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Review

Is interposition arthroplasty a viable option for treatment of moderate to severe hallux rigidus? — A systematic review and meta-analysis

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ABSTRACT

Introduction: When conservative therapy for hallux rigidus fails, surgical options such as arthrodesis and interposition arthroplasty can be considered. Although arthrodesis of MTP joint is the gold standard treatment. However patients desiring MTP joint movement may opt for either interposition arthroplasty or implant arthroplasty to avoid the movement restrictions of arthrodesis. The purpose of this systematic review was to investigate clinical outcomes and complications following interposition arthroplasty for moderate to severe hallux rigidus, for patietns who would prefer to maintain range of motion in the MTP joint.

Methods: A systematic search on MEDLINE, EMBASE and Cochrane library database was performed during February 2018. Demographics, surgical techniques, clinical outcomes, radiological outcomes and complications were recorded from each included study. Pooled statistics performed for variables with homogenous data across the studies. A linear regression model used to compare the clinical outcomes between autogenous vs allogenous material interposition arthroplasty.

Results: Fifteen articles were included in the systematic review. Mean AOFAS scores improved from preoperative 41.35 to postoperative 83.17. Mean pain, function, and alignment score improved from preoperative values of 14.9, 24.9, and 10 to postoperative values of 33.3, 35.8, and 14.5. Mean dorsiflexion increased from 21.27° (5–30) to 42.03° (25–71). Mean ROM improved from 21.06° to 46.43°. Joint space increased from 0.8 mm to 2.5 mm. The most common postoperative complications included metatarsalgia (13.9%), loss of ground contact (9.7%), osteonecrosis (5.4%), great toe weakness (4.8%), hypoesthesia (4.2%), decreased push off power (4.2%), and callous formation (4.2%).

Conclusion: Interposition arthroplasty is an effective treatment option with acceptable clinical outcomes in patients with moderate-severe hallux rigidus who prefer to maintain range of motion and accept the risk of future complications.

Level of Evidence: IV.

Contents

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1. Introduction

Hallux rigidus (HR) is a painful arthritis of the first metatarsophalangeal joint (FMTPJ), which can cause stiffness and progressive loss of motion at the joint to the point of affecting the push-off phase of normal gait. The primary treatment strategies for early stages of hallux rigidus include activity modification, orthotics, analgesics, and corticosteroids. When conservative management fails, numerous viable operative techniques exist to treat hallux rigidus, such as cheilectomy, resection arthroplasty, implant arthroplasty, and arthrodesis [1–7]. Arthrodesis, or fusion of the FMTPJ, is widely considered to be the gold standard in the treatment; however, it is often reserved for patients with advanced HR due to the potential for loss of foot function, failure of fixation, nonunion, and transfer metatarsalgia [8]. Range of motion (ROM) sparing techniques, such as interposition arthroplasty, can preserve joint function and are therefore preferred in some patients. Interposition arthroplasty involves use of a spacer made of autograft, allograft, or synthetic biologic material. The interposition arthroplasty technique for HR typically described in literature interposes the dorsal capsule, tendons of extensor digitorum, extensor hallucis brevis, plantaris, fascia lata, and gracilis. Other authors advocate the use of a regenerative collagen matrix and the medial capsule as the spacer [9,10]. Many of these procedures use a modified Keller technique, which has lower rates of transfer metatarsalgia, deformity, and toe weakness as less of the proximal phalanx is resected compared to the original Keller resection [11]. Mroczek and Miller have further advanced this technique by changing the obliquity of the proximal phalanx resection in order to retain the base of the phalanx and preserve the flexor hallucis brevis tendon [12]. Interposition arthroplasty is a surgical option of patients with moderate to severe hallux rigidus that would prefer to preserve ROM of the MTP joint.

The primary purpose of this systematic review was to investigate clinical outcomes and complications following interposition arthroplastyfor moderate to severe hallux rigidus. The secondary purpose was to report patient satisfaction and compare clinical outcomes between autogenous capsules and synthetic/allograft materials for interposition arthroplasty.

2. Materials and methods

The systematic review was performed following Preferred Reporting Items for Systematic Review and Meta-analyses (PRISMA) guidelines.

2.1. Data sources and searches

To the best of our knowledge there were no systematic review on interposition arthroplasty for HR in the literature. MEDLINE Pubmed, Embase, and Cochrane Database of Systematic Reviews (CDSR) were searched using the following query: [(Metatarsophalangeal joint) AND Arthroplasty (Title/Abstract)], [(MTP joint) AND Arthroplasty (Title/Abstract)], [(Metatarsophalangeal joint) AND interposition Arthroplasty (Title/Abstract)], [(Hallux) AND interposition arthroplasty (Title/Abstract)] and [(Hallux) AND Interposition arthroplasty (Title/Abstract)].

2.2. Eligibility criteria

Studies were included if they reported results of first MTP joint interposition arthroplasty in moderate to severe HR. Clinical outcomes must have been reported using one of the following scoring systems: 1) AOFAS, 2) FFI or 3) SF-36. The following exclusion criteria were implemented: 1) case reports, 2) review, editorial, or technique articles, 3) conference abstracts, 4) greater than 30% loss to follow up, 5) published in a language other than English, 6) less than 12 months of follow up, or 7) studies with mild grade MTP joint arthritis, systemic inflammatory disease, including RA, gout, or seronegative arthropathic patients

2.3. Study selection

The titles and abstracts were reviewed to confirm relevance of the studies. After excluding irrelevant papers, the full text articles were reviewed for inclusion by two independent investigators. [HP and RK] References of relevant studies were reviewed to identify any missed studies for inclusion. The same investigators extracted relevant data from the studies. Any disagreements in study selection and data extraction that could not be resolved by discussion were settled by a third investigator. [AS]

Out of 1099 articles, only 574 unique articles remained after duplicates were removed. After screening titles and abstracts, 20 were selected for full text review. Fifteen studies met criteria for inclusion in the final systematic review [1–3,5,9,13–22]. No additional studies were included after reviewing the references of the 15 studies. The selection process is summarized by Fig. 1.

2.4. Systematic review and quantitative analysis

Systematic review and data extraction were performed on all selected studies. Pooled statistics was performed for all the variables having homogenous data across the studies. A linear regression model comparing the change in preoperative to postoperative AOFAS scores between the autogenous versus allogenous interposition materials was performed.

