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First Metatarsophalangeal Joint-Preserving Surgery Is Effective for Forefoot Deformity With Moderate to Severe Joint Destruction in Rheumatoid Arthritis

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Abstract

Background: The study compares the clinical outcomes of first metatarsophalangeal (MTP) joint fusion vs joint-preserving surgery in rheumatoid arthritis (RA) patients with severe forefoot deformities.

Methods: This single-center retrospective study at Kyushu University Hospital reviewed RA patients who underwent either first MTP joint arthrodesis or joint-preserving surgery for hallux valgus (HV) deformity between January 2008 and December 2022. A total of 103 feet (73 cases) were analyzed, with 75 feet (58 cases) showing radiographic bone destruction of Larsen grade 3 or higher. One foot underwent resection arthroplasty, so ultimately 74 feet in 57 cases were evaluated. Surgical procedures included joint-preserving biplane osteotomy or arthrodesis with crossed screws. Clinical outcomes were measured using the Japanese Society for Surgery of the Foot (JSSF) Hallux scale, whereas radiographic assessments included HV angle (HVA). Propensity score matching was used to minimize bias when comparing postoperative outcomes between the arthrodesis and joint-preserving surgery groups.

Results: This study analyzed 74 feet undergoing either arthrodesis (27 feet) or joint-preserving surgery (47 feet) for HV. Patients in the 2 groups showed similar demographic and clinical characteristics except with respect to length of follow-up, which was greater in the arthrodesis group (5.1 $\pm$ 2.6 years vs 2.4 $\pm$ 2.0 years, $P < .01$) than the joint-preserving group. In the arthrodesis group, all patients underwent resection arthroplasty on the second to fifth toes. The joint-preserving group included first MTP joint surgery alone (n = 5) and first MTP joint and lesser MTP joint surgeries (resection arthroplasty, n = 29; joint-preserving surgery, n = 13). Functional scores significantly improved in both groups, with first metatarsophalangeal joint-preserving surgery yielding better postoperative outcomes. In cases of deformity recurrence, the recurrent cases exhibited greater immediate postsurgical HVA, but other foot function outcomes remained similar at the end of follow-up.

Conclusion: Joint-preserving surgery for advanced rheumatoid forefoot deformity showed better functional improvement than arthrodesis using the propensity score matching and comparable clinical outcomes, highlighting it as a potential treatment option for severe joint destruction.

Level of Evidence: Level IV, retrospective study.

Keywords: hallux valgus, osteotomy, rheumatoid arthritis, Joint-preserving surgery

Introduction

Rheumatoid arthritis (RA) is a chronic systemic inflammatory disorder that primarily affects multiple joints, leading to progressive joint destruction and deformities.[10,12,37] Forefoot symptoms are particularly prevalent, affecting approximately 70% of patients with RA, even in the early stages of the disease.[46] The progression of synovitis in patients with RA results in deformities such as hallux valgus (HV) at the

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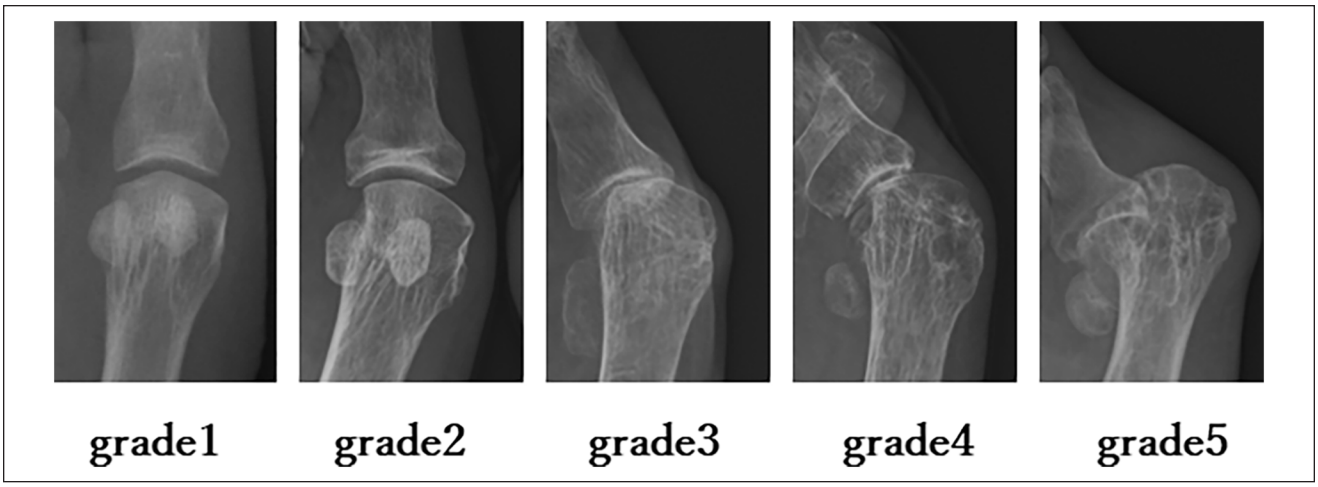

Figure 1. Larsen grade in the first metatarsophalangeal joint.

metatarsophalangeal (MTP) joint and hammertoe deformities in the lateral phalanges due to subluxation of the MTP joint.[28] Arthrodesis of the first MTP joint has been the gold standard for surgical treatment, particularly in cases of advanced joint destruction.[30] This procedure is favored for its effectiveness in alleviating pain and improving function, despite sacrificing joint mobility.[4,7,23] On the other hand, arthrodesis of the first MTP joint in RA patients was reported to result in lower union and higher complication rates than in nonRA patients.[8]

