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Interposition arthroplasty in the treatment of hallux rigidus

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Objectives: We evaluated the outcomes of interposition arthroplasty performed for the treatment of hallux rigidus.

Methods: The study included 19 feet (4 left, 15 right) of 17 patients (14 females, 3 males; mean age 61±5 years; range 55 to 71 years) who were treated with interposition arthroplasty for hallux rigidus. According to the grading system of Coughlin and Shurnas, 18 feet were grade 3, one foot was grade 4. One-third of the base of the proximal phalanx was resected at surgery. Preoperative and postoperative radiographic assessments included the measurements of the joint space width of the first metatarsophalangeal (MTP) joint, hallux valgus angle, and intermetatarsal angle. Clinical evaluations were made using the AOFAS (American Orthopaedic Foot and Ankle Society) hallux metatarsophalangeal-interphalangeal scale. Postoperative satisfaction levels of the patients were questioned. The mean follow-up period was 21 months (range 9 to 32 months).

Results: According to the AOFAS scale, the results were excellent in seven feet (36.8%), good in nine feet (47.4%), and fair in three feet (15.8%), with excellent and good results accounting for 84.2%. The mean total AOFAS score increased by 24.6 points postoperatively ($p<0.05$). The mean range of motion of the first MTP joint improved significantly from preoperative 24.2±5.4° (range 10° to 30°) to postoperative 54.3±9.4° ($p<0.05$). The mean joint space width of the first MTP joint was 1.0±0.3 mm (range 1 to 2 mm) preoperatively, it increased to 3.0±1.1 mm (range 1 to 5 mm) on final radiographs ($p<0.05$). The mean hallux valgus angle decreased from preoperative 13.8° (range 9° to 17°) to postoperative 10.2° (range 4° to 13°), and the mean intermetatarsal angle increased from preoperative 10.5° (range 8° to 14°) to postoperative 11.2° (range 8° to 15°). Patient satisfaction levels were very good in nine feet (47.4%), good in seven feet (36.8%), moderate in one foot (5.3%), and poor in two feet (10.5%). Complications included metatarsalgia aggravated by long walks (n=11, 57.9%), hypoesthesia of the big toe (n=3, 15.8%), and loss of ground contact of the big toe (n=15, 79%). The push-off power of the big toes was measured as 3/5 in five cases, 4/5 in 11 cases, and 5/5 in three cases. None of the patients developed infection or osteonecrosis postoperatively.

Conclusion: Interposition arthroplasty is an appropriate surgical treatment method for hallux rigidus for elderly patients with low functional capacity.

Key words: Arthroplasty/methods; hallux rigidus/surgery; metatarsophalangeal joint/surgery.

Hallux rigidus is a progressive disease of the first metatarsophalangeal (MTP) joint characterized by degenerative changes, limited range of motion, and pain.[1-3] It is the second most common deformity of the first MTP joint following hallux valgus. Women are more frequently affected than men.[3,4] The factors leading to hallux rigidus are still unclear. Several causes have been implicated such as long first metatarsal, trauma, osteochondritis dissecans, dorsiflexion of the first metatarsal, and inappropriate footwear.[3,5-7]

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Many methods have been defined for surgical treatment of hallux rigidus including cheilectomy, resection arthroplasty, interposition arthroplasty, implant arthroplasty, and arthrodesis.[3,4,6,8-14] Besides advantages and disadvantages of each method, the activity level and expectation of the patient and the degree of arthrosis in the first MTP should be considered when choosing the best treatment option.[3,8] Cheilectomy which consists of osseous and soft tissue debridement is recommended for low-grade hallux rigidus patients and so is not convenient for advanced hallux rigidus.[2,3,5,7,9,15] Although arthrodesis is still regarded as the most appropriate intervention in hallux rigidus, with high success rates, it has disadvantages such as long recovery period, loss of range of motion (ROM), and restrictions in footwear.[4,5,7,9,12,15-17] Implant arthroplasty, on the other hand, despite preserving the joint ROM, it is associated with implant failure and osteolysis.[2,5,6,9,18]

Resection arthroplasty, whose basic principles were defined by Riedel in 1886, was popularized by Keller for the surgical treatment of hallux valgus, and then modified by Brandes for hallux rigidus with excision of the base of the proximal phalanx and interposition of the medial joint capsule.[4,8]

