen classification (%)	Grade 1	0
	Grade 2	5.6
	Grade 3	8.3
	Grade 4	19.4
	Grade 5	66.7
Wrightington's classification (%)	Grade 1	2.8
	Grade 2	11.1
	Grade 3	30.6
	Grade 4	55.6
Simmen's classification (%)	Grade 1	52.8
	Grade 2	30.6
	Grade 3	16.7
Complications	Residual pain (mainly ulnar)	16 (15)
	Conversion to arthrodesis	4 (10)
	Superficial infection	0
	Deep infection	0
	Chronic regional pain syndrome	0
Deaths during period of follow-up		4 (10)
*Unrelated to surgery		

similar outcomes in terms of long-term pain and function—in keeping with a previous comparative study [6]. However, PIN denervation results in greater improvement of pain and function at the short-term follow-up point compared to wrist arthrodesis, suggesting PIN denervation alleviates pain and improves function faster post-operatively.

Table 2 Comparison of median pain and function scores

	Pre-operative	Post-operative 1	Post-operative 2	*p* value
Median pain score	42	16	16	$p < 0.001$
Interquartile range pain score	14.5	26	25.5	
Median function score	82	41	41	$p < 0.001$
Interquartile range function score	25.25	48	40.5	

Discussion

This study reports the medium- to long-term outcomes of PIN denervation surgery for patients with inflammatory arthritis–related symptomatic destructive wrist arthropathy. This surgical intervention is simple, has little associated morbidity and offers a very rapid recovery within 1 to 2 weeks. Using validated patient-reported outcome measures, our results suggest that PIN denervation is highly effective in relieving pain and improving function. Furthermore, the majority of patients were satisfied with the procedure, surprisingly even those who later underwent salvage wrist arthrodesis for persistent or progressive ulnar-based wrist pain.

However, 15% of patients reported residual, predominantly ulnar-based pain post-procedure, and 10% required further surgery in the form of wrist arthrodesis. Previous studies have reported mixed results [12–14] where unsatisfactory or partial pain relief was common and often attributed to the wrist's mixed and sometimes anatomically variable nerve supply [15]. It is also possible that the nerve supply to the affected part of the wrist healed or adapted [16]. A more likely factor could be the use of local anaesthetic nerve block tests performed in the pre-operative setting. Whilst such tests are commonly used to estimate the degree of pain relief provided by PIN denervation surgery, some authors have suggested a poor correlation between the test and actual pain relief [17]. This cannot be supported by our study, as the PIN infiltration test accurately predicted relief of radial and central wrist pain. We did however find that the PIN infiltration test in patients with significant ulnar-based wrist pain may be falsely positive and we postulate that the LA may also flow into a disrupted DRUJ, hence incorrectly suggesting potential ulnar pain relief also.

Throughout this study, it became apparent that concurrent presence of ulnar wrist pain was the greatest determinant of the procedure being unsuccessful. We therefore suggest, as an important lesson, that patients experiencing pain at the distal radio-ulnar joint or ulnar impingement may have a "false positive" diagnostic infiltration test, incorrectly suggesting a more favourable outcome. In our experience, patients with predominant ulnar-based wrist pain are therefore unlikely to benefit from the procedure. As such, great care is required when selecting and counselling patients for the procedure. However, even in patients who have a degree of ulnar-based wrist pain, a