3. Results

Out of 15 studies, 12 studies were level IV case series [1–3,9,13–18,21,22] and three studies were level III case control studies [5,19,20]. Among the level IV case series, eight studies were

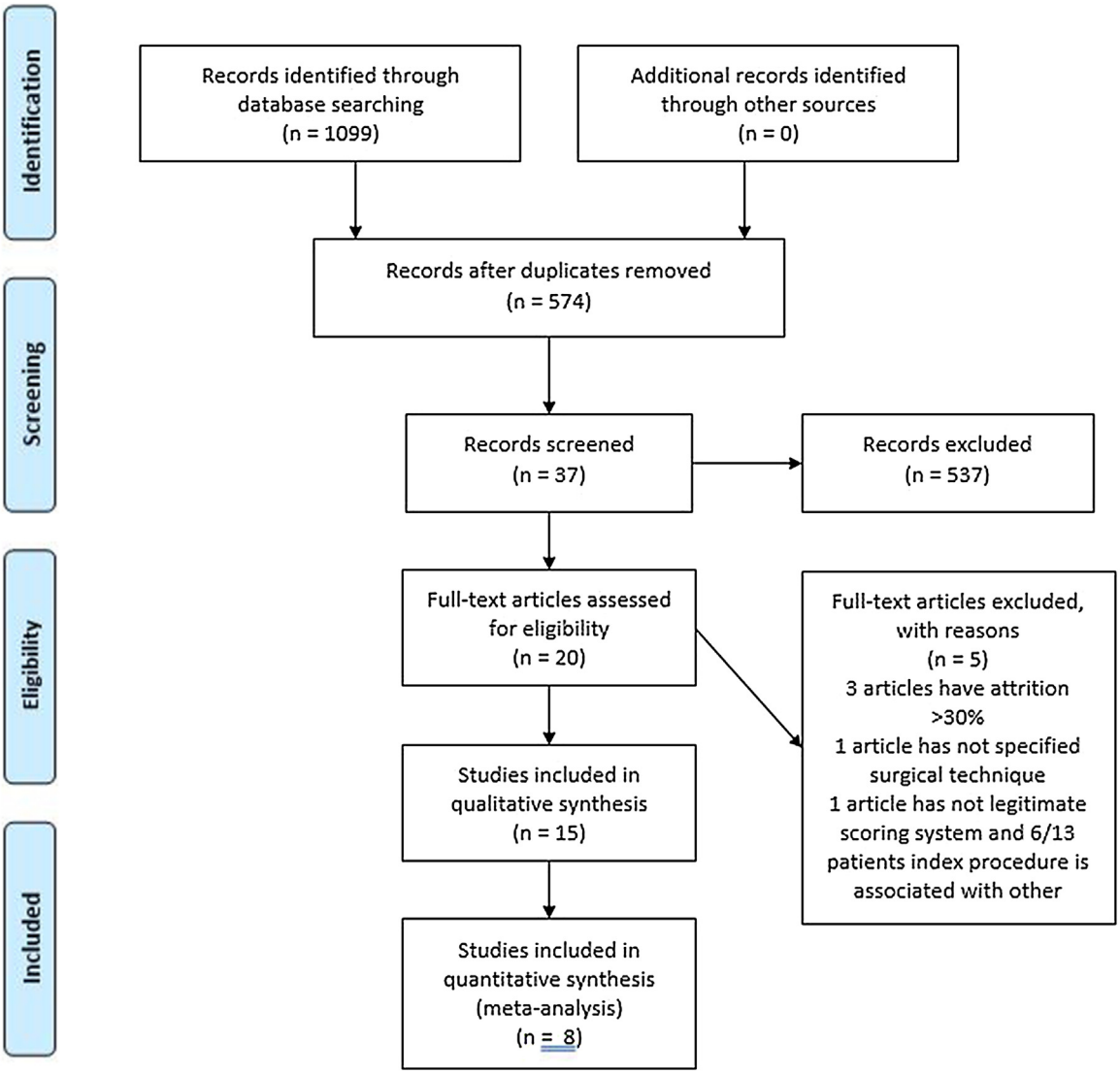

Fig. 1.

retrospective, three were prospective, and one was ambispective. Interposition materials were autogenous in ten studies [2,3,5,15,17–22] and allogenous/synthetic in four studies [1,9,13,14]. One study mentioned use of both autogenous and allogenous material [16]. Out of 15 studies, two were published in podiatry journals [7,13].

3.1. Demographic results

Fifteen studies with 340 patients and 369 feet were included in this review. Mean age at the time of surgery was 57.41 years (Range, 24–83 years). Mean duration of follow up was 38.08 months (Range, 8.1–151 months). Sex distribution was mentioned in 14 studies (322 patients), with total 102 male patients and 220 female patients [1,2,5,9,13–22]. Twelve studies reported a detailed breakdown of their patients' MTP arthritis using either Hattrup and Johnson (H&J) classification or Coughlin and Shurnas (C&S) classification [17,23]. Among four studies (66 feet) that used the H&J classification, 23 feet (35%) showed grade 2 arthritis and 43 feet (65%) showed grade 3 arthritis [3,5,13,19]. Eight studies (137 feet) used the C&S classification; with 136 feet (99.3%) classified as either grade 3 or 4 arthritis and one foot (0.7%) with grade 2 arthritis [1,2,9,14,15,17,22,24]. An overview of all included studies is given in Table 1.

