Pyrocarbon Proximal Interphalangeal Joint Arthroplasty: Outcome Audit in the Patient's Environment

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Citation

M Ng, J Clarkson, A Wilmshurst. *Pyrocarbon Proximal Interphalangeal Joint Arthroplasty: Outcome Audit in the Patient's Environment*. The Internet Journal of Hand Surgery. 2006 Volume 1 Number 1.

Abstract

A retrospective audit was carried out to evaluate the objective and subjective outcomes of pyrocarbon proximal interphalangeal joint replacement. Fifteen arthroplasties in 14 patients performed by the senior surgeon with a minimum follow-up interval of six months were included. Patients were visited at home, examined clinically and given questionnaires to fill in. The mean follow-up time was 27.4 months. The main indication for the procedure was pain. The patients had osteoarthritis, rheumatoid arthritis or post-traumatic arthritis. Infection and wound healing problems were not reported. Post-operatively, the range of movement improved. Radiographs were in keeping with the manufacturer's description of lucent zones. Pain was reduced and patients were satisfied with the procedure. The evaluation at home yielded qualitative data that is not possible to obtain at an outpatient clinic. The home visits provided an invaluable insight into the impact of the procedure on the patients.

INTRODUCTION

Dysfunction of the proximal interphalangeal joint (PIPJ) may have a negative effect on the quality of life. Two commonly employed surgical techniques for this joint are arthrodesis and arthroplasty using silicone implants. Both relieve pain; the former sacrifices movement for stability and the latter attempts to preserve or restore movement, whilst maintaining stability. Burman [1] was the first to report the use of PIPJ arthroplasty with a prosthetic replacement. Linscheid and Dobyns [2] introduced the progenitor of today's PIPJ prostheses. Since then, PIPJ prostheses have been developed to reproduce the natural joint surface as much as possible and to retain lateral stability.

Pyrocarbon prostheses are made with a graphite core and contain a small amount of tungsten to render them radio opaque. Pyrolytic carbon coats the core through chemical vapour deposition. The non-hinged, anatomical design is intended to produce a stable range of movement.

This study aims to evaluate the objective and subjective outcomes of pyrocarbon PIPJ arthroplasties carried out in our department between 2004 and 2008.

METHOD

A retrospective audit of PIPJ arthroplasties performed by the senior surgeon was carried out, with a minimum six-month follow-up period. Home visits were carried out when patients were examined and given questionnaires to fill in.

Our operative technique is identical to that recommended by the manufacturers with the exception that the central slip is split in the midline longitudinally, elevated at a sub-periosteal level and reflected, as opposed to the chevron tendon flap recommended by the manufacturer.

Range of movement (ROM) was measured with a goniometer. The goniometer was placed on the dorsum of the joint with the patient's arm resting on an armrest. The active range of movement was recorded.

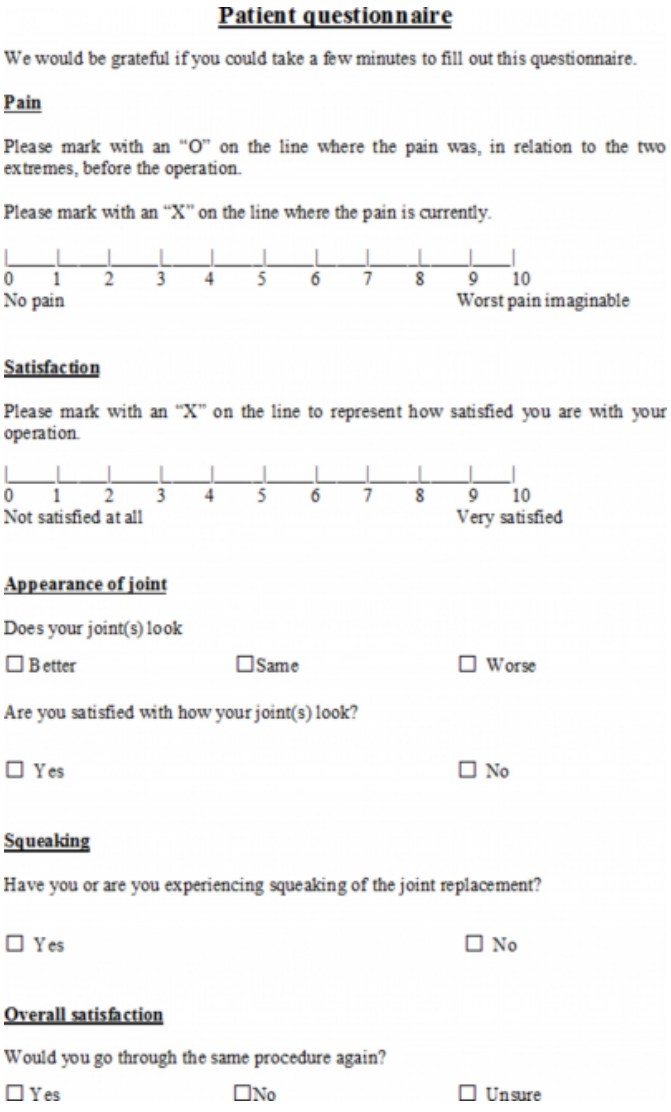
Grip strength was measured with a Jamar dynamometer (JA Preston Corp, Jackson, USA), with the handle at position 2. Pinch grip was measured with a Baseline pinch gauge (B&L Engineering, California, USA). All grip measurements were taken in a standard manner with the average of three readings taken as the final score.

