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Association of Adjunctive Procedures, Patient Demographics, or Intraoperative Factors and the Risk of Complications or Reoperation Following Total Ankle Arthroplasty or Ankle Arthrodesis

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Abstract

Background: End-stage ankle arthritis is successfully treated with surgery with either ankle arthrodesis (AA) or total ankle arthroplasty (TAA). Much is described comparing the 2 treatments in tightly selected patient groups. Limited evidence attempts to examine specific elements of technical complexity that increase perioperative risk for the surgical treatment of ankle arthritis. There is suspicion that AA may be preferable in the setting of elevated patient complexity, or that procedures may require staging to diminish complication risk when there is also foot deformity present. The aim of this study is to evaluate the effect of adjunctive procedures on overall postoperative complication (POC) risk, for both TAA and AA. Primary outcome measures were to compare overall complication and reoperation risk for TAA and AA. Secondary outcome measures were to identify patient factors, intraoperative factors, and factors of procedural complexity via number of associated surgeries and the incidence of complications and reoperation.
Methods: A retrospective chart review of AAs and TAAs performed at a single academic institution from the years 2008-2024 was performed using *Current Procedural Terminology* (*CPT*) codes identifying AA and TAA. Patient demographics, operative details, and postoperative data were abstracted to collect relevant information. Statistical analyses, including odds ratios and analysis of variance, were then performed to reveal specific risk factors and correlations.
Results: Four hundred ninety-one patients were identified in the initial database query. After exclusions, 246 remained, of which 110 underwent AA and 136 underwent TAA. The mean length of follow-up was 36.4 months for TAA patients and 46.1 months for AA patients in this study. Overall, patients who underwent TAA were older and had an increased number of preoperative comorbidities (5.74 ± 3.07) compared to AA (4.74 ± 2.76) ($P = .008$). Additionally, TAA patients experienced a lower overall rate of POCs (20/136, 14.71%) and reoperation (14/136, 10.29%) compared with patients who underwent AA (21/110, 19.09%; 21/110, 19.09%) ($P = .36$ and $P = .05$, respectively). As the number of adjunctive procedures increased, so did the rate of POCs, but not reoperation, in patients who underwent TAA. The number of adjunctive procedures was not significantly associated with complication or reoperation risk in AA patients. There were no specific adjunctive procedures that demonstrated a significant correlation with increased risk of complications or reoperation in both groups. Osteoporosis and coagulopathies were identified as predisposing TAA patients to postoperative complications.
Conclusion: In our retrospective cohort study with relatively low statistical power, we found that patients who undergo TAA or AA plus adjunctive procedures did not experience an increased risk of major complications or reoperation compared to patients who did not undergo adjunctive procedures. Several preexisting comorbidities in TAA patients were associated with higher rates of POCs or reoperation, including osteoporosis and coagulopathies; no comorbidities were linked to increased reoperation or POC risk in the AA group. These findings suggest a need to evaluate comorbidities,

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and lifestyle factors when recommending an ankle reconstruction procedure to minimize the odds of postoperative complications and improve likelihood of patient satisfaction.

Level of Evidence: Level III, retrospective cohort study.

Keywords: ankle, arthrodesis, arthroplasty, complications

Introduction

Ankle arthrodesis (AA) and total ankle arthroplasty (TAA) are procedures often performed to treat end-stage tibiotalar arthritis. Ankle arthrodesis remains the gold standard treatment; however, advances in implant design and surgical technique have made TAA an increasingly used and viable alternative.[5,20,23,25] The rate of successful fusion in patients undergoing AA is high, ranging from 85% to 100%; however, fusion causes motion loss and possible adverse stress transference to adjacent hindfoot joints, leading to abnormal biomechanics.[1,7] Radiographic evidence of arthritic degeneration in the subtalar, talonavicular, and calcaneocuboid joints has been described following AA. The development of adjacent joint arthritis following AA often necessitates additional procedures, which lead to further stiffening of the ankle, restrictions in motion, and poorer patient outcomes.[18] Notably, studies have failed to show a definitive link regarding these suspicions.[8,18]

TAA has the benefit of ankle joint motion preservation, which may spare adjacent hindfoot joint stress. However, there are long-term risks common to the usage of artificial joints, including aseptic loosening and periprosthetic fracture.[25]

Patients with end-stage ankle arthritis requiring surgical intervention often present with significant multiplanar ankle deformity, and adjunctive procedures to achieve a properly balanced and aligned foot and ankle are often performed during TAA.[10,22] Clinical outcomes and implant survivorship significantly improve when additional procedures are performed to fix moderate to severe ankle deformity, with outcomes shown in initial research to potentially be comparable to patients with neutrally aligned ankles.[15] Bony, ligamentous, and tendinous procedures are commonly performed to reestablish a biomechanically balanced ankle and hindfoot prior to closure.[4,6,19]

Despite this early and promising evidence, a definitive link between these adjunctive procedures and their effects on the outcome of the index procedure is currently ill-defined. There is commonly cited caution for performing adjunctive procedures, including increased operative time and tourniquet use, possibly increasing the risk of complications.[10] However, the effect of operative duration, tourniquet use, and additional procedures has not been properly described in TAA or AA.

