

# Sport and Exercise Activity After Isolated Ankle Arthrodesis for Advanced-Stage Ankle Osteoarthritis: A Single-Center Retrospective Analysis

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## Abstract

**Background:** Ankle arthrodesis, a recognized operative treatment for advanced-stage ankle osteoarthritis (OA), is recommended when conservative treatment proves unsuccessful. This single-center retrospective analysis examined the change in functional outcomes and the type of sport/exercise activity performed by advanced-stage ankle OA patients after ankle arthrodesis treatment.

**Methods:** A total of 61 advanced-stage ankle OA patients (age,  $63.1 \pm 12.6$  years) who had undergone ankle arthrodesis were included in this single-center retrospective study. The patients had functional outcomes evaluated via American Orthopaedic Foot & Ankle Society Score (AOFAS), Foot Function Index (FFI), Tegner Activity Level Scale (TAS), and High-Activity Arthroplasty Score (HAAS) questionnaires. Clinical status was compared across prearthritic, arthritic, and postarthrodesis periods, and satisfaction with return to sport/exercise activity was recorded.

**Results:** Patients' tarsal sagittal ROM (mean [95% CI]: 22.7 degrees [21.4-24.0]); time to union (15.7 weeks [11.8-19.6]); time to walk without gait aid (14.4 weeks [11.0-17.7]); time to return to work (17.9 weeks [15.1-20.8]); and time to exercise activity (20.6 weeks [17.9-23.4]) were recorded postarthrodesis. Hindfoot alignment angle toward a neutral position (difference: 11.4 degrees [9.2-13.6],  $P < .001$ ) and functional outcomes ( $P < .001$ ) significantly improved after arthrodesis surgery; however, only the TAS questionnaire indicated patients returned to their prearthritic activity level ( $P > .99$ ). Patients generally reported "good" satisfaction with their recovery from ankle arthrodesis surgery, with 64% of patients returning to high-impact-type activity.

**Conclusion:** Advanced-stage ankle OA patients had improved functional outcomes at ~1 year postarthrodesis surgery, enabling the majority of patients to return to high-impact-type activity.

**Level of Evidence:** Level III, retrospective cohort study.

**Keywords:** ankle arthrodesis, activity level, osteoarthritis

## Introduction

The incidence of ankle osteoarthritis (OA) is reported to be 47.7 per 100,000 in the United Kingdom.<sup>17</sup> For an advanced ankle OA patient whose condition has not been sufficiently relieved by conservative treatment, several options are available.<sup>12,18,21</sup> Ankle arthrodesis is a recognized treatment for ankle OA, with ankle arthroplasty considered an alternative for advanced-stage cases.<sup>13,18,23</sup> The advantages of ankle arthrodesis are related to its pain-relieving effects and

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modification of foot alignment, which reduce the chance of the ankle developing hindfoot arthritis.<sup>7,29,36,39</sup> However, in the long term, functional limitations and accelerated adjacent degeneration disease can arise because of the motion of adjacent joints compensating for the diminished motion of the ankle joint.<sup>13,16,18</sup>

There have been many studies that have investigated the change in clinical and functional outcomes on patient quality of life after ankle arthrodesis, yet improvements in functional outcomes are limited.<sup>13,18,19,30</sup> Previous studies, which have attempted to document the postoperative return to exercise activity, appear to demonstrate that patients have less ability to participate in sports activities.<sup>22,33,42</sup> Nevertheless, the effects of ankle arthrodesis on the return to sports activity remain unclear, with the inclusion of athletes and nonathletes (in combination) confounding the interpretation of study conclusions. To evaluate functional outcomes, valid questionnaires need to be able to detect different patient statuses over the course of receiving treatment.<sup>3,14</sup> Unfortunately, many questionnaires are still lacking in terms of their ability to evaluate patients with physical demands that are higher than normal, such as participation in sports and exercise activities. Moreover, because no assessment tool is noticeably superior,<sup>8</sup> a variety of questionnaires are recommended as a better diagnostic approach to provide a valid assessment of functional outcomes in foot and ankle surgery.<sup>8,32</sup>