Subjective outcome was assessed using a questionnaire similar to those used in previous studies to enable future comparative studies (Fig 1). Pain and satisfaction scores were obtained with a visual analogue scale. Other criteria, such as squeaking and joint appearance, were obtained using discreet answers, instead of free text. Preoperative variables were obtained from both the patients' notes and the patients' recollections during the home visit.

Data were collected on Microsoft Excel and non parametric statistical calculations were used when appropriate. A p value of less than 0.05 was considered significant.

Figure 1

Figure 1. Patient questionnaire



Patient questionnaire

We would be grateful if you could take a few minutes to fill out this questionnaire.

Pain

Please mark with an "O" on the line where the pain was, in relation to the two extremes, before the operation.

Please mark with an "X" on the line where the pain is currently.

0 1 2 3 4 5 6 7 8 9 10
No pain — Worst pain imaginable

Satisfaction

Please mark with an "X" on the line to represent how satisfied you are with your operation.

0 1 2 3 4 5 6 7 8 9 10
Not satisfied at all — Very satisfied

Appearance of joint

Does your joint(s) look

☐ Better ☐ Same ☐ Worse

Are you satisfied with how your joint(s) look?

☐ Yes ☐ No

Squeaking

Have you or are you experiencing squeaking of the joint replacement?

☐ Yes ☐ No

Overall satisfaction

Would you go through the same procedure again?

☐ Yes ☐ No ☐ Unsure

RESULTS

Fifteen joints in 14 patients were included in the study; 12 were female and two were male. The follow up time ranged from 7 to 44 months (mean 27.4). The mean age at operation was 62.5 years (range 38 to 82 years). Nine joints were on the dominant hand. There were three index fingers, eight middle fingers, three ring fingers and one little finger included in the study. No pyrocarbon PIPJ arthroplasty with more than 6 months follow up was excluded from this series.

The indications for the procedure were pain, stiffness and deformity. These were secondary to osteoarthritis (n=8), rheumatoid arthritis (n=4) or trauma (n=3). Patient factors such as diagnosis, hand dominance and side of hand operated on did not influence the clinical outcome and patient satisfaction.

All seven patients who were employed or had a hobby requiring intensive use of their hands returned to work or resumed their hobbies. Complications reported included deformity, stiffness, instability and subluxation. Three patients had subsequent soft tissue corrections, two for stiffness and one for instability. The primary procedures for these three patients took place in the first 15 months of this series, although these complications had no statistical association with increasing experience, patient age and diagnosis. There were no infections, implant failure or problems with wound healing. Tables 1a, b and c. Patient data, range of movement and outcome

Key to Tables: ADLs – activities of daily living; MUA – manipulation under anaesthetic; N/A – not available or applicable; OA – osteoarthritis; RA – rheumatoid arthritis; RCL – radial collateral ligament; ROM – range of movement; UCL – ulna collateral ligament

Patient data, range of movement and outcomes are shown in Tables 1a-c. The average preoperative degree of movement was 47.9 and increased to 67.7 postoperatively. However, this did not reach statistical significance. The mean change in degrees of movement was 15.3 (range –21 to 90 degrees). Patients with osteoarthritis tended to be in a greater degree of fixed flexion preoperatively than the post traumatic group. The 60-69 year old age group gained more ROM, whilst those in the 70 plus age group fared worse (p 0.036, χ^2 test).