Recent advances in RA management, such as conventional synthetic disease-modifying antirheumatic drugs (csDMARDs) and biological/targeted synthetic DMARDs (b/ts DMARDs), have significantly reduced the incidence of severe joint destruction,[11,21] thereby shifting the surgical paradigm toward joint-preserving techniques.[1,9,13,24,39,44,47,48] However, the indications for joint-preserving surgery in cases that have already developed severe forefoot deformities remain controversial. A meta-analysis comparing the clinical outcomes of first MTP joint fusion and resection arthroplasty for the treatment of rheumatic forefoot deformity found no significant differences in pain scores or physical activity.[16] However, joint-preserving surgery of the first MTP joint was shown to prevent functional loss compared with resection arthroplasty.[39] Although no studies have directly compared joint preservation and arthrodesis for the treatment of forefoot deformities in RA, both radiologic and clinical outcomes of joint-preserving surgery have been reported to be favorable.[1,24,32,34,43]

This study aims to address this gap by comparing the efficacy of first MTP joint fusion and joint-preserving surgery in RA patients with forefoot deformities characterized by advanced HV. This comparison is crucial for determining whether joint-preserving procedures could offer comparable or superior outcomes in terms of pain relief, functional improvement, and patient satisfaction in cases featuring moderate to severe joint destruction.

Methods

Patients

In this single-center retrospective study, we reviewed the medical records and radiographic outcomes of all consecutive RA patients who underwent first metatarsal joint arthrodesis or joint-preserving surgery for HV deformity at Kyushu University Hospital (Fukuoka, Japan) from January 2008 to December 2022. Of the 103 feet in 73 cases on which surgery was performed, radiographic bone destruction of the first MTP joint of Larsen grade 3 or higher (Figure 1) was seen in 75 feet (58 cases).[26,33] On excluding 1 foot of 1 case due to resection arthroplasty of the first MTP joint, 74 feet in 57 cases were finally analyzed (Figure 2). The following parameters were evaluated: age, sex, body mass index (BMI), RA disease duration, medical treatment of RA (methotrexate, prednisolone, and b/tsDMARDs), and blood tests at surgery (serum C-reactive protein and erythrocyte sedimentation rate [ESR]). The Steinbrocker stage was defined by radiographic abnormalities of the hand in patients with RA as follows: stage I, no destructive changes; stage II, slight cartilage and/or subchondral bone destruction and osteoporosis; stage III, cartilage and/or bone destruction and osteoporosis; and stage

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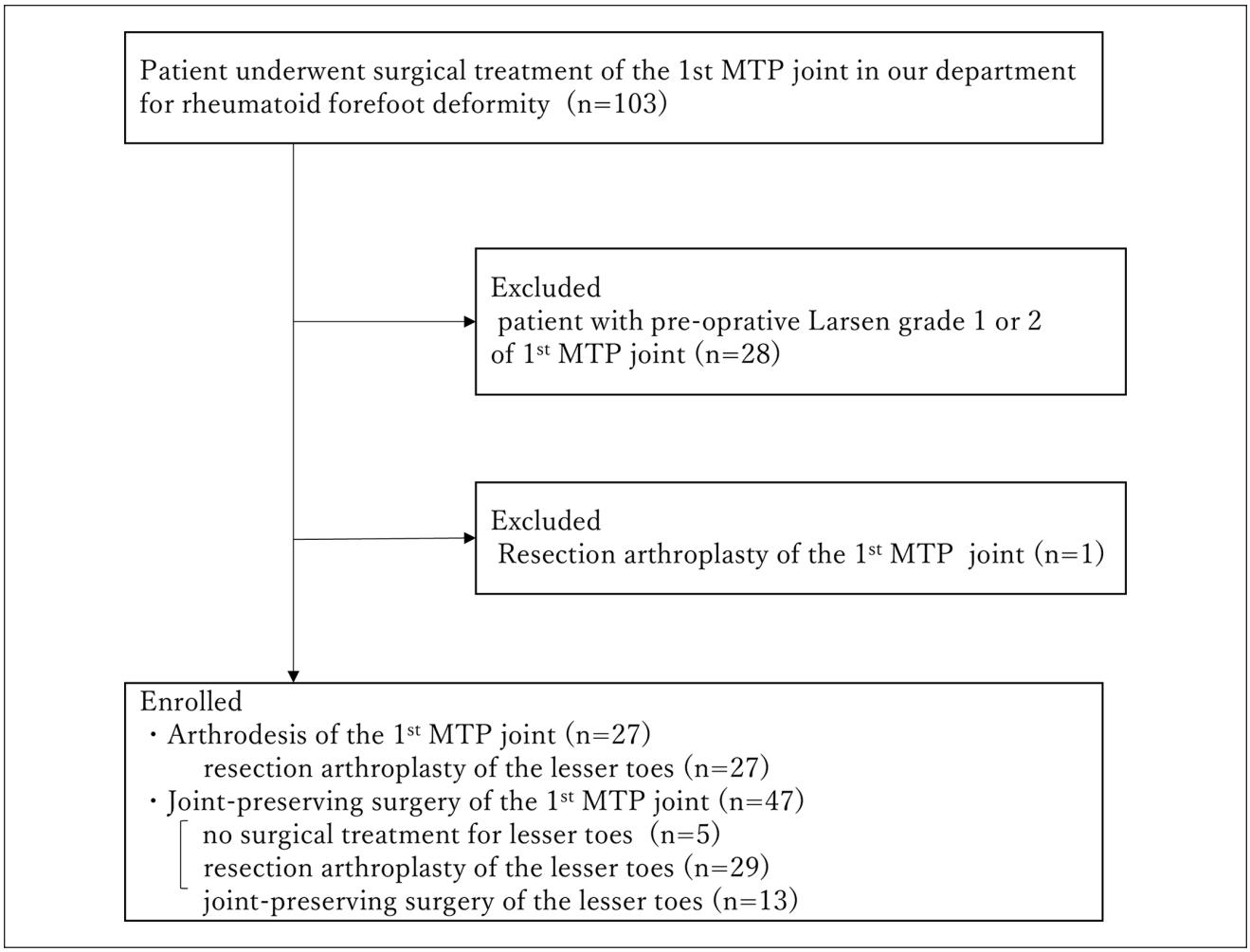