Accordingly, the aims of this retrospective study were (1) to assess the impact of arthrodesis surgery on functional outcomes and sports and exercise activity levels of advanced-stage ankle OA patients in a single-center hospital that uses various questionnaires to assess functional outcomes as part of usual care, and (2) to report patient satisfaction with the return to sports and exercise activity. It was hypothesized that ankle OA patients would experience improved functional outcomes postarthrodesis compared to the arthritic state, and that satisfaction with the return to sports and exercise activity would be comparable to that recalled during the prearthritic period.

## Materials and Methods

### Study Cohort

Sixty-one consecutive patients with advanced-stage ankle OA who underwent ankle arthrodesis between July 2006 and August 2016 were retrospectively identified from the hospital's electronic database. Patients who met the following criteria were identified for inclusion in the analysis: had received primary ankle arthrodesis; participated in exercise/sports activities; had no fusion or arthroplasty of other joints in the lower extremities performed by a foot and ankle surgeon<sup>20,26</sup>; the multiple-screw technique had been used<sup>11</sup>; patients had complete clinical and radiographic union at the

fusion site (see below); had no adjacent joint arthritis at the time of surgery; normal function (ability perform daily activities without pain) had been restored after the surgery without a nonunion problem; and complete radiographic data and medical records were available in the hospital's foot and ankle registry.

### Clinical and Radiologic Assessment

The demographic, clinical, radiographic, and complication data of the patients were extracted; the radiographic data had been examined by foot and ankle surgeons. The condition of ankle arthrodesis was categorized as "union," "nonunion," or "delayed union." The criteria for union consisted of both clinical and radiographic factors. Clinical union was defined as a pain-free fusion site with no swelling after daily activities, whereas radiographic union required complete obliteration of the fusion site in >75% of the area, or trabecular bone running across >75% of the fusion site, or the presence of solid callus formation in all 3 views (anteroposterior, lateral, and mortise). If there was still uncertainty in the union being resolved, a CT scan was performed. The hindfoot alignment of the ankle was measured postoperation to assess the return of the ankle joints to their original position (ie, to determine if they were in a valgus or varus position relative to neutral hindfoot alignment). The method used for this assessment was not recorded in the database.

### Assessment of Functional Outcomes

Patients had functional outcomes assessed during the arthritic period (the period during which the symptoms had arisen but had not yet been treated surgically) and postarthrodesis. In each period, the patients had been interviewed about their condition using questionnaires (detailed below)—part of usual care. Prearthritic functional outcome data were collected via questionnaire recall in the arthritic period.

Patient satisfaction with their surgery was only recorded during the postarthrodesis period and was taken as a proxy of the patients' current functional ability (ie, higher satisfaction being representative of a greater functional ability). Thus, we predicted patient satisfaction levels across the prearthritic and arthritic time intervals using median questionnaire scores as independent predictors in an ordinal regression model to demonstrate the change in these outcomes over time.

### Follow-up

Presurgery and postsurgery assessments had been performed by the patients' doctors periodically (2 weeks, 6 weeks, 3 months, and 6 months) until the final follow-up at ~1 year and were uploaded to the electronic database. A

plain radiograph was taken at each follow-up point. Following surgery, ankles were immobilized in a short leg slab, and the stitches were removed 2 weeks after the procedure. At 6-8 weeks, the patients were encouraged to use a walker or axillary crutches. At 10-12 weeks after ankle arthrodesis, full weightbearing was started as tolerated (with or without a gait aid), provided that bony union between the tibia and talus had commenced. Patients were encouraged to return to exercise/sports activities once there was a solid union and clear pain relief. The patients' clinical data were collected to evaluate the ankle range of motion, ankle symptoms, and any complications.

