

# Hendricks

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## **Predictors of treatment outcomes following pyrocarbon proximal interphalangeal joint arthroplasty**

### **ABSTRACT**

Studies on likely sociodemographic and pre-surgical determinants of hand function and satisfaction following pyrocarbon proximal interphalangeal joint arthroplasty (PPIJA) are scarce. This study aimed to explore the association between pre-surgical sociodemographic and clinical characteristics on post-surgical hand function and satisfaction of patients who underwent PPIJA and to evaluate the effects of the procedure on pain and active range of movement (AROM) using retrospective data and on-site follow-up assessment. Data from 48 patients aged  $62.54 \pm 9.27$  years, who had PPIJA between 2001 and 2012, with a total of 61 arthroplasties, were reviewed. Participants' pain, AROM, satisfaction and disability were also assessed. Key reason for surgery amongst participants was joint stiffness (68%). 52% of the participants were not consistent with therapy sessions. About 38% of the patients were very dissatisfied with the post-operative status of their finger and hand while mild level of disability was reported by 47.9% of the participants. Levels of satisfaction and disability were significantly associated with gender ( $p = 0.029$ ) and number of missed/cancelled therapy appointments ( $p = 0.010$ ) respectively. Pain significantly reduced ( $p < 0.001$ ) while AROM significantly increased ( $p = 0.001$ ) from pre-operative assessment to final follow-up assessment. Likely determinants of postoperative satisfaction and disability levels found were gender and number of missed therapy appointments respectively. Levels of postoperative satisfaction and disability were relatively high despite improvement in pain and ROM outcomes.

### **Keywords**

Proximal interphalangeal joint, pyrocarbon arthroplasty, hand satisfaction and function,

## INTRODUCTION

The hand is comprised of structures and joints that require optimum alignment and control for normal hand function to occur. Hand function relies on anatomic integrity, mobility, muscle strength, sensation and coordination.<sup>6</sup> Muscle activity is a major determinant of forces acting on the finger joints, with hand grip being a common task, during which increased muscle forces are sustained at the interphalangeal joints of the fingers.<sup>28</sup> The proximal interphalangeal (PIP) joint is central to hand function,<sup>3</sup> however the joint has been reported as the third most commonly affected by the presence of osteoarthritis in the hand.<sup>4</sup> Rheumatoid arthritis and primary or post-traumatic osteoarthritis in the hand are also linked with contracture and pain which accounts for reduced occupational performance.<sup>11</sup> Pinch and grip strength in the hand may be substantially reduced as a direct consequence of pain or decreased mobility in the PIP joint,<sup>4</sup> which can negatively impact on the individual's quality of life.<sup>6</sup>

Arthritis of the PIP joint is a debilitating condition, which can be treated surgically with either joint arthroplasty or arthrodesis. Arthroplasty involves the excision and replacement of damaged arthritic joint surfaces with a prosthetic joint or an artificial implant while arthrodesis is the surgical fixation of an arthritic joint to promote bone fusion and immobilisation.<sup>7</sup> However, arthroplasty is a commoner form of treatment and a favourable alternative to arthrodesis because arthroplasty offers the advantage of joint mobility.<sup>8</sup>

Pyrocarbon semi-constrained implants have been in use in Europe and in the United States since 2000 and 2002 respectively.<sup>9</sup> Pyrocarbon is popular for its durability, strength, resistance to wear and having an elastic modulus similar to cortical bone.<sup>20</sup> The implant is also beneficial in terms of low rates of periprosthetic fracture, low inflammatory reactions and good opacity for X-ray viewing.<sup>9</sup> Pyrocarbon as a surgical option of salvaging a degenerated PIP joint<sup>5</sup> and the approach is gaining favour due to reported outcomes which included excellent pain relief and implant survival.<sup>10</sup> Pyrocarbon arthroplasty of the PIP joint is commonly indicated for patients with symptomatic arthritis who have intact collateral ligaments, adequate bony stock and intact extensor tendons or extensor tendons that can be reconstructed.<sup>11</sup> The presence of arthritic pain remains a major indication for almost every proximal interphalangeal joint procedure.<sup>12</sup>