Our study aims to examine the usage of adjunctive "balancing" procedures during AA and TAA and their effects on postoperative complication (POC) and reoperation risk. The secondary aim of the study was to perform a bivariate regression analysis to identify predictive factors, such as patient demographics or preexisting comorbidities (diabetes, for example), that may also predispose to POC and reoperation.

Materials and Methods

Following IRB approval, a retrospective review was completed of all total ankle arthroplasty (TAA) and ankle arthrodesis (AA) procedures performed at a multisite institution by multiple surgeons between January 2008 and June 2024. Inclusion criteria for this study included patients undergoing TAA or AA within the previously stated time frame. Exclusion criteria included patients who did not undergo either TAA or AA, patients who underwent a revision TAA or AA as their primary procedure, and patients who underwent TAA or AA before January 1, 2008. Patients without a minimum of 1-year follow-up were excluded from this study.

The original query provided 491 patients. Two hundred forty-five patients were excluded per criteria, leaving 246 patients remaining for analysis. Patients were then assigned to either of 2 groups: total ankle arthroplasty (TAA) or ankle arthrodesis (AA), depending on the primary procedure they received. Patients assigned to the TAA group included patients who underwent TAA irrespective of implant type, manufacturer, or surgical technique used. Patients assigned to the AA group underwent ankle (tibiotalar) arthrodesis. Details regarding the various TAA implants used along with all AA surgical techniques are provided in Supplementary Table 1. Overall, 136 patients were included in the TAA group and 110 patients were included in the AA group.

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The electronic medical records (EMRs) of all 246 patients were reviewed for demographic information including age, gender, height and weight, comorbidities, medical history, operative diagnosis/indication(s), and operative details including date, primary surgeon, procedure(s) performed, procedure duration, and duration of active tourniquet use. All demographic information was gathered at the time of surgery or preoperative evaluation. Patients who received an additional procedure(s) along with primary TAA or AA were identified as having had an "adjunctive procedure." Examples of adjunct procedures include corrective osteotomies, ligament reconstruction, and adjacent joint arthrodesis. Adjunctive procedures included in our study are detailed in Supplementary Table 2. Adjunct procedures not included were postoperative splint placement and use of intraoperative fluoroscopy. Procedure duration was defined as the time elapsed from initial cut to end of closure. In addition, there was no limit or specific protocol governing tourniquet use or inflation time. Postoperative complications, reoperation details, and follow-up duration were identified in subsequent postoperative visits and progress notes in the patient's EMR.

Statistical Analysis

Descriptive statistics were described as the mean (average) for continuous variables such as age and number of comorbidities. Number (percentage) described discrete and binomial variables such as presence or absence of a comorbidity, postoperative complication, and gender. Nominal data were compared using χ^2 tests, and odds ratios (ORs) were used to assess the correlation between independent variables (eg, ± diabetes) and operative outcomes (eg, ± POCs). This was a main effects analysis between the type of procedure and the presence or absence of adjunctive procedures, which attempted to identify the adjunctive procedures' effects on patient outcomes. A priori power analysis indicates that with an estimated increase in complication risk from 20% to 40% between study groups, 81 patients would be required in each group to achieve adequate statistical power. Post hoc power analysis of reoperation rates between TAA and AA groups indicated a study power of 50.2%. In addition, Kaplan-Meier survivorship analyses were conducted for both AA and TAA groups to visualize reoperation rates as a function of several factors, including operative time and tourniquet time. Statistical significance for all tests was set at $\alpha = 0.05$. BlueSky Statistics, version 10.3.4, software was used for analyses.

Results

Two hundred forty-six patients were included in this study after exclusions, of which 136 underwent TAA and 110 underwent AA (Figure 1). Overall, TAA patients were significantly older with a higher number of comorbidities than AA patients. In addition, for TAA patients, procedure duration and tourniquet time were significantly increased. The only demographic significantly elevated in the AA group was BMI, with an average BMI of 31.45 compared with a mean BMI of 29.45 in the TAA group. Demographic data and temporal details pertaining to procedures are summarized in Tables 1 and 2, respectively.