### Patient Questionnaires

**American Orthopaedic Foot & Ankle Society Score.** The American Orthopaedic Foot & Ankle Society (AOFAS) hindfoot-ankle score is a patient-reported and physician-reported survey, which includes 9 questions that allocate a total score out of 100 points accumulated over 3 categories: pain (40 points), function (50 points), and alignment (10 points). The questionnaire consists of subjective and objective questions, allowing data from both perspectives to be collected.<sup>24</sup> Although the validity, responsiveness, and reliability of the AOFAS for ankle OA remains to be established,<sup>8,25,35</sup> the questionnaire is widely used alongside other surveys,<sup>10</sup> enabling it to be conveniently compared with earlier studies.<sup>8</sup>

**Tegner Activity Scale.** The Tegner Activity Scale (TAS) questionnaire was originally designed for anterior cruciate ligament injuries but is now commonly applied to other lower extremity activities to provide a standardized method to grade work and exercise activities.<sup>9,28,38</sup> The TAS is rated on a 0 (disability) to 10 (high-level competitive sport) numerical scale, with higher patient scores reflective of an improvement in return to exercise activity level.

**Functional Foot Index.** The Functional Foot Index (FFI) is a tool that is specific to foot and/or ankle diseases and is composed of questions suitable for postarthrodesis ankle OA. The modified FFI has 23 items (questions) categorized into 3 subscales to quantify the impact of foot problems related to pain (part 1), disability (part 2), and activity limitation (part 3).<sup>4</sup> The patients were asked to provide subjective scores based on a 0 (no pain) to 10 (worst pain imaginable) rating. The total and subscale FFI scores are used in the interpretation of foot pathology; lower scores indicate less pathology. The FFI is reported to possess good reliability and validity with excellent responsiveness.<sup>2,25,41</sup>

**High-Activity Arthroplasty Score.** The High-Activity Arthroplasty Score (HAAS) was created to study patients undertaking a high level of activity following arthroplasty

surgery.<sup>37</sup> Despite questions not being specific to the ankle and foot, the HAAS questionnaire may be considered for use with ankle arthrodesis patients because it considers high-level activities. The HAAS contains 4 categories (walking, running, stair climbing, and activity level) and is scored out of a total of 18 points; higher scores indicate improved functional ability.

### Classification of Activity

The type of exercise/sports activity that advanced OA patients were able to return to post ankle arthrodesis was classified as either high-impact or low-impact types of activities. To provide a clear definition, low-impact activities included nonweightbearing exercise (eg, swimming and cycling), which places little stress on joints. High-impact activities were characterized as involving repeated weightbearing on the joints of the hips, knee, and ankle (eg, jogging), encompassing team sports such as soccer and basketball. Sporting activities were assumed as physical activities that involve competition, skill, and rules, whereas exercise activities were defined as physical exertion performed for personal health benefits (eg, jogging and cycling).

### Satisfaction With Activity Level

On the final follow-up visit with their doctor (ie, 1 year), patients were asked to grade their satisfaction level with their current activity level (postarthrodesis) based on a 4-point ordinal scale (1 = poor, 2 = fair, 3 = good, 4 = excellent). The patients were not asked to expand on their answers.

### Statistical Analysis

The demographic data of the advanced-stage ankle OA patients were analyzed using descriptive statistics (frequency, percentage, mean, and SD). The functional outcome data were assessed for normality using a Shapiro-Wilk test and visual examination of residual plots (Q-Q plots). A paired *t* test was used to examine the difference in recorded pre- and postoperation hindfoot alignment. The differences in functional outcomes (AOFAS hindfoot, total FFI, FFI subscales, HAAS, TAS score, hindfoot alignment) between 3 time intervals (prearthritic, arthritic, and post ankle arthrodesis) were analyzed using Friedman tests because the data were not normally distributed. Dunn's multiple comparisons were applied to identify any differences between the specific time intervals. Ordinal logistic regression (cumulative logit model) was used to classify the relationship between functional outcomes and postarthrodesis satisfaction ratings (poor, fair, good, and excellent), with median questionnaire values (AOFAS hindfoot, HAAS,