Review of studies<sup>9,11,13-15</sup> investigating the outcomes following pyrocarbon PIP joint arthroplasty has shown conflicting findings regarding treatment outcomes. Although pain relief seems common to all aforementioned studies, there seems no consensus regarding results on range of movement (ROM). While authors like Meier et al.<sup>12</sup> and McGuire et al.<sup>16</sup> reported a significant increase in PIP joint ROM following pyrocarbon arthroplasty, researchers like

Bravo et al.,<sup>9</sup> Wijk et al.,<sup>5</sup> and Watt et al.<sup>17</sup> did not observe appreciable improvement in the outcome. Besides, socio-demographic, therapeutic and clinical characteristics that are likely to determine a patient's level of hand function and disability post-operatively, have not been reported. Surgeons are reportedly opting to discontinue using pyrocarbon arthroplasty due to the issue of post-operative complications.<sup>18</sup> Therefore, this study aimed to determine whether baseline socio-demographic clinical and therapeutic characteristics of patients who had PIP joint pyrocarbon arthroplasty are associated with the level of hand function and satisfaction at final follow up. The study also evaluated pre/post-surgical changes in pain and ROM outcomes of the patients.

## METHODOLOGY

The study was approved by a relevant research ethics committee (HHS/1476/2010M), the permission of management of the specialist clinic involved was also obtained.

### Study Population and Sample

The participants were 48 individuals who had pyrocarbon Proximal Interphalangeal joint arthroplasty at a specialist clinic in Cape Town, South Africa, from 2002-2012. A convenience sampling frame was used to recruit available and consented patients who have undergone pyrocarbon arthroplasty of the PIP joint for the study. All participants were literate in English, as the language is predominant in the Southern suburbs of Cape Town. All participants gave their signed informed consent prior to their participation in the study once the purpose and procedures of the study were explained to them.

Inclusion criteria were male and female patients aged 40 and 75 years; all race/ethnic groups; osteoarthritis and post-traumatic arthritis as an indication for surgery; pyrocarbon arthroplasty for PIP joints of index, middle, ring and little fingers; those with right and left dominant hands; and minimum of six months post-surgery in view of tissue healing time frames.

Patients with history of previous surgery on the affected digit; rheumatoid arthritis as an indication for surgery and those with a previous history of chronic regional pain syndrome (as this affects the course, frequency and duration of post-operative rehabilitation and post-operative outcomes) were excluded from the study.

### Study Design

This study is a descriptive cross-sectional survey with both a retrospective component and a post-operative on-site assessment at the clinic.

### Procedure

Data collection was carried out in 3 phases: a retrospective review of patients' clinical notes review; physical observation/examination of the PIP joint and objective

assessment/measurement of post-operative pain intensity, operated PIP joint's ROM and levels of hand disability and patients' satisfaction.

#### **Retrospective patient chart review**

Prospective participants attending rehabilitation sessions at the clinic <sup>24</sup> were informed of the planned study and gave their signed informed consent to allow researchers access to their medical records and contact details prior to the commencement of the research. Sociodemographic, clinical and treatment-related information such as age, gender, race, educational level, occupation/hobbies, hand dominance, digit affected, details of surgery: stage of joint degeneration and surgical approach used, reason for arthroplasty, frequency of treatments, splinting choices; compliance with treatment schedule, and complications was extracted from patient's files and clinic cards and recorded on a data recording sheet. Baseline pain intensity and ROM (before surgery and at 6th month follow-up) of the PIP joint were also sourced and recorded from participants' medical records.

#### **Physical observation/examination of the PIP joint**

Physical examination <sup>35</sup> of the PIP joint was carried out and incidence of deformities such as: Swan neck deformity; Boutonniere deformity; Hyperextension, and scarring were recorded

#### **Objective assessed outcomes**

##### *Pain and Level of Satisfaction*

Pain intensity and participants level of satisfaction with the status of their finger were assessed using Pain and Satisfaction Questionnaire (PSQ).

