

Comparison between resection arthroplasty alone and resection arthroplasty with arthrodesis of the first MTP joint for rheumatoid forefoot deformities

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Abstract It has been reported that nearly 90% of patients with rheumatoid arthritis (RA) have problems with their feet. Several methods of treating hallux valgus deformity in RA have previously been reported, including arthrodesis and joint resection, and good results have been observed with surgical procedures. In this report, we compare the clinical and radiological outcomes of resection arthroplasty alone (the first method) and resection arthroplasty with arthrodesis of the first MTP joint (the second method) for the treatment of forefoot deformities of RA patients. On clinical assessment, the American Orthopaedic Foot and Ankle Society (AOFAS) scale score significantly improved in both methods; however, the second method gave better results than the first method in relation to the footwear and alignment components. On radiographic assessment, in the first method there were no significant changes in the valgus angle (H–V angle) and the fifth metatarsal bone (M1/5) angle between preoperation and last follow-up. In contrast, these angles were decreased in the second method. One of the most important issues in the treatment of forefoot deformities in RA patients is to correct splaying foot deformity. We believe that the second method, which can correct splaying foot deformity, is currently the most reliable treatment method.

Keywords Arthrodesis · Forefoot deformity · Resection arthroplasty · Rheumatoid arthritis

Introduction

Rheumatoid arthritis (RA) is a systemic autoimmune disorder. It has been reported that nearly 90% of patients with RA have involvement of the feet, with soft-tissue instability and joint destruction resulting in hallux valgus, subluxation, or dislocation of the lesser toes with valgus sweeping, and displacement of the plantar fat pad with associated metatarsalgia [1–3]. The patients, who need to wear custom-made shoes, have difficulty walking because of pain and often need to undergo a number of surgical procedures for the I–V metatarsophalangeal (MTP) joints with countless modifications. Several methods of treating the hallux valgus deformity in RA have been reported, including arthrodesis, joint resection, and arthroplasty with implant for the MTP joint. Good results have been observed in previous surgical procedures [4–10]. However, a number of authors have found a significant rate of recurrent symptomatic deformities of both the hallux valgus and lesser toes [8, 10, 11] over time when the hallux valgus deformity is managed by resection-type arthroplasty of the MTP joint. In the presence of hallux valgus and lesser toe deformities, symptoms will persist even without active synovitis, since fixed deformities produce increased pressure points, resulting in erythema, bursitis, and painful callus formations. Our study aims to compare the clinical and radiological outcomes between resection arthroplasty alone and resection arthroplasty with arthrodesis of the first MTP joint. Until now, we have used two methods of treating hallux valgus and lesser toe dislocation in MTP joints in RA patients. One is a resection arthroplasty of I–V

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MTP joints and the other an arthrodesis of the first MTP joint and a resection arthroplasty of II–V MTP joints.

Materials and methods

Subjects

From March 1975 to May 2003, we performed surgical treatment using two different methods for the treatment of forefoot deformities of RA patients for whom conservative management, including the use of domed insoles and orthotic shoes with a wide toe-box, had failed. From March 1975 to February 1994, the first method was performed, resecting I–V MTP joints as described in the next section. From March 1994 to May 2003, the second method was utilized, adding the arthrodesis of the first MTP joint to the first method. Fifty-nine feet of 36 patients (28 females and 8 males; age 60.7 ± 2.53 years; mean disease duration 12.9 ± 3.01 years) with RA, diagnosed according to the criteria of the American College of Rheumatology [12], were involved in this study. In the first method, 30 feet of 19 patients [15 females and 4 males; mean age 60.5 ± 2.01 years; mean disease duration 6.7 ± 3.01 years (range 1.0–19); mean follow-up period; 3.5 ± 1.03 years (range 3.0–6.4)] were involved. In the second method, 29 feet of 17 patients [13 females and 4 males; age 56.9 ± 3.45 years; mean disease duration; 10.1 ± 1.87 years (range 1–33), mean follow-up period; 4.1 ± 1.24 years (range 3.2–9.5)] were involved.