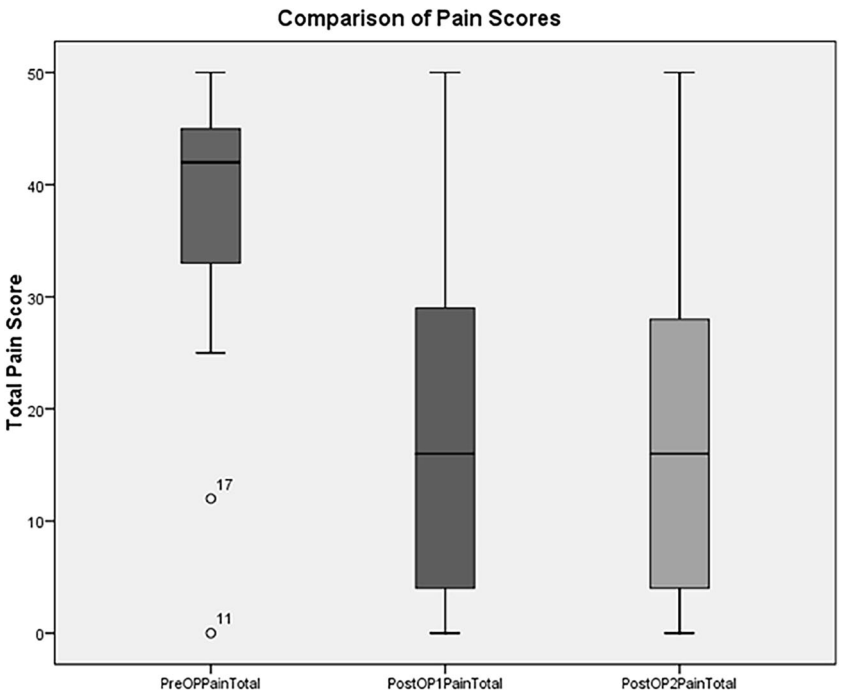

Fig. 2 Comparison of pain scores between the three groups

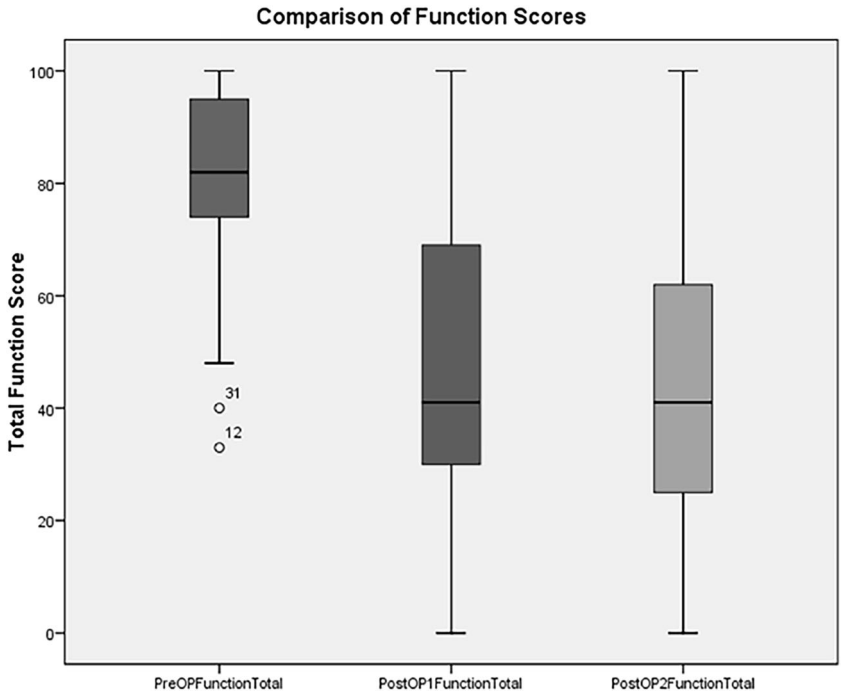

Fig. 3 Comparison of function scores between the three groups

PIN denervation may still be tried and carried out, if the predominant pain is radially and centrally based.

