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The impact of hindfoot deformities for the recurrence of hallux valgus after joint-preserving surgeries for rheumatoid forefoot deformities

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ABSTRACT

Background: Recurrence of hallux valgus (HV) is a common complication after forefoot surgery for rheumatoid forefoot deformities. The aim of this study is to evaluate the impact of hindfoot malalignment on recurrence.
Methods: This was a retrospective observational study designed to analyze the radiographic outcomes of 87 feet in 64 patients with rheumatoid arthritis treated with a joint-preserving surgery for HV deformity. Differences in hindfoot alignment preoperatively between the recurrence and nonrecurrence groups was compared.
Results: There were no significant differences in hindfoot alignment preoperatively between groups. To estimate the impact of technical problems, the HV and intermetatarsal angles measured from radiographs 3 months postoperatively were compared between groups. The HV angles in the recurrence group were significantly larger than those in the nonrecurrence group ($p = 0.02$).
Conclusions: There were no significant differences between preoperative hindfoot malalignment and postoperative recurrence of HV in rheumatoid forefoot surgeries.
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1. Introduction

Rheumatoid arthritis (RA) is a major chronic inflammatory disease that is characterized by destruction of multiple joints. In recent years, the introduction of powerful and effective antirheumatic drugs, including molecularly-targeted drugs, has dramatically controlled the disease activity of RA. With a trend toward milder disease because of improved medical treatment [1,2], patients with RA may seek better function as measured by the activities of daily living. As a result, the numbers of foot surgeries have increased especially in Japan [3].

Hallux valgus (HV) is a typical forefoot deformity in RA patients [4]. Surgical treatment is still useful to reduce symptoms related to HV, while methods of surgery for rheumatoid forefoot deformities have changed from joint-sacrificing surgery to joint-preserving surgery gradually, as the introduction of powerful antirheumatic drugs, including biologic agents, leads us to reconsider the benefits of joint preservation [5].

Recurrence is the most common complication associated with HV surgeries [6]. Recently, it has been reported that hindfoot malalignment is one reason for recurrence after HV surgery in RA patients [7–9]. However, Gines-Cespedosa et al. found patients with hindfoot misalignment did not obtain worse outcomes in HV surgery [10]. Since they excluded RA patients from the study, the influence of hindfoot malalignment on HV surgery outcomes in RA patients remains unclear. The aim of this study is to evaluate the impact of hindfoot malalignment on recurrence after HV surgery for rheumatoid forefoot deformities.

2. Methods

This was a retrospective observational study designed to analyze the radiographic outcomes of RA patients who had undergone primary joint-preserving surgery for HV deformity (HV angle of 20° or greater and intermetatarsal angle of 10° or greater). Joint-preserving surgery was applied for the patient without severe joint destruction (Larsen grade V) in their metatarsophalangeal joints. This study included patients with a minimum follow-up of one year. From October 2010 to December 2015, 97 feet in 73 consecutive RA patients were treated by a single surgeon

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with proximal rotational closing-wedge osteotomy of the first metatarsal [11]. Patients were excluded from the study if they had undergone associated procedures on hallux, including arthrodesis of the interphalangeal joint and Akin procedure, because these may change the axis of the proximal phalanx. Of these, 6 feet in 5 patients were lost to follow-up, and preoperative lateral radiographs were unavailable for 4 feet in 4 patients. The remaining 87 feet in 64 patients formed the study cohort. Information about demographic data and disease variables was obtained in interviews and from patient records. All patients had severe pain, deformity, plantar callosities, and mild or moderate destruction of the metatarsal heads. Conservative treatment, including modification of foot-wear, nonsteroidal anti-inflammatory medications, or arch supports, had failed for all patients. All patients underwent a standardized radiographic follow-up at three months and one year postoperatively, and annually thereafter. Weightbearing anteroposterior and lateral radiographs of the foot were obtained preoperatively and at each routine follow-up visit. Disease Activity Score 28 (DAS28), which is a quantitative composite measure of disease activity, was recorded before the surgery and at the latest visit. Our institutional review board approved this retrospective study.