Surgical procedure

The first method. A plantar transverse incision was made (Fig. 1a). Through the incision, all five metatarsal heads and proximal parts of all proximal phalanges were excised, with a surgeon working from medial to lateral to produce a

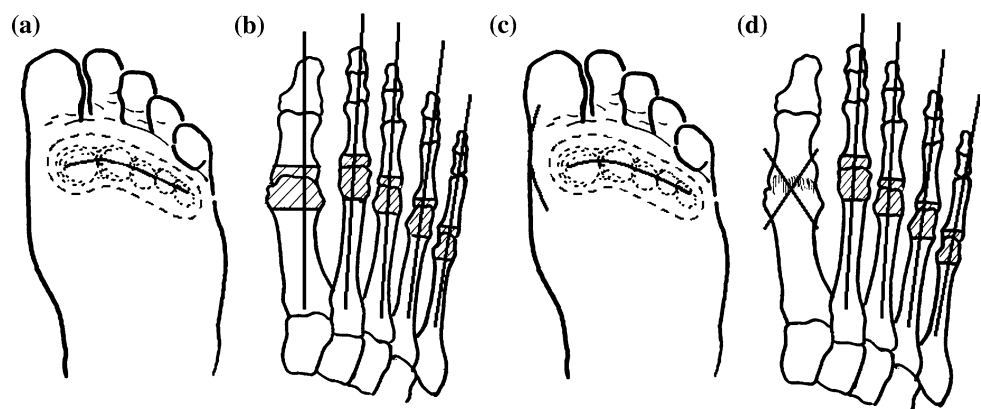
smooth crescentic curve of the remaining metatarsal necks. Adductor hallucis was cut off at the origin of os sesamoidum. All toes were then manipulated and pierced by Kirschner wires to maintain a good position (Fig. 1b). Finally, the wound was sutured.

The second method. In addition to the first method, another incision was made at the medial side of the first MTP joint (Fig. 1c). The first metatarsal head was excised by 12° of abduction and 20° of dorsiflexion from the metatarsal axis and stabilized by Kirschner wires (Fig. 1d). In this method, the adductor hallucis was not cut off.

Clinical and radiographic evaluation

For clinical assessment, the American Orthopaedic Foot and Ankle Society (AOFAS) Hallux Metatarsophalangeal-Interphalangeal Scale (full marks = 100 points) [13] was calculated pre-operation and at the last follow-up. Moreover, all components of the AOFAS score, which includes pain (full marks = 40 points), activity (full marks = 10 points), footwear (full marks = 10 points), motion [MTP + IP] (full marks = 15 points), stability (full marks = 5 points), callus (full marks = 5 points), and alignment (full marks = 15 points), were statistically compared pre-operation and at the last follow-up. For radiographic assessment, a standing anteroposterior radiograph was taken pre-operation, post-operation, and at the last follow-up to measure the hallux valgus angle (H–V angle), the angle between the first and the second metatarsal bone (M1/2), and the angle between the first and the fifth metatarsal bone (M1/5). The H–V angle was measured at the intersection of the longitudinal bisection of the first metatarsal bone and the proximal phalanx of hallux (Fig. 2). Two intermetatarsal angles, M1/2 and M1/5, were measured at the intersection of the longitudinal bisection of the two metatarsal bones, the first and the second, and the first and the fifth, respectively (Fig. 2).

Fig. 1 Surgical procedures demonstrated schematically. Skin incision in the first method (a); bone excision areas (oblique line areas) and Kirschner wires to hold all toes in a good position in the first method (solid line) (b); skin incisions in the second method (c); bone excision areas (oblique line areas) and Kirschner wires (solid line) to hold the II–IV toes in a good position and to fix the first metatarsophalangeal joint in the second method (d)