**Table 1.** Demographic Data of the Advanced-Stage Ankle Osteoarthritis Patients (n = 61).

Category	
Gender, n (%)	
Male	27 (44)
Female	34 (56)
Age, y	
Mean (SD)	63.1 (13)
Minimum-maximum	23-87
Underlying disease, n (%)	
Diabetes mellitus	41 (67)
Dyslipidemia	10 (16)
Hypertension	35 (57)
Others	3 (5)
Cause, n (%)	
Posttraumatic osteoarthritis	44 (72)
Primary ankle osteoarthritis	9 (15)
Postinflammation osteoarthritis	7 (11)
Others	1 (2)
Takakura staging, n (%)	
Stage 4	37 (61)
Stage 3B	20 (33)
Stage 3A	3 (5)
Stage 2	1 (2)

TAS, and total FFI) used as the independent model predictors. The Brant test<sup>5</sup> was used to confirm the assumption of proportional odds was met. The regression model was also used to predict satisfaction levels in the prearthritic and arthritic periods (as not documented) to provide a descriptive comparison against the postarthrodesis time point (using median scores). The clinical outcome data are presented either as median  $\pm$  95% CI or median and interquartile range (IQR). Statistical analyses were performed using GraphPad Prism version 9.0 (GraphPad Software, La Jolla, CA) with ordinal logistical regression performed using the MASS package<sup>40</sup> in R, version 3.6.3 (R Foundation for Statistical Computing). Statistical significance was considered at the  $P < .05$  level.

## Results

### Sample Size

It was calculated (post hoc) that this retrospective study had 80% power to reliably detect an effect size of  $d=0.52$  (medium) in TAS scores between the prearthritic and postarthrodesis periods using an SD of 0.86.

### Clinical Outcome Data

The demographic and postarthrodesis outcome data of the advanced-stage ankle OA patients are displayed in Tables 1 and 2, respectively. Hindfoot alignment was significantly

**Table 2.** Postarthrodesis Outcomes (n = 61).

Category	Outcome
Complications, n (%)	
Delayed union	7 (58)
Superficial wound infections	3 (25)
Subtalar OA	1 (8)
Neuralgia	1 (8)
Types of exercise activity, n (%)	
Jogging	26 (43)
Cycling	18 (30)
Badminton	6 (10)
Swimming	4 (7)
Basketball	3 (5)
Tennis	2 (3)
Soccer	1 (2)
Level of satisfaction, n (%)	
Excellent	21 (34)
Good	37 (61)
Fair	1 (2)
Poor	2 (3)
Follow-up duration, mo, mean (95% CI)	50.4 (43.2-57.6)
BMI, mean (95% CI)	27.1 (25.9-28.3)
Hindfoot alignment, degrees, mean (95% CI)	
Pre ankle arthrodesis	14.2 (12.1-16.3)
Post ankle arthrodesis	2.8 (1.4-4.2)
Tarsal ROM, degrees (95% CI)	22.7 (21.4-23.9)
Postarthrodesis milestones, wk, mean (95% CI)	
Time to union	15.7 (11.8-19.6)
Time to walk without gait aids	14.4 (11.0-17.7)
Time to return to work	17.9 (15.1-20.8)
Time to exercise activity	20.6 (17.9-23.4)

Abbreviations: BMI, body mass index; OA, osteoarthritis; ROM, range of motion.

improved postarthrodesis compared with the arthritic period (mean difference: 11.43 degrees, 95% CI 9.2-13.6,  $P < .001$ ; Table 2).

### Assessment of Functional Outcomes via Questionnaires

The AOFAS was significantly different between the 3 time intervals (Table 3), with patients providing lower scores during the arthritic period compared with the recall of prearthritic scores ( $P < .001$ ; Table 3). During the postarthrodesis period, AOFAS rating increased ( $P < .001$ ) but did not attain the scores provided for the prearthritic period (Table 3).