It was not possible to draw concrete conclusions comparing the outcome of PIN denervation to wrist arthrodesis in this study, but a previous study has directly compared wrist arthrodesis and PIN denervation and found no difference in terms of pain relief [6]. In addition, this study found that PIN denervation results in functional improvement compared to wrist arthrodesis. This most likely represents PIN denervation's shorter post-operative recovery period, as the procedure utilises a less invasive surgical technique. Overall, the findings suggest that PIN denervation can be as effective as wrist

Table 3 Comparison of pain and function score subcategories

	Pre-operative mean (SD)	Post-operative 1 mean (SD)	Post-operative 2 mean (SD)	Pre-op vs post-op 1	Pre-op vs post-op 2	Post-op1 vs post-op 2
Pain outcome						
Pain at rest	6.03 (3.09)	2.69 (2.72)	1.91 (2.55)	< 0.001*	< 0.001*	0.208
Pain on repeated wrist movement	8.05 (2.36)	4.10 (3.51)	3.42 (3.35)	< 0.001*	< 0.001*	0.527
Pain on lifting heavy object	8.33 (2.29)	4.23 (3.43)	3.22 (3.38)	< 0.001*	< 0.001*	0.107
Pain at its worse	8.60 (2.67)	4.66 (3.80)	4.61 (3.72)	< 0.001*	< 0.001*	0.851
Frequency of pain	8.64 (2.27)	4.23 (3.56)	3.21 (2.98)	< 0.001*	< 0.001*	0.134
Total pain	38.85 (10.53)	19.82 (15.98)	16.24 (14.12)	< 0.001*	< 0.001*	0.273
Function outcome						
Turning a door knob	8.02 (2.25)	4.05 (3.59)	3.27 (3.45)	< 0.001*	< 0.001*	0.109
Cutting meat using a knife	8.33 (2.43)	5.05 (3.99)	4.03 (3.88)	< 0.001*	< 0.001*	0.030*
Fasten buttons on shirt	8.25 (2.01)	4.79 (3.49)	4.85 (3.26)	< 0.001*	< 0.001*	0.876
Push up from chair	8.00 (2.47)	4.85 (3.58)	4.39 (3.80)	< 0.001*	< 0.001*	0.378
Carry a 10-lb object	8.74 (1.94)	6.10 (3.81)	6.75 (3.52)	< 0.001*	< 0.001*	0.474
Attend to personal hygiene	7.23 (2.99)	4.10 (3.62)	2.82 (3.02)	< 0.001*	< 0.001*	0.038
Personal care (dressing washing)	8.13 (5.63)	3.77 (3.23)	2.82 (3.02)	< 0.001*	< 0.001*	0.140
Household work (cleaning, maintenance)	8.15 (1.92)	5.36 (3.45)	5.48 (3.67)	< 0.001*	< 0.001*	0.781
Work (job or everyday work)	8.36 (1.78)	5.14 (3.50)	4.71 (3.62)	< 0.001*	< 0.001*	0.057
Recreational activities	8.40 (1.63)	5.59 (3.72)	6.18 (3.84)	< 0.001*	< 0.001*	0.513
Total function	80.05 (17.54)	47.15 (29.66)	43.73 (26.80)	< 0.001*	< 0.001*	0.331