A pre-coded pain and satisfaction questionnaire that incorporated all relevant aspects of hand surgery reviewed in the literature was constructed. The following response categories (specific for arthroplasty) were identified: pain using the Visual Analogue Scale (VAS); joint appearance and squeaking; participants' satisfaction and willingness to have the same surgery again.

The same principle as the VAS for pain was applied for the evaluation of a satisfaction score. The only difference is in the descriptors found at either end of the scale. For pain assessment, scores of 0 and 10 represent no pain and severe/excruciating pain respectively, in case of level of satisfaction, 0 and 10 denote very dissatisfied and extremely satisfied respectively.

Level of satisfaction responses were divided into four categories namely: 0-2: very dissatisfied, 3-4: dissatisfied, 5-7: satisfied and 8-10: highly satisfied. The VAS is highly reliable with Pearson correlations in the range of 0.40 – 0.80 and the intra-class coefficient of 0.0.<sup>19</sup>

##### *Range of movement of PIP joint*

A Sammons Preston Goniometer was used to measure the active ROM at participants' replaced PIP joint. Dorsal method of goniometric placement was used as the method <sup>10</sup> has been shown to have a higher inter-rater reliability.<sup>20</sup> The participant was requested to position the upper limb <sup>5</sup> on the table <sup>8</sup> with the elbow flexed to 90 degrees and the wrist in neutral position. Using the <sup>5</sup> dorsal aspect of the PIP joint as the axis, the stationary arm of the goniometer was

placed along the dorsal midline of the proximal phalanx while the movable arm was placed along the dorsal midline of the middle phalanx. Participants were requested to actively flex/bend the replaced PIP joint

*Level of hand disability*

The Disability of the Shoulder, Hand and Elbow (DASH) Questionnaire was used to assess participants level of disability. It is a self-report questionnaire consisting of 30 questions that explores symptom severity, physical activity and the effect of surgery on daily, social and work activity. At least 27 of the 30 items must be completed for a score to be calculated: DASH disability/Symptom score =  $[(\text{sum of } n \text{ responses}) - 1] \times 25n$ . Where n is equal to the number of responses. The score ranges from 0 (no disability) to 100 (severe disability).<sup>21</sup>

A score of 0-20 is considered normal upper limb function while scores 20-40, 40-60, 60-80 are considered mild, moderate and severe disability respectively.

The DASH questionnaire is a valid measure of health status in patients with upper extremity complaints; its Pearson correlation coefficients to the SF-36 subscales ranged from -0.36 to -0.62. Further, the questionnaire had fewer ceiling and floor scores than most of the SF-36 subscales.<sup>22</sup>

#### **Statistical analysis**

Data were analysed using SPSS 25.0 version (SPSS Inc., Chicago, Illinois, USA).

Categorical variables were summarised using frequency tables, percentages and bar charts while continuous variables such as age, post-operative PSQ and DASH scores were summarised using mean and standard deviation.

The Pearson chi-square test was used to test the associations between levels of satisfaction and disability, and socio-demographics, clinical profile and therapeutic history.

Shapiro Wilk test for normality performed on AROM and VAS scores data indicated that the data were not normally distributed. Consequently, VAS pre-operative and final scores were compared using Wilcoxon Signed Ranked test while AROM pre-operative, 6 month and final were compared using Friedman ANOVA. Multiple pairwise post-hoc analysis (for Friedman ANOVA) was computed to identify time points that significantly differ. Level of significance was set at  $p < 0.05$ .

