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Outcome after resection arthroplasty or shortening oblique osteotomy of the lesser metatarsals combined with arthrodesis of the first metatarsophalangeal joint for severe rheumatoid forefoot deformities

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Abstract

Purpose: We investigated objective and patient-reported outcomes after resection arthroplasty or shortening oblique osteotomy (SOO) of the lesser metatarsals combined with arthrodesis of the first metatarsophalangeal (MTP) joint for severe rheumatoid forefoot deformities.

Methods: 17 feet from 14 women (mean age, 67.8 years) underwent resection arthroplasty of the lesser metatarsal heads (MTH resection group), while 13 feet from nine women and two men (mean age, 68.7 years) underwent SOO of the lesser metatarsals (MTH preservation group). Arthrodesis of the first MTP joint was performed in all cases. Mean follow-up in the MTH resection and preservation groups was 25.0 and 21.3 months, respectively. Preoperative and postoperative clinical evaluation included Japanese Society for Surgery of the Foot (JSSF) scale and self-administered foot evaluation questionnaire (SAFE-Q) scores.

Results: Mean total JSSF scale significantly improved from 53.4 to 76.4 in the MTH resection group ($p < .001$) and from 50.1 to 74.2 in the MTH preservation group ($p = .002$). Pain and pain-related and shoe-related SAFE-Q subscale scores significantly improved after surgery in both groups. In the MTH resection group, recurrence of painful callosities and claw toe deformity was observed in four and three feet, respectively. In the MTH preservation group, one patient experienced recurrence of painful callosities and one underwent revision surgery for IP joint dislocation.

Conclusion: Resection arthroplasty or SOO of the lesser metatarsals combined with arthrodesis of the first MTP joint achieved significant improvement with respect to pain relief, deformity correction, and footwear comfort.

Keywords

forefoot surgery, arthrodesis, shortening oblique osteotomy, patient-reported outcome, rheumatoid arthritis

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Introduction

Foot involvement in patients with rheumatoid arthritis (RA) is common and can cause pain during weight-bearing and walking as well as disability.[1,2] Typical RA foot deformities are hallux valgus and subluxation or dislocation of the lesser toes at the metatarsophalangeal (MTP) joints.[3] Resection arthroplasty of the metatarsal head (MTH) combined with arthrodesis of the first MTP joint is a well-established procedure used to treat severe forefoot deformities in patients with long-standing RA.[4–7] However, it may involve sacrifice of a normal MTH and has been associated with higher rates of recurrent callosities and subluxations or dislocations of the MTP joint of the lesser toe than joint-preserving procedures.[8,9] We have been performing shortening oblique osteotomy (SOO) of the lesser metatarsals combined with arthrodesis of the first MTP joint for severe hallux valgus and/or destruction of the first MTP joint with mild or moderate destruction of the lesser MTP joints. However, few reports have compared clinical and radiographic outcomes between resection and SOO of the lesser metatarsals when combined with arthrodesis of the first MTP joint.

The importance of objective and patient-reported outcomes has been emphasized in previous studies of the surgical treatment of rheumatoid forefoot deformities.[9–11] This study aimed to investigate both types of outcomes in patients undergoing either resection arthroplasty or SOO of the lesser metatarsals combined with arthrodesis of the first MTP joint for severe rheumatoid forefoot deformities.

