Patient-Reported and Radiographic Outcomes of Joint-Preserving Surgery for Rheumatoid Forefoot Deformities: A Retrospective Case Series with Mean Follow-up of 6 Years

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Patient-Reported and Radiographic Outcomes of Joint-Preserving Surgery for Rheumatoid Forefoot Deformities

A Retrospective Case Series with Mean Follow-up of 6 Years

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Background: Rheumatoid arthritis (RA) is an autoimmune disorder and a chronic inflammatory disease that can damage joints throughout the body. As dramatic improvements in medical treatment have contributed to reduced progression of joint destruction, surgical methods for the treatment of RA-related forefoot deformities have gradually changed from joint-sacrificing to joint-preserving. The aim of this study was to assess the long-term outcomes, including patient-reported outcomes, of joint-preserving surgery for forefoot deformities associated with RA.

Methods: This retrospective study included 105 feet in 89 patients with RA who were treated during the period of January 2012 to May 2015 and had a minimum of 5 years of follow-up (mean, 6.0 ± 0.9 years). The patient-reported outcome measure used was the Self-Administered Foot Evaluation Questionnaire (SAFE-Q), which was completed preoperatively and at the latest follow-up (n = 53 feet). The hallux valgus angle (HVA), the intermetatarsal angle (IMA), and the position of the medial sesamoid were measured preoperatively, at 3 months postoperatively, and at the latest follow-up. Cases of delayed wound-healing, hallux valgus recurrence, nonunion at the osteotomy sites, and reoperation were recorded. Kaplan-Meier survival curves were used to determine the estimated survivorship, with reoperation as the end point.

Results: Scores of all 5 subscales of the SAFE-Q demonstrated significant improvement at the latest follow-up. The average HVA and IMA decreased significantly 3 months postoperatively, and these measurements remained significantly lower than the preoperative values ($p < 0.01$). The position of the medial sesamoid at the latest follow-up improved significantly ($p < 0.01$). Delayed wound-healing was found at the site of surgery in 21 (20.0%) of the 105 feet. Recurrence of hallux valgus was observed in 11 (10.5%) of the feet. There was no case of nonunion at any osteotomy site. Eleven (10.5%) of the feet required reoperation. The estimated survivorship of the studied joint-preserving surgery at 7 years, with reoperation as the end point, was 89.5%.

Conclusions: Satisfactory long-term patient-reported and radiographic outcomes after joint-preserving surgery for forefoot deformities associated with RA can be achieved.

Level of Evidence: Therapeutic Level IV. See Instructions for Authors for a complete description of levels of evidence.

Rheumatoid arthritis (RA) is an autoimmune disorder and a chronic inflammatory disease that can damage multiple joints throughout the body. Even though, in 1 study, 75% of the patients with RA achieved low disease activity with recent dramatic improvements in medical treatment[1], the proportion of patients who have any current symptoms in the foot or ankle joints is still high[2]. When nonoperative therapies for forefoot deformities in patients

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with RA fail, a variety of surgical procedures are considered. As patients with low disease activity should have reduced progression of joint destruction, surgical procedures for forefoot deformities in patients with RA have gradually changed from joint-sacrificing surgery, such as arthrodesis and resection arthroplasty, to joint-preserving surgery[3-11]. In the current study, our aim was to assess long-term outcomes, including patient-reported outcomes, of joint-preserving surgery for forefoot deformities in patients with RA.

Materials and Methods

This study was approved by our institutional review board. We employed a retrospective observational design to analyze the clinical and radiographic outcomes of patients with RA who underwent joint-preserving surgery with a minimum of 5 years of follow-up.

From January 2012 to May 2015, a total of 222 feet in 173 patients with RA who had symptomatic forefoot deformity, who had not undergone previous surgical intervention, and who did not respond to nonoperative therapy were treated at our institution. Among them, 128 feet in 108 patients with RA were treated with a proximal rotational closing-wedge osteotomy of the first metatarsal[11] and modified shortening oblique osteotomies of the lesser metatarsals[12] by or under the supervision of 2 staff surgeons who had extensive experience in rheumatoid foot surgeries. The inclusion criteria for undergoing osteotomies of the first metatarsal and the lesser metatarsals were the presence of symptomatic forefoot deformity, with an intermetatarsal angle (IMA) of >10°, and subluxation/dislocation of ≥1 lesser metatarsophalangeal joint (MTPJ). Conversely, the exclusion criteria were severe destruction (e.g., Larsen grade V[13]) of the MTPJ. Ultimately, 105 feet in 89 patients were included (Fig. 1). The average duration of follow-up for the entire cohort was 6.0 years (standard deviation, 0.9 years; range, 5.0 to 7.4 years). All conventional synthetic disease-modifying anti-rheumatic drugs (DMARDs) were continued throughout the perioperative period. Biologic DMARDs were withheld for 1 to 4 weeks prior to surgery and were restarted 2 weeks postoperatively.

Surgical Technique

Joint-preserving surgery was performed and included a proximal rotational closing-wedge osteotomy of the first metatarsal and modified shortening oblique osteotomies of the lesser metatarsals (Figs. 2 through 5), as previously described[11,12].