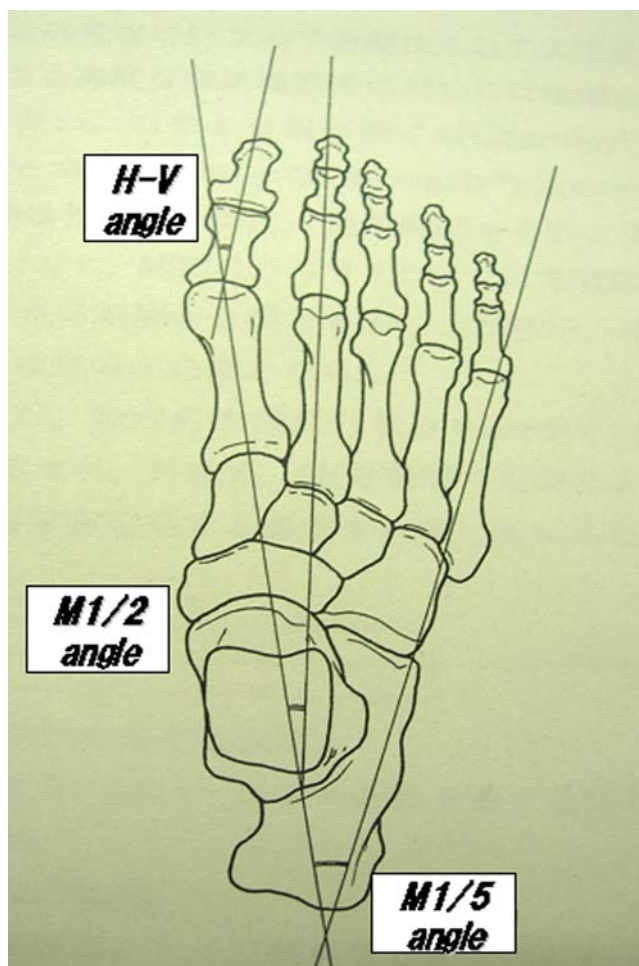


Fig. 2 The angles for radiographic assessment. *H-V angle* the hallux valgus angle, *M1/2 angle* the angle between the first and second metatarsal bones, *M1/5 angle* the angle between the first and fifth

Measurements of the M1/5 angle at pre-operation, at pre-fixation, and at post-fixation after the first MTP joint resection during the operation

Six feet of three patients (two females and one male; mean age 61.5 ± 5.86 years; mean disease duration 12.9 ± 3.01 years) with RA underwent the operation by the second method, and anteroposterior radiographies were taken at three time points—before the operation, at pre-fixation after resecting the first MTP joint, and after fixation of it during the operation—to assess which procedure for the resection or arthrodesis of the first MTP joint has an effect on the M1/5 angle.

Statistical analysis

All data are presented as mean \pm SD. M1/2, M1/5, H-V angles at pre-operation, post-operation and the last follow-up, and M1/5 angles at pre-operation, at pre-fixation and at

post-fixation during the operation were compared using the Wilcoxon signed rank test. Subtractive measurements of each component of the AOFAS score between pre-operation and the last follow-up in both methods were compared using Student's *t*-test. *P* values of less than 0.05 were considered significant. Analysis was performed on a Macintosh computer using the StatView 5.0 software package.

Results

Radiographic assessment

In the first method, mean M1/2, M1/5, and H-V angles at pre-operation were 11.2 ± 4.00 , 31.1 ± 8.77 , and 39.7 ± 11.3 degrees, respectively; those at post-operation were 10.7 ± 4.27 , 30.7 ± 5.65 , and 10.77 ± 6.92 degrees, respectively; and those at the last follow-up were 10.8 ± 3.45 , 32.3 ± 7.78 , and 22.3 ± 3.70 degrees, respectively. In the second method, the mean M1/2, M1/5, and H-V angles at pre-operation were 12.5 ± 3.77 , 33.9 ± 7.11 , and 50.4 ± 9.14 degrees, respectively; those at post-operation were 11.3 ± 4.15 , 25.7 ± 8.04 , and 7.91 ± 4.22 degrees, respectively; and those at the last follow-up were 11.8 ± 3.88 , 26.1 ± 7.21 , and 9.41 ± 3.96 degrees, respectively. In the first method, the H-V angle decreased significantly soon after the operation, but the angle deteriorated as time passed. In contrast, in the second method, the H-V angle was significantly decreased and the degradation continued during the follow-up period. The M1/2 angle did not change significantly in either method. Similarly, the M1/5 angle did not change significantly in the first method, but in the second method it decreased significantly (Fig. 3).

