Surgical Treatment of Advanced Hallux Rigidus by Interpositional Arthroplasty

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Surgical Treatment of Advanced Hallux Rigidus by Interpositional Arthroplasty

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ABSTRACT

Background: **While arthrodesis is the gold-standard for end-stage hallux rigidus, it leads to loss of mobility. The purpose of this paper was to report our clinical results with modified interpositional arthroplasty for the treatment of advanced (Grade III and IV of Coughlin and Shurnas) hallux rigidus.** ***Material and Methods:*** **Twenty-five feet with Grade III and IV hallux rigidus underwent cheilectomy, minimal proximal phalanx resection (modified Keller) and interposition of the dorsal capsule and EHB.** ***Results:*** **At a minimum followup of 15 months, the mean postoperative hallux AOFAS score was 93.6 points with a pain subscore of 36.4 (maximum, 40 points) and functional subscore of 42.5 (maximum, 45 points). Subjectively, patients were completely satisfied with the surgical outcome in 75% of the cases.** ***Conclusion:*** **The modified interpositional arthroplasty was a feasible surgical option to address advanced hallux rigidus in middle aged patients.**

Level of Evidence: IV, Case Series

Key Words: Hallux Rigidus; Operative Treatment, Interpositional Arthroplasty

INTRODUCTION

Hallux rigidus is one of the most common forms of foot and ankle arthrosis.[6,11] It was first described by Davis-Colley, in 1887, and in the same year was named hallux rigidus by Coterill.[9,16] Although described more than 120 years ago, there is still debate on its etiology and treatment. The structural factors most likely associated with hallux rigidus include a dorsiflexed first metatarsal in relation to the second metatarsal, first-ray excessive length, pes planus, Achilles tendon contracture, and flattened first metatarsophalangeal joint (MTPJ).[6,11,26,53]

Beeson and colleagues compared the classification systems for hallux rigidus and found that Coughlin and Shurnas description is the most comprehensive, taking into account radiographic aspects, objective aspects (range of motion), and subjective aspects (intensity and frequency of stiffness and pain).[3,12] In Grade 0, the patient has no pain and has passive motion limitation of 10% to 20% and radiographic changes are either minimal or absent. In Grade I, pain is mild and present only at the extremes of motion; a dorsal osteophyte is radiographically visible, and motion loss of 20% to 50% as compared to the normal side. In Grade II, pain is more severe and can be constant, radiographic sclerosis and narrowing is observed, and motion loss of 50% to 75% is present. In Grade III, pain is usually constant exacerbated by plantarflexion and dorsiflexion; subchondral cysts and sesamoid bone involvement are radiographically evident, with 75% to 100% loss of motion. In Grade IV, the same findings of Grade III are seen, but the patient presents with pain throughout the mid-range of motion on clinical examination.

In any disease stage, conservative methods should be initially instituted.[41,47] Surgical treatment is indicated for conservative treatment failures where symptom severity warrants intervention. The surgical technique is dictated by disease stage. During initial stages (Stages I and II of Coughlin and Shurnas), cheilectomy and Moberg's osteotomy, either employed in isolation or together, lead to a high percentage of good outcomes.[5,17,21,25,29,33,34,38,40,51,55] In more advanced stages, where loss of motion is more severe (Stages III and IV of Coughlin and Shurnas), arthrodesis is still the gold standard with the drawback of stiffness.[10,12,18,19,22,29,35,37,44,56] Despite range of motion sparing, Keller's resection arthroplasty is only indicated in elderly, low-physical demand patients, as the resulting first ray shortening and weakness often leads to lateral ray overloading.[7,28,29,57] Partial or total MTPJ arthroplasty has encouraging short-term results, but, apart from being a costly

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procedure, poses a considerable risk of component loosening in the long run.[1,14,15,27,30,31,32,42,43,46,50,54]

Interpositional arthroplasties for the treatment of hallux rigidus have been described since 1986.[2,4,8,13,20,23,24,39,45,52] The aim of this retrospective study was to present the outcome of the surgical treatment with a modification of the interpositional arthroplasty described by Hamilton in 1997 for advanced hallux rigidus (Grades III and IV of Coughlin and Shurnas).[23,24]