Clinical Evaluation

Clinical information was abstracted from medical records, self-administered questionnaires, and face-to-face interviews. The patients submitted their patient-reported outcome measure (PROM) 1 day preoperatively and annually postoperatively. A

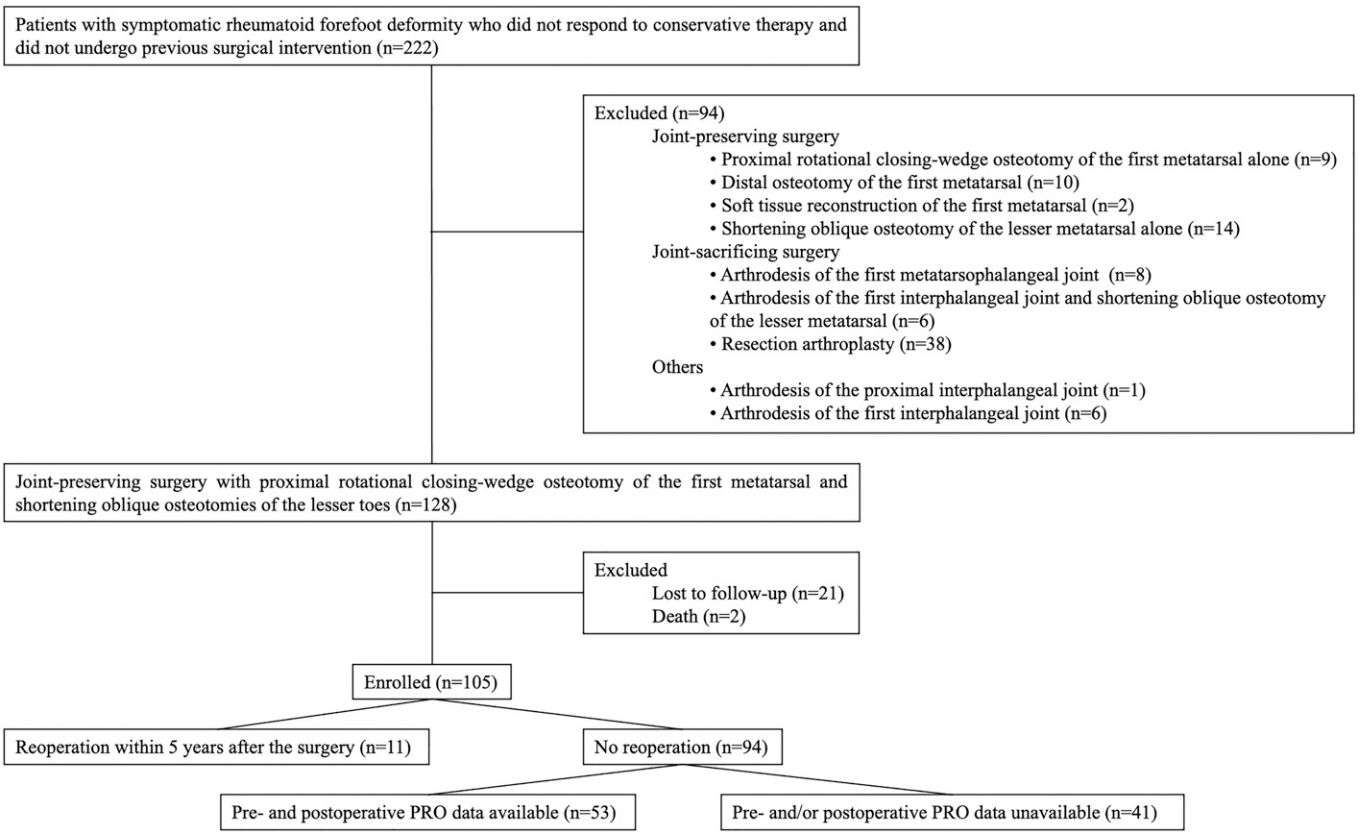

Fig. 1

Flow diagram showing the enrollment process. The values shown are the number of feet. PRO = patient-reported outcome.

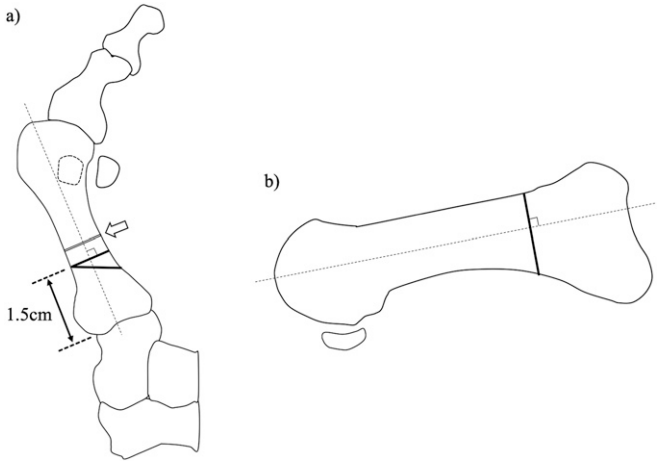

Fig. 2

Illustrations of the proximal rotational closing-wedge osteotomy of the first metatarsal. **Fig. 2-A** Anteroposterior view of the first ray. After releasing the adductor tendon and transverse metatarsal ligament, we exposed the base of the first metatarsal. A closing-wedge osteotomy of the proximal part of the first metatarsal bone was performed. The medial tip of the wedge was 1.5 cm distal to the metatarsocuneiform joint and vertical to the axis of the first metatarsal. The first metatarsal was shortened as necessary by resecting the distal end of the wedge (white arrow). **Fig. 2-B** Lateral view of the first metatarsal. The osteotomy was performed vertical to the axis of the first metatarsal to prevent secondary displacement in the sagittal plane. After abducting and rotating the distal fragment of the first metatarsal until the nail of the great toe turned to the ceiling, we performed crossed Kirschner wire fixation at the osteotomy site. After creating a shaping flap valve incision on the medial capsule of the first metatarsophalangeal joint, the medial eminence was resected as needed. The capsule was then repaired while holding the hallux in correct alignment. The wires were removed only at the request of the patient after surgery. Postoperatively, patients were allowed to walk, bearing weight on their heels. Full weight-bearing was encouraged 8 weeks postoperatively.

medical assistant digitized the data, and K.Y. maintained them. Patients who missed the follow-up were asked by telephone to visit our institute for evaluation.

