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Distal Interphalangeal Joint Arthroplasty – A Systematic Review

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Background: Arthritis of the distal interphalangeal joint (DIPJ) can result in significant functional limitations and pain. While arthrodesis is the most common surgical intervention, this can decrease grip strength and have other limitations. DIPJ arthroplasty may be an appealing alternative in select patient with this study aiming to review the outcomes of this procedure.

Methods: A search was conducted according to PRISMA guidelines using PubMed, Embase and Ovid Medline from date of inception to April 2022. Relevant studies were included if they reported on complications and functional outcomes of DIPJ arthroplasty. Data was then extracted and analysed.

Results: Seven studies were included including 171 patients with 269 digits. The mean age was 62.1 years, with 81% of the cohort being female. The indication for surgery was osteoarthritis in 97% of patients. Surgical approaches varied from dorsal transverse, dorsal T-incision, dorsal H-incision to radial incisions. A silicone implant was used in all patients. A total of 97.7% of patients were satisfied with their outcome, and pain improved or eliminated in all patients where it was reported. Joint stability was noted in 97.4% of cases. The mean preoperative DIPJ range of motion was 24° and improved to 36° post-operation. The mean preoperative extensor lag was 24° and reduced to 13° post operation. The rate of re-operation was 7.1%.

Conclusions: DIPJ arthroplasty may be a viable alternative to arthrodesis in certain settings, providing high patient satisfaction, improvements in digital range of motion and relief of pain. However, the available literature is sparse, and limited by low-quality studies and heterogenous outcome reporting.

Level of Evidence: Level III (Therapeutic)

Keywords: *DIPJ, Distal interphalangeal, Arthroplasty, Replacement, Arthrodesis, Systematic review*

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INTRODUCTION

Arthritis of the distal interphalangeal joint (DIPJ) is common and may result in significant functional limitation and pain. The most common surgical intervention for end-stage DIPJ arthritis is an arthrodesis – however,

this joint contributes to 15% of digital flexion, and fusion has been shown to decrease grip strength by up to 25%.[1] Arthrodesis may be poorly tolerated in younger patients, those requiring a full range of motion or individuals with multi-digit involvement – in these settings, DIPJ arthroplasty may be an appealing alternative.[1]

Early digital joint replacement techniques (such as resection or transplant arthroplasty) were troubled by technical difficulties and poor postoperative stability.[2] The adoption of hinged silicone prostheses and surface replacement arthroplasty has yielded promising results, particularly in the metacarpophalangeal and proximal interphalangeal joints. However, the evidence regarding arthroplasty in the DIPJ is still limited. Thus, the aim of this systematic review was to review the literature, and report on the outcomes of DIPJ arthroplasty (including extension lag, range of motion and complication profile).

METHODS

Literature search strategy: This study was conducted as per the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. An electronic literature search was performed in April 2022, utilising the databases PubMed, Embase and Ovid Medline from their date of inception. To maximise search sensitivity, various combinations of the keywords 'DIPJ', 'arthroplasty' and 'replacement' were used. Duplicates were removed and the remaining studies were filtered by title and abstracts for relevance, before select papers were obtained for full-text review. Article appraisal was performed by two separate investigators, with any discrepancies discussed with the senior author. The reference lists of included studies were then manually reviewed to identify further relevant studies.

Selection criteria: Studies were eligible for this study if they reported on either functional outcomes or postoperative complications following DIPJ arthroplasty. If multiple studies reported outcomes from the same cohort, data from the longest follow-up period was included for quantitative analysis. Studies were limited to those published in English, with case reports and conference abstracts excluded.

Data extraction and critical appraisal: All relevant data was extracted from article text, tables and figures. Data extracted included patient and digit demographics, follow-up duration, complications and functional outcomes. Primary outcomes assessed included patient satisfaction, joint stability, DIPJ range of motion and postoperative complications.

