Comparison of the Efficiency and Safety of Total Ankle Replacement and Ankle Arthrodesis in the Treatment of Osteoarthritis: An Updated Systematic Review and Meta-analysis

Yuhan Li, BS1, Jinquan He, MD2, Yongcheng Hu, MD3

1Department of Biological Sciences, Auburn University, Auburn, Alabama, USA and 2The First Department of Foot and Ankle Surgery and 3Department of Orthopaedic Oncology, Tianjin Hospital, Tianjin, China

While osteoarthritis is a common degenerative disease, ankle osteoarthritis is a subdivision that has received little attention. Two effective ways to treat osteoarthritis of the ankle are total ankle replacement (TAR) and ankle arthrodesis (AAD). Whether TAR or AAD is more beneficial for treatment is controversial. The purpose of this meta-analysis was to compare the efficiency (clinical outcome and patient satisfaction) and safety (complications and survival) of these two procedures. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement was performed as a guideline for this study. Three electronic databases, PubMed, Web of Science, and Cochrane Library, were searched up to May 2019, with no language restrictions. Prospective or retrospective comparative studies were identified. The outcomes included clinical outcome, patient satisfaction, complications, and survival. Review Manager (Revman) 5.3 software was used to conduct the data analysis. We only selected literature from the past 5 years (no earlier than 2015). Seven comparative studies were included. There were six cohort studies and one cross-sectional study. The Newcastle–Ottawa Scale (NOS) was used to assess the quality of cohort studies, and The Agency for Healthcare Research and Quality (AHRQ) checklist was chosen to assess the quality of cross-sectional studies. No significant difference was observed for efficiency and safety. Clinical outcome was included in five studies with four different scoring systems. Two of them used the American Orthopaedic Foot & Ankle Society (AOFAS) questionnaire scores to assess the two procedures (mean difference, –4.26; 95% confidence interval [CI], –11.37–2.85; P = 0.24; I² = 1%), Patient satisfaction (risk ratio [RR], 0.96; 95% CI, 0.65–1.40; P = 0.82; I² = 54%), complications (RR, 1.15; 95% CI, 0.16–8.21; P = 0.89; I² = 84%), and survival (RR, 1.91; 95% CI, 0.33–11.08; P = 0.47; I² = 90%) showed no significant difference between the TAR group and the AAD group. This meta-analysis showed no statistically significant difference between TAR and AAD in clinical outcome, patient satisfaction, complications, and survival. This revealed that TAR and AAD could appear to have similar results in these aspects. Therefore, the present results are not sufficient to conclude which of these two methods is better. Further studies are needed to obtain more clues.

Key words: AAD; Ankle Arthrodesis; Meta-analysis; Osteoarthritis; TAR; Total Ankle Replacement

Introduction

Osteoarthritis (OA) is a degenerative disease that affects joints and their cartilage, leading to the loss of structure and function1,2. Osteoarthritis affects several joints, such as the knee, the hip, and the ankle. Because the incidence of ankle osteoarthritis is relatively low compared to other types of osteoarthritis, there is less discussion on this topic2. Two practical and well-established ways to treat osteoarthritis of the ankle are total ankle replacement (TAR) and ankle arthrodesis (AAD).
AAD, also referred to as ankle fusion, is a widely used treatment for ankle osteoarthritis. The use of this type of treatment can result in good patient satisfaction and can provide pain relief and improvement in function, thus helping patients return to normal daily life. It is regarded as a standard treatment for ankle osteoarthritis. TAR is also a useful surgical treatment strategy as an alternative treatment to AAD. However, early ankle replacement was not acceptable as a surgical treatment strategy for ankle osteoarthritis. TAR is also a useful treatment for osteoarthritis, they have certain shortcomings. Ankle fusion is a traditional and popular operative treatment. However, it can lead to persistent alterations in gait, and may even lead to the development of osteoarthritis in other joints, such as the subtalar joint, the talonavicular, and the midfoot. For ankle replacement, the results for short-term and mid-term survivorship and functional outcomes are promising; however, the long-term effects require further research, and the operation is complicated and challenging for doctors.