3.2. Technique

The MTP joint was approached through dorsal incision in eight studies (205 patients, 211 feet) [1,2,13,16,17,20,21], dorsomedial incision in four studies (88 patients, 93 feet) [3,14,15,18], medial incision in two studies (34 patients, 47 feet) [5,22] and either dorso/dorsomedial incision in one study (13 patients, 18 feet) [9]. The extensor hallucis longus and dorsal cutaneous nerve of great toe were preserved and capsulotomy was performed to access the joint. The dorsal aspect of the metatarsal head and any associated osteophytes were removed using a sagittal saw. In capsular interposition arthroplasty studies, the dorsal capsule and short extensor tendon to the great toe were removed from their attachments along the dorsal ridge of the base of proximal phalanx [2,3,5,15,19–22]. After preparing the joint, either the dorsal capsule flap or the capsule together with the short extensors were interposed by suturing them to the planter plate with absorbable sutures. Extensor hallucis brevis tenotomy was performed as required to allow complete excursion of dorsal capsule over metatarsal head. Hahn et al. reported the use of a medial capsule flap instead of a dorsal capsule flap as the interposition material, suturing it onto the lateral capsule [18]. In autograft interposition arthroplasty studies, all capsular

Table 1
Eligible studies.
N/A

Author	Year	Journal	LOE	Type of study	Control group	N. Pt (feet)	Primary outcomes	Followup time (months)
DelaCruz et al. [13]	2011	Foot & Ankle Specialist	4	Retrograde case series	N/A	12 (13)	AOFAS	16.46
Ozan et al. [15]	2010	Acta orthop traumatol Turc	4	Prospective case series	N/A	17 (19)	AOFAS	21
Heller et al. [14]	2011	The Foot	4	Retrograde case series	N/A	31 (31)	AOFAS	55
Givissis et al. [9]	2017	The Foot	4	Prospective case series	N/A	13 (18)	AOFAS	108
Hahn et al. [18]	2009	FAI	4	Retrograde case series	N/A	22 (22)	AOFAS, SF −36	24
Can Akgun et al. [2]	2008	FAI	4	Prospective case series	N/A	11 (13)	AOFAS	27.2
Mackey et al. [20]	2010	Journal of Bone and Joint Surgery	3	Retrospective case-control	Arthrodesis	10 (10)	AOFAS	63
Schenk et al. [5]	2009	International Orthopedics	3	Retrospective case-control	resection arthroplasty	14 (22)	AOFAS	15.1
Sanhudo et al. [22]	2011	FAI	4	Retrospective case series	N/A	20 (25)	AOFAS	45.8
Kennedy et al. [3]	2006	CORR	4	Retrospective case series	N/A	18 (21)	AOFAS, SF-36	38
Lau and Daniels [3]	2001	FAI	3	Retrospective case-control	Cheilectomy	11 (11)	AOFAS	24
Roukis et al. [21]	2003	Journal of the American Podiatric Medical Association	4	Retrospective & prospective study	N/A	12 (15)	AOFAS	16.8
Berlet et al. [1]	2008	FAI	4	Retrograde case series	N/A	9 (9)	AOFAS	12.7
Coughlin and Shurnas [21]	2003	FAI	4	Retrospective case series	N/A	7 (7)	AOFAS	42
Aynardi et al. [16]	2017	FAI	4	Retrospective case series		133 (133)	FFI	62.2

attachments, particularly collateral ligaments, were preserved [1,9,13,14]. In 13 studies (315 patients, 336 feet), the proximal phalanx wedge shaped oblique osteotomy was performed from medial to lateral in such a way that it preserved short flexors on the plantar aspect of the base of the proximal phalanx. Four studies (63 patients, 70 feet) mentioned use of K-wires across metatarsophalangeal joint to immobilize the joint and to hold the graft in position, which were then removed at three to six weeks follow-up [9,15,18,19].

3.3. Clinical and radiographic outcome measures

Primary outcomes were reported using the AOFAS score in 14 studies. Mean AOFAS score across 14 studies (207 patients, 236 feet) improved from a preoperative pooled mean score of 41.35 points (Range, 25–63.9) to a postoperative pooled mean score of 83.17 points (Range, 71.6–93.6) at a mean follow up of 36.4 months (Table 2). Out of 14 studies, seven studies (115 patients, 135 feet) further stratified the AOFAS score into subcategories of pain, function and alignment [1,5,9,14,15,19,22]. Mean pain, function, and alignment scores improved from preoperative pooled mean values of 14.1, 24.9, and 10.0 AOFAS points to postoperative values of 33.3, 35.8, and 14.5 AOFAS points, respectively, on final follow up. One study (133 patients, 133 feet) reported Foot function index (FFI) as the primary outcome measure [16]. The mean FFI score was 77.1 at an average follow up of 62.2 months.

On physical examination, dorsiflexion was reported in five studies (64 patients, 68 feet) [13,17–19,21] and range of motion (ROM) of MTP joint was reported in four studies (60 patients, 75 feet) [2,3,5,15]. Mean dorsiflexion of MTP joint increased from

Table 2
Clinical outcomes.

Study	Outcomes of studies					
			Preoperative		Followup	
	Interposition material	Number of patients	AOFAS score	SD	AOFAS score	SD
DelaCruz et al. [13]	Cadaver meniscus allograft	12	52.54	13.44	90.01	4.05
Ozan et al. [15]	Capsule	17	60.7	5.1	85.3	8.7
Heller et al. [14]	Gelfoam	31	35	8	74	12
Givissis et al. [9]	TFL allograft	13	43.2	22.9	77.3	22.9
Hahn et al. [18][b]	Capsule	22	–	–	77.8	–
Can Akgun et al. [2]	Capsule	11	29.1	5.99	93.6	8.16
Mackey et al. [20][b]	Capsule	10	–	–	89.55	–
Schenk et al. [5]	Capsule	14	57	25.4	89	25.7
Sanhudo et al. [22][b]	Capsule	20	–	–	93.6	7.4
Kennedy et al. [3][b]	Capsule	18	–	–	78.4	–
Lau and Daniels [3][b]	Capsule	11	–	–	71.6	16.1
Roukis et al. [21]	Capsule	12	25	15	85.8	12
Berlet et al. [1]	Regenerative tissue matrix from cadaver	9	63.9	10.2	87.9	9.3
Coughlin and Shurnas [21][b]	Autogenuos same leg gracillis tendon, fascia lata, portion of peroneus longus	7	46	–	86	–
Total		207	41.35[a]		83.17[a]	

[a] Mean AOFAS score weighted per patient.
[b] Excluded this article from autograft–allograft comparative analysis.

21.27° preoperatively (Range, 5–30°) to 42.03° (Range, 25–71) on final follow up. Mean ROM improved from 27.16° preoperatively to 51.12° on final follow up.

Patient satisfaction was reported in six studies (194 patients, 205 feet) [3,9,16,17,19,21]. Patients were asked about their satisfaction on final follow up and asked if they would prefer to go through this surgery again if required. Out of 194, 169 patients (87%) reported good to high satisfaction with their surgery and would choose to undergo surgery again if required.