MATERIALS AND METHODS

Between January 2003 and December 2008, 25 consecutive patients with advanced, symptomatic hallux rigidus refractory to conservative treatment underwent a modification of Hamilton's interpositional arthroplasty. All patients were operated upon by the same surgeon (JAVS). Twenty patients were available and fulfilled the criteria for study participation. Five patients had bilateral operations resulting in a total of 25 feet. One patient died and four patients were not available. Patients with milder grades of hallux rigidus were treated with another surgical technique and thus were excluded from the study. Patients with associated systemic disease (hyperuricemia, rheumatoid arthritis, and seronegative arthritides), and patients with hallux valgus accompanied with arthrosis were excluded. Mean age at the time of surgery was 60.8 (range, 43 to 76) years. There were four male patients (one bilateral case), and 16 female patients (four bilateral cases). There were 19 right and six left feet. One patient had had a previous cheilectomy, one had undergone a Keller's arthroplasty, one had had a previous bursectomy, and one had undergone previous bilateral dorsal osteophyte removal.

Associated surgical procedures with the interpositional arthroplasty included a second toe claw correction in one patient, one patient had neuromas removed from the second and third intermetatarsal spaces by a single dorsal, longitudinal incision, and one had second-, third-, and fourth metatarsal Weil osteotomy through a single dorsal, transverse incision.

All patients were interviewed and examined by one of the authors (J.A.V.S. or R.K.M.) during a specific appointment to collect the data. Minimum followup was 15 months and the maximum followup was 80 (mean, 45.8) months.

Statistical analysis was performed with independent samples Student's t test, with the level of significance of $p \leq 0.05$. The SPSS (Statistical Package for Social Sciences) software version 17.0 was employed.

Surgical technique

All patients had ankle block anesthesia. An Esmarch bandage just above the ankle joint was used as a tourniquet. Through a medial incision at the hallux metatarsophalangeal joint, the capsule was longitudinally incised in line with the skin incision (Figure 1A). The dorsal capsule at the first metatarsal and the proximal phalanx of the hallux was detached. At the plantar side, metatarsosesamoid ligaments, ie. the proximal capsule insertion, were detached from the neck of first metatarsal to eliminate possible joint contracure and to facilitate hallux extension (Figure 1B). The adductor tendon was not released from the lateral sesamoid. If osteoarthrosis of the sesamoids was detected, the sesamoids had osteophyte removal but no sesamoidectomy was performed. An oscillating microsaw was employed to perform the cheilectomy, with 30-50% of dorsal head removed from the first metatarsal, along with a restricted Keller's osteotomy, removing 3 to 4 mm of the base from the proximal phalanx, ideally leaving a cartilage halo at the center of the phalanx (Figure 1C and 1D). The dorsal capsule was carefully separated from the skin, protecting the hallux dorsal cutaneous nerve and the extensor hallucis longus tendon (Figure 1E). After total dorsal capsule detachment from the proximal phalanx, the cheilectomy area was covered by the capsule (Figure 1F). In cases of insufficient coverage, the extensor hallucis brevis tendon which adhered to the dorsal capsule was tenotomized at the level of the first metatarsal shaft to facilitate distal capsular displacement. The hallux was then distally retracted exposing the plantar plate and allowing the attachment of the dorsal capsule at that plantar region by two vicryl-0 stitches fixed just distal to the sesamoid bones, which covered the metatarsal head while restricting proximal sesamoid migration. This is the most technically demanding step of the procedure; however, it can be achieved with proper hallux distraction, and with the use of a small, curved needle. The medial capsule was closed (Figure 1G). Hallux MTPJ mobility was tested, and at least seventy degrees of hallux dorsiflexion should be obtained (Figure 1H). Subcutaneous tissue and skin were sutured with vicryl 3-0 and monofilament nylon 4-0, respectively. Figure 2 graphically demonstrates the metatarsosesamoid ligament release, the extent of osseous resection, and the capsular interposition enabled by joint decompression and manual distraction.