Figure 2. Flow chart, which clarifies the inclusion and exclusion criteria.

IV, osseous ankylosis.[35,38] This study was approved by the Ethics Committee of Kyushu University Hospital (approval number: 23259-00).

Surgical Procedure

For forefoot deformity associated with HV due to RA, all cases underwent first MTP joint arthrodesis (15 feet) between 2008 and 2011, whereas all cases underwent first MTP joint-preserving surgery (24 feet) between 2018 and 2022. From 2012 to 2017, MTP joint-preserving surgery was performed on 23 feet that met the following criteria: (1) no pain during movement of the first MTP joint, and (2) a preoperative range of motion (dorsiflexion + plantarflexion) of the first MTP joint exceeding 30 degrees. In the remaining cases, resection arthroplasty was performed in conjunction with arthrodesis of the first MTP joint (12 feet).

All arthrodeses of the first MTP joint were performed with resection arthroplasty of the lesser toes. After incising the capsule of the first MTP joint, the articular surfaces were exposed. The proximal phalanx and distal metatarsal were then osteotomized using a microbone saw to facilitate the articular connection of the cancellous surfaces. The great toe was positioned in 15-20 degrees dorsiflexion relative to the axis of the first metatarsal, with neutral rotation and an estimated 10 degrees valgus. Proper alignment was confirmed by applying flat metal surfaces to the heel and the ball of the first metatarsal, simulating a weightbearing position of the foot. The ideal position of the MTP joint was then stabilized with 2 crossed screws (Figure 3, top). Joint-preserving surgery with biplane osteotomy of the first metatarsal for HV deformity was performed as previously reported.[13,44] This procedure involves creating an osteotomy at 2 planes to correct the angulation of the metatarsal. The first plane is typically oriented to correct the sagittal plane deformity, whereas the second plane addresses the coronal or transverse deformities. The medial ridge was excised from the first metatarsal head, the adductor tendon was excised, an osteotomy line was created perpendicular to the first and second metatarsal shafts, and the biplane osteotomy was completed using a