As a radiographic outcome, joint space was measured preoperatively and postoperatively in three studies (43 patients, 56 feet) [5,15,21]. The average joint space increased from 0.8 mm preoperatively to 2.5 mm on final follow up. Table 2 provides detailed information about these variables.

3.4. Complications

The complications reported in each study were shown in Table III . Overall complications following autograft interposition arthroplasty included: metatarsalgia in 23 feet (13.9%), loss of ground contact in 16 feet (9.7%), osteonecrosis in nine feet (5.4%), weakness of great toe in eight feet (4.8%), diminished push off power in seven feet (4.2%), callous formation in seven feet (4.2%), hypoesthesia in seven feet (4.2%), stress fracture in four feet (2.4%), restricted movement in two feet (1.2%), and algodystrophy in one foot (0.6%). Complications of allograft interposition arthroplasty included: failure leading to revision surgery in two feet (2.8%), recurrence of hallux valgus in two feet (2.8%), claw toe deformity in one foot (1.4%), and weakness of the great toe in one foot (1.4%). Studies that used the Mroczek and Miller modification of modified Keller interposition arthroplasty and studies that used allograft with preservation of the flexor hallucis brevis had very low rates of loss of push of power, loss of ground contact, and great toe weakness of great toe. A study of 133 patients by Aynardi et al. reported a failure rate of 3.8% after interposition arthroplasty at a mean follow up of 62.2 months. Of the five failed procedures, three were converted to arthrodesis— two reported good results and one reported excellent results [16].

3.5. Comparison of outcomes between allograft vs autograft

Only studies with preoperative and postoperative scores and standard deviation were selected to maintain quality outcomes for comparison. Eight studies (119 patients, 140 feet) were included for quantitative comparison: four studies (54 patients, 69 feet) with autogenous interposition [2,5,15,21] and four studies (65 patients, 71 feet) with allogenous interposition material [1,9,13,14]. Seven studies were excluded from this quantitative comparison due to lack of enough statistical data. There was no significant difference in the preoperative AOFAS scores between the allograft and autograft groups ($p = 0.771$), but the postoperative scores in the autograft group were significantly higher than in the allograft group ($p = 0.003$). There were significant improvements from the preoperative to postoperative scores in both groups ($p < 0.001$). These complications are summarized in Table 3 while Table 4 compares AOFAS scores between materials.

4. Discussion

The goal of any operative intervention for the arthritic joint should be establishment of a pain free and functional joint [3]. Though arthrodesis or arthroplasty are the two procedures currently recommended for moderate to severe hallux rigidus, the optimal treatment option still remains controversial [20]. FMTP joint arthrodesis is still considered the gold standard for advanced hallux rigidus, but it only fulfills one goal of arthritic joint treatment: a pain free joint. Loss of motion at the joint due to arthrodesis restricts shoe choice, which contributes to patient dissatisfaction, particularly in females [22]. On the other hand, partial and total MTP joint arthroplasty is associated with limited lifespan and many serious complications including soft tissue reactions, joint stiffness, prosthesis dislocation, loosening, breakage and subsidence of implanted material [25–28]. Interposition arthroplasty is a viable option for young patients who want to preserve MTP joint movement to preserve the ability to squat either recreationally or in an occupational setting, and for women who want to wear high-heeled shoes [29]. This is possible because interposition arthroplasty allows pain free joint motion, and maintenance of push off strength and length of the first metatarsal ray. This is the first systematic review showing outcomes of interposition arthroplasty as an option for treatment of moderate to severe hallux rigidus. This review synthesizes the clinical outcomes, techniques, and complications associated with interposition arthroplasty in moderate to severe hallux rigidus.

4.1. Operative technique

Interposition arthroplasty is performed using autogenous or allogeneic material for interposition between joint. This review found statistically higher postoperative AOFAS scores with autogenous interposition arthroplasty when compared to allografting techniques. However, proper technique of capsular interposition arthroplasty is crucial for good outcomes. Two studies (Lau and Schenk) cleared the short flexors from the base of the proximal phalanx during joint preparation, as described in Hamilton et al.'s modification of Keller arthroplasty [18,27,30]. The remaining six studies with capsular interposition arthroplasty preserved the short flexors and the flexor hallucis longus during joint preparation, as described by the Mroczek and Miller modification of Hamilton et al.'s technique [2,3,12,15,18,20,22]. This newer modification improves joint stability and preserves planter flexion, maintaining push off power. It also limits cock up deformity postoperatively and improves dorsiflexion [1,21,31]. X-rays were included to show preoperative (Fig. 2a, b), postoperative (Fig. 3a, b), and follow up for the procedure.

4.2. Subjective outcomes

Across 14 studies (207 patients, 236 feet), pooled mean AOFAS score improved from 41.35 to 83.17 points at an average of 36.4 months follow up (Fig. 4). These results are comparable to outcomes after MTP arthrodesis and implant arthroplasty [30, 32–35].

Defrino et al reported AOFAS score improvement from a mean of 38 points preoperatively to 90 points postoperatively at a mean of 34 months following MTP joint arthrodesis for moderate to severe hallux rigidus [33]. Similarly, Erdil et al. reported improvement in AOFAS score from a mean of 33.6 points preoperatively to 76.1 points postoperatively at an average follow up of 35.3 months [34]. The study by DeFrino used two parallel cortical screws for fixation, whereas Erdil et al. used two compression screws. Givissis et al. reported mid to long term follow up at an average of 108 months after interposition arthroplasty. The mean AOFAS score increased from 43.2 points preoperatively to 77.3 points at final follow up, which is comparable to Aas et al.'s reported mean postoperative AOFAS score of 74 at an average of 96 months following arthrodesis [32]. As arthrodesis leads to loss of movement at the MTP joint, the maximum AOFAS score is reduced to 90, which is a potential reason for slightly lower AOFAS scores in arthrodesis patients compared to those treated with interposition arthroplasty.

Table 3
Summary of postoperative complications.