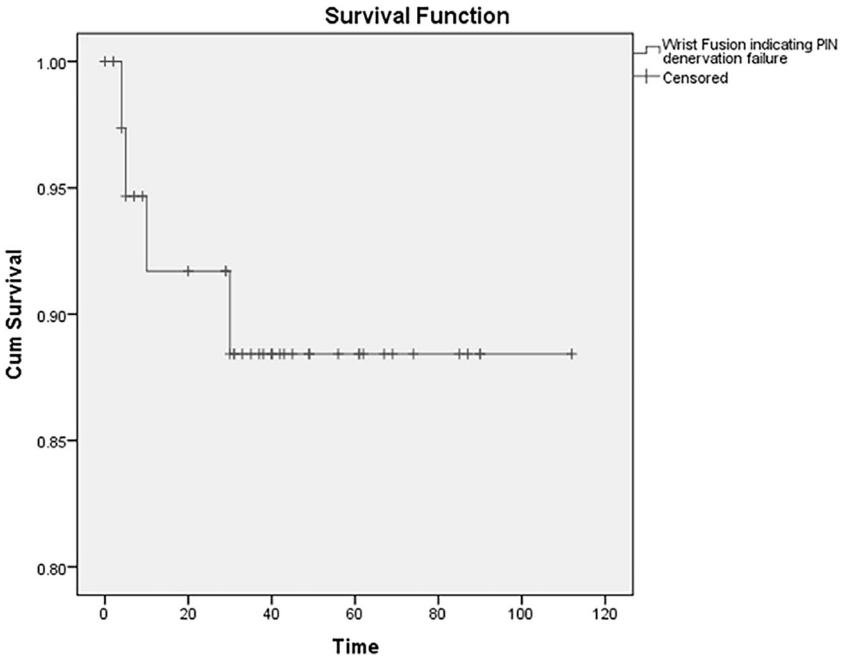

Fig. 4 Kaplan–Meier analysis of cumulative survival over time

arthrodesis in providing pain relief and support its continued use as a surgical management option in inflammatory wrist pain.

Importantly and in contrast to the literature [7], our study found no significant change in pain during the entire follow-up period (mean 4 years). The 4 patients with "failure", i.e. persistent, mainly ulnar-based wrist pain, were identified relatively early, within the first 6–18 months after the index PIN procedure. Thereafter, no further failures and recurrence of pain occurred. This is a somewhat surprising finding when considering the literature published. Vanden Berge et al.'s systematic review found that 25.5% of patients had some recurrence of pain at an average of 12.3 months [7]. However, these authors included only one study that focused on PIN denervation in the rheumatoid wrist. It is possible that a lower-demand cohort of patients may have different degrees of pain recurrence.

Sixteen cases (40%) were followed up over 5 years. Three were lost to follow-up, but no pain recurrence was reported. All patients with failure re-presented early and underwent further surgery within 18 months of the initial procedure. Using our outcome data, we cautiously suggest that pain recurrence is unlikely to occur if patients experienced a satisfactory reduction in pain following the PIN denervation procedure. If proven, then short-term outcomes could predict long-term outcomes in pain recurrence.

Limitations

This study represents the analysis of data collected prospectively from a single surgeon in a tertiary clinic. As a result, there are some limitations of the study design which may influence the results as patients were selected in a non-randomised fashion and there is no specific comparative group. The study population was small, although previously published systematic reviews have highlighted that this is a recurring issue given the low number of patients who fit the inclusion criteria for this procedure [7]. The results could therefore overestimate the significance of the findings. This particularly applies to the second post-operative group, which experienced three cases being lost to follow-up. However, as all cases were from a single-surgeon series, this helped to standardise the setting and minimise other potentially influencing variables such as surgeon technique.

The majority of patients completed each questionnaire and returned them to the study team. Whilst we were principally measuring the outcome of pain and function experienced at the wrist, we noticed that several patients reported about global function and pain levels related to other small joints around the wrist and hand. This could be a potentially confounding factor and may artificially elevate measured levels of pain and disability. However, as this would have affected both the pre-operative and post-operative scores equally, the overall trend observed is unlikely to be affected.

However, further targeted research is needed to confirm these findings. It is difficult to increase sample size as often studies are based on single-surgeon series, but attempts should focus on increasing the duration of follow-up period, whilst continuously recruiting new suitable patients. In view of treatment protocols and options for surgical intervention in RA patients, it would also be helpful to compare PIN denervation to wrist arthrodesis in a prospective randomised controlled trial.

Conclusions

This study demonstrates that PIN denervation is a very useful procedure in relieving pain, improving function and maintaining mobility in patients suffering from wrist pain due to inflammatory arthropathy. PIN denervation surgery is associated with negligible operative risks, allows a swift recovery for patients and is associated with an extremely high patient satisfaction rate.

Patient-reported outcome measures suggest that PIN wrist denervation is highly successful in relieving pain and improving function with the advantage of preservation of residual wrist mobility compared with wrist arthrodesis. Our findings suggest an approximate 10% risk of secondary wrist arthrodesis in patients with persistent or progressive ulnar wrist pain. If patients are correctly selected for this procedure, this study suggests no recurrence of pain and disability at medium- and long-term follow-ups.

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Compliance with ethical standards

Disclaimer The authors retain full control of all primary data utilised in this study. Anonymised data shall be made available if requested.

Disclosures None.

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