2.1. Radiological evaluation

Standard anteroposterior and lateral radiographs of the foot under weightbearing conditions were analyzed. Weightbearing radiographs 3 months after surgery were regarded as the baseline post-operative radiographs because all patients were nonweightbearing for 2 months following surgery. HV deformity was determined on standing anteroposterior radiographs by measuring the hallux valgus (HV) angle and the intermetatarsal (IM) angle (Fig. 1). The HV angle was subtended by lines bisecting the longitudinal axis of the first metatarsal and the proximal phalanx. The IM angle was subtended by lines bisecting the longitudinal axis of the first and second metatarsals. The position of the medial sesamoid was assessed in relation to a line drawn along the longitudinal axis of the first metatarsal. It was classified as grade I, II, III, IV, V, VI, or VII, according to the measurement system proposed by Hardy and Clapham [12]. The shape of the lateral edge of the first metatarsal head was evaluated and classified as one of three types: round (type R), angular (type A), and intermediate (type I), according to the classifications advocated by Okuda et al. [13]. Hindfoot alignment was determined on lateral radiographs by measuring the calcaneal pitch (CP) angle, the talus-first metatarsal (T-1MT) angle, and the naviculocuboid (NC) overlap (Fig. 2). These radiographic parameters are reliable and valid measures for evaluation of hindfoot malalignment [14]. The CP angle was the angle between the line drawn from the plantar surface of the calcaneus to the inferior border of the calcaneocuboid joint and the horizontal line. The T-1MT angle was the angle between the long axis of the talus and first metatarsal. The NC overlap was the overlapped portion of the navicular and cuboid divided by the vertical height of the cuboid. The radiographic recurrence of HV was defined as an angle (delta-HV angle) that increased more than 5° at the latest follow-up compared to the angle 3 months postoperatively.

2.2. Operative techniques

As reported previously, we performed joint-preserving surgeries with the proximal rotational closing-wedge osteotomy of the first metatarsal for RA patients with symptomatic moderate to severe rheumatoid HV deformity [11]. As necessary, a modified method of shortening oblique osteotomies [15] of the second through fifth metatarsals was added simultaneously. The simplified procedures are described below.