There was a significant difference in TAS scores between the 3 time intervals (Table 3). The patients' activity levels decreasing during the arthritic compared with the prearthritic time point (Table 3). Activity levels were rated higher postarthrodesis compared with the prearthritic activity period (Table 3).

**Table 3.** Questionnaire Scores Across Time Periods (n = 61).

Questionnaire	Prearthritic, Median (IQR)	Arthritic, Median (IQR)	Postarthrodesis, Median (IQR)	P Value
AOFAS	100.0 <sup>ab</sup> (98.5-100.0)	42.0 <sup>ac</sup> (29.0-50.5)	90.0 <sup>bc</sup> (85.0-96.5)	<.001
HAAS	14.0 <sup>ab</sup> (13.0-16.0)	6.0 <sup>ac</sup> (5.0-7.5)	13.0 <sup>bc</sup> (12.0-14.0)	<.001
TAS score	5.0 <sup>a</sup> (4.0-5.0)	2.0 <sup>ac</sup> (2.0-3.0)	5.0 <sup>c</sup> (4.0-5.0)	<.001
FFI	2.4 <sup>ab</sup> (0.0-4.2)	87.7 <sup>ac</sup> (83.2-91.5)	27.7 <sup>bc</sup> (19.2-36.2)	<.001
FFI (subscale)				<.001
Part 1 (pain)	0.0 <sup>ab</sup> (0.0-0.0)	45.0 <sup>ac</sup> (41.0-47.0)	14.0 <sup>bc</sup> (10.0-18.0)	
Part 2 (disability)	2.0 <sup>ab</sup> (0.0-6.0)	83.0 <sup>ac</sup> (78.0-86.0)	27.0 <sup>bc</sup> (21.0-31.0)	
Part 3 (activity limitation)	0.0 <sup>ab</sup> (0.0-0.0)	25.0 <sup>ac</sup> (23.0-27.0)	10.0 <sup>bc</sup> (8.0-13.0)	

Abbreviations: AOFAS, American Orthopaedic Foot & Ankle Society hindfoot-ankle score; FFI, Foot Function Index; HAAS, High-Activity Arthroplasty Score; TAS, Tegner Activity Scale.

<sup>a</sup>Significant difference between the Prearthritic and Arthritic periods.

<sup>b</sup>Significant difference between the Prearthritic and Postarthrodesis periods.

<sup>c</sup>Significant difference between the Arthritic and Postarthrodesis periods.

The HAAS was rated significantly differently across the 3 time intervals (Table 3). The HAAS was rated lower during the arthritic compared with the prearthritic period (Table 3). HAAS increased postarthrodesis but remained lower than prearthritic values (Table 3).

Total FFI scores were also significantly different across the 3 time intervals (Table 3) with FFI rated higher during the arthritic period compared with the recall of prearthritic scores (Table 3). Lower total FFI scores were provided postarthrodesis, however, patients still provided higher scores than prearthritic ratings (Table 3).

FFI subscale scores were also rated significantly different across the 3 time intervals with higher scores provided for part 1 (pain), part 2 (disability), and part 3 (activity limitation) in the arthritic period compared with the recall of prearthritic scores (all  $P < .001$ ; Table 3). FFI scores were rated lower during the postarthrodesis compared with the arthritic period in each subscale section (all  $P < .001$ ; Table 3), however, scores remained higher than prearthritic period (all  $P < .001$ ; Table 3).

### Satisfaction With Return to Activity

Ordinal logistic regression analysis showed that the increase in AOFAS hindfoot scores were not significantly associated with an increase in the odds of patients having higher satisfaction with an increase in the odds of patients having a higher satisfaction with their activity level ( $P = .50$ ; Table 4). In contrast, a score increase in all other questionnaires (while