An adjunctive procedure was performed in 57 of 136 (41.91%) TAA and 57 of 110 (51.82%) AA patients (Table 3). The mean number of adjunctive procedures was 0.56 (range, 0-4) in TAA and 0.79 (range, 0 to 4), a significantly higher amount ($P = .03$), in AA patients. The mean length of follow-up was 36.39 months (range, 12-147) in TAA patients and 46.09 months (range, 12-170) in AA patients. AA group follow-up duration was significantly longer than for the TAA group ($P = .01$).

Postoperative complications (POCs) were noted in 20 of 136 (14.71%) TAA and 21 of 110 (19.09%) in AA patients. A reoperation was performed in 14 of 136 (10.29%) TAA and 21 of 110 (19.09%) AA patients. Reoperation rate approached significance ($P = .056$, OR 2.06, CI 0.99-4.26) in AA patients when compared to the TAA group. To achieve significance, a subsequent fragility analysis indicated that a single reoperation could either be added to the AA group or subtracted from the TAA group ($P = .038$ and .037, respectively).

The most common reoperation was revision arthrodesis (11 of 110, 10%) in AA patients. There were 2 cases of revision arthroplasty (2 of 136, 1.47%) in the TAA group.

Increased procedural length and additional adjunctive procedures in the TAA group were both found to correlate to increased complication rates ($P = .03$ and .03, respectively). The number of preoperative comorbidities also positively influenced reoperation rates in TAA patients ($P = .04$). No correlations were seen between any variables (preoperative or intraoperative) and rate of complications or reoperations in the AA group (Table 4).

Operative time and tourniquet times for AA and TAA study groups were further compared through a Kaplan-Meier survivorship analysis. Survival rates showed no significant difference between the groups when operative time was chosen as the independent variable ($P = .825$). When tourniquet time was chosen as the independent variable, however, a statistically significant difference was observed ($P < .001$), indicating that tourniquet time may play a larger role in outcomes of AA than TAA.

Discussion

Patients with end-stage ankle arthritis who undergo either ankle fusion or replacement can often present with significant multiplanar ankle deformity requiring 1 or more adjunctive procedures to achieve neutral ankle