Because of the controversy over whether TAR or AAD is more advantageous and progressive, a comparative study of these two methods is vital to clinical research. There have been few previous studies and meta-analyses comparing TAR and AAD; however, some new literature has been published. Therefore, it is necessary to conduct an updated systematic review and meta-analysis. In our meta-analysis, we included studies published in the past 5 years (from 2015 to 2019) and assessed clinical outcomes, patient satisfaction, complications, and survival to explore the efficiency and safety of these two procedures and then to determine which approach is more effective for osteoarthritis.

Methods
The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement was used to guide the study.

Information Sources and Search Strategy
The relevant works of literature selected in this study were mainly from three electronic databases up to May 2019, with no language restrictions: PubMed, Web of Science, and Cochrane Library. The keywords identified in this search were Medical Subject Headings (MeSH) “Osteoarthritis,” and all synonyms (free terms), MeSH “Arthroplasty, Replacement, Ankle” and all synonyms (free terms), MeSH “Arthrodesis,” “Arthrodesis,” “Ankle Arthrodesis,” and “Ankle fusion.” The combination of these MeSH terms and free terms was then applied.

Eligibility Criteria
The following criteria for inclusion were applied:
(i) population: adult patients with osteoarthritis; (ii) intervention: treatment with TAR; (iii) comparison: treatment with AAD; (iv) outcome: efficiency (clinical outcome and patient satisfaction) and safety (complications and survival); and (v) design: prospective or retrospective comparative studies (randomized controlled trials [RCT] and non-randomized controlled studies [included observational studies]). The duplicated studies were excluded.

Data Collection
The first author extracted all information about patients and treatments. These data involved: (i) the first author, year of publication, study type, number of subjects, mean age of subjects, and follow up; (ii) outcome measures; and (iii) intervention characteristics of the TAR groups and the AAD groups. The other author reviewed and checked the extracted data. Any disagreements between the two authors were resolved by discussion.

Quality Assessment
The Agency for Healthcare Research and Quality (AHRQ) checklist was chosen to assess the quality of cross-sectional studies. It included 11 quality items, and “yes,” “no,” and “unclear” could be applied to each item. The Newcastle–Ottawa scale (NOS) was selected to assess the quality of other non-randomized controlled studies. There were three domains (selection, comparability, and outcome) and a total of eight detailed quality items in this scale. In “selection” and “outcome” domains, a maximum of one star could be awarded for each quality item. In the “comparability” domain, a maximum of two stars could be given. More stars obtained meant higher quality assessed.

For the included studies that were RCT, the Cochrane Collaboration’s tool for assessing the risk of bias was appropriate. The evaluation criteria were as follows: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other bias. Because no RCT studies were included in this meta-analysis, this quality assessment tool was not used.

Two authors conducted the quality assessment independently. Any disagreements between the two authors were resolved by discussion.

Data Analysis
The statistical software used in this study for data analysis was Review Manager (Revman) 5.3. For the dichotomous outcomes, the selected effect size was the risk ratio (RR) with a 95% confidence interval (CI), and the chosen method was the Mantel–Haenszel method. Weighted mean difference (WMD) with 95% CI was selected for the continuous outcomes. The F2-statistic test was used to detect the statistical heterogeneity between studies. If the value of F2 was less than 50%, indicating that the heterogeneity was low, the fixed-effects model was
Study Selection

A total of 487 studies were identified and extracted from the initial three databases by using the inclusion criteria and the data collection strategy mentioned above. Among them, there were 242 works of literature from PubMed, 242 from Web of Science (only included trials), and 3 from Cochrane Library (only included trials). A total of 114 studies were included in the quantitative analysis, and the high heterogeneity was considered statistically significant. Due to the small number of studies included (fewer than 10), the publication bias was not assessable, and the funnel plots were not used to indicate potential publication bias.