Twenty patients with one-sided disease were operated as outpatients, and those with bilateral disease remained in the hospital one day. Hindfoot weightbearing with a postoperative shoe was allowed immediately. Sutures were removed between 10 and 14 days after the procedure, when active and passive motion exercises were started. The postoperative shoe was changed to a normal, open shoe or to an enlarged toebox shoe after the fourth postoperative week.

RESULTS

The mean postoperative hallux AOFAS score was 93.6 ($\pm$7.4) with a mean pain subscore of 36.4 (maximum, 40 points), functional subscore of 42.5 (maximum, 45 points), and alignment subscore of 14.7. Comparing the 18 Grade III and the seven Grade IV patients, we observed that both groups showed a high postoperative AOFAS score. There

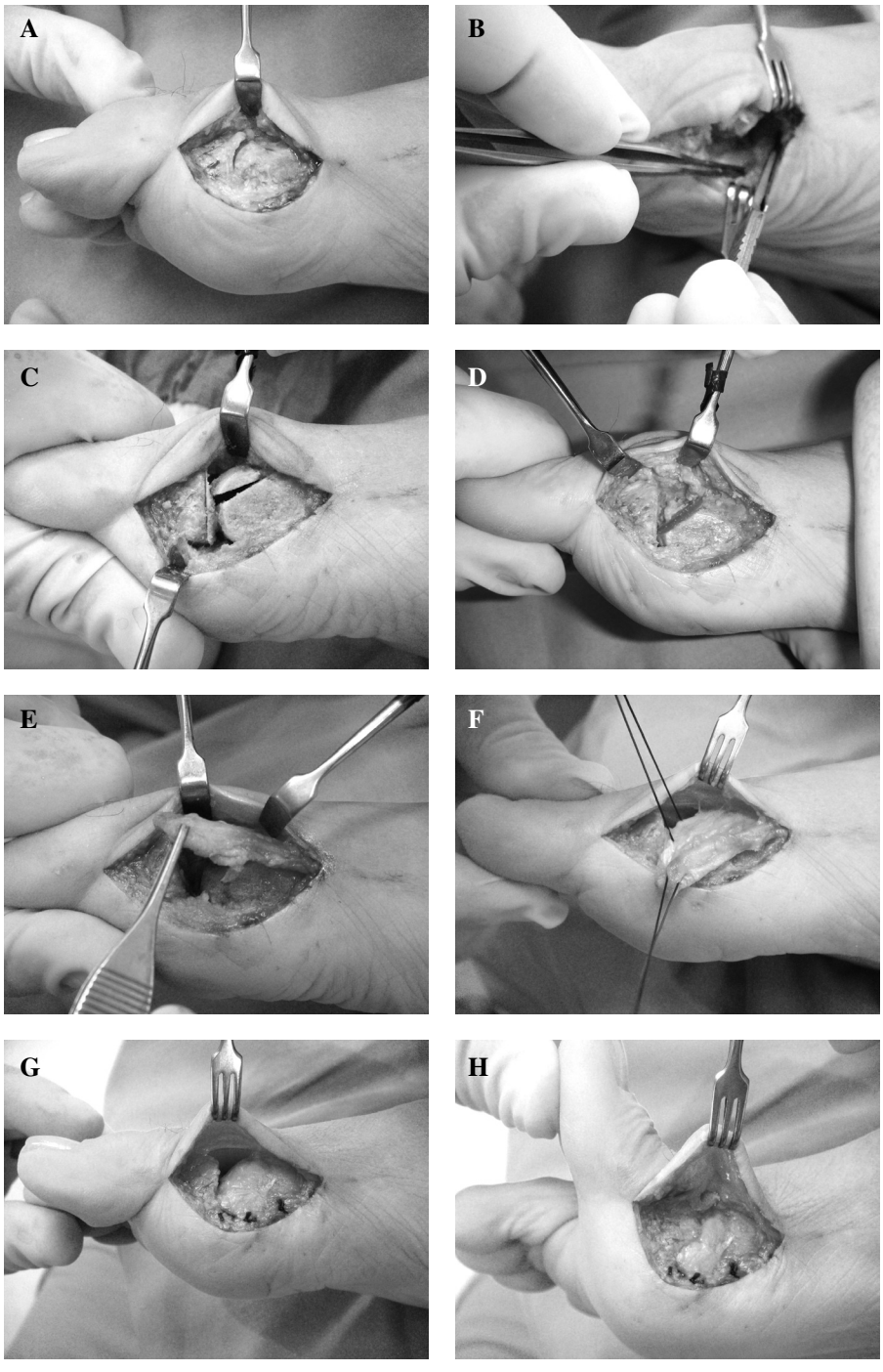

Fig. 1: (A) perioperative image of open joint, where advanced arthrosis is seen with visible osteophytes; (B) medial and lateral metatarsosesamoid ligaments detached from the neck of first metatarsal to release possible contracture (C) and (D) cheilectomy and restricted proximal phalanx base removal; (E) dissection and distal detachment of dorsal capsule; (F) the capsule was sutured at the plantar region by two vicryl-0 stitches fixed just distal to medial and lateral sesamoids; (G) first metatarsal head covered with dorsal capsule; (H) significant dorsiflexion is observed.

was a statistically significant difference between Groups III and IV postoperatively in all assessed parameters (Table 1).

Preoperatively, 23 (92%) feet had metatarsophalangeal joint (MTPJ) mobility below 30 degrees and two (8%) had MTPJ mobility between 30 and 74 degrees. Postoperatively, 18 (72%) feet had MTPJ mobility equal or above 75 degrees and seven (28%) feet had MTPJ mobility between 30 degrees and 74 degrees. None had MTPJ mobility below 30 degrees.

One patient who had a bilateral operation was partially satisfied because of mild postoperative metatarsalgia of both feet, but he did not need any treatment during followup. Four other patients were partially satisfied because of residual