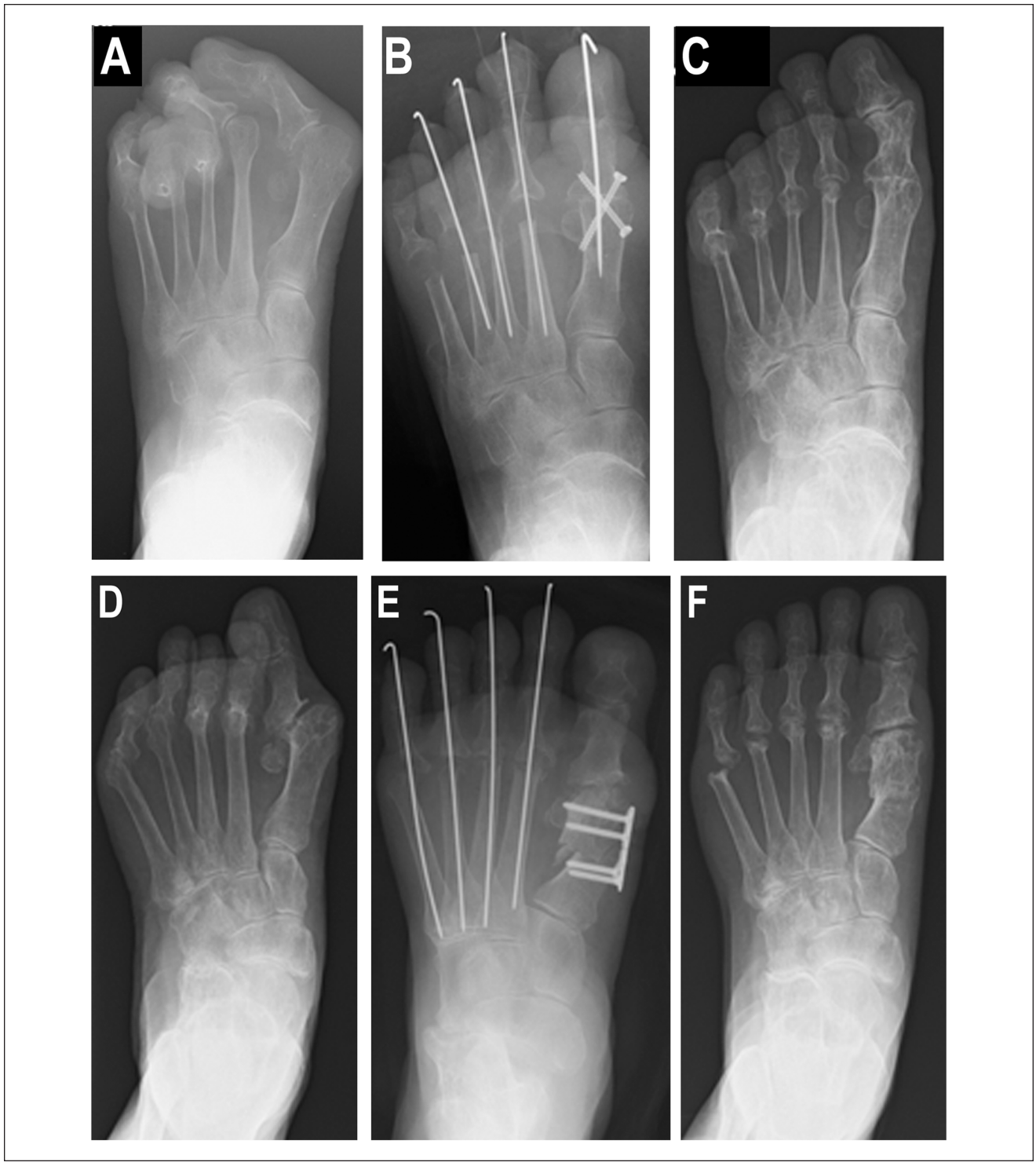

Figure 3. *Top*: Representative preoperative and postoperative radiographs of a 54-year-old woman who underwent arthrodesis of the first metatarsophalangeal (MTP) joint and resection arthroplasty of the lesser toes. (A) The preoperative hallux valgus angle (HVA) was 73 degrees, and the preoperative total Japanese Society for Surgery of the Foot (JSSF) scale score was 52. (B) Radiographs immediately after surgery with arthrodesis of the first MTP joint and resection arthroplasty of the lesser toes. (C) The final HVA was 13 degrees and the final total JSSF scale score was 70. *Bottom*: Representative preoperative and postoperative radiographs of a 73-year-old woman who underwent first MTP joint preservation and resection arthroplasty of the lesser toes (bottom). (D) The preoperative HVA was 38 degrees and the preoperative total JSSF scale score was 34. (E) Radiographs immediately after surgery with the first MTP joint preservation and resection arthroplasty of the lesser toes. (F) The final HVA was 16 degrees, and the final total JSSF scale score was 75.

microbone saw. The distal bone fragment was slid laterally and secured with a locking plate, and then the medial capsule and abductor tendon were sutured (Figure 3, bottom).

In cases of severe HV deformity, a closed wedge osteotomy of the first metatarsal was performed: a wedge-shaped osteotomy was made along the first and second metatarsal shafts as with a biplane osteotomy, and the osteotomy site was stabilized by internal fixation with a plate. In the lesser toe, Weil shortening osteotomy or resection arthroplasty was performed as needed, with resection of the proximal phalanx head and extensor tendon lengthening as appropriate. In a Weil osteotomy of the lesser metatarsal, the distal head bone fragment was displaced, shortened, and fixed with a 2.0-mm cannulated cancellous bone screw. If a bunionette was also present, a sliding oblique metatarsal osteotomy was performed on the fifth metatarsal.[2]

Clinical and Radiographic Evaluation

Clinical outcomes were assessed using the Japanese Society for Surgery of the Foot (JSSF) Hallux scale. This scale ranges from 0 to 100 points and includes 3 items: pain (40 points), function (45 points), and alignment (15 points).[22,31] Higher points indicate better clinical outcome. In this study, anteroposterior and posterior radiographs of the foot in the standing position were analyzed before surgery and at final follow-up; HV deformity was assessed using HV angle (HVA), measured as the angle between the longitudinal direction of the first metatarsal and the proximal phalanx axis, and intermetatarsal (M1M2) angle, measured as the angle between the longitudinal directions of the first and second metatarsals.[5] Recurrent HV was defined radiographically as HVA greater than 20 degrees at the latest follow-up, in accordance with previous reports on forefoot deformity in RA.[9,24,29,44]

Statistical Analysis

Statistical analyses were conducted using JMP Pro version 17 (SAS Institute Inc, Cary, NC). To analyze the differences between the 2 groups, Fisher exact test was used for categorical variables, and the Mann-Whitney *U* test was employed for continuous variables because of their nonparametric distribution. A *P* value of .05 was considered statistically significant.

To assess the effect of first metatarsophalangeal (MTP) joint-preserving surgery on postoperative clinical outcomes, we used a propensity score matching method to minimize selection bias and confounding variables. Propensity scores were calculated using a logistic regression model that included the following covariates: age, sex, disease duration, methotrexate use, and preoperative function as reflected by the JSSF Hallux scale. Matching was performed using a nearest-neighbor algorithm with a caliper width set at ±0.20 SDs of the propensity score, ensuring that matched pairs had similar baseline characteristics. This approach allowed us to create balanced groups for a more accurate comparison of postoperative outcomes between patients who underwent joint-preserving surgery and those who underwent joint fusion.