#### **RESULTS**

Data regarding 48 participants, with a total of 61 PIPJ arthroplasties, were reviewed and analysed. For the purpose of this study, the most symptomatic joint (with higher/highest VAS scores was chosen for patients with multi-digit arthroplasty). The mean age at final follow-up assessment was  $62.54 \pm 9.27$  years. The summary of participants' sociodemographic characteristics and clinical profile is presented in Table I. It was observed that 35 of the participants (73%) were female while 62% of the participants were retired. All participants

(100%) presented with late OA as the stage of degeneration. The digit most operated on was the middle finger with 22 arthroplasties. Participants' main reason for surgery was joint stiffness (68.8%). All participants (100%) had the Modified Central Slip surgical approach. Of the 48 patients who had surgery, 40 (83.3%) only had one joint operated on while the remaining 8 had surgery for more than one joints. Sixteen patients (33%) however required repeat surgery. Table II shows the therapeutic history of the participants. The mean total follow-up time was  $18.4 \pm 16.8$  months with most participants (41.7%) having been followed up between 11-20 months. Post-operatively, all participants (100%) had a dorsal blocking splint fabricated combined with the Modified Early active protocol. Twenty-one participants (43.8%) and 28 (58.3%) attended a total of 5-10 sessions of physiotherapy and occupational therapy respectively. Only 25 participants (52.1%) were consistent in attending therapy sessions, while the remaining 23 participants (48%) missed or cancelled between 1 and 4 sessions each. Twenty-two (36.1%) of the 61 fingers operated presented with post-surgical complications. Swan neck deformity was the most prevalent (13.1%) complication observed. The distribution of post-surgical complications observed among the participants is presented in Figure I. The mean PSQ and DASH scores were  $3.6 \pm 1.9$  and  $22.0 \pm 13.0$  respectively. Categorical distribution of levels of satisfaction and disability is presented in Table III. The majority of participants (37.5%) were very dissatisfied with the post-operative status of their hand. Only 2 participants (4.2%) were highly satisfied. Mild disability was reported by 47.9% of the participants but there were no reports of severe disability.

The association between variables and post-operative levels of satisfaction and disability is displayed in Table IV. The results indicate that the level of satisfaction had a significant association with gender ( $p = 0.029$ ) only while level of disability had a significant association with the number of missed/cancelled therapy appointments ( $p = 0.010$ ).

Participants' pre-operative (baseline) VAS and final VAS scores, as well as AROM at the three-time points of pre-operative, 6 month and final assessment, are compared in Table V. Final VAS scores were significantly lower than the preoperative scores ( $p < 0.001$ ). The results demonstrate a significant increase in median scores of AROM across the three-time points of assessment. Post-hoc analysis showed that AROM at 6-month follow-up and the final assessment was significantly higher than the value obtained at baseline but values obtained at 6-month follow-up was not significantly different from those obtained during the final assessment.

## DISCUSSION

The purpose of the study was to explore the association between pre-surgical sociodemographic and clinical characteristics on post-surgical hand function and satisfaction

of patients who had pyrocarbon PIPJ arthroplasty and <sup>13</sup> to evaluate the effects of the procedure on pain and AROM. A large proportion of the patients were very dissatisfied with the post-operative status of their hand while about half of them reported mild disability. The participants, however, had significant improvement in pain <sup>41</sup> and AROM of PIP joint.

In view of <sup>the</sup> nature and distribution of osteoarthritis in the hand, multi-digit surgery in an individual patient is common.<sup>10,17</sup> Participants' mean age (about 62.5 years) at the time of surgery is consistent with the literature,<sup>15,17,23,24</sup> as PIPJ osteoarthritis predominantly affects the ageing population. There was a higher proportion of female in the study sample which highlights the higher incidence of PIPJ osteoarthritis in females as it appears to be a common trend in the literature.<sup>25</sup> The mean total follow-up of 18.44±16.81 months observed in the study appears a relatively short follow-up compared to a minimum 7 year follow-up review reported by Storey et al.<sup>26</sup>

<sup>33</sup> The main indication for surgery was joint stiffness followed by pain and decreased hand function. The literature supports pyrocarbon PIPJ arthroplasty as the primary surgical indication to address PIPJ osteoarthritis as it provides pain relief and improvement of functional ROM.<sup>9,16,17,23,24,26,27</sup> The digit most involved was the middle finger which was operated on followed by the ring finger. There is minimal evidence in the literature regarding whether a specific isolated digit shows better or improved treatment outcomes.