The PROM instrument used was the Self-Administered Foot Evaluation Questionnaire (SAFE-Q)[14,15]. The SAFE-Q was developed as a region-specific measurement tool by the Japanese Society for Surgery of the Foot that has been reported to have good validity and responsiveness for patients with RA[16]. The main part of the SAFE-Q consists of 34 questions with 5 subscale scores: "pain and pain-related," "physical functioning and daily living," "social functioning," "shoe-related," and "general health and well-being." Because SAFE-Q data were collected starting in 2013, after the instrument was first published, subjects enrolled prior to 2013 did not have PROM evaluation.

Radiographic Evaluation

Standard anteroposterior radiographs of the foot under weight-bearing conditions were analyzed preoperatively, at 3 months postoperatively, and at the latest follow-up.

The hallux valgus angle (HVA) and IMA were measured on anteroposterior radiographs with full weight-bearing, as described elsewhere[17]. We used the classification of medial sesamoid displacement as described by Hardy and Clapham to estimate the internal rotation of the first metatarsal, as the lateral shift of the sesamoids and internal rotation of the first metatarsal occur simultaneously with severe hallux valgus[18]. K.Y. and H.T. performed unblinded radiographic assessments, and the values measured by K.Y. were used in this study. The intraclass correlation coefficient values for interobserver reliability were 0.95 for the HVA and 0.85 for the IMA. To define radiographic recurrence of hallux valgus impacting PROMs, we assessed the relationship between SAFE-Q scores and an increase in the HVA of > 5°, >10°, and >15° at the latest follow-up compared with the angle at 3 months postoperatively. Hallux varus was defined as an HVA of <0°.

Complications

Each surgeon recorded all complications in the patients' medical records, with complications of interest including delayed wound-

Fig. 3

Photograph of the location of the skin incisions. For the first ray, a dorsomedial incision was made, beginning at the metatarsophalangeal joint and ending at the metatarsocuneiform joint. For the second through fourth rays, a lazy-S-shaped dorsal incision was made, beginning at the base of the second proximal phalanx, passing over the third metatarsal, and ending at the base of the fourth metatarsal. For the fifth ray, a vertical incision was made beginning at the metatarsophalangeal joint and ending at the proximal third of the fifth metatarsal.

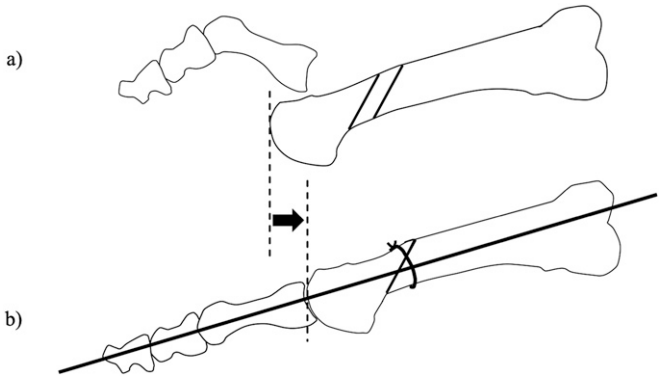

Fig. 4

Illustrations of the modified method used for the shortening oblique osteotomies of the lesser metatarsals. **Fig. 4-A** After cutting the metatarsal neck twice in a parallel manner, we removed the bone fragment. The amount of shortening was limited to ≤10 mm. When a dorsiflexion contracture persisted, the extensor digitorum brevis tendons, the dorsal aspect of the capsule, and the collateral ligaments were progressively released, and/or Z-plasty lengthening of the extensor digitorum longus tendons was performed. **Fig. 4-B** After verifying that it was possible to reduce the dislocation, we temporarily fixed the metatarsophalangeal joints and the osteotomy sites using a single Kirschner wire for each toe. Moreover, the osteotomy sites were ligated with sutures to gain better bone-on-bone contact. The black arrow indicates shortening of the metatarsal.

healing, recurrent lesser MTPJ dislocation and hallux valgus, hallux varus, painful plantar forefoot callosity, nonunion at the osteotomy sites, and reoperation; K.Y. obtained this information from the medical records. When the frequency of a complication exceeded 10%, SAFE-Q scores were compared between cases with and without these complications.

Statistical Methods

We used the Wilcoxon signed rank-sum test to compare the preoperative and postoperative SAFE-Q scores and radiographic values. The distribution-based minimal clinically important difference (MCID) was estimated by calculating 50% of the standard deviation of the change between preoperative and postoperative scores in this patient population[19]. The Mann-Whitney U test was used to compare 2 independent groups. The Fisher exact test was used to compare the categorized data. Kaplan-Meier survival curves with 95% confidence intervals were employed to determine the estimated survivorship, with reoperation as the end point. The level of significance was set at $\alpha = 0.05$. Statistical analyses were performed using the R software package (The R Project for Statistical Computing).

Results

The demographic characteristics of the patients ultimately included in this study and those lost to follow-up are shown in Table I. Age at surgery and the 28-joint Disease Activity Score were significantly lower, and the disease duration was significantly shorter, among the patients lost to follow-up compared with the included patients. A significant difference was not demonstrated for other variables.