Complications	Autograft											Allograft				
	Ozan et al. [15]	Hahn et al. [18]	Can Akgun et al. [2]	Mackey et al. [20]	Schenk et al. [5]	Sanhudo et al. [22]	Kennedy et al. [3]	Lau and Daniels [3]	Roukis et al. [21]	Coughlin and Shurnas [21]	Total (%)	DelaCruz et al. [13]	Heller et al. [14]	Givissis et al. [9]	Berlet et al. [1]	Total (%)
Metatarsalgia	11	–	1	–	3	–	1	3	–	4	23 (13.9%)	–	–	–	–	–
Callous formation	–	–	–	–	–	–	–	3	–	4	7 (4.2%)	–	–	–	–	–
Failure leading to revision surgery	–	–	–	–	–	–	–	–	–	–	–	–	1	1	–	2 (2.8%)
Hypoesthesia	3	–	2	–	2	–	–	–	–	–	7 (4.2%)	–	–	–	–	–
Restricted movement	–	–	–	–	–	–	2	–	–	–	2(1.2%)	–	–	–	–	–
Loss of ground contact	15	–	–	–	1	–	–	–	–	–	16 (9.7%)	–	–	–	–	–
Stress fracture	–	2	1	–	–	–	1	–	–	–	4 (2.4%)	–	–	–	–	–
Recurrence of hallux valgus	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	2 (2.8%)
Claw toe deformity	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1 (1.4%)
Algodystrophy	–	–	–	–	1	–	–	–	–	–	1 (0.6%)	–	–	–	–	–
Osteonecrosis of 1 st MTP head	–	–	–	–	9	–	–	–	–	–	9 (5.4%)	–	–	–	–	–
Limited toe extension	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1 (1.4%)
Neuroma leading to pain	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1 (1.4%)
Weakness of great toe	–	–	–	–	–	–	–	8	–	–	8 (4.8%)	1	–	–	–	1 (1.4%)
Push off power $\leq$ 3/5	5	–	–	–	–	–	–	2	–	–	7 (4.2%)					
Infection	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1 (1.4%)

Table 4
Comparison of AOFAS scores between Allograft versus Autograft as Metatarsophalangeal Interposition Arthroplasty Materials.

AOFAS Score (points)	Allograft	S.D.	Autograft	S.D.	*p* value
Preoperative	43.88	11.95	45.37	18.45	0.77
Postoperative	79.54	7.79	88.06	3.65	0.002
p value	<0.0001		<0.0001		–

Several studies have reported favorable outcomes with MTP arthroplasty for moderate to severe HR. One such study by Dos Santos et al. reported AOFAS score improvement from 32 points preoperatively to 77.2 points postoperatively at a mean of 44.7 months following HemiCap resurfacing arthroplasty [35]. Titchener et al. also reported improvement in AOFAS scores in patients with severe hallux rigidus treated with ToeFit Plus total MTP joint arthroplasty, from a preoperative mean score of 41.4 points to a postoperative mean score of 91 points at an average follow up of 33 months [30]. In this review, all but two of the included studies reported mean postoperative AOFAS scores greater than 75 on final follow up. The two exceptions were the studies by Heller and Lau, which reported pooled mean postoperative AOFAS scores of 74 and 71.6 points, respectively.

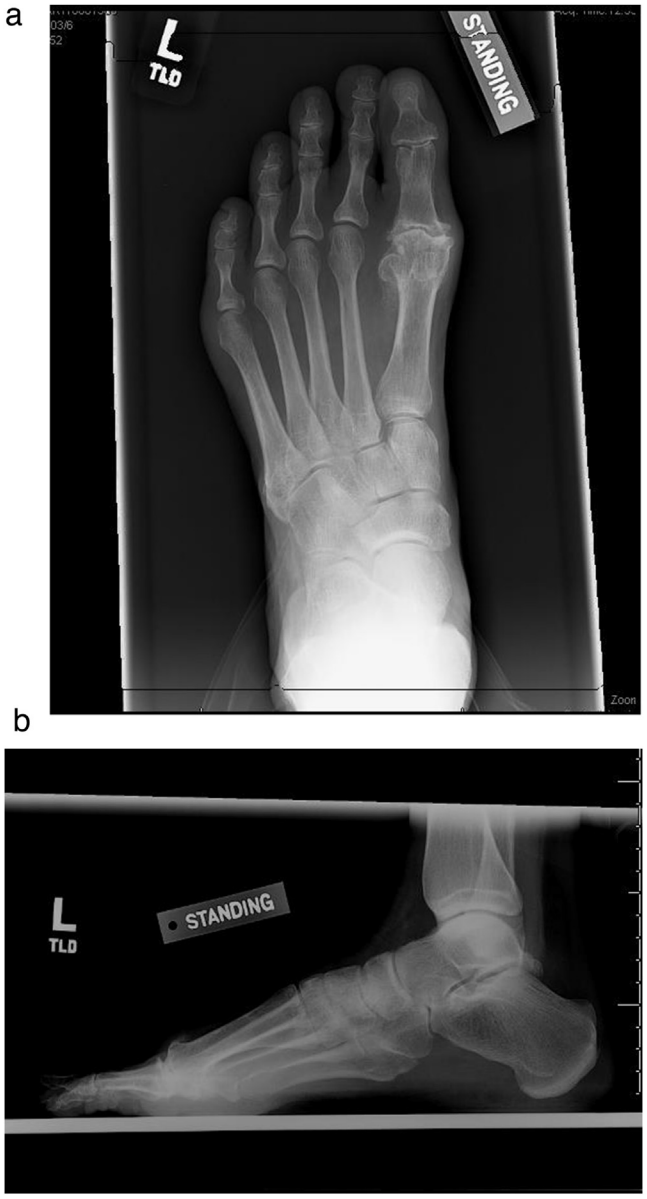

Fig. 2.