<sup>40</sup> The modified central slip splitting technique adopted at this study venue <sup>4</sup> could be described as an early active protocol in view of the fact that it is slightly accelerated in comparison to the standard pyrocarbon arthroplasty protocol. An early active mobilisation protocol has been associated with minimal complications with postoperative stiffness.<sup>5,16,24</sup> All participants followed the modified early active protocol with a dorsal blocking splint for protection. Only 6 (12.5%) patients required a dynamic extensor splint to address or prevent extensor tendon deficit (extensor lag). The choice of splinting following arthroplasty may affect patient compliance with rehabilitation and exercise protocols.<sup>28</sup> This study found that only 25 participants (52.1%) were compliant with rehabilitation sessions.

A mean PSQ score of 3.6±1.9 was observed and 37.5% of the participants were very dissatisfied with the postoperative status of their operated finger and hand. These findings suggest that the level of satisfaction might be due to other factors besides pain and reduced ROM, such as the aesthetic appearance of the joint, audible 'squeaking' on active movement and stiffness. Only two participants were highly satisfied with their postoperative outcome. The significant improvement observed in terms of pain and AROM outcomes do not align with the level of satisfaction reported by the majority of the participants. There is evidence <sup>1</sup> that pain



relief and patient satisfaction are generally good after pyrocarbon PIPJ arthroplasty as a large percentage (71-84%) of participants has been reported to be very satisfied.<sup>9,16,17,23,24,26,27</sup> Nunley et al.<sup>14</sup> have reported a low satisfaction score among just 14% of their participants but also found a gradual decline of initial high satisfaction scores over a period of time and concluded that complications could generally develop at a later stage.

Almost half of the participants (47.9%) reported mild disability when performing daily tasks and activities with a mean DASH score of about 22. This seems to align with reviews conducted by other authors.<sup>12,17,18</sup> McGuire et al.<sup>16</sup> argued that functional scores don't offer a meaningful interpretation in a progressive polyarthritic condition like osteoarthritis. McGuire and colleagues<sup>16</sup> are of the opinion that postoperative improvement in one particular joint of the hand may not be a reflection of improvements in the functional score as the diseased adjacent fingers may affect pain levels and skew the result. Contrary to this opinion, Dieppe and Lohmander,<sup>29</sup> submitted that reduction in pain may improve movement and functional ability.

According to Tagil et al.,<sup>12</sup> pain and stiffness remain the major indications for almost every osteoarthritic procedure but overall hand function would likely improve when pain-free movement at the PIPJ is restored or maintained. Further, when tasks considered important to the patient are performed with ease and minimal pain, a higher satisfaction score can be expected.<sup>30</sup> The significant association observed between gender and level of satisfaction suggests that the perception of satisfaction by male and female participants in this study may be different. Literature has shown that females appear to express pain more easily and readily compared to the males,<sup>31</sup> this will consequently impact on their perception of their health status. It is also relevant to note that the level of disability had a significant association with the total number of missed or cancelled therapy appointments. It appears there is a dearth of literature regarding the number of therapy sessions patients attended or missed; however, it is logical to infer that a patient who misses his/her appointments and consequently had the number of treatment sessions reduced will come up with poor treatment outcomes.

Consistent pain relief and reduction of preoperative pain appear to be the most uniform finding in published literature.<sup>9,16,17,23</sup> The significant reduction in pain observed in this study may be directly attributed to arthroplasty which involves removal of subchondral bone cysts and osteophytes along the articular joint surfaces of the arthritic PIPJ.<sup>32</sup> Pyrocarbon arthroplasty has been associated with decreased pain by the majority of previous studies.<sup>9,11,13,14</sup>

Significant increase in ROM of PIP joint observed in this study suggests that PIP joint pyrocarbon arthroplasty is also beneficial regarding the outcome. Improvement in ROM is an anticipated and expected postoperative outcome. However, it is important to consider the

extent or magnitude of the recorded increase in ROM. It is clinically relevant to identify whether ROM follows a trend of plateauing, increasing or decreasing over a period of time.