Eleven patients (11 feet) required reoperation before the 5-year follow-up, and the preoperative SAFE-Q scores were not available for 40 patients (41 feet), including 32 patients (32 feet) who were enrolled in the study before PROM data were collected. Pre- and postoperative SAFE-Q scores were available for 48 patients (53 feet) (Fig. 1). Scores of all 5 subscales improved significantly at the latest follow-up (Table II). The improvement in scores for the 5 subscales was above MCID estimates.

As shown in Figure 6, the average HVA and IMA decreased significantly 3 months postoperatively. Although the angles at the latest follow-up increased significantly compared with those 3 months postoperatively, they remained significantly lower than the preoperative values ($p < 0.01$). The position of the medial sesamoid at the latest follow-up improved significantly ($p < 0.01$). The average number of lesser toes operated on was 3.4 per foot.

We looked at those with an increase in the HVA of ≤5° versus >5°, ≤10° versus >10°, and ≤15° versus >15°. Significant improvement in all subscales of the SAFE-Q was found for the group with an increase in the HVA of ≤5°, and significant improvement in 3 subscales (pain and pain-related, shoe-related, and general health and well-being) was noted for the group with an increase in the HVA of >5°. Similarly, significant improvement in all subscales of the SAFE-Q was found for the group with an increase in the HVA of ≤10°, and significant improvement in 2 subscales (pain and pain-related and social functioning) was noted for the group with an increase in the HVA of >10°. However, while significant improvement in all subscales of the SAFE-Q was found for the group with an increase in the HVA of ≤15°, the group with an increase in the HVA of >15° did not demonstrate significant improvement in any subscale (data not shown). On the basis of these results, recurrent hallux valgus was defined as an increase in the HVA of >15° at the latest follow-up compared with 3 months postoperatively.

The Akin procedure for the first proximal phalanx or arthrodesis of the first interphalangeal joint was performed in 4 (3.8%) of the 105 feet. Arthrodesis of the proximal interphalangeal joints of the lesser toes was performed in 4 feet (3.8%). Z-plasty lengthening of the extensor digitorum longus tendons (EDLs) for ≥1 lesser toe was performed in 31 feet (29.5%). Scores of 2 of the 5 SAFE-Q subscales (physical functioning and daily living, and shoe-related) at the latest follow-up were significantly lower for patients with, versus those without, Z-plasty lengthening (data not shown).

Delayed wound-healing was found at the site of surgery in 21 (20.0%) of the 105 feet. All wounds healed after nonoperative treatment. Recurrence of hallux valgus was observed in 11 (10.5%) of the feet. Hallux varus deformity developed in 4 (3.8%) of the feet. Recurrent lesser MTPJ dislocation was found in 24 joints (7.7%). Painful callosities occurred or remained in 16 (17.0%) of the 94 feet without reoperation. Scores