Results

Table 1: Summary of characteristics of the studies included in the meta-analysis

| First author | Year | Study type | Number of subjects | Mean age of subjects | Follow-up (months) | Clinical outcome | Patient satisfaction | Complications | Survival |
|--------------|------|------------|-------------------|---------------------|-------------------|-----------------|---------------------|--------------|----------|
| Chorpa10     | 2017 | Retrospective | TAR:12 AAD:12 | TAR:56.4 AAD:56.4 | TAR:NR AAD:NR | FAAM | NR | NR | NR |
| Croft11      | 2017 | Retrospective | TAR:362 AAD:169 | TAR:40.8 AAD:40.8 | TAR:NR AAD:NR | NR | TAR:62 AAD:8 |
| Henricson12  | 2016 | Retrospective | TAR:7 AAD:7 | TAR:61.1 AAD:66.4 | TAR:77.0 AAD:77 | SEFAS | TAR:7 AAD:6 | TAR:2 AAD:1 |
| Mehdi13      | 2019 | Retrospective | TAR:25 AAD:25 | TAR:60.0 AAD:68.0 | TAR:65.0 AAD:65 | AOFAS; Pain VAS | TAR:16 AAD:20 | TAR:7 AAD:2 | TAR:9 AAD:1 |
| Norvell14    | 2018 | Prospective  | TAR:395 AAD:98 | TAR:63.3 AAD:54.2 | TAR:12.0 AAD:12 | NR | TAR:33 AAD:17 | AAD:13 |
| Pedowitz15   | 2016 | Retrospective | TAR:41 AAD:27 | TAR:65.0 AAD:55 | TAR:33.7 AAD:33 | SF-12MCS; SF-12PCS; VAS; FAAM; AOS | NR | NR | NR |
| Pinsker16    | 2015 | Prospective  | TAR:85 AAD:15 | Total:61.2 | TAR:30.0 AAD:30.0 | SMFA; WOMAC; AOFAS; LEFS; FR; AOS | NR | NR | NR |

Survival = revision, re-operation, or operation failure. ADL, activities of daily living; AOFAS, American Orthopaedic Foot & Ankle Society questionnaire; AOS, ankle osteoarthritis scale; FAAM, foot and ankle ability measure score; FFI, foot function index; LEFS, lower extremity functional scale; MCS, mental component summary; NR, not reported; PCS, physical component summary; SEFAS, self-reported foot and ankle score; SF-12, Short Form-12; SMFA, short musculoskeletal function assessment; VAS, visual analogue scale; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.
excluded because of duplication and 333 studies were excluded after screening titles and abstracts because they did not study the two treatments (TAR and AAD) comprehensively or only studied one of them. The remaining 40 articles were reviewed by reading full texts to obtain more details. Of these, 20 were excluded because they were published earlier than 2015. There were 6 works of literature excluded because they did not clearly compare the efficiency and safety of the two therapies (TAR and AAD), and another 7 studies were excluded because they could not be studied in the quantitative synthesis. Finally, 7 studies were included in the meta-analysis because they met the eligibility criteria. The process of the selection is shown in Fig. 1.

**Study Characteristics**

Only studies from 2015 to 2019 (the past 5 years) were included. A total of 1280 patients were included in the 7 studies selected, of which 927 were treated with TAR and 353 with AAD. The follow-up cycles were provided in all 7 studies, with the shortest one being 12.0 months and the longest being 77.0 months, while 5 studies showed the average age of patients. Five studies involved clinical outcome, 2 studies presented patient satisfaction, two studies compared complications, and four studies reported survival. Because of the lack of directly given data, the standard deviations were estimated for the clinical outcome part of the studies by Mehdi and Pedowitz. Table 1 depicts the specific study characteristics and more details.

**Quality Assessment**

The quality of the 7 studies was evaluated, with 6 cohort studies and 1 cross-sectional study included. Cohort studies were assessed using the NOS, and the cross-sectional study was assessed using AHRQ checklist. The evaluation results and summary are shown in Tables 2 and 3.