RESULTS

Search results: The initial database search yielded 246 references (Fig. 1). After removal of duplicates, title and abstract screening resulted in 163 papers for full-text review. A total of seven papers were eligible for inclusion in the study.[3–9]

Baseline characteristics: The seven included studies yielded a cohort of 171 patients with 269 digits for analysis. The index and middle fingers were most frequently involved (40% and 30% respectively), followed by the ring finger (16%) and little finger (14%). Mean postoperative follow-up was 58 months (range: 10–120). The mean patient age at time of arthroplasty was 62.1 years (range: 58–70). Most patients undergoing DIPJ arthroplasty were female (81%). The underlying aetiology was predominantly osteoarthritis (97%) followed by post-traumatic arthritis (2%) and rheumatoid arthritis (1%). A summary of patient demographics can be found in Table 1.

Surgical details: A variety of surgical approaches were utilised, including a dorsal transverse incision (1 study; $n = 39$), dorsal T-incision (1 study; $n = 38$), dorsal H-incision (2 studies; 132), radial-based hockey incision (1 study; $n = 22$) and modified Kilgore incision (1 study; $n = 7$). An extensor tenotomy and repair was performed in all studies barring one, where the extensor mechanism was preserved via the modified Kilgore incision. All included studies used a Swanson silicone implant (Wright Medical Group, Switzerland) ranging from size 00 to size 1.

Clinical outcomes: A total of 97.7% of patients were satisfied with their outcome (range: 87–100; 3 studies; $n = 176$). Where assessed, pain was improved or eliminated in all patients (3 studies; $n = 91$). A joint was stable if there was no opening of the lateral joint line or if it opened to a firm endpoint when applying a lateral force to a fully extended DIPJ. From the included studies, the DIPJ was stable postoperatively in 97.4% of patients (3 studies; $n = 76$). The mean preoperative DIPJ range of motion was 24.2° (2 studies; $n = 132$) which improved to 35.7° postoperation (range: 15–41; 4 studies; $n = 202$). The mean preoperative extensor lag from full extension was 24° (1 study; $n = 131$) which reduced to 12.8° after the operation (range: 11–17, 5 studies; $n = 261$). A summary of clinical outcomes can be found in Table 2.

Complications: Patients underwent re-operation at a mean rate of 7.1% (range: 3–21; 5 studies; $n = 261$). Conversion to arthrodesis occurred in 52.6% of patients undergoing revision (range: 33–100; 4 studies, $n = 19$).