Patients and methods

Patients

This retrospective study was approved by the ethics committee of our institution (approval number: 2194). All patients provided written informed consent. 30 feet with a forefoot deformity from 21 women and two men with RA underwent resection arthroplasty or SOO of the lesser metatarsals combined with arthrodesis of the first MTP joint in our institution from July 2014 to November 2018. All patients met the American Rheumatism Association 1987 revised criteria for RA.[12] The Larsen grading system was used to assess the severity of destruction of the MTP and interphalangeal (IP) joints: grades I and II indicated mild destruction, grade III indicated moderate, and grades IV and V indicated severe.[13] Arthrodesis of the first MTP joint was generally indicated for older adults (>65 years) with severe hallux valgus and/or destruction of the first MTP joint and low activity level. For the lesser toe, resection arthroplasty was indicated for severe MTP joint dislocation and/or severe MTH destruction in patients with poorly controlled RA, while SOO of the lesser metatarsals was indicated for forefoot deformity with subluxation/dislocation of one or more MTP joints and mild or moderate destruction of the MTP joints. The metatarsal length is not a consideration in choice of procedures. SOO of the second, third, fourth, and fifth lesser metatarsal was performed in 12, 12, 11, and 10 feet, respectively. 17 feet from 14 women (mean age, 67.8 years) underwent resection arthroplasty of the lesser MTHs combined with arthrodesis of the first MTP joint (MTH resection group), while 13 feet from nine women and two men (mean age, 68.7 years) underwent SOO of at least two lesser metatarsals combined with arthrodesis of the first MTP joint (MTH preservation group).

Mean disease duration in the MTH resection and preservation groups was 32.2 and 21.1 years, respectively. Mean follow-up was 25.0 and 21.3 months, respectively (minimum 12 months). 19 patients had been treated with conventional synthetic disease-modifying antirheumatic drugs before surgery (methotrexate, $n = 15$; salazosulfapyridine, $n = 5$; bucillamine, $n = 2$; prednisolone, $n = 7$; tacrolimus, $n = 4$; iguratimod, $n = 1$). Biologic disease-modifying antirheumatic drugs had been used before surgery in nine patients (infliximab, $n = 1$; etanercept, $n = 3$; adalimumab, $n = 1$; abatacept, $n = 1$; golimumab, $n = 2$; certolizumab pegol, $n = 1$). Infliximab was withheld 4 weeks before surgery while adalimumab, abatacept, golimumab, and certolizumab pegol were withheld 2 weeks before. Based on our previously reported strategy, etanercept was withheld 7–10 days before surgery.[14] One patient was not taking any medication at the time of surgery. All patients continued treatment with the same medications after surgery. Mean disease activity score 28 c-reactive protein (DAS28-CRP)[15] in the MTH resection and preservation groups was 2.7 and 2.8, respectively. Mean health assessment questionnaire-disability index (HAQ-DI) score[16] was 1.2 and 1.3, respectively. Patient characteristics are summarized in Table 1.

Clinical assessment

Pre- and postoperative clinical evaluation included objective assessment of the Japanese Society for Surgery of the Foot (JSSF) scale using the standard rating system for the RA foot and ankle scale for pain (0–30 points), deformity (0–25 points), range of motion (ROM; 0–15 points), walking ability (0–20 points), and activities of daily living (ADL; 0–10 points).[17] Patients also completed the self-administered foot evaluation questionnaire (SAFE-Q) before and after surgery. The main body of this questionnaire consists of 34 items, which provide five subscale scores (pain and pain-related; physical functioning and daily living; social functioning; shoe-related; and general health and well-being). Each subscale score ranges from 0 to 100 points.[18,19] In two patients who underwent resection arthroplasty combined with arthrodesis of the first MTP joint on one foot and SOO combined with arthrodesis of the first MTP joint on the other

Table 1. Patients' demographic and clinical parameters.

Characteristic	MTH resection (n = 17)	MTH preservation (n = 13)
Age (y)	67.8 (57-82)	68.7 (57-79)
Disease duration (y)	32.2 (22-55)	21.1 (3-44)
Follow-up period (m)	25.0 (12-44)	21.3 (12-38)
csDMARDs MTX	11 (64.7)	10 (76.9)
Other	6 (35.3)	7 (53.8)
PSL	3 (17.6)	5 (38.4)
BDMARDs	6 (35.2)	5 (38.4)
DAS28-CRP	2.7 (1.1-4.0)	2.8 (1.5-4.1)
HAQ-DI	1.2 (0.1-2.5)	1.3 (0-2.4)

All values are expressed as mean (range) or n (%).
Abbreviations: Metatarsal head (MTH); Conventional synthetic disease-modifying antirheumatic drugs (csDMARDs); Methotrexate (MTX); Prednisolone (PSL); Biologic disease-modifying antirheumatic drugs (bDMARDs); Disease activity score 28 c-reactive protein (DAS28-CRP); Health assessment questionnaire-disability index (HAQ-DI).

foot, the same evaluations were used to assess the JSSF scale relating to ADL and SAFE-Q for both feet; the JSSF scale excluding ADL and radiographic outcomes were assessed for each foot separately. All feet were examined for the presence of symptomatic plantar callosities, residual toe deformities, delayed wound healing, and surgical site infection after surgery. Delayed wound healing was defined as a wound that had not healed within 3 weeks of surgery.