In the present study, we evaluated the results of interposition arthroplasty performed in patients who did not benefit from previous nonsurgical treatment methods for grade 3-4 hallux rigidus according to the classification of Coughlin and Shurnas.[6]

Patients and methods

The study included 19 feet (4 left, 15 right) of 17 patients (14 females, 3 males; mean age 61±5 years; range 55 to 71 years) who were treated with interposition arthroplasty for hallux rigidus between 2003 and 2006. Two patients

Table 1
Clinical and radiographic system for grading hallux rigidus[6]

Grade	Dorsiflexion	Radiographic findings*	Clinical findings
0	40° to 60° and/or 10% to 20% loss compared with the normal side.	Normal	No pain; only stiffness and loss of motion on examination.
1	30° to 40° and/or 20% to 50% loss compared with the normal side.	Dorsal osteophyte is the main finding, minimal joint space narrowing, minimal periarticular sclerosis, minimal flattening of the metatarsal head.	Mild or occasional pain and stiffness. Pain at extremes of dorsiflexion and/or plantar flexion on examination.
2	10° to 30° and/or 50% to 75% loss compared with the normal side.	Dorsal, lateral, and possibly medial osteophytes (flattened appearance of the metatarsal head). Less than 1/4 of dorsal joint space is involved on the lateral radiograph. Mild-to-moderate joint space narrowing and sclerosis. Sesamoids are usually not involved.	Moderate-to-severe pain and stiffness that may be constant; pain occurs just before maximum dorsiflexion and maximum plantar flexion on examination.
3	<10° and/or 75% to 100% loss compared with the normal side. There is notable loss in metatarsophalangeal plantar flexion, as well (plantar flexion is often <10°).	Same as in grade 2, but with substantial narrowing and periarticular cystic changes. More than 1/4 of dorsal joint space is involved on the lateral radiograph. Enlarged sesamoids and/or cystic irregular changes.	Nearly constant pain and marked stiffness at extremes of range of motion. No pain in the mid-range of motion.
4	Same as in grade 3.	Same as in grade 3.	Same features as in grade 3, but there is definite pain in the mid-range of passive motion.

*Weight-bearing anteroposterior and lateral radiographs are used.

Fig. 1. Radiographs of a patient with hallux rigidus. **(a)** Preoperative view, **(b)** postoperative view at 2 weeks, **(c)** postoperative view at 2 years.

had bilateral involvement. According to the grading system developed by Coughlin and Shurnas (Table 1),[6] 18 feet were grade 3, one was grade 4. Preoperative and postoperative radiographic assessments included standing anteroposterior and lateral X-rays to measure the joint space width of the first MTP joint, hallux valgus angle, and intermetatarsal angle (Fig. 1). For subjective evaluation, the patients were asked to rate their postoperative satisfaction level as very good, good, moderate, or poor. Clinical evaluations were made using the AOFAS (American Orthopaedic Foot and Ankle Society) hallux metatarsophalangeal-interphalangeal scale.[19] In this scale, pain, function, and anatomical structure of the joint are scored with maximum points of 40, 45, and 15, respectively, where total scores of ≥90, 80-89, 70-79, and 0-69 points show excellent, good, fair, and poor results, respectively. The mean follow-up period was 21 months (range 9 to 32 months).

Statistical analysis was performed with the SPSS 15.0 (for Windows) package program. Preoperative and postoperative data were compared using the paired t-test and Wilcoxon signed-rank test. A p value of less than 0.05 was accepted as statistically significant.

Surgical technique

All the patients were operated on in the supine position under spinal or general anesthesia, and with a tourniquet applied. A longitudinal incision of the skin and subcutaneous tissues was made from the dorsomedial aspect of the first MTP joint. The dorsomedial sensory nerve and extensor hallucis longus tendon were preserved, the capsule was longitudinally opened to expose the base of the proximal phalanx and metatarsal head, and the joint was reached (Fig. 2a). The extensor hallucis brevis tendon was released dorsally with the joint capsule (Fig. 2b). Osteophytes around the metatarsal head were removed. One-third of the base of the proximal phalanx was resected (Fig. 2c). A Kirschner wire was inserted retrograde from the metatarsal head parallel to the axes of the distal phalanx and proximal phalanx (Fig. 2d). The extensor hallucis brevis tendon and the joint capsule were sutured onto the plantar region of the joint space, covering the metatarsal head (Fig. 2e, f). The subcutaneous tissue and the skin were closed (Fig. 2g, h).