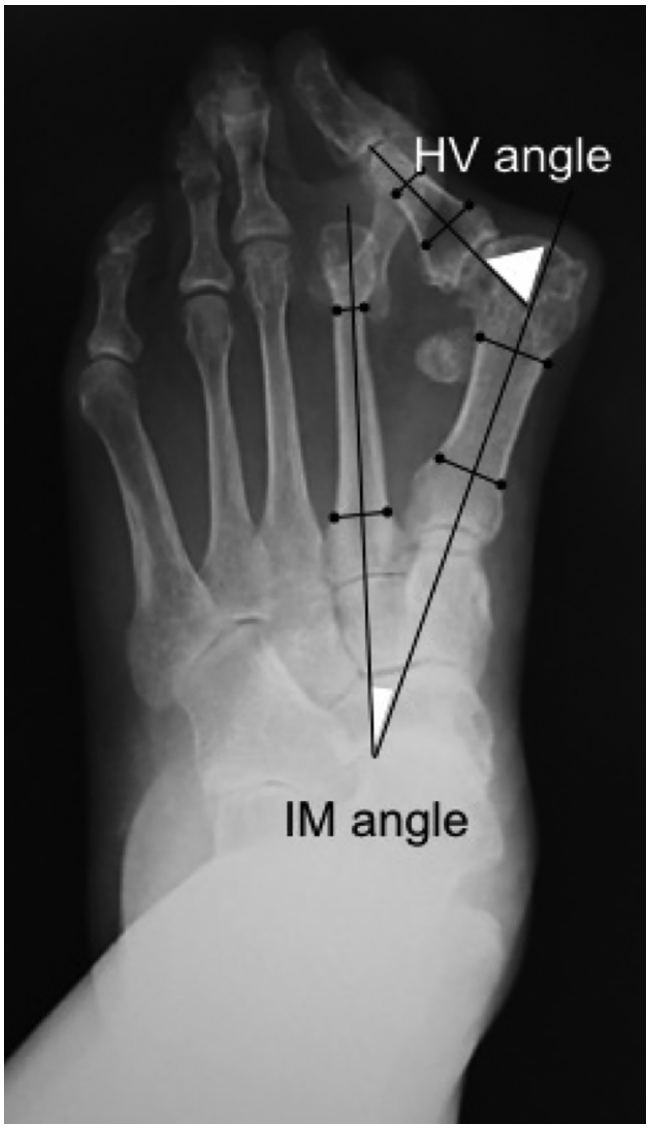

Fig. 1. Anteroposterior weightbearing radiograph. The hallux valgus (HV) angle was subtended by lines bisecting the longitudinal axis of the first metatarsal and the proximal phalanx. The Intermetatarsal (IM) angle was subtended by lines bisecting the longitudinal axis of the first and second metatarsals.

The dorsomedial incision began from the metatarsophalangeal joint and ended at the metatarso-cuneiform joint. After releasing the adductor tendon from the lateral aspect of the lateral sesamoid and the base of the proximal phalanx, a closing-wedge osteotomy of the proximal first metatarsal was performed. As necessary, a modified method of shortening oblique osteotomies of the second through fifth metatarsals was then performed. The length of the metatarsals of the lateral toes was adjusted, making the second metatarsal the longest, followed by the third, fourth, and fifth. After confirming any dislocation was reduced, the MTP joints and the osteotomy sites of the lesser toes were temporarily fixed by 1.2 mm diameter K-wires. The first metatarsal was shortened as necessary by resecting the distal end of the wedge, making the heads of the first and second metatarsals almost the same level. After rotating the first metatarsal to reposition the pronation of the metatarsal, cross K-wire fixation (1.5 mm diameter) was performed (Fig. 3).