Radiographic assessment

Pre- and postoperative radiographic assessments included measurement of the hallux valgus angle (HVA), intermetatarsal angle (IMA) of the first and second metatarsals (M1M2A), IMA of the first and fifth metatarsals (M1M5A), and IMA of the second and fifth metatarsals (M2M5A) on anteroposterior weightbearing radiographs using Miller's method.[20]

Operative technique

In both groups, bunionectomy was performed and the medial MTP joint capsule of the great toe was opened. After resection of the first MTH and the base of the proximal phalanx, arthrodesis was performed to achieve a 20° angle of dorsiflexion at the MTP joint using screws or a locking plate (Figures 1 and 2). Two types of cannulated cancellous screw (DARTFIRE® [Wright Medical Technology, Memphis, TN, USA] and ACE screw [Zimmer Biomet, Warsaw, IN, USA]), two types of headless compression screw (Acutrak 2 mini screw [Acumed, Beaverton, OR, USA] and HCS [Depuy Synthes, Solothurn, Switzerland]), and double-threaded headless screws (DTJ screw; MEIRA Corp., Nagoya, Japan) were used in 15, 6, 4, 1, and 2 feet, respectively. In two feet, arthrodesis of the first MTP joint was performed using a locking plate (MPJ Fusion plate; Wright Medical Technology) with a headless compression screw (Acutrak 2-mini screw, Acumed).

For the lesser toe, in the MTH resection group, resection arthroplasty was performed using Hoffmann's method, which involves resection of the second to fifth MTHs (Figure 1).[8,21] In the MTH preservation group, we performed the SOO to correct lesser toe deformities then the metatarsal bone was fixed with a screw instead of a longitudinal K-wire from the distal phalanx to the metatarsal shaft (Figure 2).[22] After the oblique osteotomy, an additional bone resection was made to the proximal cut surface of the fifth metatarsal bone to tilt internally. The distal fragment was internally rotated with slight varus position to correct the M2M5A, and fixed by a screw. The osteotomy site was fixed using cannulated cancellous screws (DARTFIRE®, Wright Medical Technology) and cortex screws (Modular Hand System, DePuy Synthes) in 11 and 2 feet, respectively. The proximal interphalangeal (PIP) joint was manipulated in all feet. Extensor plication and dermodesis at the PIP joints were performed in three toes from three feet and four toes from two feet in the MTH resection and preservation groups, respectively. Arthrodesis of the PIP joints was performed using the PRO-TOE™ VO Hammertoe Fixation System (Wright Medical Technology) in four toes from two feet in the MTH preservation group. Extensor release and joint resection at the PIP joint were performed in one toe in the MTH preservation group. Z-lengthening of the extensor digitorum longus (EDL) tendon with release of the extensor digitorum brevis (EDB) tendon was performed in 28 toes from nine feet and 24 toes from eight feet in the MTH resection and preservation groups, respectively.