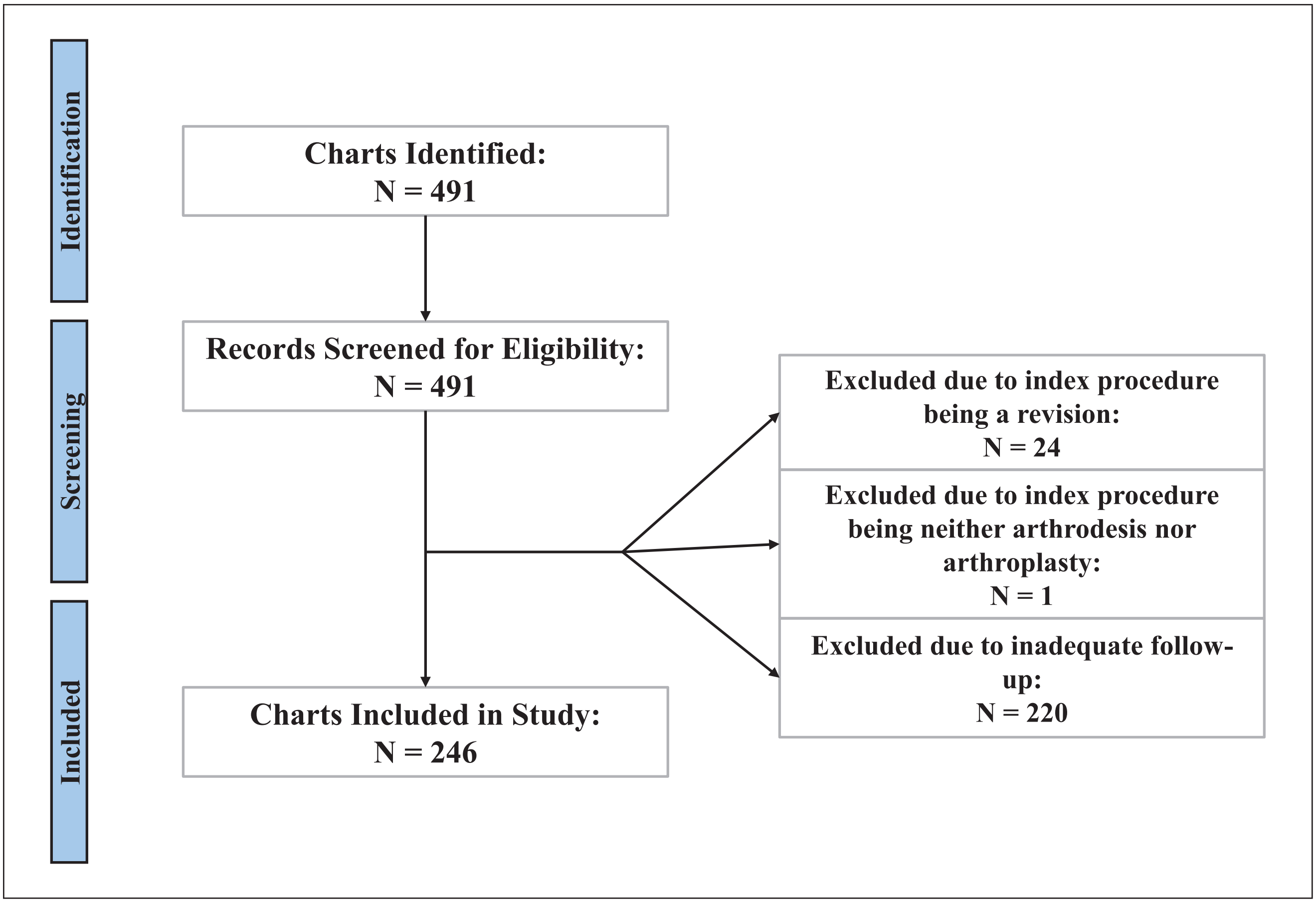

Figure 1. Flow Chart for Exclusions.

Table 1. Demographics: Total Ankle Arthroplasty and Ankle Arthrodesis Cohorts (N = 246).

	TAA (n = 136)			AA (n = 110)			
Characteristic	Mean ± SD	Min	Max	Mean ± SD	Min	Max	*P*
Age, y	68.28 ± 8.71	37	86	62.63 ± 13.55	27	90	**.0001***
BMI	29.45 ± 4.76	19.91	42.86	31.45 ± 6.88	19.84	73.83	**.008***
Comorbidities (n)	5.74 ± 3.07	0	13	4.74 ± 2.76	0	15	**.008***

Abbreviations: AA, ankle arthrodesis; BMI, body mass index; TAA, total ankle arthroplasty.
*Statistically significant ($P < .05$).

Table 2. Operative Details: Total Ankle Arthroplasty and Ankle Arthrodesis Cohorts (N = 246).

	TAA (n = 136)			AA (n = 110)			*P*
Operative Detail	Mean ± SD	Min	Max	Mean ± SD	Min	Max	*P*
Adjunctive procedures, n	0.56 ± 0.77	0	4	0.79 ± 0.91	0	4	**.03***
Procedure duration, min	135.79 ± 35.64	75	264	118.98 ± 45.72	53	299	**.01***
Tourniquet time, min	127.49 ± 36.08	50	288	99.88 ± 30.17	45	183	**<.0001***
Length of follow-up, mo	36.39 ± 25.76	12	147	46.09 ± 35.00	12	169.89	**.01***

Abbreviations: AA, ankle arthrodesis; TAA, total ankle arthroplasty.
*Statistically significant ($P < .05$).

Table 3. Frequency of Adjunctive Procedure(s), Postoperative Complication(s), and Reoperation.

Variable	Total Ankle Arthroplasty, n (%)	Ankle Arthrodesis, n (%)	OR (CI)	P
Adjunctive procedure(s)	57 (41.91)	57 (51.82)	0.67 (0.40-1.11)	.12
Postoperative complication(s)	20 (14.71)	21 (19.09)	0.73 (0.37-1.43)	.36
Reoperation	14 (10.29)	21 (19.09)	2.06 (0.99-4.26)	.05

Abbreviation: OR, odds ratio.

Table 4. Analysis of Variance.

Variable[a]	Total Ankle Arthroplasty		Ankle Arthrodesis	
(+) Postoperative complications				
	Mean (SD)	P	Mean (SD)	P
Adjunctive procedures (n)	0.90 (1.07)	**.03***	0.90 (1.00)	.53
Comorbidities (n)	6.75 (3.43)	.11	4.24 (2.90)	.36
Age (y)	65.85 (10.81)	.18	64.52 (12.12)	.48
BMI	28.41 (3.64)	.29	29.24 (3.85)	.10
Procedure duration (min)	151.75 (50.21)	**.03***	104.81 (26.90)	.11
Tourniquet time (min)	138.41 (52.39)	.18	94.29 (28.11)	.35
(+) Reoperation				
Adjunctive procedures (n)	1.00 (1.18)	.02	1.00 (1.00)	.24
Comorbidities (n)	7.36 (3.32)	**.04***	4.38 (3.01)	.51
Age (y)	65.70 (11.19)	.05	64.00 (12.25)	.61
BMI	28.98 (4.07)	.70	29.48 (4.28)	.15
Procedure duration (min)	139.71 (50.80)	.67	109.95 (39.65)	.32
Tourniquet time (min)	127.75 (57.14)	.98	97.95 (33.07)	.75