Herren et al.<sup>13</sup> reported an increase of 8 degrees<sup>8</sup> with a mean follow-up of 19 months. The retrospective review of 50 pyrocarbon PIP joints arthroplasty in 35 subjects at a 27-month follow-up by Bravo et al.<sup>9</sup> showed an insignificant ROM increase of 7 degrees.<sup>22</sup> Wijk et al. and Nunley et al.<sup>5,9</sup> both reported a decrease in active range of movement, -8 degrees and -2 degrees respectively.<sup>32</sup> Watts et al.<sup>17</sup> did not find a significant difference in ROM following a retrospective review on 97 pyrocarbon PIP joint arthroplasties at a five-year follow-up.<sup>31</sup> The findings of the highlighted authors seem not consistent with the results of the present study.<sup>9</sup> Interrater assessments and differences in duration of follow-up assessments may have accounted for the observed difference.

Active ROM at 6 months and final assessment were comparable. This finding is in agreement with the report of Reissner et al.<sup>18</sup> which indicated that postoperative findings may show a decrease or plateau in ROM at a longer follow-up period.<sup>18</sup> The plateau in AROM has been attributed to a combination of scar tissue formation and patients decreasing their exercise intensity and frequency.<sup>33</sup>

#### *Limitations*

The follow-up time of about 18 months appears relatively short and not conducive for detection of deformity and/or a decrease in the active range of movement at the PIPJ as most complications are expected to occur beyond 2 years post-surgery. The small sample size and convenient sampling from a single clinic may limit the generalisability of results.<sup>30</sup> Another limitation of this study is that pain was not assessed at the 6th month follow-up. In addition, there were no pre-operative DASH and PSQ scores assessments according to available records.

Patients were treated and assessed by more than one therapists and the time of final follow-up was not the same for all participants; these could have impacted on the validity of our findings.<sup>21</sup>

#### **CONCLUSION**

In spite of improvement in pain and ROM outcomes, levels of dissatisfaction and disability were still relatively high among patients who had PIP joint pyrocarbon arthroplasty. Patient's sex and missing of therapy appointments are likely predictors of post-operative levels of

satisfaction and disability respectively and should be considered in planning of rehabilitation programmes.

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## REFERENCES

1. McPhee SD. Functional hand evolution: A review. *Am Journal Occup Ther* 1987;41(3):158-63.
2. Chiasson CE, Zhang Y, Sharma L, Kannel W, Felson DT. Grip strength and the risk of developing radiographic hand OA: results from the Framingham study. *Arthritis Rheum* 2001;42 (1):33-38.
3. Lewis AR, Nolan MJ, Hodgson RJ, Benjamin M, Ralphs JR, Archer, CW, Tyler JA, Hall, LD. High resolution magnetic imaging of the Proximal Interphalangeal Joint: Correlation with histology and production of three-dimensional data set. *J Hand Surg Eur Vol*, 1996;21(4):488-495. DOI: 10.1016/S0266-7681(96)80053-2
4. Sweets TM, Stern PJ. (2011). Pyrolytic carbon resurfacing arthroplasty for osteoarthritis of the proximal interphalangeal joint of the finger. *J Bone Joint Surg Am* 2011;93(15):1417–25. <https://doi.org/10.2106/JBJS.J.00832>
5. Wijk U, Wollmark M, Kopylov P, Tägil M. (2010). Outcomes of Proximal Interphalangeal Joint Pyrocarbon Implants. *J Hand Surg* 2010;35(1):38–43. <https://doi.org/10.1016/j.jhsa.2009.08.010>
6. Ng M, Clarkson J, Wilmschurst A. Pyrocarbon proximal interphalangeal arthroplasty: Outcome audit in patient's environment. *Internet J Hand Surg* 2006;1:1-7. <https://print.ispub.com/api/0/ispub-article/8404>
7. Chung KC, Ram A, Shauver M. (2009). Outcomes of pyrolytic carbon arthroplasty for the proximal interphalangeal joint. *Plast Reconstr Surg* 2009;123(5): 1521–1532. doi: 10.1097/PRS.0b013e3181a2059b
8. Rizzo M. Metacarpophalangeal joint arthritis. *J Hand Surg Am*. 2011;36(2):345-53. doi: 10.1016/j.jhsa.2010.11.035.
9. Bravo CJ, Rizzo M, Hormel, KB, Beckenbaugh RD. Pyrolytic carbon proximal interphalangeal joint arthroplasty: Results with a minimum 2-year follow-up evaluation. *Am J Hand Surg*, 2007;32(1), 1-11. <https://doi.org/10.1016/j.jhsa.2006.10.017>
10. Dickson DR, Nuttall D, Watts AC, Talwalkar SC, Hayton M, Trail IA. Pyrocarbon Proximal Interphalangeal Joint Arthroplasty: Minimum Five-Year Follow-Up. *The J Hand Surg*, 2015;40(11), 2142–2148.e4. <https://doi.org/10.1016/j.jhsa.2015.08.009>