Result

Table 1 presents the demographic characteristics of this study. Of the 74 cases, 27 feet underwent arthrodesis of the first MTP joint, whereas 47 feet were treated with joint-preserving surgery. All patients who underwent arthrodesis also underwent resection arthroplasty of the second to fifth MTP joints. In the joint-preserving group, 5 patients underwent surgery exclusively on the big toe, 29 patients underwent resection arthroplasty of the lesser toes, and 13 patients underwent preservation surgery of the lesser MTP joints. The mean follow-up duration was 3.1 ± 2.5 years. Demographic and clinical characteristics such as age, sex, BMI, and disease duration showed no significant differences between the 2 groups. But the follow-up duration tended to be significantly longer in the arthrodesis group. Regarding medical treatment, there were no significant differences in the use of prednisolone (PSL) or the initiation of biologic agents; however, the rate of methotrexate (MTX) usage was significantly higher in the arthrodesis group, as shown in Table 1.

Regarding forefoot alignment, there were no significant differences in the preoperative metatarsal and M1-M2 angles between the 2 groups. Postoperative correction of the big toe angle was significantly greater in the joint-preserving group, achieving a mean correction to 8 ± 7 degrees immediately after surgery, but this difference was not maintained at the final follow-up, when there was no significant difference between the 2 groups. The rate of those with a final HVA of more than 20 degrees was 30% in both the arthrodesis and the joint-preservation groups (Table 2).

The JSSF Hallux scale indicated a significant improvement in the scores from the preoperative values in both groups. Although there were no significant differences between the groups in terms of pain and alignment scores, the joint-preserving group demonstrated significantly better functional outcomes both preoperatively (22 ± 1 vs 17 ± 8, $P = .01$) and at the final follow-up (31 ± 7 vs 27 ± 8, $P = .01$) (Table 2). A subgroup analysis using propensity score matching was performed in 38 feet of 32 patients (Supplemental Table 1), matched for age, sex, disease duration, history of methotrexate use, and preoperative functional scores on the JSSF Hallux scale. This analysis revealed a significantly greater improvement in the functional scores in the joint-preserving group (32 ± 6 vs 28 ± 8, $P = .04$) (Table 3).

In the joint-preserving group, patients with recurrent deformity had a significantly greater HVA immediately after surgery than those without recurrence (13 ± 6 vs 6 ± 6, $P < .01$). The final JSSF scale showed a significant

Table 1. Characteristics of Patients With RA Forefoot Deformity Who Underwent Surgical Treatment.

	Arthrodesis Group (n = 27)	Joint-Preserving Group (n = 47)	*P* Value[a]
Age at surgery, y, mean ± SD	63 ± 6	65 ± 11	.20
Sex, female, n (%)	26 (96)	45 (96)	>.99
BMI at surgery, mean ± SD	22 ± 2	22 ± 3	.58
Disease duration, y, mean ± SD	21 ± 8	23 ± 12	.95
Steinbrocker stage III or IV, n (%)	26 (96)	39 (83)	.14
Larsen grade 3/4/5, n (%)	6 (22) / 14 (52) / 7 (26)	21 (45) / 21 (45) / 5 (10)	.08
Serum CRP, mg/dL, mean ± SD	0.3 ± 0.3	0.4 ± 0.9	.21
Medical treatment, n (%)			
Methotrexate use	24 (89)	29 (62)	**.02**
Prednisolone use	14 (54)	27 (57)	.81
b/ts DMARD use	8 (30)	17 (36)	.61
With surgery of lessor, n (%)	27 (100)	42 (89)	.08
Joint-preserving surgery in lessor, n (%)	0 (0)	13 (31)	<**.01**
Follow-up duration, y, mean ± SD	5.1 ± 2.6	2.4 ± 2.0	<**.01**

Abbreviations: BMI, body mass index; b/tsDMARDs, biological/targeting synthetic disease modifying antirheumatic drug; CRP, C-reactive protein; RA, rheumatoid arthritis.
[a]Boldface indicates significance ($P < .05$).

Table 2. Preoperative and Postoperative Radiographic and Clinical Outcomes.

		Arthrodesis Group (n = 27)	Joint-Preserving Group (n = 47)	*P* Value[a]
Radiographic outcomes				
HVA, degrees, mean ± SD				
	Preoperative	52 ± 15	49 ± 13	.41
	Postoperative	14 ± 10	8 ± 7	<**.01**
	Final	17 ± 9	15 ± 14	.79
M1-M2 angle, degrees, mean ± SD				
	Preoperative	14 ± 6	14 ± 5	.60
	Postoperative	10 ± 4	9 ± 4	.12
	Final	9 ± 4	8 ± 5	.07
Final HVA >20 degrees, n (%)		8 (30)	14 (30)	>.99
Clinical outcomes				
Preoperative JSSF Hallux scale, mean ± SD				
Total (0-100 points)		40 ± 17	47 ± 14	.11
Pain (0-40 points)		23 ± 8	23 ± 7	.78
Function (0-45 points)		17 ± 8	22 ± 1	**.01**
Alignment (0-15 points)		1 ± 3	1 ± 3	.11
Final JSSF Hallux scale, mean ± SD				
Total (0-100 points)		74 ± 15	80 ± 11	.15
Pain (0-40 points)		34 ± 6	36 ± 5	.35
Function (0-45 points)		27 ± 8	31 ± 7	**.01**
Alignment (0-15 points)		13 ± 4	13 ± 3	.44

Abbreviations: HVA, hallux valgus angle; JSSF, Japanese Society for Surgery of the Foot.
[a]Boldface indicates significance ($P < .05$).

decrease in alignment (12 ± 4 vs 14 ± 3, $P = .03$) and a trend toward decreased function (30 ± 7 vs 32 ± 6, $P = .33$) in the recurrent group compared with the nonrecurrent group, with comparable improvement in pain (36 ± 5 vs 35 ± 6, $P = .97$). Finally, there was no significant difference in the total JSSF scale between the recurrent and nonrecurrent groups (77 ± 12 vs 81 ± 11, $P = .34$) (Table 4 and Supplemental Table 2).