**Table 4.** Logit Coefficients for the Effect of Questionnaire on Satisfaction With Activity Level.

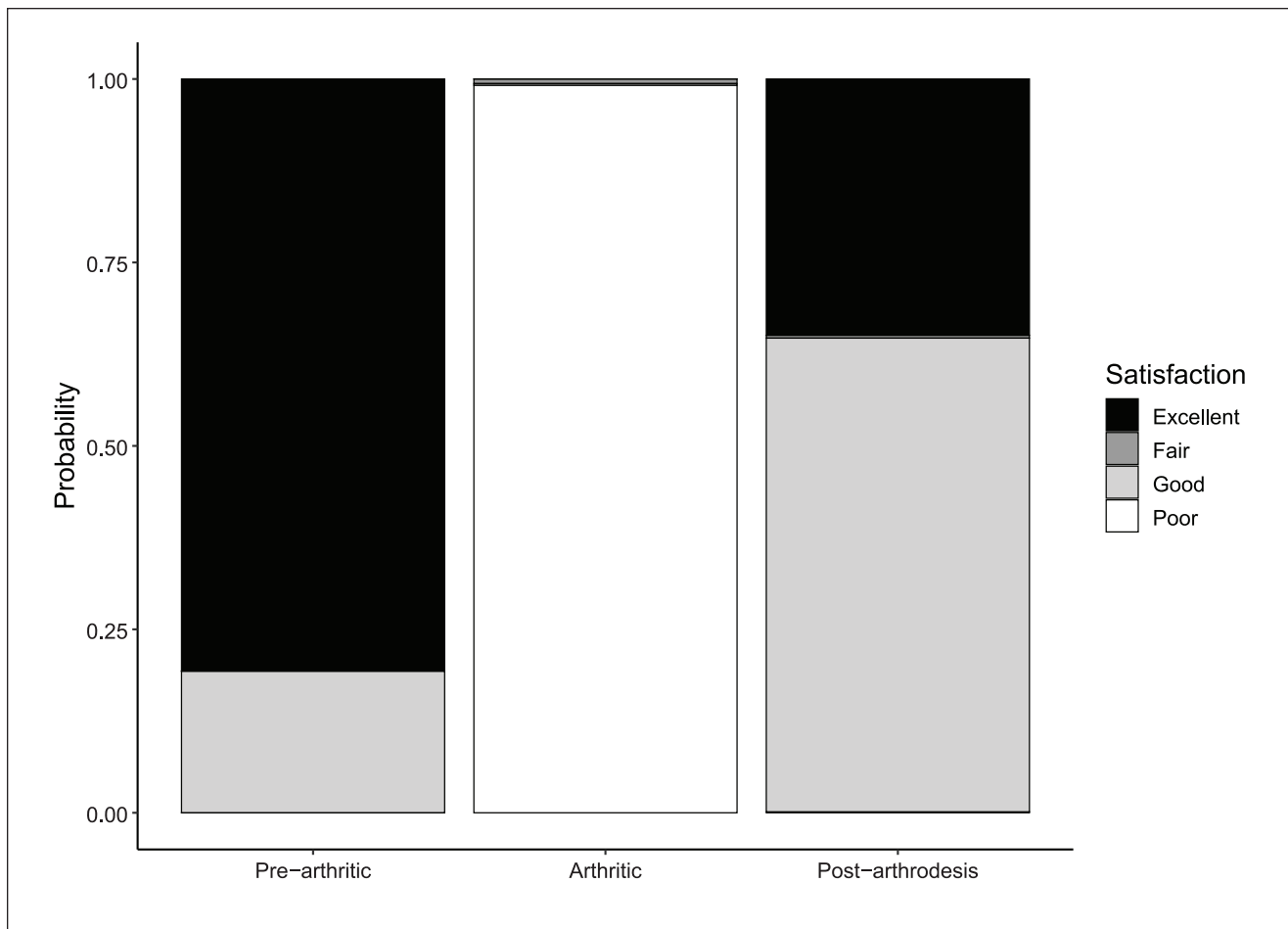
Coefficients	Estimate	SE	Wald (95% CI)
AOFAS	0.027	0.040	-0.05 to 0.10
HAAS	0.387 <sup>a</sup>	0.171	0.05 to 0.72
TAS score	1.351 <sup>b</sup>	0.442	0.48 to 2.22
FFI (total)	-0.055 <sup>a</sup>	0.026	-0.11 to 0.00
Intercepts			
Poor   fair	6.099	3.798	-13.54 to 1.35
Fair   good	7.447	3.740	-14.78 to -0.12
Good   excellent	13.322 <sup>b</sup>	4.265	-21.68 to -4.96
Odds ratios exponentiated from logit coefficients			
AOFAS	1.027	-0.04	0.95 to 1.11
HAAS	1.473 <sup>a</sup>	-0.171	1.07 to 2.04
TAS score	3.862 <sup>b</sup>	-0.442	1.63 to 9.14
FFI (Total)	0.946 <sup>a</sup>	-0.026	0.90 to 1.00