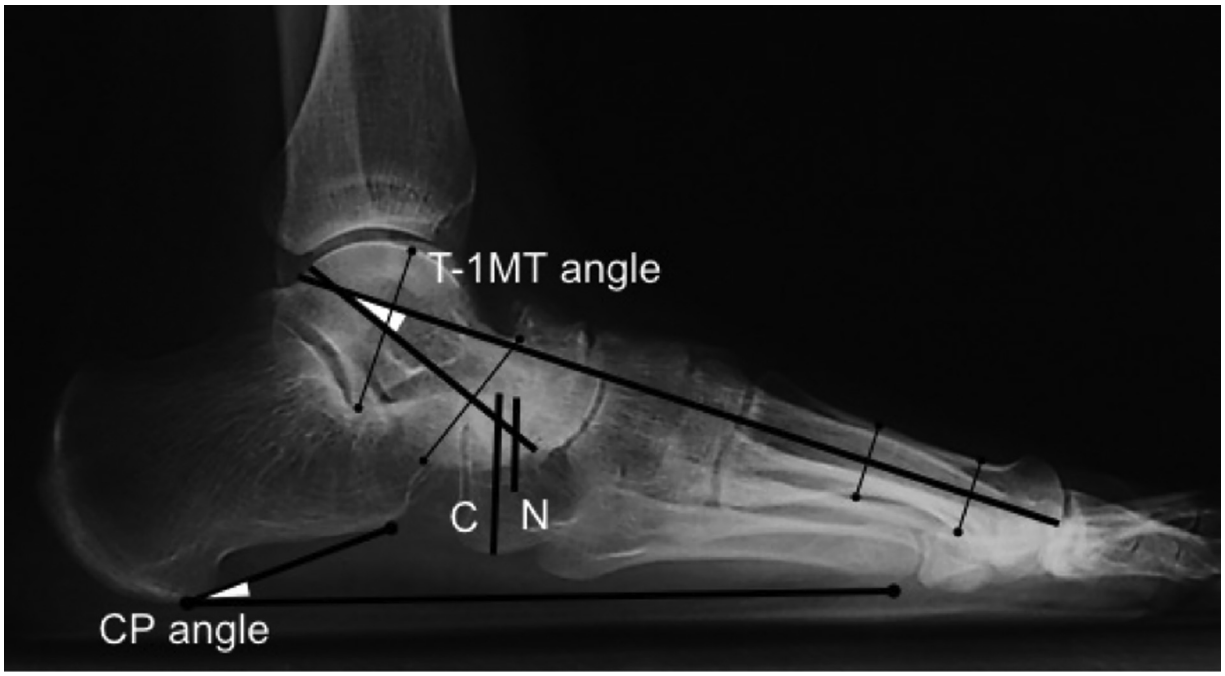

Fig. 2. A lateral weightbearing radiograph. The calcaneal pitch (CP) angle was the angle between the line drawn from the plantar surface of the calcaneus to the inferior border of the calcaneocuboid and the horizontal line. The talus-first metatarsal (T-1MT) angle was the angle between the long axis of the talus and first metatarsal. The naviculocuboid (NC) overlap (N/C) was the overlapped portion of the navicular and cuboid divided by the vertical height of the cuboid.

Postoperatively, the foot was placed in a bulky dressing and patients were allowed to walk, bearing weight on their heels. The temporary K-wires in lesser toes used for fixation of the MTP joints and the osteotomy site were removed 3 weeks after surgery to prevent joint contracture according to the original method [15], and the patients were advised to continue heel gait with arch support until 2 months after surgery, when bony fusion would be obtained. Full weightbearing with arch support was encouraged 2 months after surgery.

2.3. Statistical analysis

Continuous data were summarized using the mean, standard deviation, and range, and categorical variables are presented as counts and percentages. The Kolmogorov–Smirnov test showed that all continuous variables followed a normal distribution. A paired Student's *t*-test was used to compare preoperative and postoperative radiographic values and DAS28. A Student's *t*-test was used to assess differences in hindfoot alignment preoperatively between recurrence (delta-HV angle is 5° or greater) and nonrecurrence (delta-HV angle less than 5°) groups. The Fisher's exact test was used to compare categorical data between the two groups. Statistical analyses were performed using the R software package (http://www.r-project.org/). The level of significance was set at $\alpha = 0.05$.

3. Results

The baseline characteristics of the patients are shown in Table 1. The average age at surgery was 59.7 (range, 28–76) years, the average duration of RA affliction was 19.7 (range, 2–43) years, and the average DAS28 at surgery was 3.24 (range, 1.14–6.74). The average duration of follow-up for the entire cohort was 34.9 (range, 12–70) months. The modified method of shortening oblique osteotomies of the lesser metatarsals was performed in 78 of 87 feet (89.7%). Five lesser metatarsals in 4 patients had non-union (4.6%), but all first metatarsals had united in 12 months. Delayed wound healing was seen in 18 feet (20.7%). The incidence of surgical site Infection according to the standard of Centers for Disease Control and Prevention was 4.6% [16]. New erosions were appeared in 5 first metatarsal heads after the surgery, while existed erosions prior to the surgery were healed in 8 first metatarsals.

As shown in Table 2, the average HV, IM angles, and the position grade of the medial sesamoid decreased significantly 3 months postoperatively, and remained significantly lower at the latest follow-up ($p < 0.01$). The average CP and T-1MT angles decreased significantly at the latest follow-up when compared to preoperative values ($p < 0.01$). The average NC overlap had increased significantly at the latest follow-up ($p < 0.02$).