Table 3. Preoperative and Postoperative Radiographic and Clinical Analysis by the Propensity Score–Matching Method.

		Arthrodesis Group (n = 19)	Joint-Preserving Group (n = 19)	*P* Value[a]
Radiographic analysis				
HVA, degrees, mean ± SD				
	Preoperative	57 ± 13	51 ± 14	.34
	Postoperative	12 ± 9	8 ± 6	**.03**
	Final	16 ± 8	13 ± 12	.43
M1-M2 angle, degrees, mean ± SD				
	Preoperative	14 ± 6	14 ± 5	.60
	Postoperative	10 ± 4	9 ± 4	.12
	Final	9 ± 4	8 ± 5	.07
Final HVA >20 degrees, n (%)		4 (22)	6 (30)	.71
Clinical analysis				
Preoperative JSSF Hallux scale, mean ± SD				
Total (0-100 points)		43 ± 18	41 ± 12	.38
Pain (0-40 points)		23 ± 9	21 ± 9	.07
Function (0-45 points)		19 ± 9	20 ± 7	.71
Alignment (0-15 points)		1 ± 3	1 ± 3	.35
Final JSSF Hallux scale, mean ± SD				
Total (0-100 points)		75 ± 15	80 ± 10	.31
Pain (0-40 points)		34 ± 6	35 ± 5	.44
Function (0-45 points)		28 ± 8	32 ± 6	**.04**
Alignment (0-15 points)		14 ± 4	13 ± 3	.50

Abbreviations: HVA, hallux valgus angle; JSSF, Japanese Society for Surgery of the Foot.
[a]Boldface indicates significance ($P < .05$).

Table 4. Comparison of Radiographic and Clinical Evaluation Between the Groups With Final HVA >20 Degrees and HVA ≤20 Degrees in the Joint-Preserving Group.

		Final HVA > 20 Degrees (n = 14)	Final HVA ≤ 20 Degrees (n = 33)	*P* Value[a]
Radiographic outcome				
HVA, degrees, mean ± SD				
	Preoperative	49 ± 12	50 ± 14	.85
	Postoperative	13 ± 6	6 ± 6	<**.01**
	Final	31 ± 8	9 ± 10	<**.01**
M1-M2 angle, degrees, mean ± SD				
	Preoperative	15 ± 6	15 ± 4	.73
	Postoperative	10 ± 5	8 ± 4	.12
	Final	9 ± 6	7 ± 4	.18
Clinical outcome				
Preoperative JSSF Hallux scale, mean ± SD				
Total (0-100 points)		43 ± 14	49 ± 13	.19
Pain (0-40 points)		22 ± 9	24 ± 5	.61
Function (0-45 points)		20 ± 8	24 ± 8	.17
Alignment (0-15 points)		1 ± 3	1 ± 3	.76
Final JSSF Hallux scale, mean ± SD				
Total (0-100 points)		77 ± 12	81 ± 11	.34
Pain (0-40 points)		36 ± 5	35 ± 6	.97
Function (0-45 points)		30 ± 7	32 ± 6	.44
Alignment (0-15 points)		12 ± 4	14 ± 3	**.03**

Abbreviations: HVA, hallux valgus angle; JSSF, Japanese Society for Surgery of the Foot.
[a]Boldface indicates significance ($P < .05$).

Discussion

In this study, we retrospectively compared the effect of arthrodesis or joint-preserving surgery of the first MTP joint in patients with rheumatoid arthritis. There was no significant difference in the rate of HVA >20 degrees at the final follow-up between the arthrodesis and joint-preservation groups, and the score on the JSSF scale at the final follow-up was also not significantly different, whereas it was significantly higher in the joint-preservation group for "function." Owing to possible differences in background factors, the groups were divided by the propensity matching score, but the arthrodesis and joint-preservation procedures were still comparable and outperformed the postoperative "function" scale.

Arthrodesis of the first MTP joint has been widely adopted for managing forefoot deformities in RA, offering a high rate of bone fusion and effectively alleviating pain while preventing lateral toe deformities, regardless of severity.[16] Conventionally, the combination of MTP joint arthrodesis of the hallux and resection arthroplasty of the lesser has been regarded as the first choice for forefoot deformities in RA, especially severe destruction of the joint.[15,19,40,45] However, this approach has several disadvantages: it reduces the range of motion of the first MTP joint, there may be nonunion, and adjacent joint disorder can occur at the interphalangeal joint.[3,18,34,42] With the advent of biologic agents, the progression of bone erosion in RA has been substantially controlled, leading to an increase in reports of joint-preserving surgeries.[13,39,47,48] These procedures are particularly advantageous as they preserve the range of motion of the MTP joint, thereby allowing patients to maintain the push-off function during walking, which is crucial for overall mobility and quality of life.[17]