Postoperative management

In the MTH resection group, a bulky compression bandage was applied with the toe held in plantarflexion for 10–14 days. Heel gait and passive and active ROM exercises were permitted for the lesser toe on postoperative day 1. Full weightbearing with an arch support was permitted 3 weeks after surgery. After removal of the bandage, an arch support was worn for 2 months[11]

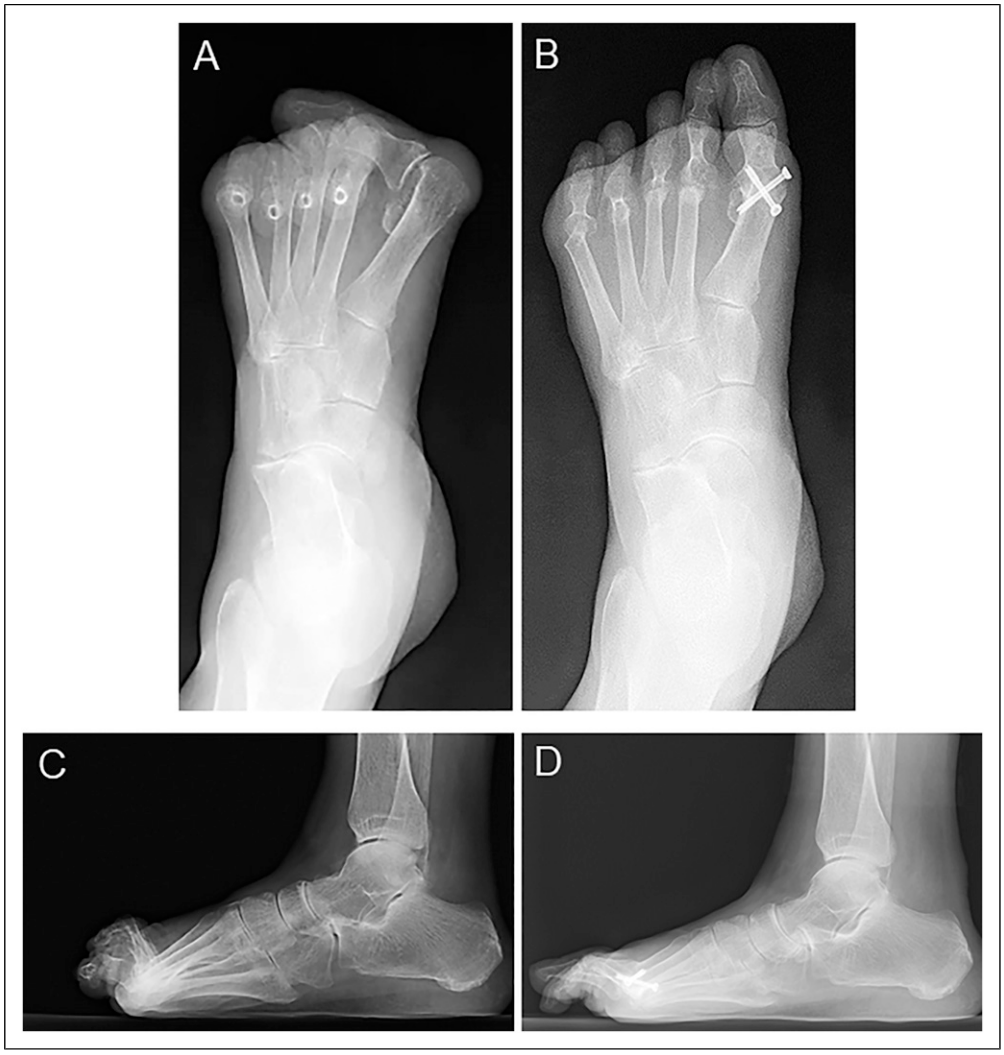

Figure 1. Pre- and postoperative anteroposterior and lateral weightbearing radiographs of the left foot in a MTH resection group patient. (a, c) Preoperative radiograph showing severe hallux valgus and destruction of the metatarsophalangeal (MTP) joints. (b, d) Postoperative radiograph taken after resection arthroplasty of the metatarsal heads combined with arthrodesis of the first MTP joint.

In the MTH preservation group, a bulky compressive bandage was applied with the toe held in plantarflexion for 7–10 days. Passive and active ROM exercises for the lesser toe were initiated 5–7 days after surgery. Heel gait was permitted at 7 days if possible and full weightbearing with an arch support was allowed at 3 weeks. An arch support was worn for 2 months.

Statistical analysis

Statistical analyses were performed using R for Windows (www.r-project.org). Pre- and postoperative clinical and radiographic evaluations were compared within each treatment group using the Wilcoxon signed-rank test. $p < .05$ was considered significant.