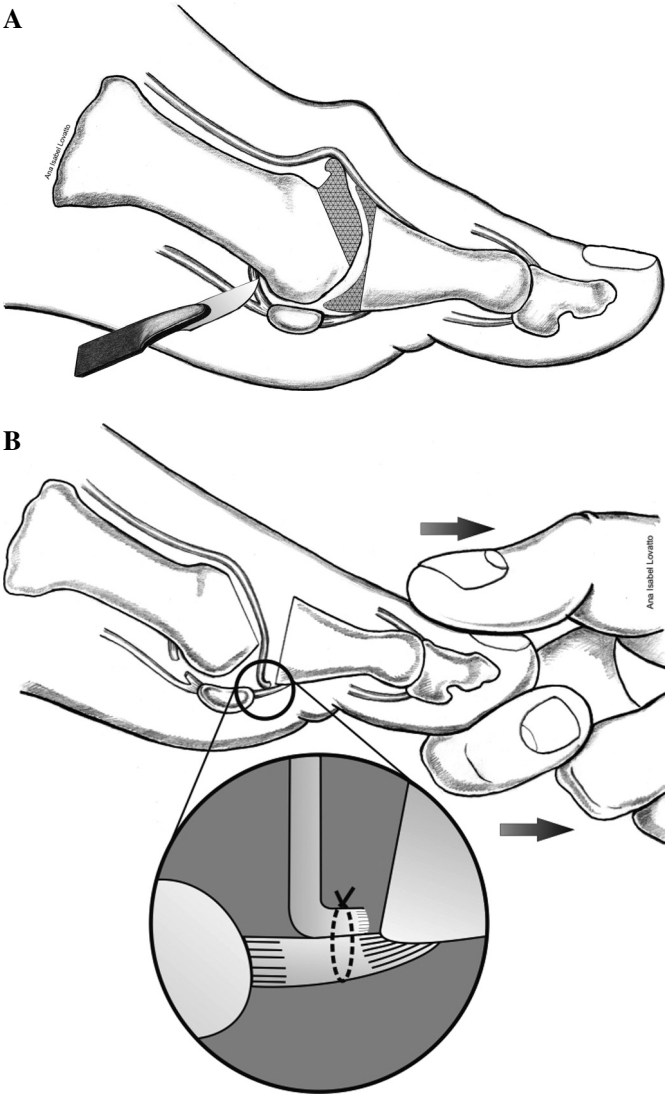

Fig. 2: (A) Graphic representation of the metatarsosesamoid ligament release and the extent of the osseous resection (hatched area); and (B) the capsular interposition enabled by joint decompression and manual distraction.

stiffness. Fifteen patients (75%) were completely satisfied with the procedure. All 20 patients confirmed that under the same circumstances they would undergo the same procedure. In no case was perioperative or postoperative MTPJ instability observed. No patient had wound problems, deep infection, or deep vein thrombosis.

DISCUSSION

Hallux rigidus is the most frequent first ray disease after hallux valgus. Although conservative treatment may be effective, surgical treatment is often indicated. Cheilectomy results in good outcomes during initial phases of the disease, but the procedure has a higher rate of unsatisfactory results when used for more advanced stages.[5,17,21,25,29,33,34,40,55] Keller's resection arthroplasty may be indicated for elderly patients with low physical demand, but the first-ray shortening and the high incidence of secondary metatarsalgia preclude its large-scale use.[7,28,29,57] Hallux MTPJ arthrodesis is still the gold standard for the treatment of advanced hallux rigidus. The procedure only addresses one of dysfunctional problems, which is the pain, with further loss of motion restricting shoe choice, particularly in females. Arthrodesis is a technically demanding procedure, with little tolerance for sagittal plane angular deviations, and may take from 60 to 90 days to achieve bone healing. In the long term, the procedure may overload the hallux interphalangeal joint, leading to arthrosis.[10,12,18,19,22,29,35,37,44,56] Besides being a technically very difficult and costly procedure, MTPJ partial or total replacement has a limited lifespan and potentially serious complications, as is true of all implant arthroplasties.[1,14,15,27,30,31,32,42,43,46,50,54]

The addition of a cheilectomy with a minimal Keller resection has the benefits of both techniques. Interpositional arthroplasties with autograft may be divided into capsular- and bundle-techniques, and aim to eliminate pain and to re-establish joint motion.[2,8,13,20,23,24,36,39,45,52] Most are a combination of proximal phalanx and/or first metatarsal head resection and capsular or tendon interposition. Interpositional

Table 1: AOFAS Postoperative Score

AOFAS / Groups	Pain mean ± SD	Function mean ± SD	Alignment mean ± SD	Total mean ± SD
Grade III (*n* = 18)	**37.0 ± 4.6**	**43.2 ± 2.7**	**14.6 ± 1.6**	**94.8 ± 5.1**
Grade IV (*n* = 7)	**34.1 ± 7.3**	**40.7 ± 4.2**	**15.0 ± 0.0**	**89.9 ± 10.5**
*p** (comparison between Grade III and Grade IV group results)	$p \leq 0.001$	$p \leq 0.001$	$p \leq 0.001$	$p \leq 0.001$
Grades III and IV (*n* = 25)	**36.4 ± 5.7**	**42.5 ± 3.4**	**14.7 ± 1.4**	**93.6 ± 7.4**

*, independent samples Student's t-test.