Clinical assessment

Patient satisfaction was high and not dependent on the operation procedure. The mean AOFAS score improved significantly from 29.3 ± 20.6 and 30.1 ± 19.9 points to 66.9 ± 14.8 and 73.3 ± 12.3 points in the first and second methods, respectively. There were significant improvements in all components of the AOFAS score between pre-operation and at last follow-up in both methods (Table 1). However, for the footwear and alignment components, there were significant differences at last follow-up between the two methods (Table 2), with the results of the second method being better than those of the first method. The first method often seemed to result in recurrence of hallux valgus, although there was usually adequate correction of the deformity soon after the operation. Moreover, forefoot splaying was not ameliorated after the operation. In the first

Fig. 3 The results from radiographic measurements at pre-operation, at post-operation, and at the last follow-up. M1/2 angle in the first method (a), M1/5 angle in the first method (b), H-V angle in the first method (c), M1/2 angle in the second method (d), M1/5 angle in the second method (e), and H-V angle in the second method (f). Data are represented as mean ± standard deviation

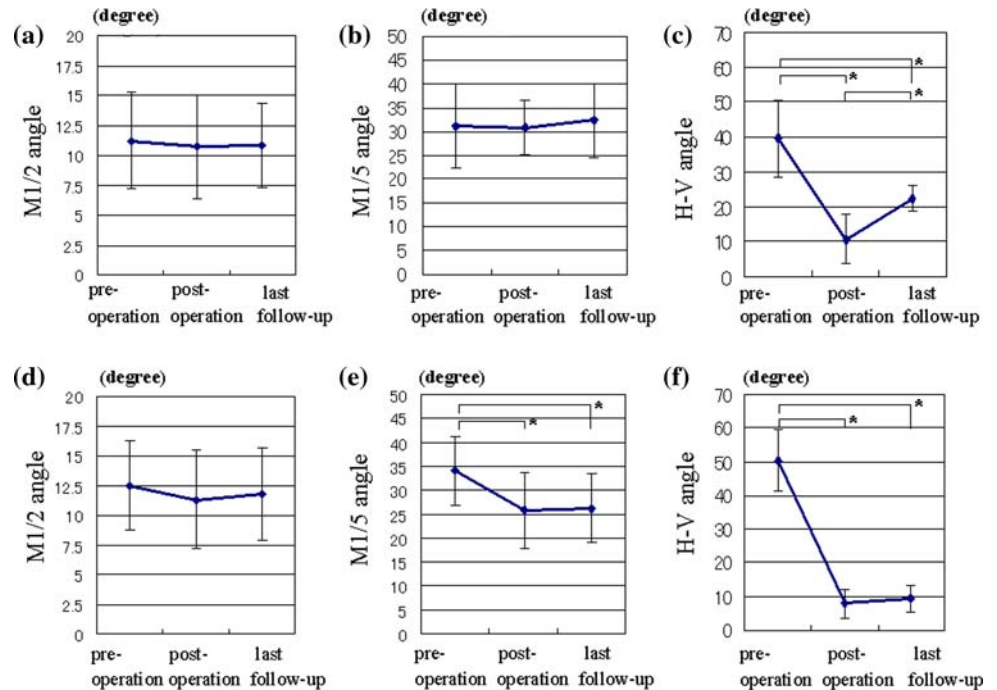


Table 1 Total AOFAS scores and the scores of each AOFAS score component pre-operation and at last follow-up in the first method and the second method

	Total score	Every content score						
		Pain	Activity	Footwear	Motion	Stability	Callus	Alignment
First method								
Pre-operation	29.3 ± 20.6	13.1 ± 9.68	2.93 ± 1.80	3.33 ± 2.40	3.83 ± 2.40	1.83 ± 2.45	1.17 ± 2.15	3.20 ± 4.16
Last follow-up	66.9 ± 14.8**	31.0 ± 7.12*	7.00 ± 2.23*	4.67 ± 1.27*	5.17 ± 2.45*	4.50 ± 1.53*	4.50 ± 1.53*	10.1 ± 3.26*
Second method								
Pre-operation	30.1 ± 19.9	14.5 ± 9.10	3.03 ± 1.74	2.93 ± 2.51	3.45 ± 2.35	1.55 ± 2.35	1.03 ± 1.45	3.59 ± 3.88
Last follow-up	73.3 ± 12.3**	34.1 ± 5.68*	7.31 ± 2.02*	5.69 ± 1.76*	4.31 ± 1.76*	4.66 ± 1.29*	4.14 ± 2.00*	13.1 ± 3.19*