Results

Objective outcomes

In the MTH resection group, the mean total JSSF scale improved significantly from 56.4 to 76.4 ($p < .001$); the mean JSSF subscale significantly improved from 19.4 to 26.8 ($p < .001$) for general pain, 12.6 to 20.1 ($p < .001$) for deformity, 12.1 to 15.9 ($p = .042$) for walking ability, and 3.8 to 5.3 ($p = .010$) for ADL. In the MTH preservation group, the mean total JSSF scale improved significantly from 50.1 to 74.2 ($p = .002$); the mean JSSF subscale significantly improved from 20.8 to 26.9 ($p = .006$) for general pain, 10.7 to 19.0 ($p = .002$) for deformity, 10.0 to 16.2 ($p = .010$) for walking ability, and 2.2 to 3.8 ($p = .005$)

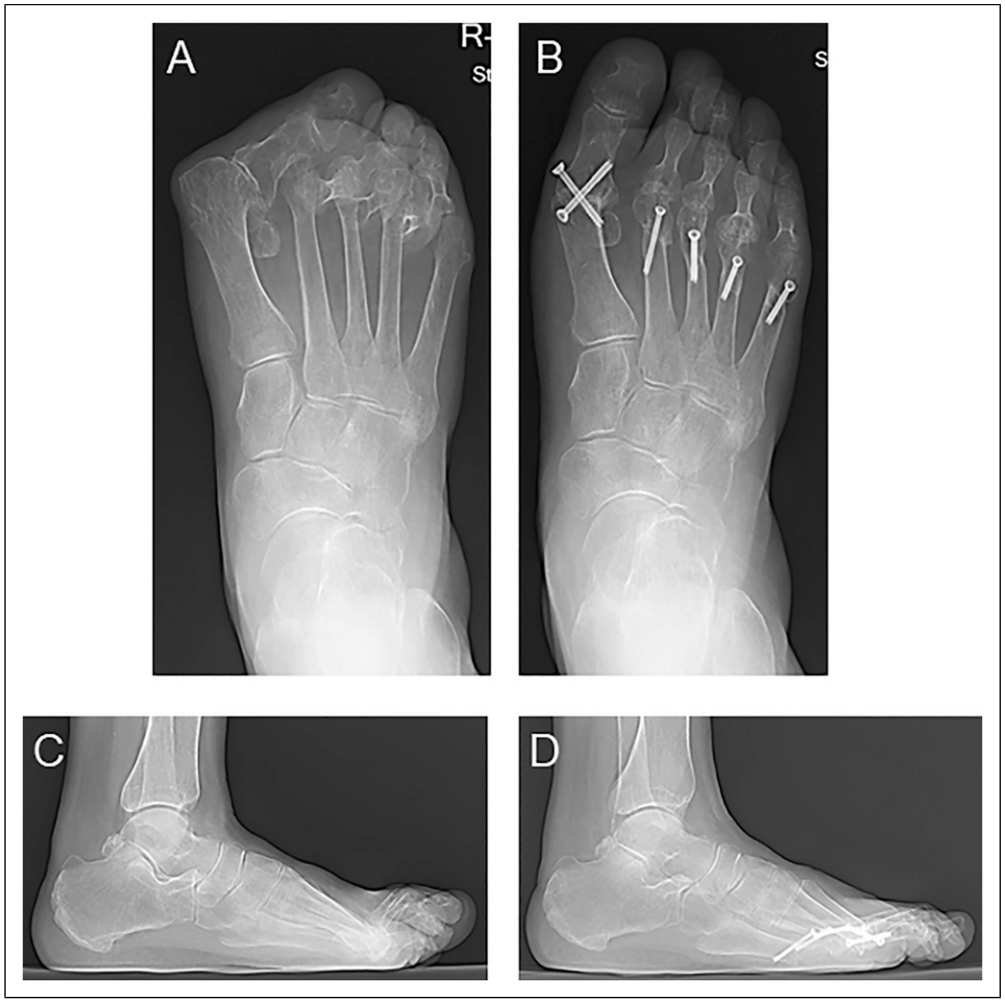

Figure 2. Pre- and postoperative anteroposterior and lateral weightbearing radiographs of the right foot in a MTH preservation group patient. (a, c) Preoperative radiograph showing severe hallux valgus and moderate destruction of the lesser metatarsophalangeal (MTP) joints. (b, d) Postoperative radiograph taken after shortening oblique osteotomy of the lesser metatarsals combined with arthrodesis of the first MTP joint.