**Data Analysis**

**Clinical Outcomes**

Of 7 studies, 5 studies involved clinical outcomes, but they used various scoring systems. Two of them used the American Orthopaedic Foot & Ankle Society (AOFAS) questionnaire scores to assess the two groups: the TAR group and the AAD group (mean difference, −4.26; 95% CI, −11.37–2.85; P = 0.24; I² = 1%) (Fig. 2).

**Patient Satisfaction**

Two studies reported on patient satisfaction, involving 32 patients of the TAR group and 32 patients of the AAD group. Of these, 23 TAR patients were satisfied, and 26 AAD patients were satisfied.

The result showed that there was no statistically significant difference between the TAR group and the AAD group (RR, 0.96; 95% CI, 0.65–1.40; P = 0.82; I² = 54%) (Fig. 3).

**Complications**

Two studies involved complications, including 420 TAR subjects and 123 AAD subjects. The pooled data revealed that there was no statistical significance (RR, 1.15; 95% CI, 0.16–8.21; P = 0.89; I² = 84%) (Fig. 4).

**Survival**

Four studies presented survival details; that is, revision, reoperation, or operation failure. Although there was no statistically significant difference found between the two groups, the RR showed that the risk of survival in the TAR group was relatively higher than that of the AAD group (RR, 1.91; 95% CI, 0.33–11.08; P = 0.47; I² = 90%) (Fig. 5).

**Discussion**

This is an updated systematic review and meta-analysis reporting on the comparison of the efficiency and safety of the two therapies (TAR and AAD) included in the meta-analysis.
This meta-analysis was based on 7 studies published in the past 5 years (2015–2019).

Kim et al. conducted a similar meta-analysis comparing TAR and AAD for end-stage ankle arthritis in 2016. The main finding of our study was relatively consistent with this previous meta-analysis: TAR and AAD shared similar efficacy and safety in some aspects. Kim’s work, like ours, concluded that TAR and AAD had no significant difference in clinical outcomes and patient satisfaction, but their conclusions showed that TAR patients had more re-operations and complications than AAD. This discrepancy might occur because the works of literature included in our meta-analysis were published more recently, and the surgical techniques might be improving. This might also be because the focuses on the details were different; for example, they were concerned about end-stage ankle arthritis, while we were concerned about osteoarthritis.

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There are some potential limitations of this study. First, this meta-analysis had a limited sample size. A small number of studies was included, and each study reported different outcome measures so that each outcome had a relatively small sample size. In addition, some of the included studies had few subjects. This might lead to potential bias or heterogeneity. For instance, various scoring systems were used to assess clinical outcomes in the included studies, and only two of the studies shared the same scoring system, AOFAS scores. For some rare complications, such a limited sample size might not be adequate. Besides, due to the different focuses of each included study, some assessments could not be performed because of the insufficient data. Therefore, further research is needed to resolve this issue.

Second, there was no RCT among the 7 studies included in this meta-analysis, which were all observational studies. RCT is a relatively challenging type of research, so there are fewer RCT studies than other types of studies. Due to the characteristics of this study, ethical issues also need to be considered. RCT research focuses on randomness, and the existence of ethical problems makes such research difficult. Therefore, we found few relevant RCT studies, which led to higher heterogeneity.

Then, the search was not comprehensive enough. This was due to the imperfect retrieval strategy: only limited network databases (Cochrane Library, PubMed, Web of Science) were used in this meta-analysis without searching published physical books.

In conclusion, although each therapy tends to have relatively better performance in some of the above aspects, it is difficult to judge which of the two is superior: there was no statistically significant difference between the two treatments. The current limitations of this meta-analysis, mentioned above, indicate that it is necessary to increase the sample size and improve the retrieval strategy to reduce heterogeneity and bias. Further studies are necessary to assess and compare the efficiency and safety of TAR and AAD.

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