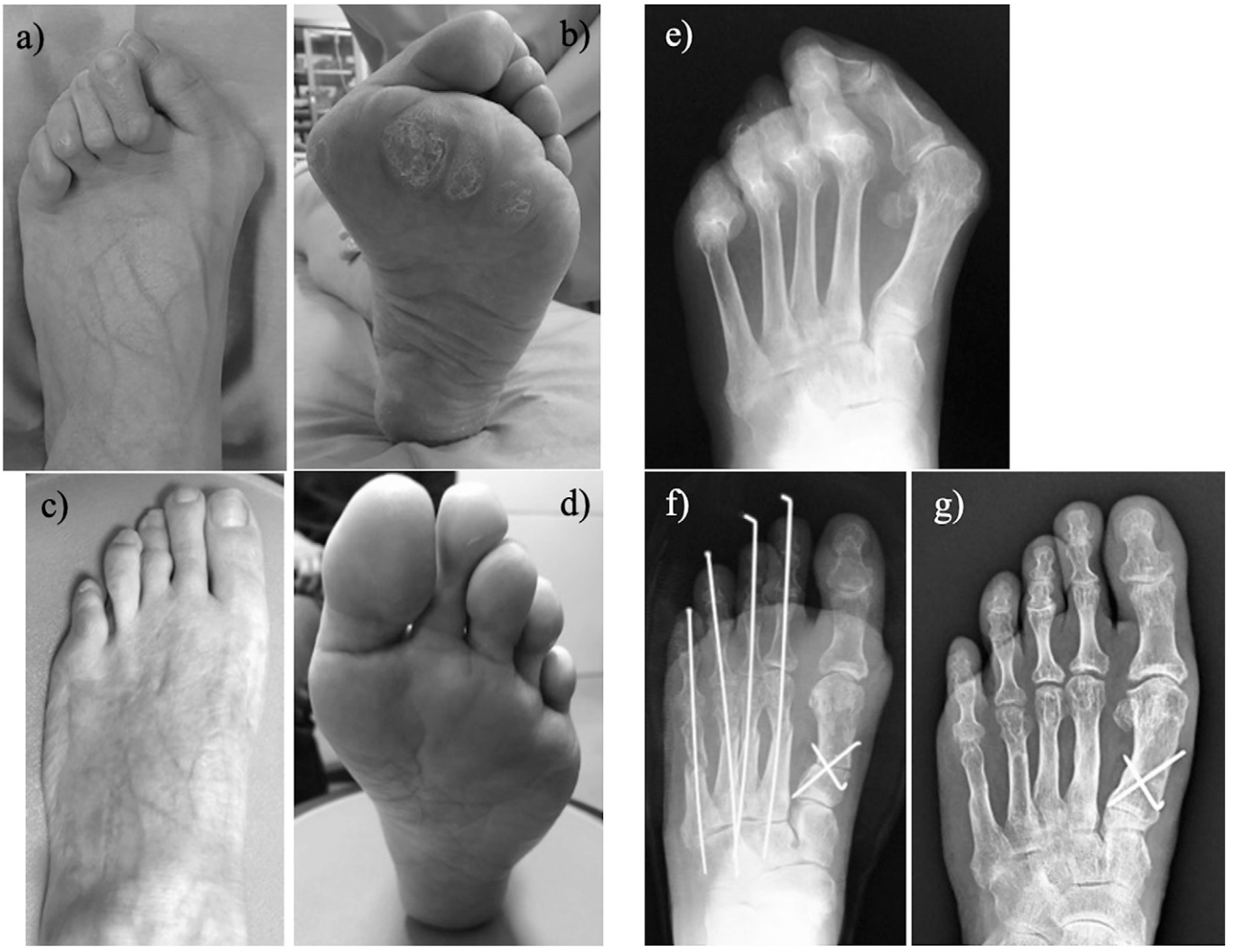

Fig. 5

Images from the case of a 59-year-old woman treated with a rotational closing-wedge osteotomy of the first metatarsal and distal shortening oblique osteotomies of the second through the fifth metatarsals, including photographs of the left foot preoperatively (**Figs. 5-A and 5-B**) and at the latest follow-up (**Figs. 5-C and 5-D**) and anteroposterior radiographs of the foot under weight-bearing conditions preoperatively (**Fig. 5-E**), 3 months postoperatively (**Fig. 5-F**), and at the latest follow-up (**Fig. 5-G**).

of 3 of the 5 subscales of the SAFE-Q were significantly lower at the latest follow-up for patients with painful callosity compared with those without painful callosity (Table III). There was no nonunion at any osteotomy site including of the lesser metatarsals. Reoperation was needed in 11 (10.5%) of the feet (Table IV). The estimated survivorship of this joint-preserving surgery at 7 years, with reoperation as the end point, was 89.5% (Fig. 7).

Discussion

To our knowledge, this is the largest series in which multiple outcomes of joint-preserving surgery for rheumatoid forefoot deformities were evaluated. Our analysis showed that PROM scores and radiographic outcomes were satisfactory at a mean long-term follow-up of 6.0 years. Although the rates of recurrent lesser MTPJ dislocation, hallux varus, and nonunion were low, delayed wound-healing, recurrence of hallux valgus, and painful callosity occurred in up to 20% of the cases. PROMs demonstrated less improvement in patients with recurrent hallux valgus, defined as an increase in the HVA of >15°. The estimated survivorship of this joint-preserving surgery at 7 years, with reoperation as the end point, was 89.5%.

The joint-preserving surgery was associated with improvement in the median scores of all 5 subscales of the SAFE-Q in comparison with preoperative values. Other authors have described postoperative SAFE-Q scores after joint-preserving surgeries for patients with RA[5,6,20]. Ebina et al. compared postoperative and preoperative scores of the SAFE-Q after joint-preserving surgery, reporting that all 5 subscales of the

TABLE I Characteristics of Included Cases and Cases Lost to Follow-up*

	Included Cases (N = 105)	Lost to Follow-up (N = 23)	P Value†
Age† *(yr)*	62.0 (56.0, 67.0)	52.0 (44.5, 60.0)	0.006
Female sex *(no. [%])*	104 (99.0%)	21 (91.3%)	0.08
Disease duration† *(yr)*	18.0 (14.0, 24.0)	14.0 (9.0, 18.8)	0.047
DAS28-ESR†	3.1 (2.5, 4.3)	2.2 (2.1, 3.1)	0.044
PSL use *(no. [%])*	44 (41.9%)	9 (39.1%)	0.82
PSL dose† *(mg/day)*	0 (0, 3.3)	0 (0, 3.8)	0.88
MTX use *(no. [%])*	67 (63.8%)	19 (82.6%)	0.06
MTX dose† *(mg/wk)*	7.0 (0, 10.0)	8.0 (6.0, 10.0)	0.26
Biologic DMARDs use *(no. [%])*	25 (23.8%)	7 (30.4%)	0.6
Biologic DMARDs *(no.)*	IFX: 5, ETN: 13, ADA: 2, GLM: 1, TCZ: 2, ABT: 2	IFX: 1, ETN: 5, ABT: 1	—
Operative time† *(min)*	118.0 (100.0, 137.0)	121.0 (107.0, 158.0)	0.42
Hallux valgus angle† *(deg)*	47.8 (38.0, 55.0)	46.6 (35.6, 55.5)	0.89
Intermetatarsal angle† *(deg)*	15.7 (13.5, 18.4)	16.0 (13.7, 18.5)	0.79
Grades of the position of the medial sesamoid by Hardy and Clapham[18] *(no.)*	III: 1, IV: 4, V: 16, VI: 20, VII: 64	IV: 2, V: 2, VI: 3, VII: 16	0.61

*Cases lost to follow-up (n = 23) include 2 patients who died. DAS28-ESR = 28-joint Disease Activity Score with erythrocyte sedimentation rate, PSL = prednisolone, MTX = methotrexate, DMARD = disease-modifying anti-rheumatic drug, IFX = infliximab, ETN = etanercept, ADA = adalimumab, GLM = golimumab, TCZ = tocilizumab, and ABT = abatacept. †Mann-Whitney U test was used to compare quantitative variables, and Fisher exact test was used to compare the categorized variables. ‡The values are given as the median, with the interquartile range in parentheses.

SAFE-Q improved significantly after surgery[21], similar to our finding. Only 1 study, to our knowledge, utilized other PROMs (a visual analog scale for pain and the Short Form-36) to compare pre- and postoperative results of the joint-preserving surgeries, and the results were satisfactory[22].