Abbreviations: AOFAS, American Orthopaedic Foot & Ankle Society hindfoot-ankle score; FFI, Foot Function Index; HAAS, High-Activity Arthroplasty Score; TAS, Tegner Activity Scale.

<sup>a</sup> $P < .05$ . <sup>b</sup> $P < .01$ .

other questionnaire scores are held constant) was significantly associated with an increase in the odds of patients reporting a higher satisfaction level ( $P < .05$ ; Table 4). The insertion of median questionnaire scores into the regression model predicted that patients rated their satisfaction levels as “excellent” during the prearthritic period, “poor” during the arthritic period, and “good” postarthrodesis (Figure 1).





**Figure 1.** Patient satisfaction with their activity level across the prearthritic, arthritic, and postarthrodesis time intervals. Patient satisfaction was predicted using an ordinal regression model and interpreted based on the probability of the response.

## Discussion

The main findings from this retrospective analysis were that advanced-stage ankle OA patients were able to return to sport and exercise activity postarthrodesis; however, patient functional ability generally did not return to the prearthritic capacity level. Nevertheless, the improvement in postarthrodesis functional outcomes led to a “good” level of patient satisfaction, with many patients able to return to high-impact-type activity.

All the questionnaires used in this study demonstrated that patients had a marked improvement in their functional ability postarthrodesis (Table 3). However, only the TAS questionnaire indicated that ankle OA patients were able to return to their prearthritic functional level (Table 3). Our findings are in agreement with Kerkhoff et al,<sup>22</sup> who used a visual analog scale (VAS), Foot and Ankle Ability Measure (FAAM), and FFI assessments to demonstrate that sports activity could be well maintained postoperation (79.5% at disability onset vs 68.8% postoperation). Unfortunately, as the employed measurement tools were

not specifically designed for assessing sports activities per se, high-activity functional outcomes were not assessed in their work. In contrast, in this retrospective analysis, higher activity demands were considered; thus, previous observations are somewhat extended by providing an ecologically valid description of return to sport/exercise activity postoperation.

The improvement in functional capacity and ability to return to sport and exercise activity postarthrodesis (Tables 2 and 3) were likely related to the improvement in the tarsal motion of the patients. It is known that tarsal motion largely depends on postoperative hindfoot alignment, with good alignment leading to a lower level of adjacent joint degeneration and a reduction in pain and motion limitation.<sup>29</sup> The marked postoperative correction in hindfoot alignment allows the tarsal bones to provide compensatory motion for the ankle, likely explaining the improvement in patient functional outcomes and “good” postarthrodesis satisfaction levels.<sup>1</sup> Indeed, this satisfaction rating coincided with the majority (61%) of patient responses, representing a substantial improvement from “poor” patient satisfaction levels

that were predicted during the arthritic period. A closer inspection of the model coefficients suggested that omission of the AOFAS hindfoot scores may improve model precision (ie,  $P > .05$ ; Table 4), perhaps not surprising because the validity and reliability of the AOFAS for ankle OA is not established.<sup>8,25,35</sup> Both physician- and patient-reported responses are included in this questionnaire, with objective physician assessments (ie, alignment) potentially skewing the interpretation of patients' functional ability.