Data are represented as mean ± standard deviation

* *P* < 0.05 versus first method

** *P* < 0.01 versus first method

Table 2 Difference in each AOFAS score component between pre-operation and last follow-up for the first method and the second method

	Pain	Activity	Footwear	Motion	Stability	Callus	Alignment
First method	18.0 ± 10.6	4.07 ± 2.72	1.33 ± 2.25	1.33 ± 2.25	2.67 ± 2.54	3.33 ± 2.40	6.90 ± 4.16
Second method	19.7 ± 11.2	4.28 ± 2.19	2.76 ± 2.86*	0.86 ± 1.92	3.10 ± 2.47	3.10 ± 2.47	9.49 ± 3.49*

Data are represented as mean ± standard deviation

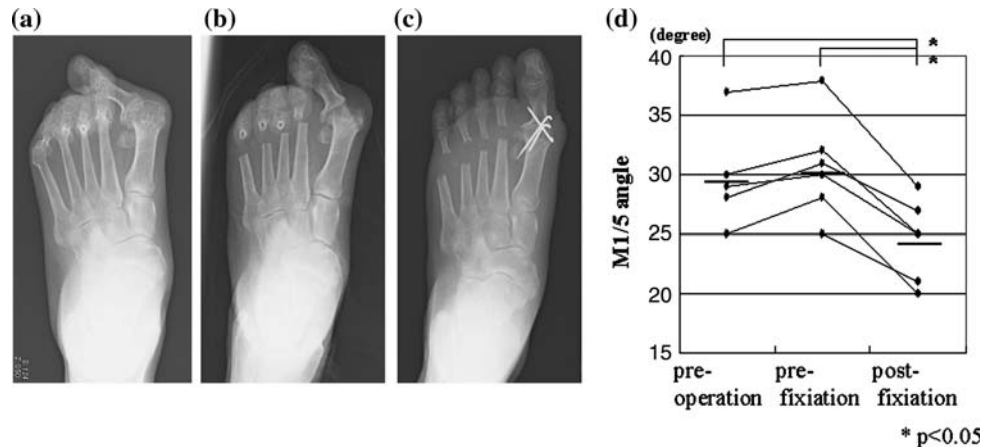
* *P* < 0.05 versus first method

method, the patients were restricted with regard to the types of shoes that could be worn because they could not strain their toes when walking.

In the second method, the bone union in the first MTP joint was recognized in all but one case. The single

nonunion had a non-painful ankylosis of the first MTP joint and a good clinical result in the AOFAS score. No deep infection was observed. Although three superficial infection cases had delayed healing, remission was achieved in these cases in response to treatment with an antibiotic drug.

Fig. 4 Radiographies of foot taken during the operation and the measurement of the M1/5 angle before and after fusing the MTP joint. Radiographies of the foot, 64-year-old male patient, taken pre-operation (a), at pre-fixation after resection of the MTP joint (b) and at post-fixation of the MTP joint (c). Scores of all patients that had the M1/5 angle measured at the three points (d). Bar represents the mean of the M1/5 angle for each group



Measurements of the M1/5 angle at pre-operation, at pre-fixation, and at post-fixation of the first MTP joint during the operation by the second method

There were no significant differences in the M1/5 angles between pre-operation and pre-fixation during the operation. The M1/5 angles of the radiographies taken at post-fixation of the first MTP joint were significantly decreased in all cases compared with pre-fixation (Fig. 4).