11. Meier R, Schultz M, Krimmer H, Stutz N, Lanz U. Proximal interphalangeal joint replacement with pyrolytic carbon prosthesis. *Oper Orthop Traumatol* 2007;19: 1-15.
12. Tagil M, Geijer M, Abramo A, Kopylov P. Ten years' experience with a pyrocarbon prosthesis replacing the proximal interphalangeal joint. A prospective clinical and radiographic follow-up. *J Hand Surg Eur Vol* 2014;39(6):587–595.  
<https://doi.org/10.1177/1753193413479527>
13. Herren DB, Schindele S, Goldhahn, J, Simmen, BR. Problematic bone fixation with pyrocarbon implants in proximal interphalangeal joint replacement: short-term results. *Journal Hand Surg Br* 2006;31:643-51
14. Nunley RM, Boyer MI, Goldfarb CA. Pyrolytic Carbon Arthroplasty for post traumatic arthritis. *J Hand Surg Am* 2006;31(9), 1468-1472.
15. Tuttle HG, Stern PJ. (2006). Pyrolytic carbon proximal phalangeal joint resurfacing arthroplasty. *J Hand Surg Am*. 31A:930–93
16. McGuire DT, White CD, Carter SL, Solomons MW. (2012). Pyrocarbon proximal interphalangeal joint arthroplasty: outcomes of a cohort study. *J Hand Surg Eur Vol*, 2012; 37(6):490–6. <https://doi.org/10.1177/1753193411434053>
17. Watts AC, Hearnden AJ, Trail IA, Hayton MJ, Nuttall D, Stanley JK. Pyrocarbon proximal interphalangeal joint arthroplasty: Minimum two-year follow-up. *J Hand Surg* 2012;37(5):882–888. <https://doi.org/10.1016/j.jhsa.2012.02.012>
18. Reissner, L., Schindele, S., Hensler, S., Marks, M., & Herren, D. B. (2014). Ten year follow-up of pyrocarbon implants for proximal interphalangeal joint replacement. *J Hand Surg Eur Vol* 2014;39(6), 582–586. <https://doi.org/10.1177/1753193413511922>
19. Brokelman RB, Haverkamp D, van Loon C, Hol A, van Kampen A, Veth R. The validation of the visual analogue scale for patient satisfaction after total hip arthroplasty. *Eur Orthop Traumatol* 2012; 3(2):101-105.
20. Groth GN, VanDeven KM, Phillips EC, Ehretzman RL. Goniometry of the proximal and distal interphalangeal joints, Part II: placement, preferences, interrater reliability, and concurrent validity. *J Hand Ther* 2001;14(1):23-9.
21. Beaton DE, Davis AM, Hudak P, Mconnel S. The DASH (Disabilities of the Arm, Shoulder and Hand) outcome measure: What do we know about it now? *Br J Hand Ther* 2001;6 (4), 109-118.
22. SooHoo NF, McDonald AP, Seiler JG, McGillivray GR. Evaluation of the construct validity of the DASH questionnaire by correlation to the SF-36. *J Hand Surg Am* 2002;27(3):537-41.
23. Branam BR, Tuttle HG, Stern PJ, Levin L. Resurfacing arthroplasty versus silicone arthroplasty for proximal interphalangeal joint osteoarthritis. *J Hand Surg*, 2007;32(6):775–88. <https://doi.org/10.1016/j.jhsa.2007.04.006>