A short leg cast was applied postoperatively and weight bearing was not allowed during the first postoperative week; then partial weight bearing was allowed and the sutures were removed at the end of the second week. At 4 weeks, the Kirschner wire and short leg cast were removed in the outpatient setting and full weight bearing was allowed.

Results

According to the AOFAS scale, the results were excellent in seven feet (36.8%), good in nine feet (47.4%), and fair in three feet (15.8%). Compared with the preopera-

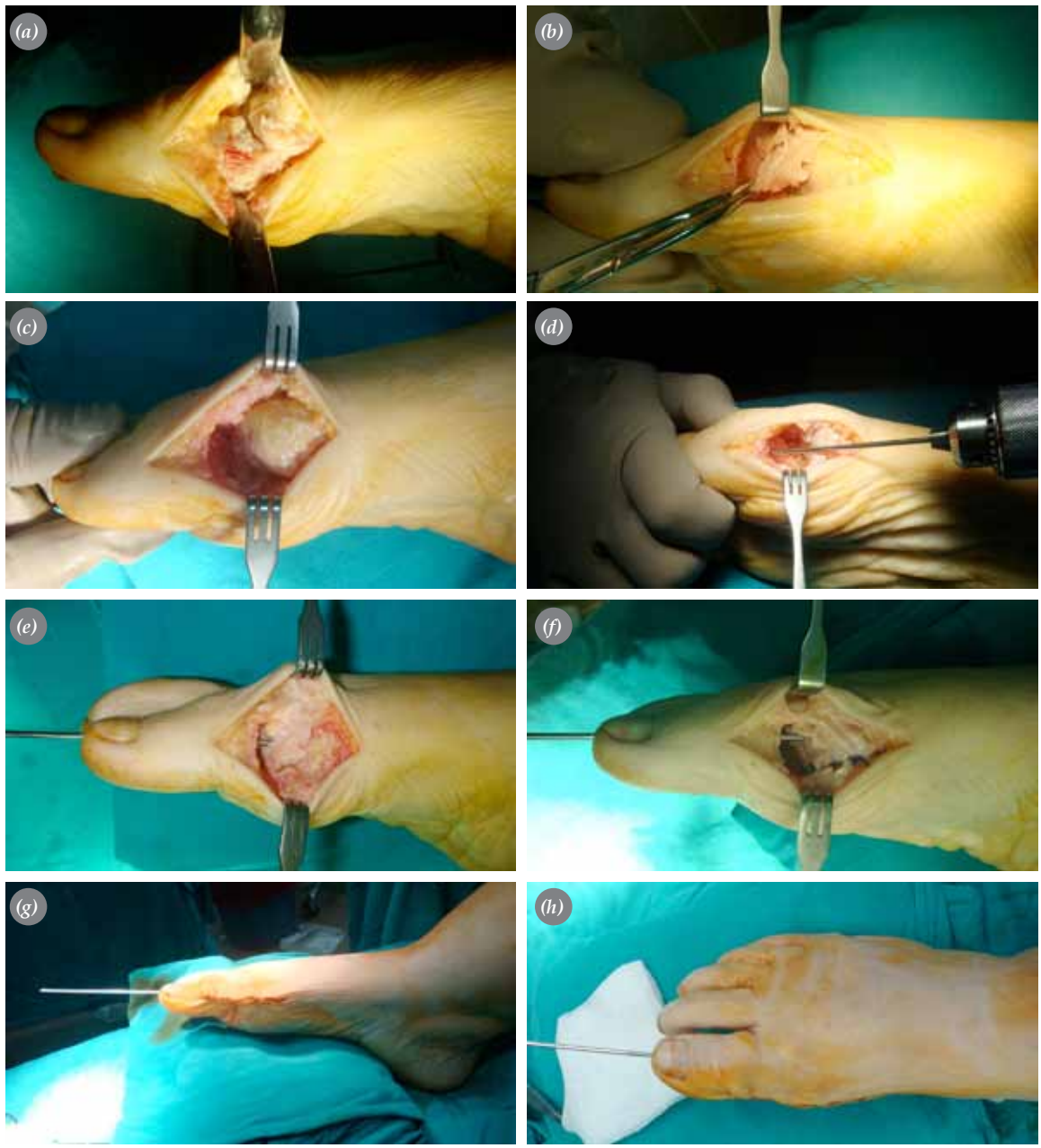

Fig. 2. **(a)** The appearance of the first metatarsophalangeal joint of a patient with hallux rigidus. **(b)** Loosening of the extensor hallucis brevis tendon along with the joint capsule. **(c)** Perioperative view after removal of osteophytes from the metatarsal head and base resection of the proximal phalanx. **(d)** Insertion of the Kirschner wire. **(e, f)** Covering the metatarsal head with the joint capsule and the extensor hallucis brevis tendon. **(g, h)** The appearance of the foot at the end of the operation.

tive value, the mean total AOFAS score increased by 24.6 points postoperatively ($p<0.05$). While pain and function subscores improved by 17.9 and 4.9 points, respectively ($p<0.05$), the alignment subscore remained unchanged postoperatively (Table 2).