Recurrence of HV was found in 28 of 87 feet (32.2%). In both the recurrence and nonrecurrence groups, the average HV, IM angles, and the position grade of the medial sesamoid decreased significantly 3 months postoperatively, and remained significantly lower at the latest follow-up ($p < 0.01$). The average CP and T-1MT angles decreased significantly at the latest follow-up when compared to preoperative values ($p < 0.01$). The average NC overlap had increased significantly at the latest follow-up in the recurrence group ($p = 0.02$), but did not change in the nonrecurrence group ($p = 0.16$).

To evaluate the impact of hindfoot alignment for the recurrence of HV surgery, the preoperative CP angles, T-1MT angles, and NC overlap were compared between the recurrence and nonrecurrence groups. There were no significant differences between the groups. To estimate the impact of the surgical procedures, the HV, IM angles, and the position of the medial sesamoid 3 months postoperatively were compared between the groups. The HV angle 3 months postoperatively in the recurrence group was significantly larger than that in the nonrecurrence group ($p = 0.02$). No significant differences were found in the IM angles and the position of the medial sesamoid between the groups ($p = 0.44$ and $p = 0.26$, respectively). The position grade of the medial sesamoid at the latest follow-up in the recurrence group was significantly larger than that in the nonrecurrence group ($p = 0.002$). There was no significant difference in disease activity between the groups

Fig. 3. The proximal rotational closing-wedge osteotomy of the first metatarsal [11] and a modified method of shortening oblique osteotomies [15] of the second through fifth metatarsals. (a) Preoperative weightbearing right foot radiograph. (b) Twelve months postoperative weightbearing right foot radiograph.

($p = 0.64$) (Table 2). To assess the relationship between the recurrence of HV and the shape of the head of the first metatarsal, the shape of the lateral wedge of the first metatarsal head was compared between the recurrence and nonrecurrence groups. There was no significant difference in the shape of the lateral wedge of the first metatarsal head between the groups preoperatively, 3 months postoperatively, and at the latest follow-up ($p = 1.0$, $p = 0.67$, and $p = 0.25$, respectively) (Table 2).

Table 1
Patient demographics.

Age, years, mean ± SD (range)	59.7 ± 9.82 (28–76)
Gender, female	96.9%
Disease duration, years, mean ± SD (range)	19.7 ± 8.9 (2–43)
DAS28, mean ± SD (range)	3.24 ± 1.2 (1.14–6.74)
PSL use	57.4%
MTX use	79.4%
Biologic DMARDs use	29.4%

Abbreviations: SD, standard deviation; DAS28, Disease Activity Score 28; PSL, Prednisolone; MTX, Methotrexate; DMARDs, disease modified anti-rheumatic drugs.

4. Discussion

Some reports suggest that hindfoot malalignment affects the progression of forefoot deformities, including HV [8,9,17,18]. This is important in treating rheumatoid forefoot deformities, because RA patients often have deformities both in forefoot and in hindfoot simultaneously. Therefore, surgeons should consider the involvement of midfoot and hindfoot deformity when treating a forefoot deformity in RA patients [8]. Indeed, some case reports suggest the relationship between hindfoot and forefoot in RA foot and ankle surgeries. Yamada et al. reported a patient with RA in whom HV improved naturally after surgical correction for severe valgus and pronated hindfoot deformity [19]. Hirao et al. described a patient with RA in whom a hindfoot valgus deformity appeared after HV surgery because of poor control of RA disease activity, and the HV deformity recurred soon after surgery [20]. However, the present study revealed no significant differences between preoperative hindfoot malalignment and postoperative recurrence of HV. This is consistent with the prospective study that evaluated the influence of hindfoot misalignment in HV surgery outcomes [10]. Gines-Cespedosa et al. found no significant differences between varus,

Table 2
Comparison of radiographic findings and DAS28 preoperatively, three months postoperatively, and at the latest follow-up.