Figure 2

Table 1a. Patient data

Patient	Pre operative ROM	Post operative ROM	Degrees of gain or loss	Complications	Re-operation
1	13-56	10-69	16	Nil	
2	0-70	-10-80	20	Nil	
3	N/A	-30-100	N/A	Swan neck	
4	75-100	15-60	20	Extensor lag	
5	5-80	0-85	10	Nil	
6	9-40	50-60	-21	Stiffness	Soft tissue realignment
7	35-92	-8-80	31	Pain and instability	Repair RCL and UCL
8	32-50	60-60	-18	Stiffness	MUA and arthrolysis
9	7-70	-14-75	26	Nil	
10	0-80	10-90	0	Slight extensor lag	
2	0-0	60-80	20	Stiffness	
11	5-30	-10-105	90	Nil	
12	0-65	-4-70	9	Subluxation, swan neck	
13	4-62	-10-40	-8	Swan neck	
14	22-83	20-100	19	Mild palmar Dupuytrens	

Figure 3

Table 1b. Patient outcomes – range of movement and complications

Patient	Sex	Diagnosis	Age at operation (years)	Follow up (months)	Digit	Main preoperative symptoms
1	M	OA	41	44	Index	Pain
2	F	OA	63	41	Index	Pain
3	F	OA	71	41	Middle	Pain
4	F	RA	62	38	Little	Deformity
5	F	OA	76	37	Middle	Pain
6	F	RA	42	37	Middle	Pain
7	M	Post-traumatic	38	36	Middle	Pain
8	F	Post-traumatic	54	29	Ring	Stiffness
9	F	OA	63	24	Middle	Pain
10	F	OA	82	24	Middle	Pain
2	F	OA, arthrodesed	64	20	Index	Stiffness
11	F	RA	77	12	Middle	Pain
12	F	OA	70	11	Ring	Stiffness
13	F	RA	73	10	Middle	Deformity
14	F	Post-traumatic	61	7	Ring	Pain

Figure 4

Table 1c. Patient outcome – return to activities

Patient	Hobbies or employment	Outcome	
		Return to hobbies or work	Return to ADLs
1	Gardening	Yes	Yes
2	Nil	N/A	Yes
3	Card making	Yes	Yes
4	Knitting	Yes	Yes
5	Nil	N/A	Yes
6	Working	Yes	Yes
7	Working, cycling	Yes	Yes
8	Nil	N/A	No
9	Nil	N/A	Yes
10	Sewing	Yes	Yes
2	Nil	N/A	Yes
11	Nil	N/A	Yes
12	Nil	N/A	Yes
13	Nil	N/A	Yes
14	Golf	Yes	Yes

Grip strength measurements were taken post operatively for all patients. Pinch tests were undertaken appropriate to the finger operated on. The hand operated on was compared to the other hand. There were no preoperative values available for comparison. The mean grip strength on the operated hand was 39.27 lbs (range 8 to 76.3 lbs) and on the contralateral hand 41.13 lbs (range 8 to 95 lbs). The pinch, lateral and tripod grip of the operated hand, when matched for age and sex [3], were on the low end of normal or below normal.

Postoperative x-rays were available for 13 of the 15 joints. Radiographs were taken between 2 and 34 months postoperatively (mean 10.85 months). Coronal angulation was found in five patients, ranging from 0 to 15 degrees. One joint was subluxed and loosened, in a non-dominant, osteoarthritic left ring finger. There were no findings of subsidence or erosion of the joints. We found that all prostheses were surrounded by an apparent zone of lucency 0.8 to 1mm in thickness, in keeping with the manufacturer's literature [4], and representing the pyrolytic carbon layer. Figure 2a and 2b is an example of the preoperative and postoperative radiological appearance.

Figure 5

Figure 2a. Preoperative x-rays showing AP and lateral views of left ring finger

Figure 6

Figure 2b. Postoperative x-rays showing AP and lateral views of left ring finger

Pain scores on the visual analogue scale decreased from the pre-operative average of 7.6 (range 0 to 10) to 1.7 postoperatively (range 0 to 7), which was significant ($p<0.05$, paired T test). There was a correlation between the level of preoperative pain and the degree of reduction of pain (p 0.014, Spearman's Rho).

Ten joints were considered by the patient to look better following surgery, two remained the same and three appeared worse. Of interest, one patient whose joint looked worse after the arthroplasty reported to be satisfied with its appearance. Patients reported squeaking in six joints.

Satisfaction with the procedure scores ranged from 0 to 10, with 57.1% of patients reporting satisfaction at seven or more (mean 6.86). The only patient who scored zero had postoperative stiffness, and four patients scored 10. When asked whether they would undergo the same procedure again, ten patients responded yes, one no and two were unsure.

DISCUSSION

To date, there are four published works that look at the postoperative outcomes of pyrocarbon PIPJ arthroplasties with an average follow up time of more than 12 months (Branam et al., 2007; Bravo et al., 2007; Herren et al., 2006; Tuttle and Stern, 2006). Branam et al [5] reported on almost the same cohort of patients as Tuttle and Stern [6], with the average follow-up time increased from 13 to 19 months, and comparing them with a series of silicone joint replacements. Bravo et al [7] had the largest number of patients (n=50). The outcomes measured by Branam et al [5] and Bravo et al [6] were similar, which allows comparison of data from the two centres. Herren et al [8] compared the outcomes of using dorsal and palmar approaches, and the radiological findings. There have yet to be any reports on the outcomes of the procedure on a British population.