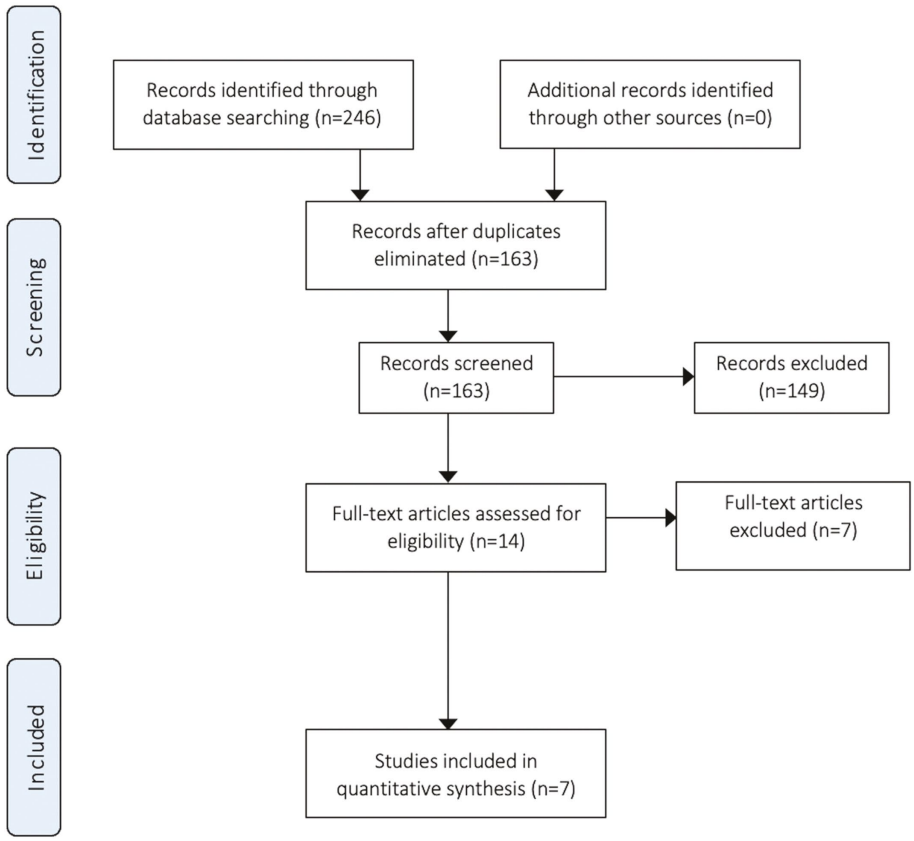

Fig. 1. PRISMA flowchart of systematic review assessing distal interphalangeal joint arthroplasty.

Table 1. Summary of Patient Demographics and Surgical Details

Author	Year	Patients	Fingers	Mean age (years)	Mean follow-up (months)	Approach	Implant	Extensor management	Immobilisation post-op
Neukom	2020	24	39	69 (SD 6.8)	52 (range 13–76)	Dorsal transverse	Swanson Silicon Size 00	Tenotomy and repair with 4-0 PDS	Extension splint 4 weeks then active unloaded ROM for 2 weeks
Sierakowski	2012	85	131	-	-	Dorsal H	Swanson Silicon Size 00/0/1	Tenotomy and repair with 5-0 prolene	Extension splint 8 weeks then active ROM exercises
Wilgis	1997	23	38	58 (range 47–70)	120	Dorsal T	Swanson Silicon Size 00/0	Tenotomy and repair 4-0 non absorbable suture	Extension splint 8 weeks (K-wire out after 4 weeks) then active ROM
Brown	1989	13	22	62 (range 52–76)	26 (range 3–60)	Radially based hockey stick	Swanson Silicon Size 0/1	Tenotomy and figure 8 repair with 5-0 prolene	Plaster immobilisation for 3 weeks (functional position) then active ROM
Snow	1977	7	7	-	-	Modified Kilgore	-	Extensor mechanism preserved (ulnar collateral taken down)	-
Schwartz	1998	1	1	70	10	Dorsal H	Swanson Silicon Size 0	Tenotomy and repair	Extension splint and K-wire for 6 weeks
Zimmerman	1991	18	31	58.3	72 (range 13–123)	-	-	-	-

SD: standard deviation; ROM: range of motion.

Table 2. Summary of Clinical Outcomes and Complications

Author	Year	Mean pre-op DIPJ ROM (degrees)	Mean post-op DIPJ ROM (degrees)	Mean pre-op extensor lag	Mean post-op extensor lag	Satisfaction outcomes	Pain outcomes	No. stable joints (%)	No. re-operations (%)	Conversion to arthrodesis
Neukom	2020		28 (SD 14)		17 (SD 14)	4.3 out of 5 score	0.2 out of 10		8 (20.5)	5 (12.8)
Sierakowski	2012	24 (range 5–45)	39 (range 15–70)	20 (range 0–45)	11 (range 0–45)	100% satisfied			4 (3.1)	3 (2.3)
Wilgis	1997		(range 10–50)		12.7 (range 0–45)	87.1% satisfied	Pain improved compared to pre-op for all patients	22 (96)	3 (7.9)	1 (2.6)
Brown	1989		(range 5–70)		12 (range 0–30)	Overall high satisfaction	Pain completely resolved all patients	22 (100)	1 (4.5)	1 (4.5)
Snow	1977		(range 40–45)			100% satisfied				
Schwartz	1998	50	15							
Zimmerman	1991		32		13		Pain completely resolved all patients	30 (97)	3 (9.7)	

SD: standard deviation.

The aetiology of revision included wound breakdown and infection (1.5%), instability (1.1%), pain (1.1%), implant breakage (0.8%) and deformity (0.4%). The timing of re-operation was inconsistently reported across studies. Five cases of revision to arthrodesis occurred between 1 and 5 years post operation. There were two cases of wound breakdown and infection at 3 months and another one at 9 months after the operation. A mallet finger deformity requiring extensor shortening occurred at 18 months, and a single case of prosthesis fracture required re-operation at 30 months after operation.