Joint-sacrificing procedures, including arthrodesis, resection arthroplasty, or silicone implant arthroplasty of the MTPJ, have been used to correct forefoot deformities in patients with RA. Some mid- and long-term outcomes of those surgeries have been reported[23-27]. However, in resection arthroplasty, the high recurrence rate of hallux valgus, the loss of joint function, abnormal plantar pressure, and gait abnormality at mid- and long-term follow-up have been reported[20,28-36]. Loss of range of motion, nonunion, and interphalangeal joint arthritis in arthrodesis[17,37-39] and osteolysis, osteophyte formation, and breakage of implants in silicone implant arthroplasty[40-42] have also been reported. The introduction of new DMARDs has caused a dramatic paradigm shift in the treatment of RA[43]. The prevention of joint destruction by these medications has been reported[44-46]. Compared with joint-sacrificing surgeries, joint-preserving surgeries have the advantages of preserving range of motion and stability of the MTPJ, obtaining push-off, and improving plantar pressure distributions[20,21,47,48]. There is an ongoing debate as to whether joint-preserving or joint-sacrificing procedures are superior in the treatment of rheumatoid forefoot deformities. Some research has shown that joint-preserving surgery results in equivalent or better

TABLE II Pre- and Postoperative PROM Scores (N = 53)*

SAFE-Q Subscale	Preop.†	Latest Follow-up†	MCID	P Value‡
Pain and pain-related	50.0 (38.9, 77.8)	75.0 (66.1, 82.6)	9.2	<0.01
Physical functioning and daily living	70.5 (54.5, 79.5)	81.8 (61.4, 91.5)	9.1	<0.01
Social functioning	75.0 (58.3, 95.8)	91.7 (66.7, 100)	11.8	<0.01
Shoe-related	33.3 (25.0, 41.7)	58.3 (41.7, 75.0)	10.3	<0.01
General health and well-being	60.0 (45.0, 80.0)	80.0 (65.0, 95.0)	10.2	<0.01

*53 cases treated with joint-preserving surgery for rheumatoid forefoot deformities with available pre- and postoperative SAFE-Q (Self-Administered Foot Evaluation Questionnaire) scores. PROM = patient-reported outcome measure, and MCID = minimal clinically important difference. †The values are given as the median, with the interquartile range in parentheses. ‡Wilcoxon signed rank-sum test.

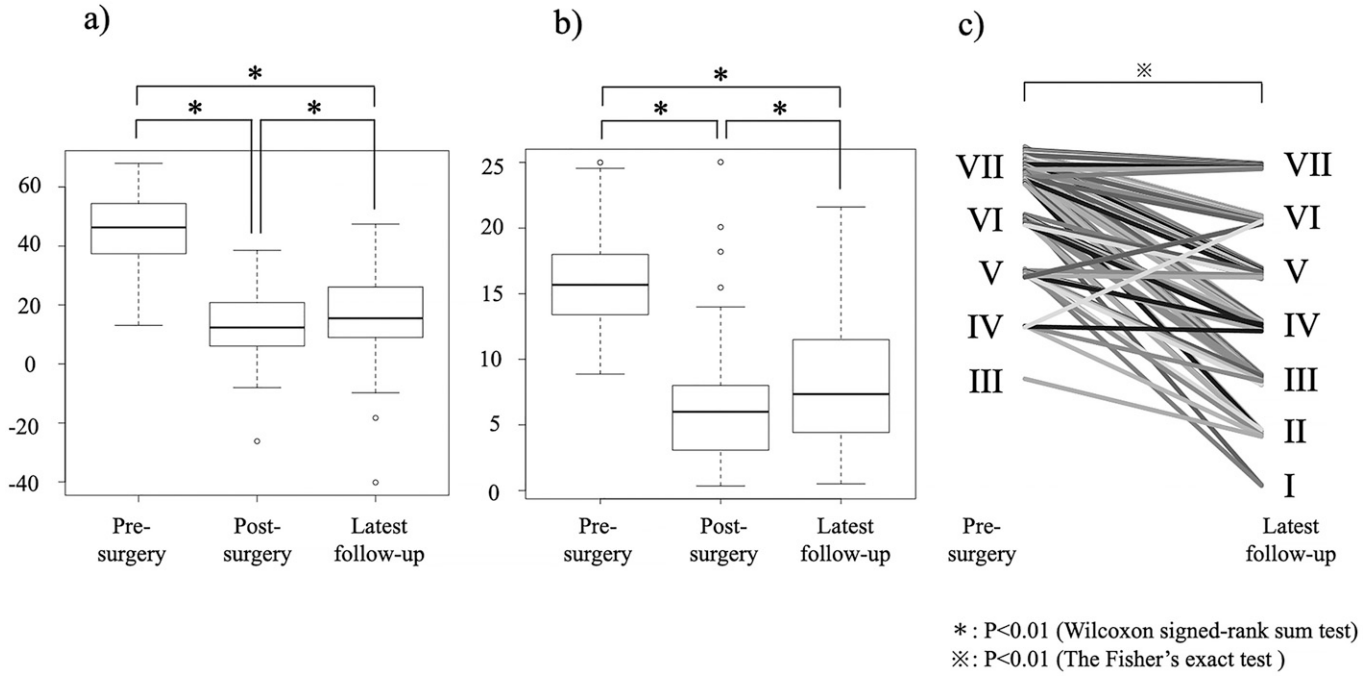

Fig. 6

Radiographic outcomes. Each box represents the interquartile range of values, with the bold horizontal lines within the boxes showing the median value. The vertical dashed lines show maximum and minimum values that fall within 1.5 box lengths, and the open circles show extreme values >1.5 box lengths. **Fig. 6-A** Median hallux valgus angles. **Fig. 6-B** Median intermetatarsal angles. **Fig. 6-C** The position of the medial sesamoid, classified as grade I to VII according to the measurement system proposed by Hardy and Clapham[18].

outcomes[20,21,49,50]. In the only randomized clinical trial that we are aware of to compare joint-preserving with joint-sacrificing procedures, Schrier et al. found that there was no clinical difference between joint-preserving (n = 10) and joint-sacrificing (n = 13) surgery at 1 year of follow-up[47].