Joint-preserving surgery has been shown to be superior to conventional methods primarily involving joint fusion, with multiple studies reporting significant improvements in functional outcomes.[1,24,47,48] Several studies[13,19,24] demonstrated notable enhancements in the JSSF functional scale when comparing first MTP joint fusion surgery with joint-preserving surgery. As previously reported, a high preoperative Larsen classification had no significant effect on postoperative function in joint-preserving surgeries, supporting the notion that preserving joint integrity may be beneficial even in cases of advanced joint destruction.[9,24] To minimize the influence of preoperative foot function, we employed propensity score matching to examine 38 matched cases, revealing that joint-preserving surgery had clinical results comparable to those of arthrodesis, even for severe arthropathic destruction. Notably, the joint-preserving group demonstrated superior results in the functional subscale compared with the arthrodesis group. Laroche et al[25] investigated the relationship between kinematic parameters and the MTP joint range of motion during gait in patients with RA and found that the dorsiflexion range of motion was positively correlated with the stride length and walking speed and negatively correlated with the knee and hip range of motion during walking. These findings suggest that preserving the MTP joint may confer significant benefits to gait function. Thus, joint-preserving surgery for advanced cases with a high Larsen classification may yield comparable or superior outcomes to joint fusion surgeries.

The recurrence of HV is a notable concern after surgical correction, especially in joint-preserving surgery for RA patients. Previous reports have shown that the recurrence rate of joint-preserving surgery was 16% to 26% for HV with severe joint destruction.[24,39] In our study, postoperative HVA greater than 20 degrees was seen in 30% of cases. This high recurrence rate may have been due to our study group including cases of advanced joint destruction and deformity, including Larsen grade 5. However, as shown in Supplemental Table 2, there was no significant difference between the Larsen grade 3-5 in HV recurrence and non-recurrence groups. The proportion of b/tsDMARDs use was low in the recurrent group, and it is possible that control of disease activity with b/tsDMARDs influences recurrence, in fact, b/tsDMARDs have effect of prevention for joint destruction.[41] Furthermore, severe HV deformity has been reported to lead to lower foot health scores.[27] The recurrent cases had severe preoperative HV deformity in this study, and the clinical score may have improved because HVA was improved compared with that preoperatively. In this study, 8 patients in the arthrodesis group had a final HVA of more than 20 degrees. The original HV deformity was severe, and there was a possibility of loss of correction immediately after surgery (Supplemental Table 3). In addition, it has been reported that arthrodesis in RA results in higher nonunion than arthrodesis in non-RA patients[8] and RA patients have poorer bone quality,[36] and there was a possibility of loss of correction after fixation because of the time required for bone union and poor bone quality. Furthermore, reports comparing cross-screw and plate fixation for arthrodesis found that plate fixation was superior,[6,14] and recurrences in RA with screw fixation have also been reported.[20] Dorsal plate fixation may have been able to suppress recurrence of HV.

This study has some limitations. First, it was conducted at a single institution and was retrospective in nature, which may have introduced patient bias. Because the transition from conventional methods to joint-preserving approaches occurred around 2012, the subject group's historical context may have contributed to selection bias related to the treatment background. Therefore, we compared the 2 groups using propensity score matching. Second, patient backgrounds may have been different. Until 2012, all patients underwent arthrodesis, and from 2017 onward, all patients underwent joint preservation. From 2013 to 2016, patients were selected, and total preoperative JSSF functional scores in the joint-preserving group were also good. To unify these

backgrounds, the propensity matching score described above was used to unify the backgrounds (Supplemental Table 1) and then the analysis was performed. However, we did have a relatively large difference in time to follow-up that must be considered when interpreting the data. The length of follow-up in the arthrodesis group (5.1 ± 2.6 years) was about twice that of the joint-preserving group (2.4 ± 2.0 years, $P < .01$). Third, this study analyzed only a small number (n = 52) of RA patients from a single institution. However, this study had the strength that it involved comparison of the clinical outcomes of arthrodesis and joint preservation of the first MTP joint with advanced destruction using propensity matching scores to match patient backgrounds. Even with this method, the JSSF scale was equivalent, and joint-preserving surgery can be said to be a valid option that can achieve the same therapeutic effect as arthrodesis. This study provides robust support for recent research advocating joint-preserving surgery in cases of severe joint destruction caused by rheumatoid arthritis (Larsen grade 3 or higher).

Conclusion

This study compared the results of arthrodesis and joint-preserving surgery of the first MTP joint in patients with advanced rheumatoid forefoot deformity. Postoperative recurrence was slightly more common, but there was no clear difference in the clinical evaluation between the arthrodesis and joint-preserving groups with different average periods of follow-up. Even when patient backgrounds were matched using the propensity score matching, joint-preserving surgery demonstrated significant improvement over arthrodesis in the functional subscale, suggesting that joint-preserving surgery can be a viable treatment option for patients with severe joint destruction, comparable to arthrodesis.

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Ethical Approval

Ethical approval for this study was obtained from the Kyushu University Institutional Review Board (approval number: 23259-00). The study was conducted in accordance with the Declaration of Helsinki.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article. Disclosure forms for all authors are available online.

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Supplemental Table 1. Characteristics of Patients With RA Forefoot Deformity After the Propensity Score Matching Method.