	Whole feet (n = 87)	Recurrence group (n = 28)	Nonrecurrence group (n = 59)	P^*
Preoperative				
HV angle, degree	47.2 ± 11.0 (22.0–72.0)	49.7 ± 9.8 (32.2–69.0)	46.0 ± 11.4 (22.0–72.0)	0.15
IM angle, degree	16.7 ± 3.5 (10.0–25.0)	17.4 ± 3.6 (10.0–23.3)	16.4 ± 3.4 (10.0–25.0)	0.22
Position of the medial sesamoid	6.5 ± 0.8 (3–7)	6.4 ± 1.0 (3–7)	6.6 ± 0.6 (5–7)	0.30
Shape of the lateral wedge of the first metatarsal head, n (%)				1.0
Type R	40 (46.0)	14 (50.0)	26 (44.1)	
Type I	19 (21.8)	7 (25.0)	12 (20.3)	
Type A	7 (8.0)	2 (7.1)	5 (8.5)	
Unmeasurable because of bone erosion	21 (24.1)	5 (17.9)	16 (27.1)	
CP angle, degree	16.4 ± 6.0 (−1.8 to 29.3)	16.4 ± 6.8 (−1.8 to 28.4)	16.5 ± 5.5 (3.0–29.3)	0.96
T-1MT angle, degree	−5.6 ± 9.3 (−29.0 to 18.5)	−4.3 ± 9.5 (−22.3 to 18.5)	−6.2 ± 9.0 (−29.0 to 14.9)	0.28
NC overlap	0.52 ± 0.16 (0.24–0.88)	0.48 ± 0.16 (0.24–0.83)	0.54 ± 0.16 (0.25–0.88)	0.10
DAS28	3.24 ± 1.2 (1.14–6.74)	3.21 ± 1.2 (1.14–6.32)	3.26 ± 1.2 (1.30–6.74)	0.87
3 months postoperative				
HV angle, degree	15.4 ± 9.0[a] (−5.0 to 38.5)	18.8 ± 8.2[a] (5.5–38.0)	13.8 ± 8.9[a] (−5.0 to 38.5)	0.02
IM angle, degree	7.5 ± 4.7[a] (−2.5 to 25.0)	6.9 ± 4.5[a] (−2.5 to 20.1)	7.7 ± 4.8[a] (−2.3 to 25.0)	0.44
position of the medial sesamoid	3.8 ± 1.2[a] (1–6)	4.0 ± 1.1[a] (2–6)	3.7 ± 1.2[a] (1–6)	0.26
Shape of the lateral wedge of the first metatarsal head, n (%)				0.67
Type R	1 (1.1)	0 (0)	1 (1.7)	
Type I	12 (13.8)	5 (17.9)	7 (11.9)	
Type A	48 (55.2)	15 (53.6)	33 (55.9)	
Unmeasurable because of bone erosion	26 (29.9)	8 (28.6)	18 (30.5)	
The latest follow-up				
HV angle, degree	17.7 ± 12.5[a] (−9.0 to 47.0)	29.2 ± 9.3[a] (14.0–47.0)	12.2 ± 9.8[a] (−9.0 to 38.0)	–
IM angle, degree	8.8 ± 4.8[a] (−1.0 to 20.0)	11.7 ± 4.5[a] (4.0–20.0)	7.4 ± 4.5[a] (−1.0 to 20.0)	–
Position of the medial sesamoid	4.3 ± 1.4[a] (2–7)	5.0 ± 1.3[a] (2–7)	4.0 ± 1.3[a] (2–7)	0.002
Shape of the lateral wedge of the first metatarsal head, n (%)				0.25
Type R	1 (1.1)	1 (3.4)	0 (0)	
Type I	10 (11.5)	2 (7.1)	8 (13.6)	
Type A	47 (54.0)	17 (60.7)	30 (50.8)	
Unmeasurable because of bone erosion	29 (33.3)	8 (9.2)	21 (35.6)	
CP angle, degree	13.6 ± 5.6[a] (−8.0 to 30.0)	12.6 ± 7.3[a] (−8.0 to 30.0)	14.1 ± 4.5[a] (4.2–25.0)	0.23
T-1MT angle, degree	−12.2 ± 10.8[a] (−35.0 to 25.0)	−10.8 ± 12.7[a] (−32.0 to 25.0)	−12.9 ± 9.6[a] (−35.0 to 7.0)	0.40
NC overlap	0.55 ± 0.16[a] (0.16–0.87)	0.53 ± 0.17[a] (0.20–0.84)	0.56 ± 0.15 (0.16–0.87)	0.39
DAS28	3.24 ± 1.1 (1.47–6.18)	3.15 ± 1.1 (1.47–5.79)	3.28 ± 1.1 (1.56–6.18)	0.64