The benefits of proximal rotational closing-wedge osteotomy are (1) large correction owing to the proximal location of the osteotomy, (2) correction of the pronation deformity of the first metatarsal by supinating the distal fragment of the first metatarsal, (3) simple shortening of the first metatarsal according to the amounts of the shortening of the lesser metatarsals, and (4) easy correction only by the contact of the osteotomy surfaces since the cutting-edge angle was equal to the preoperatively planned IMA. In this study, the average HVA, IMA, and grade of the position of the medial sesamoid at the latest follow-up decreased significantly compared with preoperatively. However, the recurrence of hallux valgus was found in 11 (10.5%) of the feet. In several large studies of resection arthroplasty, recurrent hallux valgus was present in >50% of the cases[28,30,33,40]. The authors of other studies of joint-preserving surgeries reported a rate of hallux valgus recurrence of 0% to 27% of the patients[4,6,8,10]. Considering that patients with RA who require surgery often have severe hallux valgus (with mean

TABLE III Comparison of SAFE-Q Scores at Latest Follow-up Between Cases With and Without Painful Callosity*

SAFE-Q Subscale	No Callosity (N = 44)†	With Callosity (N = 9)†	P Value‡
Pain and pain-related	77.8 (67.8, 85.7)	36.7 (32.2, 72.8)	<0.01
Physical functioning and daily living	84.1 (70.5, 93.2)	65.9 (47.7, 81.8)	0.10
Social functioning	95.8 (75.0, 100)	79.2 (25.0, 79.2)	0.03
Shoe-related	58.3 (41.7, 75.0)	33.3 (8.3, 58.3)	0.01
General health and well-being	80.0 (75.0, 100)	70.0 (65.0, 75.0)	0.051

*SAFE-Q = Self-Administered Foot Evaluation Questionnaire. †Cases with pre- and postoperative SAFE-Q scores. The values are given as the median, with the interquartile range in parentheses. There was a significant difference between the 2 groups in the pain and pain-related subscale score preoperatively. ‡Mann-Whitney U test.

preoperative HVA of 46.4° ± 11.4° in the current study), the risk of recurrence may be high.

The benefits of the modified shortening oblique osteotomies of the lesser toes include (1) the simple surgical technique, (2) larger contact surface of cancellous bone that is beneficial for bone-healing, (3) the ease of adding joint-sparing procedures to the MTPJ using the same incision as the osteotomy, and (4) the ease of adjusting the metatarsal length to preserve the metatarsal parabola. The radiographic outcomes achieved in this study were not inferior to those reported in previous studies of other joint-preserving surgeries for rheumatoid forefoot deformities (see Appendix). We also previously described that the distance of movement of the center of pressure was extended in patients treated with these osteotomies for RA-associated forefoot deformities[48].

Delayed wound-healing was observed in 21 (20.0%) of the feet in this study, while other reports of joint-preserving surgery showed delayed wound-healing in 5.3% to 16.2% of cases[5,6,8,21,22]. Most of those studies determined the length of shortening preoperatively by measuring the distance of overlap between the distal end of the metatarsal and the proximal end of the proximal phalanx of each lesser toe[5,6,8,21], whereas we limited the amount of shortening to ≤10 mm. Also, the location of incisions may differ across studies. Although we previously found tha a longer operative time was a risk factor for delayed wound-healing for those undergoing rheumatoid forefoot surgery, the amount of shortening of the lesser metatarsals and the location of incisions may also affect delayed wound-healing[51].

Nonunion was found in 0% of the cases after a mean of 6.0 years of follow-up, despite the poor bone quality of patients with RA. We previously reported on techniques of metatarsal osteotomy that were associated with a decrease in the rate of nonunion[52], which may achieve great success. Other osteotomies in past reports have also demonstrated a low nonunion rate (0% to 6.3%)[4-6].

Painful plantar callosities were present in 17.0% of the cases at the latest follow-up, but because we did not obtain preoperative data on callosities, it is unclear whether each callosity was newly formed after the surgery or existed prior to surgery and remained until the latest follow-up. In this study, PROM scores in

TABLE IV Reoperation Data*

Case	Age at Primary Surgery *(yr)*	Sex	Time to Reoperation *(yr)*	Reason for Reoperation	Reoperation Procedures
1	63	F	0.8	Recurrence of HV	Re-release of the adductor tendon Reconstruction of the capsule of the first MTPJ
2	47	F	0.5	Recurrence of HV	Re-release of the adductor tendon Reconstruction of capsule of the first MTPJ
3	69	F	1.5	Recurrence of dorsal dislocation of the fifth MTPJ	Shortening oblique osteotomy of the fifth metatarsal
4	58	F	1.8	Plantar callus on the third MTPJ	Shortening oblique osteotomy of the third metatarsal Z-plasty lengthenings of second, fourth, and fifth EDL
5	61	F	1.7	Hyperdorsiflexion of the hallux IPJ	Z-plasty lengthening of EHL tendon
6	73	F	0.4	Recurrence of HV and contracture of the second MTPJ	Reconstruction of the capsule of the first MTPJ Release of the dorsal capsule of the second MTPJ
7	62	F	3.7	Recurrence of HV and lesser toes deformities	Arthrodesis of the first MTPJ Shortening oblique osteotomies of the second through fifth metatarsals
8	66	F	1.3	Recurrence of HV	Horizontal osteotomy of the first metatarsal
9	54	F	4.3	Recurrence of HV and lesser toes deformities	Re-release of the adductor tendon Reconstruction of the capsule of the first MTPJ Z-plasty lengthening of the second EDL tendon Release of the dorsal capsule of the third MTPJ
10	64	F	0.5	Recurrence of HV	Re-release of the adductor tendon Reconstruction of the capsule of the first MTPJ
11	73	F	1.1	Recurrence of HV	Re-release of the adductor tendon Reconstruction of the capsule of the first MTPJ