arthroplasties of joint capsule are usually created with a medial-distal or dorsal-proximal flap base. Hamilton et al. reported on dorsal capsule and extensor hallucis brevis tendon interposition in 30 patients (37 feet) with a mean age of 56.2 years, and found that 93% (28/30) of the patients reported satisfaction with the procedure.[23,24] Lau and Daniels published a study comparing interpositional arthroplasty performed in 11 patients with Grade III hallux rigidus and cheilectomy in 19 patients with Grade II hallux ridigus. Postoperative AOFAS scores after 2 years of followup were higher in the cheilectomy group, but the mean age was lower, and the disease was less advanced as compared to the arthroplasty group. Lateral metatarsalgia was seen in three of 11 patients submitted to interpositional arthroplasty (27.3%), and the sensation of loss of strength of the hallux was the main complaint in this group of patients (8/11, 72.7%).[33] Mroczek and Miller presented the results of interposition arthroplasty with dorsal capsule combined with a modified oblique Keller's arthroplasty with excellent results, and concluded that the procedure was a reasonable alternative for arthrodesis in cases of more advanced arthrosis.[39] Mackey and colleagues compared a cohort of ten patients that underwent a modified Keller's arthroplasty with a group of twelve patients who had a first metatarsophalangeal joint arthrodesis at an average followup of 63 and 68 months, respectively. The AOFAS score was significantly higher for the arthroplasty group than the arthrodesis group, and the plantar pressure data revealed significantly higher pressures under the great toe in the arthrodesis group. They concluded that interposition arthroplasty produced clinical outcomes that were equivalent to arthrodesis, having the added benefit of motion preservation and more normal plantar pressure during gait.[36]

Thordarson and colleagues presented the result of interpositional arthroplasty using the medial capsule in 22 patients, and showed increased AOFAS and SF-36 postoperative scores, reporting as a complication only two cases of a stress fracture of a lesser metatarsal.[52]

In bundle soft-tissue interpositional arthroplasty, tendon structures such as the plantaris or gracilis are employed as spacers to fill a cavity that is created at the base from the proximal phalanx. Coughlin and Shurnas described a series of seven cases of gracilis tendon interposition arthroplasty with 42 months of followup. The AOFAS score improved from 46 preoperatively to 86 postoperatively. Lateral metatarsalgia was the most common complication, and was observed in more than half of the patients.[13]

Berlet and colleagues published a retrospective study of nine patients who had an interpositional arthroplasty with allograft (regenerative tissue matrix, consisting of collagen and extracellular protein matrices created from human cadaver tissue), with 12 months of followup. They reported AOFAS score improvement from 63.9 preoperatively to 87.9 postoperatively. They did not observe any complications at the short followup of this series with a small number of patients.[4]

Interpositional arthroplasty has the advantage of approaching both key problems of hallux rigidus, namely loss of joint motion and pain, avoiding the need of nonbiological implants. The technique presented in this study has two modifications as compared to Hamilton's original technique: metatarsosesamoid ligament release, aiming to remove any possible sesamoid retraction, to facilitate dorsiflexion;[49] and less removal of the base of the proximal phalanx, which reduces first-ray shortening and the chance of metatarsalgia secondary to the procedure (Figure 3). Only one patient from our study, who underwent bilateral surgery, complained of metatarsalgia on followup; nonetheless, it was mild and has not required any treatment. No patient from this series required a second-ray plantar condylectomy, a procedure subsequently performed in some patients from Hamilton's series.[23] It must be highlighted, however, that the low incidence of metatarsalgia in our series is at least partly due to our patients' lifestyle, as no one was a high-performance athlete or dancer.

The postoperative AOFAS score of 93.6 achieved in this series is better than the best possible outcomes with MTPJ arthrodesis, as 10 points are lost due to the loss of joint motion. Our results also compare favorably to recent studies with implant arthroplasty. Konkel and colleagues achieved AOFAS scores of 89 after 72 months of followup with a Futura hemi-great toe implant in patients with hallux rigidus of Grades III and IV. Arbuthnot and colleagues had an AOFAS score of 84 after 24 months of followup with a ceramic-coated endoprosthesis.[1,31]

Results from this series may also be favorably compared with other studies of interpositional arthroplasties. Thordarson and colleagues had a mean of 77.8 points in 22 patients with a mean age of 58 years that underwent medial capsular interposition, after a mean followup of 24 months. Berlet and colleagues found a mean of 87.9 in nine patients with an average age of 53.3 years, who underwent interpositional arthroplasty with allograft, after mean followup of 12.7 months. Lau and Daniels had a postoperative AOFAS score of 71.6 points in 11 patients with a mean age of 59 years submitted to interpositional arthroplasty with extensor hallucis brevis (EHB) tendon, after an average followup of 2 years. Hamilton and colleagues found a postoperative AOFAS score of 95.4 points in 30 patients with a mean age of 56.2 years that were submitted to interpositional arthroplasty with EHB tendon.[4,24,33,52]

This study's limitations include the retrospective character, the relatively patient high age (43 to 76 years; mean, 60 years), and lower demand lifestyle, creating doubts on the possibility of technique extension to younger, and physically more active individuals.