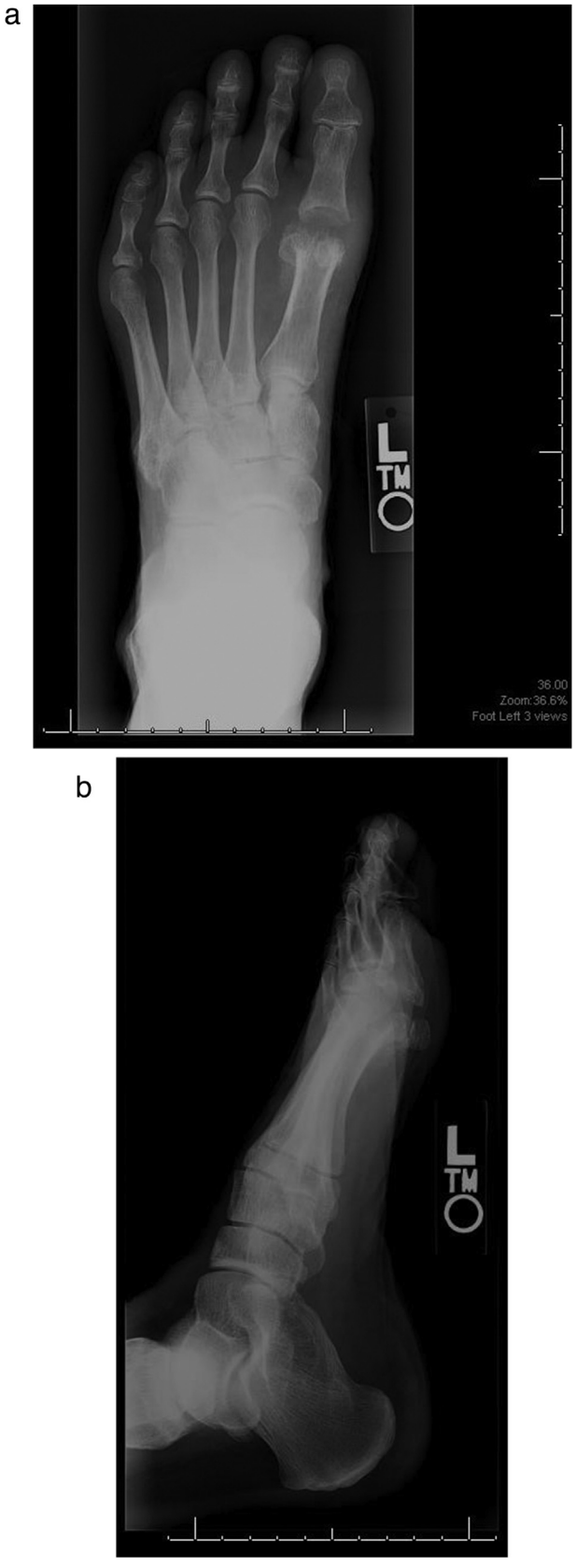

Fig. 3.

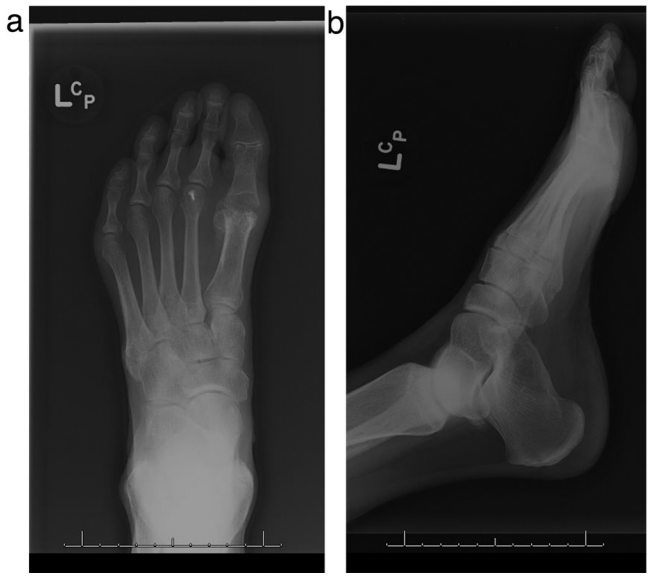

Fig. 4.

The study by Heller included a cohort of 31 patients with a relatively low mean preoperative AOFAS score of 35 points, which may explain the low postoperative scores. The study by Lau did not report preoperative AOFAS scores and included almost exclusively patients with severe arthritis (H&J grade III). Furthermore, Lau used Hamilton et al.'s modification of Keller arthroplasty, in which the short flexors are cleared from the planter side of the proximal phalanx during joint preparation. This may suggest inferior functional outcomes with this technique compared to the Mroczek and Miller modification. The study by Schenk, on the other hand, reported a relatively high mean postoperative AOFAS score of 89 points with the Hamilton technique. Notably, however, the majority of patients in Schenk's study had only moderate arthritis (H&J grade II), and the preoperative mean AOFAS score was 57 points, which suggests a below average AOFAS score improvement of 32 points.

4.3. Objective outcome

Improved range of motion is one of the major reported advantages of interposition arthroplasty. Indeed, this review found that range of motion improved across all studies, though this improvement was comparable to published results for total joint replacement or resurfacing arthroplasty. Among the studies in this review, interposition arthroplasty improved range of motion of the MTP joint from an average of 27.16° preoperatively to an average of 51.12° postoperatively. In comparison, Erdil et al. reported results for total joint replacement and metatarsal head resurfacing Hemiarthroplasty for moderate to severe hallux rigidus at an average of 27.9 and 30.2 months follow up, respectively. Range of motion improved from 15.08 to 40.00° following total joint replacement, and from 20.50 to 47.86° following metatarsal head resurfacing. As arthrodesis leads to fusion of the MTP joint, ROM following arthrodesis is 0°. However, statistically relevant pain relief following arthrodesis compared to hemi/total joint arthroplasty has been reported [34].

The overall patient satisfaction rate in this systematic review was 86% among 176 patients, which compares favorably to patient satisfaction rates following total joint arthroplasty, which have been reported as high as 90.9% [36].

4.4. Complications

Interposition arthroplasty lacks the risk of nonunion, diminished ROM, and footwear restriction while maintaining a painless and mobile joint [11,15,17]. Metatarsalgia was reported in the majority of the reviewed studies, occurring in 13.6% to 57% of patients [2,3,5,15,17,19]. Metatarsalgia is caused by shortening of the first ray and overloading of lateral metatarsals, and it has been reported to affect 27–36% of patients following cheilectomy and arthrodesis [3,15]. Maintenance of hallux length and plantarflexion power were the most important means of preventing metatarsalgia, and selecting patients with a long first ray may also reduce the incidence [2,12]. While the rates of metatarsalgia with interposition arthroplasty were similar to cheilectomy or arthrodesis procedures, the advantages of interposition arthroplasty including maintenance of range of motion and improved joint function suggest that interposition arthroplasty may be a more effective treatment relative to this complication [2,15].

When further subcategorizing autograft interposition arthroplasty complications by study, the studies by Lau and Schenck reported the highest number of complications, potentially because they did not preserve the flexor hallucis brevis tendon during joint preparation [19,27]. Ozan et al. mentioned that damage to the flexor hallucis brevis tendon during excision of the proximal phalanx might be the potential cause for loss of ground contact of great toe in their study. They further explained that FHB damage leads to loss of its stabilizing effect, which may result in dorsal retraction of great toe [15].