*HV = hallux valgus, MTPJ = metatarsophalangeal joint, EDL = extensor digitorum longus, IPJ = interphalangeal joint , and EHL = extensor hallucis longus.

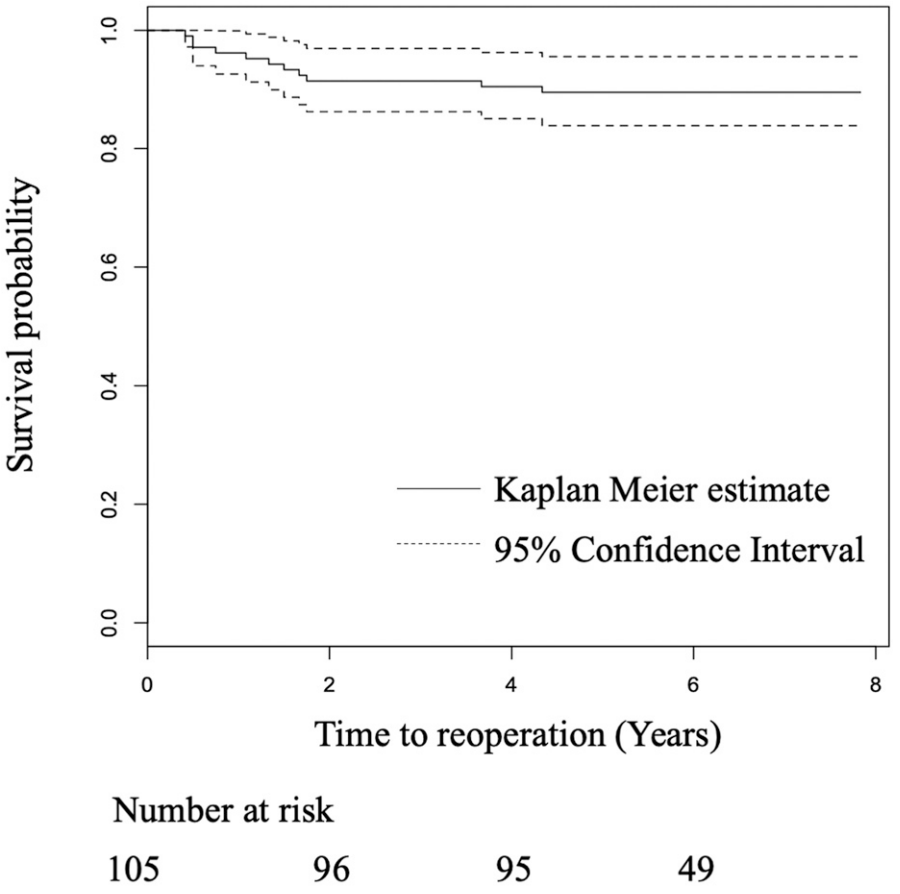

Fig. 7

Kaplan-Meier survival curves for joint-preserving surgery showing an estimated survival rate of 89.5% (95% confidence interval, 84% to 96%) at 7 years, with reoperation as the end point.

the cases with painful callosities at the latest follow-up were significantly worse than those in cases without them. It is important to reduce the rate of plantar callosities to assess the outcomes of forefoot surgeries because they also cause impairments of gait and foot function in patients with RA. The rate in this study was superior compared with the high incidence (37.5% to 79%) of plantar callosities after resection arthroplasty[28,33,34,53].

The Kaplan-Meier survival analysis showed a satisfactory cumulative survivorship of this joint-preserving surgery. The reoperation rate in this study was 10.5%, which was comparable with rates (2.5% to 16.2%) in other reports of joint-preserving surgery[5,8,22]. However, the decision for reoperation often depends on a patient's intention despite recurrent or residual deformities. Not all of the patients with recurrent hallux valgus and painful callosity decided to undergo reoperation. Reported reoperation rates for joint-sacrificing surgery are between 9% and 30%[17,53-55], and they may be higher than those for joint-preserving surgery.

Our study had limitations. First, because the study was limited by its retrospective nature, we could not obtain all of the relevant clinical and radiographic data from patients. Second, this study was conducted in a single institution; thus, our results may not be reproducible or generalizable to other settings or populations. Third, the preoperative clinical assessment for some patients was insufficient because some of the patients enrolled in this study before the development of the PROM instrument that we utilized. Fourth, our final follow-up time point was not at a uniform interval, but rather, at the latest follow-up, and PROM scores may deteriorate over time because of aging. Other limitations include a lack of blinding, confounding by multiple other surgical procedures, and varying reasons for reoperation.

In conclusion, overall patient-reported outcomes improved and radiographic outcomes were satisfactory at a mean follow-up of 6.0 years after joint-preserving surgeries for forefoot deformities in patients with RA.

Appendix

eA Supporting material provided by the authors is posted with the online version of this article as a data supplement at jbjs.org (http://links.lww.com/JBJS/G300). ■

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