for ADL. The mean JSSF ROM subscale did not significantly improve in either group after surgery (Table 2).

Patient-reported outcomes

The mean pain and pain-related, physical functioning and daily-living, social functioning, shoe-related, and general health and well-being subscale scores of the SAFE-Q in the MTH resection group improved from 52.1 to 70.5 (p = .002), 56.1 to 69.0 (p = .002), 56.1 to 68.6 (p = .109), 35.5 to 54.4 (p = .005), and 63.3 to 77.4 (p = .025), respectively. In the MTH preservation group, the corresponding SAFE-Q subscale scores improved from 50.8 to 67.6 (p = .013), 43.4 to 54.2 (p = .142), 49.0 to 51.0 (p = .726), 43.6 to 64.1 (p = .020), and 54.2 to 63.5 (p = .284), respectively (Table 2).

Radiographic outcomes

In the MTH resection group, the mean HVA, M1M2A, and M1M5A significantly improved from 54.9° to 22.5° (p < .001), 13.6° to 9.2° (p = .001), and 36.0° to 32.8° (p = .032), respectively; the mean M2M5A did not significantly improve. In the MTH preservation group, the mean HVA, M1M2A, M1M5A, and M2M5A improved significantly from 59.4° to 12.9° (p = .002), 11.9° to 8.3° (p = .006), 32.3° to 24.6° (p = .002), and 20.8° to 16.2° (p = .028), respectively (Table 2).

Postoperative complications

In the MTH resection group, recurrence of painful callosities and claw toe deformity occurred in four (23.5%) and three (17.6%) feet, respectively. In the MTH preservation

Table 2. Clinical and radiographic outcomes of MTH resection and preservation groups.

	MTH resection (n = 17)			MTH preservation (n = 13)		
Characteristic	Preoperative	Postoperative	p Value	Preoperative	Postoperative	p Value
JSSF-RA scale						
General pain (30 points)	19.4 (10-30)	26.8 (20-30)	< .001[a]	20.8 (20-30)	26.9 (20-30)	.006[a]
Deformity (25 points)	12.6 (1-22)	20.1 (10-28)	< .001[a]	10.7 (3-19)	19.0 (3-25)	.002[a]
Motion (15 points)	8.5 (0-15)	7.8 (0-13)	.622	6.4 (0-15)	7.5 (0-10)	.225
Walking ability (20 points)	12.1 (5-20)	15.9 (10-20)	.042[a]	10.0 (5-20)	16.2 (10-20)	.010[a]
Activities of daily living (10 points)	3.8 (0-8)	5.3 (0-10)	.010[a]	2.2 (0-5)	3.8 (1-9)	.005[a]
Total (100 points)	56.4 (42-77)	76.4 (42-93)	< .001[a]	50.1 (28-66)	74.2 (43-89)	.002[a]
SAFE-Q subscale						
Pain and pain-related (100 points)	52.1 (8.3-86.7)	70.5 (26.1-100)	.002[a]	50.8 (8.3-75.8)	67.6 (26.1-100)	.013[a]
Physical functioning and daily living (100 points)	56.1 (9.1-86.3)	69.0 (15.9-93.0)	.002[a]	43.4 (9.1-90.9)	54.2 (15.9-84.1)	.142
Social functioning (100 points)	56.1 (0-83.3)	68.6 (16.7-100)	.109	49.0 (0-100)	51.0 (4.2-87.5)	.726
Shoe-related (100 points)	35.5 (8.3-75.0)	54.4 (25-100)	.005[a]	43.6 (16.7-83.3)	64.1 (25-100)	.020[a]
General health and well-being (100 points)	63.3 (15.0-95.0)	77.4 (25-100)	.025[a]	54.2 (20-100)	63.5 (25-95)	.284
HVA (°)	54.9 (12-98)	22.5 (13-35)	< .001[a]	59.4 (37-102)	12.9 (1-28)	.002[a]
M1M2A (°)	13.6 (3-25)	9.2 (3-17)	.001[a]	11.9 (6-19)	8.3 (1-12)	.006[a]
M1M5A (°)	36.0 (19-57)	32.8 (15-45)	.032[a]	32.3 (15-44)	24.6 (9-34)	.002[a]
M2M5A (°)	22.4 (11-38)	23.6 (10-36)	.308	20.8 (9-35)	16.2 (1-24)	.028[a]