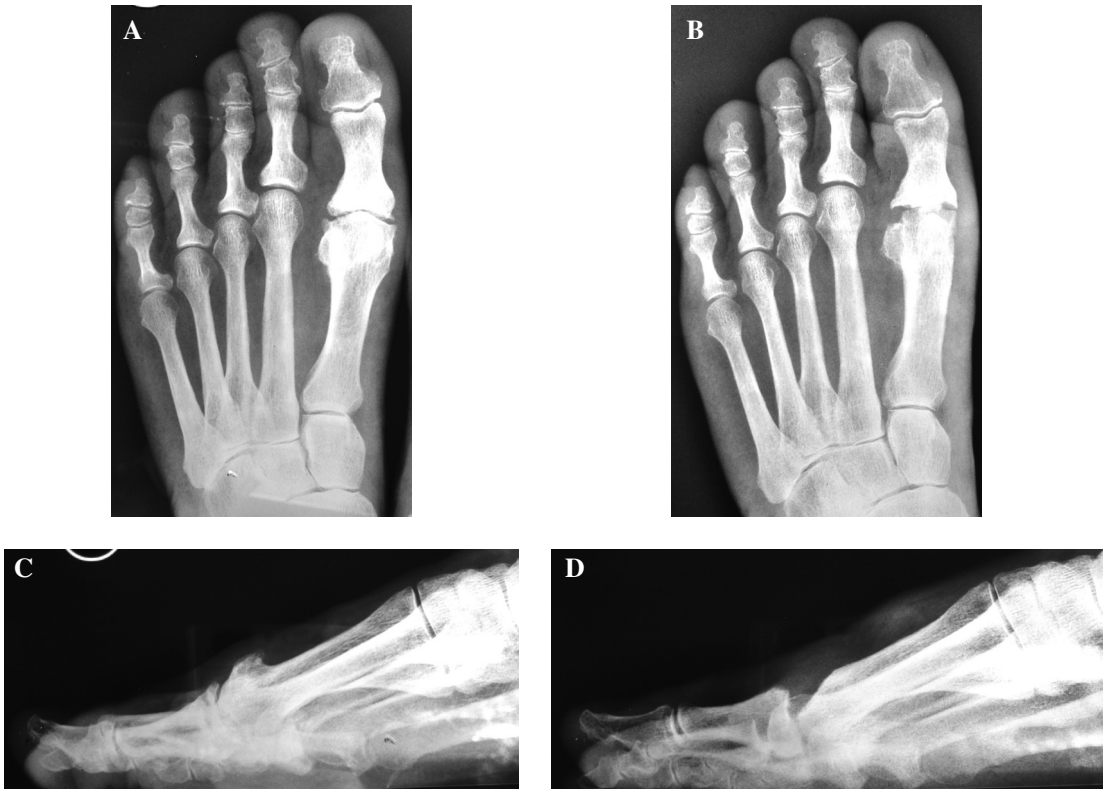

Fig. 3: (A and C) Anteroposterior and lateral X-ray of Grade III hallux rigidus; (B and D) Postoperative anteroposterior and lateral view of the same foot after the modified interpositional arthroplasty. Note the minimal shortening of the first ray.

CONCLUSION

This study presents a relatively long followup compared to other studies that involve interpositional arthroplasties, and demonstrates a high rate of patient satisfaction. We believe interposition arthroplasty with dorsal capsule and EHB tendon release is an attractive alternative for the surgical treatment of symptomatic, middle-aged patients with advanced grades of hallux rigidus.

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