DISCUSSION

This study reviews the literature for outcomes following DIPJ arthroplasty. It finds that DIPJ arthroplasty has predominantly been performed in the setting of osteoarthritis, and that nearly all patients have been satisfied with their outcome (97%). DIPJ arthroplasty also resulted in improved functional outcomes (such as range of motion and extensor lag), while reducing pain. However, the rate of revision was 9.1%. Ultimately, there was significant heterogeneity in outcomes reporting among the published studies, and results must be interpreted with caution.

Arthrodesis is the most utilised surgical modality for DIPJ arthritis, providing a stable construct and successfully eliminating pain.[10] However, it reduces finger range of motion, and may compromise both fine motor function and power grip. Arthrodesis may be complicated by non-union, with the literature demonstrating failure to unite in between 3.9% and 15% of patients.[11,12] Prior series have also reported rates of revision surgery of 12.5%, and minor complications (such as superficial infection and skin necrosis) in up to 16% – both of which are higher than in our review of DIPJ arthroplasty.[5,13] However, no studies directly compare DIPJ arthrodesis to arthroplasty for end-stage arthritis, and this should be an area of focus in future studies.

A variety of bearing surfaces can be utilised in small joint arthroplasty, including silicone, cobalt-chromium and, more recently, pyrocarbon. Pyrocarbon exhibits greater wear resistance and can withstand increased loads without deformation.[14] Surface replacement arthroplasty with cobalt–chromium implants preserves bone stock and can yield greater functional range of motion.[14] This review finds that all reports of DIPJ arthroplasty have involved silicone implants. The implant design includes a hinged element for stability, while still permitting motion in multiple planes. Silicone arthroplasty has demonstrated various advantages and disadvantages in the proximal interphalangeal joint – while they result in superior range of motion and lower revision rates when

compared to alternate bearing surfaces, silicone implants also demonstrate greater instability and digital deviation resulting in malalignment.[15,16] Silicone implants may also fracture, although this does not always result in pain or instability, with reports of long-term survivorship following implant breakage.[14] This review finds satisfactory stability post-DIPJ arthroplasty in the majority of patients, despite reported ranges of stability in series varying from 56% to 100%. This variability is likely due to heterogeneity in measurements of stability across the included studies.

A number of surgical approaches can be utilised for DIPJ arthroplasty, with the majority of patients in the review receiving a dorsal approach, which has been shown to allow easier access to the joint.[15] This approach does not compromise the volar plate, although extensor tenotomy is usually required to insert the prosthesis.[17] As such, patients will require immobilisation for up to 8 weeks postoperatively. However, Sierakowski et al reported a dorsal approach that preserves the extensor tendon and allows early range of motion, though there was no obvious improvement in functional outcomes.[3] Due to the insertion of the flexor digitorum profundus tendons, a volar approach would not be advisable for DIPJ arthroplasty. However with proximal interphalangeal joint arthroplasty, some studies have shown that a volar approach allows earlier exercise and greater improvement in arc of motion.[15]

This review has several limitations. The small number of studies available for analysis, all of which were low in quality, limits interpretation of cause and effect. Significant heterogeneity was noted among the included studies regarding duration of follow-up and outcomes reporting, limiting meaningful statistical analyses. Almost all patients underwent arthroplasty for end-stage osteoarthritis, and thus, these results may not be generalisable to other indications. Follow-up has been limited to the medium term, and thus, long-term survivorship cannot be commented upon.

This article finds that DIPJ arthroplasty may be a viable alternative to arthrodesis in certain settings, providing high patient satisfaction, improvements in digital range of motion and relief of pain. However, the available literature is sparse, and limited by low-quality studies and heterogenous outcome reporting. Adequate patient selection is likely to be key in obtaining satisfactory postoperative outcomes. Prospective randomised trials would be useful to glean further information on the safety and efficacy of DIPJ arthroplasty.

DECLARATIONS

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Informed Consent: There is NO information (names, initials, hospital identification numbers or photographs) in the submitted manuscript that can be used to identify patients.

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