In line with recent literature,<sup>15</sup> our retrospective analysis demonstrated that posttraumatic OA (ie, trauma directly or indirectly via injury to surrounding structural elements; Table 1) was the principal cause of ankle OA. Naal et al<sup>31</sup> recommended ankle arthrodesis as a surgical option for posttraumatic ankle OA as these patients experience the problem of bone loss, malalignment, and soft tissue damage. Therefore, the success of ankle arthrodesis surgery in achieving satisfaction with the return to sport/exercise activity likely depends on the prearthritic status and corrective postoperative hindfoot alignment. In support, Buchner and Sabo<sup>6</sup> suggested that an ankle plantarflexion greater than 5 degrees correlates with worse functional outcomes. Similarly, Mann and Rongstad<sup>27</sup> indicated that without malalignment, a good functional outcome could be achieved, others suggesting inappropriate alignment and adjacent joint degeneration affect functional outcomes.<sup>19</sup> A past survey<sup>42</sup> that questioned key stakeholders (orthopaedic surgeons, trainers, and athletes) proposed there is a consensus to avoid higher impact sports in patients elected for foot and ankle fusion. This was because high-impact activity potentially accelerates the development of adjacent degenerative joint disease.<sup>42</sup> However, the descriptive analysis conducted in this study established that many patients were able to return to some form of high-impact activity (64%); jogging being the most popular (43%) postarthrodesis exercise activity (Table 2). Nevertheless, it is important to note that the advancing age of patients, gender, and/or disease complications can play a role in influencing the type of activity taken up after ankle arthrodesis.

The data showed that delayed union was the most common complication ( $n=7$ ), coinciding with the number of weeks patients used gait aids, the time to return to work, and sports activity (Table 2). The time frame of returning to sports activity (21 weeks) is indicative of not suffering a loss of essential tarsal mobility. Although only 1 patient was identified as having OA at the subtalar joint, a longer patient follow-up period ( $>1$  year) may be expected to result in adjacent joint degeneration becoming more apparent because of the maintenance of high activity levels. This could arise because of the compensatory motion of adjacent joints or the gradual progression of preexisting arthritis in the adjacent joint that steadily progresses over time.<sup>34</sup> Although superficial wound infections were also a reported

complication ( $n=3$ , Table 2), they could be effectively treated with oral antibiotics.

The questionnaire recall of prearthritic functional outcomes (performed during the arthritic period) represents a major limitation in making an inference to changes in functional outcomes across time periods. However, this is a consequence of patients not seeking clinical intervention when not experiencing arthritic symptoms. Furthermore, as our retrospective analysis found an aged patient demographic ( $63 \pm 13$  yrs; Table 1), a younger patient cohort that has greater exposure to high-impact sports would be more befitting of an exercise/sport activity evaluation. Indeed, OA patients are more likely to move toward less strenuous (low-impact) forms of exercise with advancing age, thus confounding the interpretation of functional ability postarthrodesis. Accordingly, large multicenter studies (employing various questionnaires) are required to provide more relevant data about younger patient cohorts.

In conclusion, our single-center retrospective analysis showed that advanced-stage ankle OA patients were able to improve their functional ability after ankle arthrodesis surgery. Patients generally reported "good" satisfaction with their return to sport/exercise activity, with the majority of patients able to return to high-impact-type activity. Although the activity questionnaires tracked improvements in functional ability postarthrodesis, prearthritic values were not attained. It appears that ankle arthrodesis is a good option for OA patients still wanting to return to relatively intense sports and exercise activity.

### Code availability

The code for the ordinal regression model is available at: [https://osf.io/4dzs7/?view\\_only=5ab8133c29384a379c2ff5cf6dc5695c](https://osf.io/4dzs7/?view_only=5ab8133c29384a379c2ff5cf6dc5695c)

### Ethical Approval

Ethical approval for this study was obtained from the Siriraj Institutional Review Board (Si 138/2017).

### Declaration of Conflicting Interests

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