There were seven feet (4.8%) that developed hypoesthesia on the dorsum of the great toe following autograft interposition arthroplasty. Hypoesthesia is an iatrogenic complication due to damage to the dorsal cutaneous nerve which can occur with the dorsomedial approach [12]. One potential contributing factor to this complication is surgeon skill.

The good to excellent results following revision arthrodesis for failed interposition arthroplasty in study by Aynardi may be due to the fact that interposition arthroplasty required less bone resection, maintaining first ray length [16]. Arthrodesis following failure of interposition arthroplasty is associated with few more complications than primary arthrodesis including, slower union, higher reoperation rate and lower AOFAS scores [6,37]. Even though arthrodesis in failed interposition arthroplasty generally gives good to excellent outcomes, patients should be advised that arthrodesis will likely not be as successful as a primary procedure.

4.5. Limitations

Due to the nature of systematic review, the quality of the studies used is a limitation of the study. Twelve of the studies used were level IV evidence and three had level III evidence. Furthermore, studies were relatively small, ranging in size from seven to 31 patients. Another limitation is the lack of reporting of preoperative scores in many included studies. For any treatment, improvement in outcome is more important than the final outcome score. Due to possible heterogeneity in unrecorded pre-operative score, follow up AOFAS score was less noteworthy. One more limitation of our study was lack of long term follow up. Although mid-term results showed good to excellent outcomes of interposition arthroplasty, long term data supporting it relative to arthrodesis has not been recorded in the literature. Further randomized prospective trials with greater sample sizes, more uniform methods, and longer follow up times are needed to further support its applicability as treatment option of choice before arthrodesis.

5. Conclusion

Although the mean postoperative AOFAS scores was improved in autogenous arthroplasty compared to allograft interposition arthroplasty on meta-analysis, a randomized control trial providing direct comparison with level I evidence would be required to confirm this finding.

Overall, Interposition arthroplasty is a effective treatment option with acceptable clinical outcomes in patients with moderate-severe hallux rigidus who prefer to maintain range of motion and accept the risk of future complications. Furthermore, it does not preclude arthrodesis if the procedure fails.

Declarations of interest

None.

References

[1] Berlet G.C., Hyer CF, Lee TH, Philbin TM, Hartman JF, Wright ML. Interpositional arthroplasty of the first MTP joint using a regenerative tissue matrix for the treatment of advanced hallux rigidus. Foot Ankle Int 2008;29:10–21, doi:http://dx.doi.org/10.3113/FAI.2008.0010.

[2] Can Akgun R, Sahin O, Demirors H, Cengiz Tuncay I. Analysis of modified oblique Keller procedure for severe hallux rigidus. Foot Ankle Int 2008, doi:http://dx.doi.org/10.3113/FAI.2008.1203.

[3] Kennedy JG, Chow FY, Dines J, Gardner M, Bohne WH. Outcomes after interposition arthroplasty for treatment of hallux rigidus. Clin Orthop Relat Res 2006, doi:http://dx.doi.org/10.1097/01.blo.0000201166.82690.23.

[4] Mermerkaya MU, Adli H. A comparison between metatarsal head-resurfacing hemiarthroplasty and total metatarsophalangeal joint arthroplasty as surgical treatments for hallux rigidus: a retrospective study with short- to midterm follow-up. Clin Interv Aging 2016;11:1805–13, doi:http://dx.doi.org/10.2147/CIA.S110865.

[5] Schenk S, Meizer R, Kramer R, Aigner N, Landsiedl F, Steinboeck G. Resection arthroplasty with and without capsular interposition for treatment of severe hallux rigidus. Int Orthop 2009, doi:http://dx.doi.org/10.1007/s00264-007-0457-z.

[6] Reize P, Schanbacher J, Wülker N. K-wire transfixation or distraction following the Keller-Brandes arthroplasty in hallux rigidus and hallux valgus? Int Orthop 2007;31:325–31, doi:http://dx.doi.org/10.1007/s00264-006-0178-8.

[7] Thermann H, Becher C, Kilger R. Hallux rigidus treatment with cheilectomy extensive plantar release, and additional microfracture technique. Tech Foot Ankle Surg 2004;3:210–5, doi:http://dx.doi.org/10.1097/00132587-200412000-00004.

[8] Clews CNL, Kingsford AC, Samaras DJ. Autogenous capsular interpositional arthroplasty surgery for painful hallux rigidus: assessing changes in range of motion and postoperative foot health. J Foot Ankle Surg 2015, doi:http://dx.doi.org/10.1053/j.jfas.2014.09.004.

[9] Givissis PK, Symeonidis PD, Kitridis DM, Daskalakis DN, Christodoulou AG. Minimal resection interposition arthroplasty of the first metatarsophalangeal joint. Foot (Edinb) 2017;32:1–7, doi:http://dx.doi.org/10.1016/j.foot.2017.03.004.

[10] Vulcano E, Chang AL, Solomon D, Myerson M. Long-term follow-up of capsular interposition arthroplasty for hallux rigidus. Foot Ankle Int 2017, doi:http://dx.doi.org/10.1177/1071100717732124.

[11] Hamilton WG, O'Malley MJ, Thompson FM, Kovatis PE. Capsular Interposition Arthroplasty for Severe Hallux Rigidus. Foot Ankle Int 1997;18:68–70, doi:http://dx.doi.org/10.1177/107110079701800204.

[12] Mroczek KJ, Miller SD. The modified oblique Keller procedure: a technique for dorsal approach interposition arthroplasty sparing the flexor tendons. Foot Ankle Int 2003;24:521–2, doi:http://dx.doi.org/10.1177/107110070302400702.

[13] DelaCruz EL, Johnson AR, Clair BL. First metatarsophalangeal joint interpositional arthroplasty using a meniscus allograft for the treatment of advanced hallux rigidus: surgical technique and short-term results. Foot Ankle Spec 2011;4:157–64, doi:http://dx.doi.org/10.1177/1938640011402821.

[14] Heller E, Robinson D. Gelfoam first metatarsophalangeal replacement/interposition arthroplasty—a case series with functional outcomes. Foot (Edinb) 2011;21:119–23, doi:http://dx.doi.org/10.1016/j.foot.2010.11.007.