Discussion

Hallux valgus, splaying of the forefoot, and flattening of the longitudinal arch, all of which are known to be typical of rheumatoid foot, have been found to progress in patients with RA. Surgeons have reported varied results in response to various surgical procedures with dorsal or plantar incisions, with repositioning of the fat pad, and upon excision of the metatarsal heads and/or the proximal halves of the proximal phalanges [5, 14–16]. Most attention has been directed at treating the first ray, with some surgeons fusing the MTP joint and others resecting part of it.

In the present study, on clinical assessment, patient satisfaction was high regardless of the procedure method. All patients derived complete or partial relief of their forefoot pain. Eighty percent and 85% of the patients were satisfied with the surgical outcome in the first and second methods, respectively. There were significant improvements in all components of the AOFAS score between pre-operation and at last follow-up in both methods. This high satisfaction rate is similar to those reported in other works [6, 15, 17, 18]. However, significant differences were identified between the two methods. The second method reported significantly higher satisfaction in terms of alignment and footwear.

In the first method, hallux valgus deformity often seemed to recur, although adequate correction was

obtained soon after the operation and splaying of the forefoot was not ameliorated. On radiographic assessment, the H–V angle decreased significantly soon after the operation, but the angle deteriorated as time passed. In contrast, in the second method, the H–V angle was significantly decreased by the operation and the angle was maintained during the follow-up period. We assume that this result was obtained as follows. As all five metatarsal heads and parts of the proximal phalanges were excised and the adductor hallucis was cut off at the origin of the os sesamoideum, splaying of the forefoot was not corrected. When all five metatarsal heads and parts of the proximal phalanges were left excised for a long time after the operation, the periphery of the hallux was medially pulled by the first metatarsal bone and soft tissues which were splaying. Moreover, the flexor and extensor hallucis longus tendon, which slid laterally, encouraged the transfer. As a result, hallux valgus deformity recurred. In contrast, M1/5 angles at post-fixation of the first MTP joint were decreased compared with at pre-fixation. This decrease likely occurred because, in the second method, the adductor hallucis was not cut off and the first metatarsal joint was stabilized, and the first metatarsal bones were strained laterally by the tensed adductor hallucis that was attached at the lesser metatarsal bones. In addition, M1/5 angles taken at post-fixation during the operation were lower than those taken at pre-fixation during the operation, although there were no significant differences between pre-operation and pre-fixation values during the operation. Therefore, the first MTP joint fixation resulted in the correction of the splaying of the forefoot. Several studies have indicated that resection arthroplasty often seems to result in recurrence or inadequate correction of hallux valgus [4–8]. However, no previous studies have clarified why splaying of forefoot is not ameliorated or the mechanism of recurrence of hallux valgus deformities. Our study is the first to demonstrate this point. Therefore, we surmised that arthrodesis of the first MTP joint to treat forefoot deformity

of patients with RA has significant advantages over resection arthroplasty alone. Mann et al. [19] have supposed that after resection arthroplasty, the MTP joints frequently experience a recurrence of the hallux valgus deformity and a “cocking up” of the lesser MTP joints, and that these deformities can lead to a recurrence of plantar callosities and pain. We assume that splaying foot that has not been ameliorated by resection arthroplasty may cause a recurrence of the hallux valgus deformity.

The patients treated by the first method suffered difficulties with footwear. In patients treated by the second method, the highest pressure was supported by the fixed first MTP joint and a more favorable pressure distribution to the II–V metatarsi was achieved. In contrast, the first MTP joint treated by resection arthroplasty could not adequately support the pressure, so there were more difficulties with footwear in patients treated by the first method.

Aside from arthroplasty and arthrodesis, replacement of the first metatarsal joint has also been performed. Several reports have suggested that this method produces favorable clinical results [20–22]. Good results have been obtained recently due to advances made in implants and methods [22]. A comparison of the results from arthrodesis of the first metatarsal joint with the results from replacing the first metatarsal joint should be made in a further study. Although resection arthroplasty with arthrodesis of the first MTP joint for foot deformity of RA makes it impossible to bend the toe, resulting in a reduced range of motion, and makes it difficult to wear shoes, we believe that this procedure is currently the most reliable treatment method.

Conflict of interest statement There are no conflict of interest statements included in the manuscript.

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