All values are expressed as mean (range).
Abbreviations: Metatarsal head (MTH); Japanese Society of Surgery of the Foot standard rating system for the rheumatoid arthritis foot and ankle scale (JSSF-RA scale); Selfadministered foot evaluation questionnaire (SAFE-Q); Hallux valgus angle (HVA); Intermetatarsal angle of the first and second metatarsals (M1M2A); Intermetatarsal angle of the first and fifth metatarsals (M1M5A); Intermetatarsal angle of the second and fifth metatarsals (M2M5A).
[a]Statistically significant ($p < 0.05$).

Table 3. Number of complications in MTH resection and preservation groups.

Complication	MTH resection (n = 17)	MTH preservation (n = 13)
Painful callosities	4 (23.5)	1 (7.7)
Recurrence of Hallux valgus (HVA > 30°)	0 (0.0)	0 (0.0)
Claw toe	3 (17.6)	0 (0.0)
Delayed wound healing	1 (5.9)	1 (7.7)
Infection	0 (0.0)	0 (0.0)

All values are expressed as n (%).
Abbreviations: Metatarsal head (MTH); Hallux valgus angle (HVA).

group, recurrence of painful callosities occurred in one (7.7%) foot. Delayed wound healing occurred in one foot each in the MTH resection and preservation groups (5.9% and 7.7%, respectively). Recurrent hallux valgus and postoperative infection did not occur (Table 3). One foot with severe hallux valgus (HVA 98°) that underwent arthrodesis to achieve a HVA of 35° in the MTH resection group was excluded from the recurrence of hallux valgus assessment. Bone union was achieved in all feet. Arthritic progression was not observed in any foot; however, dislocation of the IP joint occurred 18 months after surgery in one foot in the MTH preservation group. This dislocation was treated with IP joint arthrodesis using a cannulated cancellous screw (DARTFIRE®, Wright Medical Technology) inserted from the tip of the toe into the proximal phalanx.

Discussion

In this study, significant postoperative improvements were observed in both groups for all JSSF subscales except ROM as well as the pain and pain-related and shoe-related SAFE-Q subscales. These results suggest that resection arthroplasty or SOO of the lesser metatarsals combined with arthrodesis of the first MTP joint can relieve pain, correct the forefoot deformity, and allow use of comfortable

footwear in patients with RA. A previous study has also reported good clinical outcomes for a joint-preserving lesser toes procedure and resection arthroplasty combined with arthrodesis of the first MTP joint; however, radiographic assessments were not conducted.[23]