[15] Ozan F, Bora OA, Filiz MA, Kement Z. Interposition arthroplasty in the treatment of hallux rigidus. Acta Orthop Traumatol Turc 2010, doi:http://dx.doi.org/10.3944/AOTT.2010.2243.

[16] Aynardi MC, Atwater L, Dein EJ, Zahoor T, Schon LC, Miller SD. Outcomes after interpositional arthroplasty of the first metatarsophalangeal joint. Foot Ankle Int 2017;38:514–8, doi:http://dx.doi.org/10.1177/1071100716687366.

[17] Coughlin MJ, Shurnas PJ. Soft-tissue arthroplasty for hallux rigidus. Foot Ankle Int 2003;24:661–72, doi:http://dx.doi.org/10.1177/107110070302400902.

[18] Hahn MP, Gerhardt N, Thordarson DB. Medial capsular interpositional arthroplasty for severe hallux rigidus. Foot Ankle Int 2009, doi:http://dx.doi.org/10.3113/FAI.2009.0494.

[19] Lau JT, Daniels TR. Outcomes following cheilectomy and interpositional arthroplasty in hallux rigidus. Foot Ankle Int 2001.

[20] Mackey RB, Thomson AB, Kwon O, Mueller MJ, Johnson JE. The modified oblique keller capsular interpositional arthroplasty for hallux rigidus. J Bone Joint Surg Am 2010;92:1938–46, doi:http://dx.doi.org/10.2106/JBJS.I.00412.

[21] Roukis TS, Landsman AS, Ringstrom JB, Kirschner P, Wuenschel M. Distally based capsule-periosteum interpositional arthroplasty for hallux rigidus Indications, operative technique, and short-term follow-up. J Am Podiatr Med Assoc 2003, doi:http://dx.doi.org/10.7547/87507315-93-5-349.

[22] Sanhudo JA, Gomes JE, Rodrigo MK, J.A S, J.E G, M.K R. Surgical treatment of advanced hallux rigidus by interpositional arthroplasty. Foot Ankle Int 2011;32:400–6, doi:http://dx.doi.org/10.3113/FAI.2011.0400.

[23] Hattrup SJ, Johnson KA. Subjective results of hallux rigidus following treatment with cheilectomy. Clin Orthop Relat Res 1988;182–91.

[24] Terrell RD, Montgomery SR, Pannell WC, Sandlin MI, Inoue H, Wang JC, et al. Comparison of practice patterns in total ankle replacement and ankle fusion in the United States. Foot Ankle Int 2013;34:1486–92, doi:http://dx.doi.org/10.1177/1071100713494380.

[25] Arbuthnot JE, Cheung G, Balain B, Denehey T, Higgins G, Trevett MC. Replacement arthroplasty of the first metatarsophalangeal joint using a ceramic-coated endoprosthesis for the treatment of hallux rigidus. J Foot Ankle Surg 2008;47:500–4, doi:http://dx.doi.org/10.1053/j.jfas.2008.08.007.

[26] Ibrahim T, John Saint Clair Taylor G. The new press-fit ceramic Moje metatarsophalangeal joint replacement: short-term outcomes. Foot 2004;14:, doi:http://dx.doi.org/10.1016/j.foot.2004.01.002.

[27] Konkel KF, Menger AG, Retzlaff SA. Mid-term results of futura hemi-great toe implants. Foot Ankle Int 2008;29:831–7, doi:http://dx.doi.org/10.3113/FAI.2008.0831.

[28] McGraw IWW, Jameson SS, Kumar CS. Mid-term results of the Moje Hallux MP joint replacement. Foot Ankle Int 2010;31:592–9, doi:http://dx.doi.org/10.3113/FAI.2010.0592.

[29] Johnson MD, Brage ME. Total toe replacement in the United States: what is known and what is on the horizon. Foot Ankle Clin 2016;21:249–66, doi:http://dx.doi.org/10.1016/j.fcl.2016.01.004.

[30] Titchener AG, Duncan NS, Rajan RA. Outcome following first metatarsophalangeal joint replacement using TOEFIT-PLUS: a mid term alert. Foot Ankle Surg 2015;21:119–24, doi:http://dx.doi.org/10.1016/j.fas.2014.10.005.

[31] Shereff MJ, Baumhauer JF. Hallux rigidus and osteoarthrosis of the first metatarsophalangeal joint. J Bone Joint Surg Am 1998.

[32] Aas M, Johnsen TM, Finsen V. Arthrodesis of the first metatarsophalangeal joint for hallux rigidus—optimal position of fusion. Foot (Edinb) 2008;18:131–5, doi:http://dx.doi.org/10.1016/j.foot.2008.03.002.

[33] DeFrino PF, Brodsky JW, Pollo FE, Crenshaw SJ, Beischer AD. First metatarsophalangeal arthrodesis: a clinical, pedobarographic and gait analysis study. Foot Ankle Int 2002;23:496–502, doi:http://dx.doi.org/10.1177/107110070202300605.

[34] Erdil M, Elmadağ NM, Polat GG, Tunçer N, Bilsel K, Uçan V, et al. Comparison of arthrodesis, resurfacing hemiarthroplasty, and total joint replacement in the treatment of advanced hallux rigidus. J Foot Ankle Surg 2013;52:, doi:http://dx.doi.org/10.1053/j.jfas.2013.03.014.

[35] Dos Santos ALG, Duarte FA, Seito CAI, Ortiz RT, Sakaki MH, Fernandes TD. Hallux rigidus prospective study of joint replacement with hemiarthroplasty. Acta Ortop Bras 2013;21:71–5, doi:http://dx.doi.org/10.1590/S1413-78522013000200001.

[36] Wassink S, Burger BJ, Saragas NP, Asuncion Marquez J, Trtik L, Harlaar J. A prospective 24 months follow-up of a three component press-fit prosthesis for hallux rigidus. Foot Ankle Surg 2017;23:157–62, doi:http://dx.doi.org/10.1016/j.fas.2016.08.008.

[37] Gross CE, Hsu AR, Lin J, Holmes GB, Lee S. MTP revision Arthrodesis for Failed MTP Arthroplasty. Foot Ankle Spec 2013;6:471–8, doi:http://dx.doi.org/10.1177/1938640013502725.