Mean ± standard deviation (range).
Abbreviations: HV, hallux valgus; IM, inter-metatarsal; R, round; I, intermediate; A, angular; CP, calcaneal pitch; T-1MT, talus-first metatarsal; NC, naviculocuboid; DAS28, Disease Activity Score 28.
[*] P value for comparison between recurrence and nonrecurrence groups.
[a] Significant difference from preoperative value in the same group ($P < 0.05$).

normal, and valgus hindfoot groups when the HV and IM angles at 2-year follow-up were compared, but RA patients were excluded in this study [10]. In clinical practice, there are many RA patients suffering forefoot and hindfoot deformities simultaneously. The present study shows that performing a forefoot surgery prior to surgery on hindfoot deformity without any symptoms is allowed in RA patients. We agree with Gines-Cespedosa et al. [10] that preventive hindfoot surgery to avoid the recurrence of HV may not be necessary, even in patients with RA.

In the present study, the HV angles 3 months postoperatively in the recurrence group were significantly larger than those in the nonrecurrence group. This means that an insufficient correction of the HV deformity in rheumatoid forefoot surgery can result in the recurrence of HV. Therefore, it is important to correct deformities sufficiently to avoid this recurrence. Since fixation using K-wires has a lower risk of recurrence than that using a plate and screws [21], the stabilization with K-wires is assumed not to affect the recurrence rates.

Almost all hindfoot alignment measures were significantly worsened at the latest follow-up, except for the NC overlap in the nonrecurrence group ($p = 0.16$). Because many of the patients could not achieved remission during the study period (the average DAS28 was 3.24 preoperative and was also 3.24 at the latest follow-up), inflammation due to RA probably induced the progression of hindfoot malalignment. Furthermore, the joint preserving surgery procedure itself might cause the change of hindfoot alignment.

This study has some limitations. Firstly, because the study design was retrospective, we were unable to obtain all the relevant radiographic data for the study patients. Lee et al. found that the talonavicular coverage angle and talus-first metatarsal angle on the weightbearing anteroposterior radiographs also were reliable and valid measures for the evaluation of hindfoot valgus and varus deformities [14]. However, in the present study, some of the weightbearing anteroposterior radiographs did not show the talus clearly, so anteroposterior talonavicular coverage angles and anteroposterior talus-first metatarsal angles were excluded. Also, the evaluation of hindfoot malalignment may be incomplete because of the lack of the long axial radiographic view in this study. Secondly, most of clinical data are missed. Thirdly, since we used weightbearing radiographs 3 months after surgery as the baseline post-operative radiographs, it is possible that there was a rapid recurrence during 3 months after surgery. Some of these might be caused by malunion of the first metatarsal. Finally, this study might have been underpowered due to the relatively small number of patients. The strength of our study, however, is that the surgeon and operative procedure were unified, so technical bias was minimized. On the other hand, because the operative procedure was unified, we could not evaluate the influence of hindfoot malalignment on recurrence of HV after different HV surgeries.

5. Conclusions

No significant difference could be detected between preoperative hindfoot malalignment and postoperative recurrence of HV following rheumatoid forefoot surgery. Performing forefoot surgery prior to hindfoot surgery is acceptable in RA patients.

Conflict of interest

There are no conflicts of interest in regards to this study from either of the authors.

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