	Arthrodesis Group (n = 19)	Joint-Preserving Group (n = 19)	*P* Value[a]
Age at surgery, y, mean ± SD	64 ± 7	60 ± 12	.40
Sex, female, n (%)	18 (95)	18 (95)	>.99
BMI at surgery mean ± SD)	21 ± 2	22 ± 3	.47
Disease duration, y mean ± SD	22 ± 8	21 ± 11	.40
Steinbrocker stage III/IV, n (%)	18 (95)	15 (79)	.18
Larsen grade 3/4/5, n (%)	3 (16) / 11 (58) / 5(26)	9 (47) / 7(37) / 3(16)	.11
Serum CRP, mg/dL, mean ± SD	0.3 ± 0.3	0.4 ± 0.8	.23
Medical treatment, n (%)			
Methotrexate use	16 (84)	17 (89)	.63
Prednisolone use	11 (58)	12 (63)	.74
b/ts DMARD use	7 (37)	7 (37)	>.99
With surgery of lessor, n (%)	19 (100)	19 (100)	>.99
Joint-preserving surgery in lessor, n (%)	0 (0)	6 (32)	<**.01**
Follow-up duration, y, mean ± SD	4 ± 3	2 ± 1	.11

Abbreviations: BMI, body mass index; b/tsDMARDs, biological/targeting synthetic disease modifying antirheumatic drug; CRP, C-reactive protein; HVA, hallux valgus angle; RA, rheumatoid arthrosis.
[a]Boldface indicates significance ($P < .05$).

Supplemental Table 2. Characteristics of Patients With RA in Final HVA≤20 and Final HVA>20 Group in Joint-Preserving Group.

	Final HVA > 20 degrees (n = 14)	Final HVA ≤ 20 degrees (n = 33)	*P* Value[a]
Age at surgery, y, mean ± SD	68 ± 7	63 ± 12	.33
Sex, female, n (%)	13 (93)	32 (97)	.52
BMI at surgery mean ± SD)	21 ± 3	22 ± 3	.40
Disease duration, y mean ± SD	22 ± 10	23 ± 12	.96
Steinbrocker stage III/IV, n (%)	13 (93)	26 (79)	.28
Larsen grade 3/4/5, n (%)	6 (43)/ 6 (43)/ 2(14)	16 (49)/ 14(42)/ 3(9)	.85
Serum CRP, mg/dL, mean ± SD	0.7 ± 1.4	0.3 ± 0.6	.94
Medical treatment, n (%)			
Methotrexate use	8 (57)	21 (64)	.68
Prednisolone use	9 (64)	18 (55)	.54
b/ts DMARD use	2 (14)	15 (45)	**.04**
With surgery of lessor, n (%)	12 (86)	31 (94)	.36
Joint-preserving surgery in lessor, n (%)	2 (17)	11 (35)	.40
Follow-up duration, y, mean ± SD	3 ± 2	3 ± 2	.46

Abbreviations: BMI, body mass index; b/tsDMARDs, biological/targeting synthetic disease modifying antirheumatic drug; CRP, C-reactive protein; HVA, hallux valgus angle; RA, rheumatoid arthrosis.
[a]Boldface indicates significance ($P < .05$).

Supplemental Table 3. Characteristics of Patients With RA in Final HVA≤20 and Final HVA>20 Group in the Arthrodesis Group.

	Final HVA > 20 degrees (n = 8)	Final HVA ≤ 20 degrees (n = 19)	*P* Value[a]
Age at surgery, y, mean ± SD	61 ± 4	64 ± 7	.21
Sex, female, n (%)	8 (100)	18 (95)	.51
BMI at surgery mean ± SD)	21 ± 2	22 ± 2	.28
Disease duration, y mean ± SD	20 ± 9	22 ± 8	.73
Steinbrocker stage / , n (%)	7 (88)	19 (100)	.11
Larsen grade 3/4/5, n (%)	3 (38)/ 4 (50)/ 1(12)	2 (10)/ 11(58)/ 6(32)	.22
Serum CRP, mg/dL, mean ± SD	0.3 ± 0.2	0.3 ± 0.3	.58
Medical treatment, n (%)			
Methotrexate use	8 (100)	16 (84)	.23
Prednisolone use	5 (63)	9 (50)	.56
b/ts DMARD use	1 (13)	7 (37)	.21
Radiographic outcome			
HVA, degrees, mean ± SD			
Preoperative	49 ± 10	54 ± 17	.35
Postoperative	24 ± 9	9 ± 7	**<.01**
Final	28 ± 5	12 ± 5	**<.01**
M1-M2 angle, degrees, mean ± SD			
Preoperative	14 ± 3	15 ± 7	.98
Postoperative	11 ± 2	10 ± 1	.24
Final	9 ± 4	9 ± 5	.98
Clinical outcome			
Preoperative JSSF Hallux scale, mean ± SD			
Total (0-100 points)	43 ± 14	49 ± 13	.19
Pain (0-40 points)	22 ± 9	24 ± 5	.61
Function (0-45 points)	20 ± 8	24 ± 8	.17
Alignment (0-15 points)	1 ± 3	1 ± 3	.76
Final JSSF Hallux scale, mean ± SD			
Total (0-100 points)	77 ± 12	81 ± 11	.34
Pain (0-40 points)	36 ± 5	35 ± 6	.97
Function (0-45 points)	30 ± 7	32 ± 6	.44
Alignment (0-15 points)	12 ± 4	14 ± 3	**.03**
Follow-up duration, y, mean ± SD	4 ± 3	5 ± 3	.71

Abbreviations: BMI, body mass index; b/tsDMARDs, biological/targeting synthetic disease modifying antirheumatic drug; CRP, C-reactive protein; HVA, hallux valgus angle; JSSF, Japanese Society for Surgery of the Foot; RA, rheumatoid arthrosis.
[a]Boldface indicates significance ($P < .05$).