Preoperatively, the mobility of the first MTP joint was limited in all the patients. The mean ROM of the first MTP joint improved significantly from preoperative 24.2±5.4° (range 10° to 30°) to postoperative 54.3±9.4° (range 30° to 65°) ($p<0.05$).

Postoperatively, 11 feet (57.9%) exhibited metatarsalgia with marked aggravation after long walks, three big toes (15.8%) showed hypoesthesia, and 15 big toes (79%) displayed loss of ground contact (Fig. 3). The

Table 2
Preoperative and postoperative scores of the AOFAS hallux metatarsophalangeal-interphalangeal scale

	Preoperative			Postoperative			
	Mean±SD	Median	Range	Mean±SD	Median	Range	*p*
Total AOFAS score (100 points)	60.7±5.1	59	54-67	85.3±8.7	85	70-95	**0.000**
Pain score (40 points)	20.0±0.0	20	20-20	37.9±5.4	40	20-40	**0.000**
Alignment score (15 points)	15.0±0.0	15	15-15	15.0±0.0	15	15-15	1.000
Function score (45 points)	27.5±5.1	24	19-32	32.4±4.4	30	27-40	**0.003**

push-off power of the big toes was measured as 3/5 in five cases, 4/5 in 11 cases, and 5/5 in three cases. None of the patients developed infection or osteonecrosis postoperatively.

The mean joint space width of the first MTP joint was 1.0±0.3 mm (range 1 to 2 mm) preoperatively, it increased to 3.0±1.1 mm (range 1 to 5 mm) on the final radiographs ($p<0.05$). The mean joint space width measured on the first postoperative day was 9.3±2.3 (range 5 to 13 mm).

The mean hallux valgus angle decreased from preoperative 13.8° (range 9° to 17°) to postoperative 10.2° (range 4° to 13°), whereas the mean intermetatarsal angle increased from preoperative 10.5° (range 8° to 14°) to postoperative 11.2° (range 8° to 15°).

At the end of the follow-up, patient satisfaction levels were very good in nine feet (47.4%), good in seven feet (36.8%), moderate in one foot (5.3%), and poor in two feet (10.5%).

Discussion

Hallux rigidus is generally characterized by limited ROM and pain secondary to degenerative changes in the first MTP joint.[8] Although its pathogenesis remains unknown, trauma along with metabolic and congenital diseases have been proposed as the underlying mechanisms.[20] Such predisposing factors lead to cartilage damage on the joint surface. During the course of the process, patients experience pain and limitation of dorsiflexion secondary to synovitis, narrowing of the joint space, and periarticular osteophyte formation.[7]

Non-surgical treatment of hallux rigidus encompasses reduction of activities, shoe modifications, oral anti-inflammatory drugs, and intra-articular injections.[2] Surgery can be recommended to patients who do not benefit from conservative treatment. Several surgical methods of treatment for hallux rigidus exist including plantar release in grade 0, decompressive osteotomy in grade 1, cheilectomy in grade 2, and resection arthroplasty, implant arthroplasty, and arthrodesis in grade 3 and 4 cases.[21]

Cheilectomy is an appropriate method for grade 1-2 hallux rigidus unresponsive to conservative treatment; however, patients with advanced hallux rigidus are not suitable for cheilectomy.[5,7,9,15]

While arthrodesis is the standard treatment in grade 3 and 4 hallux rigidus, it is mainly performed in cases with recurrent hallux valgus deformity, instabilities after failed surgeries, and advanced degenerative arthritis in the MTP joint.[4,7,9,12] Arthrodesis restores the weight distribution in the first row of the foot, and maintains normal transfer of weight to the big toe while walking. Pedobarographic measurements and gait analyses have shown that arthrodesis provides a more normal plantar pressure pattern.[16,22,23] However, despite these advantages, arthrodesis is a more difficult technique compared with the others and requires bone-to-bone healing