The conclusions reached in these previous studies in terms of outcome and patient satisfaction are similar to our series. The procedure significantly reduced pain. Range of movement was improved in both flexion and extension, but not significantly. A common outcome was hyperextension of the PIPJ, which is likely to be due to detachment or redundancy of the volar plate. This did not, however, appear to cause problems with the functioning of the finger.

Herren et al [8] reported nearly half of their cohort to show implant migration on x-ray, with one requiring joint fusion. A further three cases had increased radiolucent lines. This is in contrast with our study population which did not have any observable implant migration found on x-rays. It is not clear why such a large number of implants migrated in that study.

Preoperative pain scores were not recorded, but retrospective scores are reported to be reliable [9].Surprisingly, the degree of pain relief afforded by the procedure did not influence the level of satisfaction; instead being able to extend the joint further seemed to please patients more.

Squeaking was deemed an unsatisfactory outcome by patients in previous studies. The patients in our study who reported squeaking found it a curiosity rather than a negative outcome. One described entertaining her grandchildren with her musical joint. The incidence of squeaking in our group of patients was marginally lower than previous reports.

Although statistical calculations were carried out in this

study, the results were interpreted with caution. With the small number treated, they were liable to Type I and Type II errors, and reliance on statistical significance was therefore minimised.

In our practice, the clinical decision to proceed with arthroplasty is a balance of the benefit the procedure can provide, the expectations of the patient and the actual demand placed upon the hands on a daily basis. The surgeon's judgement of surgical success should incorporate the perspective of the patient.

In an effort to collect data as efficiently as possible, our follow-up was carried out in patients' homes. This provided an invaluable insight into how the procedure had impacted upon their lives and activities of daily living. The situation is far removed from the clinical setting, where hand function is divorced from the common duties of opening doors for visitors and making them cups of tea.

Quantitative data allow objective assessment outcome following surgery. There are a number of well-validated tests that quantify various aspects of hand function. None are specific to small joint replacement and generic tools may not be appropriate in the presence of other health problems. Self-reporting is an integral part of tools such as the DASH Score but self-reporting of physical function may not be entirely reliable in the elderly population [10]. We opted to use hand measurements commonly employed by hand therapists that were easy to administer and a simple questionnaire utilised in previous studies [5-7]. This allows future comparisons of outcomes between centres.

However, it is the patients who reap the benefits of the procedure and to each patient the outcome is unique. Quantitative data, unfortunately, do not wholly capture this human element of the patient's subjective outcome. The home visits provided the opportunity to collect both quantitative and qualitative data. Each visit was a snapshot of how the arthroplasty had impacted upon the patient's life and on those around the patient. The patient's expectations of the procedure, the eventual outcome and daily activity levels were all put into context during the home visit.

Home visits have been shown to identify more problems in the elderly population than in clinic assessments [11]. In our experience, they also added an extra dimension to the data we collected from our patients. Qualitative data collection can be obtained from the researcher's observations, provide a deeper understanding of the patient experience and allow for the variability of individuals, which quantitative data cannot accommodate [12].We offer short descriptions of two cases which illustrate how home visits offer further information unavailable at a clinic. Patient 3 lives alone in a house with a large garden she keeps herself. We observed that the garden was well-kept, she was able to grip door handles and operate the latch with ease. She used a normal biro pen to mark on the visual analogue scale her pain scale with no awkwardness or discomfort. Upon leaving, we noted a large pile of cards on a table. The patient stated she had returned to her hobby of making intricate greeting cards, which required intensive use of her fingers. Patient 12 lived with her husband in a cottage. She was her husband's main carer and it was evident during the home visit that she tended to all his needs, including dressing him. Her husband was dressed in full Scottish regalia, which requires grip strength to fasten buckles and manipulate a heavy kilt. Despite not having hobbies, being able to care for her husband was a priority to her.

As a result of this study, some issues with our service provision have been highlighted. We have considered implementing peri-operative home visits by the hand therapists. The quality of data collection was reduced by incomplete preoperative records. It is necessary to employ a more structured approach to data collection and recording for future audits as part of our service development in this area, with the aim of conferring greater benefit to our patients.

In conclusion, the procedure improves the range of movement and reduces pain. Patient selection is key to providing maximum benefit. Home visits provide a useful insight into the overall hand function of patients after joint reconstruction in the hand. In our view, semi-qualitative data obtained from satisfaction questionnaires should carry more weight in the judgement of outcome in reconstructive hand surgery.

ACKNOWLEDGEMENTS

Cyndi Svee-McCulloch, Hand Therapist, Ninewells Hospital, Dundee and Kim Stewart, Senior Occupational Therapist, Perth Royal Infirmary, Perth for their advice, assistance and patience.

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