Our radiographic assessments demonstrated that HVA, M1M2A, and M1M5A significantly improved after surgery in both the MTH resection and preservation groups, while M2M5A did not improve in the MTH resection group. A previous study reported that spread of M2M5A was a risk factor for recurrence of subluxation of the MTP joint of the lesser toe.[24] In our study, the claw toe recurrence rate was higher in the MTH resection group than in the MTH preservation group. Resection arthroplasty combined with arthrodesis of the first MTP joint is associated with a risk of recurrent dislocation of the lesser MTP joint; callosities with bony proliferation may also occur on the metatarsal stump over the long-term.[5] However, when MTP joint destruction is mild or moderate, lesser MTP joint preservation is superior to resection arthroplasty with respect to joint stability.[25] In severe rheumatoid forefoot deformities, Weil osteotomy of the lesser metatarsals combined with arthrodesis of the first MTP joint provides stabilization of the first MTP joint and offloads the lesser metatarsal heads.[26,27] Therefore, we suggest that SOO of the lesser metatarsals combined with arthrodesis of the first MTP joint may be a good option for severe hallux valgus and/or destruction of first MTP joint with mild or moderate destruction of the lesser MTP joints, while severe MTP joint dislocation and/or severe MTH destruction of the lesser toe in patients with poorly controlled RA can be treated by resection arthroplasty of the lesser MTHs with acceptable clinical outcome at least in the short term.

Arthrodesis of the first MTP joint provides joint stability and is associated with a low rate of hallux valgus recurrence; however, disadvantages of this approach include risks of IP joint degeneration and nonunion as well as the relatively high rate of reoperation.[28,29] Moreover, malalignment of the first MTP joint causes difficulties with shoe wearing and painful callosities on the plantar side of the first MTH and IP joint because of excessive loading.[5,30,31] These complications positively correlate with patient dissatisfaction.[7] In our study, painful callosities on the plantar side of the first MTH were observed in only one foot of the MTH resection group; recurrence of hallux valgus and nonunion were not. In the MTH preservation group, IP joint dislocation occurred in one foot and subsequently underwent IP joint arthrodesis.

The rates of delayed wound healing and surgical site infection were relatively lower in our study than in previous reports.[10,32,33] Our antirheumatic drug discontinuation protocol, performance of MTP joint synovectomy, and practice of restarting antirheumatic drugs after surgical wound healing seemed to be effective in avoiding these complications.

Although our research demonstrated significant pain relief and radiographic improvement in conjunction with a relatively low complication rate, patient satisfaction for social function did not significantly improve in either group. The level of ADL has been positively correlated with all subscales of the SAFE-Q, especially physical functioning and daily living, social functioning, and general health and well-being subscale scores.[34] Furthermore, higher HAQ-DI score (>1.0) indicates the patient has moderate to severe functional disabilities and could predict worse outcomes.[35,36] Both procedures in our study were performed in older adults with relatively low ADL. It is reasonable to presume that toe arthroplasty alone resulted in only limited improvement in SAFE-Q subscale scores. Therefore, we should pay attention to patient-reported outcomes for arthroplasty performed for rheumatoid forefoot deformities in older adults with relatively low ADLs, even though the objective outcomes appear satisfactory.

This study has several limitations. First, surgical indications were dependent upon patient age, control of RA activity, ADL, HVA, and MTP joint destruction. Surgical outcomes could not be directly compared between procedures because of differences in patient background and surgical indications. Second, our sample size was small and the follow-up period was relatively short. Third, first MTP joint arthrodesis was performed using a variety of fixation devices. Fourth, we included patients who underwent bilateral foot operations and those who underwent unilateral surgery; toe arthroplasty on the contralateral foot was performed in four patients of each group during the follow-up period. In two patients who underwent different procedures on their feet, both procedures relieved pain, corrected forefoot deformities, and led to no recurrent callosity and dislocation of the lesser MTP joint. Radiographically, M2M5A improved in the joint-preserving surgery but not in the resection surgery. However we were unable to compare the outcomes due to only two patients with different procedures on their feet. Further study with a larger number of patients would be required to improve our understanding of the differences in the outcomes after these procedures. Nonetheless, a strength of this study is our use of clinically validated assessments. Furthermore, our patients truly completed the patient-reported assessments before and after surgery. Retrospective patient-reported scoring of preoperative status is inaccurate and can lead to overestimation of the effect of surgery.[37]

In conclusion, resection arthroplasty or SOO of the lesser metatarsals combined with arthrodesis of the first MTP joint achieved significant improvement with respect to pain relief, deformity correction, and footwear comfort. Longer follow up of this patient cohort is required to determine

whether both procedures can maintain good clinical outcomes over time.

Declaration of conflicting interests

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