Fig. 3. Postoperative appearance of a big toe showing loss of ground contact.

which necessitates adequate blood supply, healthy bone stock, stable fixation, patient compliance, and a longer recovery period.[5,15,16] The incidence of nonunion has been reported in a range of 0% to 30% after arthrodesis.[17] Inadequate arthrodesis of the big toe may result in malalignment, which in turn leads to transfer metatarsalgia, severe limitation in footwear, malposition of the phalanges, and osteoarthritis in the interphalangeal joint due to excessive stress on the adjacent joints.[4,7,9,12,15,16]

Implant arthroplasty can be recommended to patients with advanced age or limited activity, and reduces pain in the first MTP joint and preserves joint mobility; however, the technique has a high rate of failure. Many factors limit the use of implant arthroplasty in the surgical treatment of hallux rigidus, including loss of osseous tissue as a result of surgery, risk for implant failure, difficulty of revision surgery following implant failure, osteolysis, tissue weakness, and the risk for soft tissue reaction.[2,5,9,10,18]

Keller procedure, which comprises base resection of the proximal phalanx, is generally recommended to hallux rigidus patients with an advanced age, low functional capacity, and advanced osteoarthritis in the first MTP joint.[7,10,24] This procedure is mostly contraindicated in young and active patients because it may result in many complications such as valgus deformity, hammer toe, transfer metatarsalgia, recurrence of hallux rigidus, poor cosmetic appearance, joint instability, and inability to stand on the toes.[8,10,18,25-27] However, modifications of the Keller procedure combined with interposition arthroplasty techniques are applied as an alternative to implant arthroplasty or resection arthroplasty, with increasing popularity particularly in young and active patients who refuse MTP arthrodesis, and provide better clinical results such as pain reduction, correction of the deformity, increased ROM and stability, less bone loss, preservation of the toe length, and use of normal footwear.[4,5,8,13,14,18,28-30]

Hamilton et al.[29,31] performed cheilectomy in combination with base resection of the proximal phalanx and interposition arthroplasty (suturing the extensor hallucis brevis tendon to the flexor hallucis brevis tendon) in young and active patients with grade 3 hallux rigidus and achieved excellent or good results in 94% of the patients.

Miller[28] modified the interposition technique described by Hamilton et al.[29,31] by applying an oblique osteotomy to the base of the proximal phalanx to preserve the insertion site of the flexor digitorum brevis and interposition of the extensor hallucis brevis and reported better functional results. Moreover, in an unsuccessful case with postoperative pain secondary to sesamoid arthritis, he removed the interpositional capsule for histopathologic examination and observed a viable fibrocartilaginous flap.[28]

Akgün et al.[14] treated their patients with an oblique osteotomy of the base of the proximal phalanx and interposition of the extensor hallucis brevis, and reported excellent or good results in all the patients, with sufficient flexion power of the big toes, preserved ROM, and no instability.

Kennedy et al.[13] performed interposition arthroplasty in 18 patients (mean age 56 years) with hallux rigidus and, after a mean follow-up of 38 months, they reported a remarkable increase of 37° in the ROM of the MTP joint, disappearance of pain in 16 patients, and transfer metatarsalgia in one patient. The authors concluded that interposition arthroplasty provided a painless and functional joint in hallux rigidus patients and was associated with fewer complications compared with the conventional treatment methods.

Coughlin and Shurnas[30] treated seven patients with hallux rigidus with soft tissue interposition arthroplasty using a gracilis tendon graft, and reported excellent functional results in all the patients, with preserved flexion power of the big toe and increased joint ROM.

Berlet et al.[4] performed soft tissue interposition arthroplasty in young and active patients using a minimally invasive interposition technique and allogeneic biological materials, and achieved excellent results in the early period, without complications such as loss of push-off power of the big toe, transfer metatarsalgia, or instability.

In contrast to the above-mentioned studies reporting good results, some studies using the Keller modifications have reported poor results.[10,32] Schenk et al.[10] compared radiographic and clinical outcomes of interposition arthroplasty and Keller procedure after a mean follow-up of 15 months and found no significant differences between the two treatment groups.

Lau and Daniels[32] compared the results of cheilectomy and interposition arthroplasty after a mean follow-up of two years, and reported poor results in patients treated with interposition arthroplasty, including weakness in the big toes and development of transfer metatarsalgia.