24. Mashhadi SA, Chandrasekharan L, Pickford MA. Pyrolytic carbon arthroplasty for the proximal interphalangeal joint: results after minimum 3 years of follow-up. *J Hand Surg Eur Vol* 2012;37(6), 501–5. <https://doi.org/10.1177/1753193412443044>
25. Srikanth VK., Fryer JL, Zhai G, Winzenberg TM, Hosmer D, Jones G. A meta-analysis of sex differences prevalence, incidence and severity of osteoarthritis. *Osteoarthritis Cartilage* 2005;13(9), 769–781. <https://doi.org/10.1016/j.joca.2005.04.014>
26. Storey PA, Goddard M, Clegg C, Birks ME, Bostock SH. Pyrocarbon proximal interphalangeal joint arthroplasty: a medium to long term follow-up of a single surgeon series. *J Hand Surg Eur Vol* 2015; 40(9), 952–956. <https://doi.org/10.1177/1753193414566552>
27. Wagner ER, Luo TD, Houdek MT, Kor DJ, Moran SL, Rizzo M. (2015). Revision proximal interphalangeal arthroplasty: An outcome analysis of 75 consecutive cases. *J Hand Surg* 2015;40(10):1949–1955. <https://doi.org/10.1016/j.jhsa.2015.05.015>
28. Riggs JM, Lyden AK, Chung KC, Murphy SL. Static versus dynamic splinting for proximal interphalangeal joint pyrocarbon implant arthroplasty: A comparison of current and historical cohorts. *J Hand Ther* 2011;24:231–239. <https://doi.org/10.1016/j.jht.2011.03.003>
29. Dieppe PA, Lohmander LS. Pathogenesis and management of pain in osteoarthritis. *Lancet* 2005;365(9463):965-973.
30. Law M, Cooper B, Strong S, Stewart D, Rigby P, Letts L. The Person-Environment-Occupation Model: A Transactive Approach to Occupational Performance. *Canadian J Occup Ther* 1996; 63(1):9–23. <https://doi.org/10.1177/000841749606300103>
31. Barsky AJ, Peekna HM, Borus JF. Somatic Symptom Reporting in Women and Men. *J Gen Intern Med* 2001;16(4):266–275. doi: [10.1046/j.1525-1497.2001.00229.x]
32. Goldring SR, Goldring MB. Clinical aspects, pathology and pathophysiology of osteoarthritis. *J Musculoskelet Neuronal Interact* 2006;(6)376-378.
33. Yang G, McGlinn EP, Chung KC. (2014). Management of the stiff finger: evidence and outcomes. *Clin Plast Surg* 41(3): 501–512. doi: [10.1016/j.cps.2014.03.011]

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Sharma, Ashish, and Edward Mah. "Arthritis of the hand", Mercer s Textbook of Orthopaedics and Trauma Tenth edition, 2012.

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---

36

Chan, Kevin, Olubimpe Ayeni, Leslie McKnight, Teegan A. Ignacy, Forough Farrokhyar, and Achilleas Thoma. "Pyrocarbon versus Silicone Proximal Interphalangeal Joint Arthroplasty : A Systematic Review", Plastic & Reconstructive Surgery, 2013.

Publication

---

37

A. Completo, A. Nascimento, A.F. Girão, F. Fonseca. "Biomechanical evaluation of pyrocarbon proximal interphalangeal joint arthroplasty: An in-vitro analysis", Clinical Biomechanics, 2018

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---

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[lup.lub.lu.se](http://lup.lub.lu.se)

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[www.assh.org](http://www.assh.org)

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McGuire, D. T., C. D. White, S. L. Carter, and M. W. Solomons. "Pyrocarbon proximal

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