As interposition arthroplasty is a modification of resection arthroplasty, complications of resection arthroplasty can also be seen in interposition arthroplasty. In our study, 11 feet (57.9%) demonstrated metatarsalgia after interposition arthroplasty, which became more marked after long walks. Because of postoperative disruption of weight distribution in the first row of the foot, metatarsal heads receive excessive weight, resulting in transfer metatarsalgia.[23,25,32] The incidences of transfer metatarsalgia after interposition arthroplasty were reported as 30% by Hamilton and Hubbard,[31] 57% by Coughlin and Shurnas,[30] 27% by Lau and Daniels,[32] and 13.6% by Schenk et al.[10]

The loss in the insertion site of the flexor hallucis brevis tendon, which has a stabilizing effect, due to excision of the proximal phalanx potentially leads to dorsal retraction of the big toe. In order to avoid this, the tendon should be reinserted or bone resection modified to preserve the insertion site.[2,4,7,28,29,33] Despite our efforts to preserve the insertion site of the tendon, 15 big toes (79%) developed loss of ground contact.

The dorsomedial incision used in our operations has some risks, as well,[28] such as iatrogenic dorsal cutaneous nerve injury seen in three big toes (15.8%). Another risk is the injury to the extensor hallucis longus tendon due to inadequate retraction during bone resection.[28] This complication was not observed in our patients.

Complications seen after interposition arthroplasty in our patients may cause a disparaging effect on the utility of the technique. However, the incidences of transfer metatarsalgia and malposition in alternative treatment methods without interposition arthroplasty have been reported to be 27% to 38%.[13] Interposition arthroplasty does not have risks such as nonunion, loss of joint ROM, limited activity, and footwear restriction.[29,30] The aim of surgery on an arthritic joint is to obtain a painless and functional joint, and interposition arthroplasty can meet both of these expectations.[2,13]

In our patients, the most influential factor for deciding to have an operation was pain. Postoperatively, there was no pain in 16 feet (84.2%). Similar rates have been reported by Reize et al.[8] and Schenk et al.,[10] being 83.3% and 95.4%, respectively. Postoperative AOFAS scores were excellent or good in 84.2% of our cases, which were comparable with the rates of 90.8% (Breitenseher et al.),[34] 92% (Anderl et al.),[27] 77% (Schenk et al.),[10] and 94% (Hamilton and Hubbard).[31]

The total AOFAS score, and pain and function subscores increased in our patients by 24.6, 17.9, and 4.9 points, respectively ($p<0.05$). Increases in the total AOFAS score, pain and function subscores were reported as 23.1, 23.1, and 18.7 points by Roukis et al.[2] following capsule-periosteum interposition arthroplasty, and 23, 11, and 9 points by Schenk et al.[10] following capsule interposition arthroplasty, respectively. Berlet et al.[4] treated their patients with interposition arthroplasty using an allogeneic biological material, and reported these increases as 25.4 points in the total AOFAS score, 16.7 points in the pain subscore, and 7.3 points in the function subscore after a mean follow-up of 12.7 months.

The highest patient satisfaction has been reported to be obtained from resections involving the 1/3 to 1/2 of the base of the proximal phalanx, and achievement of adequate joint space has been associated with remarkable decreases in pain complaints.[8,34] Resections involving less than 1/3 of the base of the proximal phalanx may result in insufficient decompression of the first MTP joint, while excessive resections lead to an unstable big toe and dysfunction.[27,32] In our study, we resected 1/3 of the base of the proximal phalanx. At the end of the follow-up period, the width of the first MTP joint space was found to be 3.0 ± 1.1 mm ($p<0.05$). Hamilton et al.[29] and Schenk et al.[10] reported the final values of the first MTP joint space as 2.9 mm and 2.4 mm, respectively. Postoperatively, the mean increase in the joint ROM was 30.1° in our patients ($p<0.05$), and the rate of excellent or good patient satisfaction was 84.2% (16 feet).

Although many methods have been described for surgical treatment of hallux rigidus, the best one has yet to be determined.[10] While arthrodesis is regarded as the gold standard for young and active patients with hallux rigidus,[17,24] excisional

arthroplasty and its modifications appear to be feasible techniques for elderly patients with low functional capacity.[15,18,32] Our study included a relatively small the number of patients and there was no control group. The role of interposition arthroplasty in hallux rigidus surgery can be more clearly demonstrated by studies having longer follow-up periods and control groups.

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