Abbreviation: BMI, body mass index.
(+) indicates that the patient experienced a postoperative complication or underwent a reoperation.
[a]Degrees of freedom (dF) were equal to 1 for all variables.
*Statistically significant ($P < .05$).

alignment.[10,22] There is some limited, but growing evidence showing that clinical outcomes significantly improve when adjunctive procedures are used to achieve proper ankle alignment.[15,17,27] However, adjunctive procedures theoretically increase the risk of complications due to factors such as increased operative time and tourniquet use.[10] We hypothesized that adjunctive procedures would not increase the risk of complications or reoperation in either group; instead, they may possibly improve outcomes by addressing significant preoperative deformities despite an increase in total operative time.

Our results demonstrated no significant correlations between number of adjunctive procedures and complication or reoperation rates in patients who underwent AA. However, the number of adjunctive procedures was positively correlated with complication rate, but not reoperation, in TAA patients. A 2018 study by Lee et al[17] analyzed whether patients with significant deformity before TAA would experience different outcomes compared with those with neutral alignment preoperatively. Their study demonstrated that patients with a significant varus deformity underwent more adjunctive procedures to achieve proper alignment but demonstrated similarly good outcomes compared to patients with preoperative neutral alignment. Additionally, they found that there was no significant difference in the prevalence of major complications between groups. Combined with studies that demonstrate improved patient outcomes with proper ankle alignment, our retrospective study lends some support to the notion that the additional risks incurred with adding operative and tourniquet time could possibly be outweighed by the benefits of balancing the ankle at the time of definitive surgery, especially in AA patients.

Prolonged procedure duration is associated with an increased risk of postoperative complications such as surgical site infections and venous thromboembolism.[16,30] The use of a tourniquet to create a bloodless field is common in orthopaedic surgery and the risk of complications, such as sensory loss and wound issues, has previously been shown to increase with prolonged use.[12] However, there are multiple studies exhibiting that the duration of tourniquet use does not increase the risk of complications.[9,30] Our results demonstrated that procedure duration was significantly correlated with complication rate ($P=.03$) in TAA patients. However, there was no correlation between procedure duration and reoperation in the TAA group. Next, our study demonstrated that procedure duration had no significant correlation with either POCs or reoperation rates in the AA group. Additionally, no significant correlation was found between length of active tourniquet use and complications or reoperation in both groups. These results suggest that longer, more complex ankle reconstructions do not predispose a patient to greater risk of returning for reoperation. Thus, complex ankle reconstructions can be performed, without being a staged procedure, to achieve proper ankle alignment with minimal patient risk.

The results of this study showed that patients who underwent AA were significantly younger compared with those who underwent TAA. This result may be due to AA traditionally being offered to younger patients with higher functional demand.[3,13] Conversely, TAA has historically been reserved for older patients with lower functional demand as previous evidence has shown mixed outcomes in younger patients who undergo TAA. Some studies quote high rates of postoperative complications and implant failure whereas others demonstrate that TAA has similar outcomes regardless of patient age.[1,2,20] The results of our study exhibited that there was no significant correlation between age and complication or reoperation rates in both groups at a mean follow-up of 40.7 ± 30.5 months. This suggests that contrary to the historical opinion of AA being the only relevant treatment option for young patients with ankle arthritis, modern TAA can be considered a viable alternative as well.

Currently, there appears to be a bias toward offering AA, instead of TAA, to patients with significant obesity. This bias may be due to obesity being a known risk factor for the development of perioperative and postoperative complications in patients undergoing joint arthroplasty.[24] However, much of this evidence is derived from studies investigating hip and knee arthroplasty, and there is limited evidence suggesting that obesity is a significant risk factor for complications after ankle arthroplasty.[14,29] A prospective study by Gross et al[11] looked at 455 patients that underwent primary TAA, of which 189 were obese as defined by a BMI greater than 30. They found that obese patients did not experience significantly increased rates of complications, infection, or implant failure compared with nonobese patients. Similarly, our study found no correlation between obesity (BMI $>$ 30) and POCs or reoperation in either TAA or AA patients, although the bias toward obese patients receiving AA was evident, with a statistically significant difference in BMI observed between the 2 groups.

In addition, there is a significant amount of evidence investigating different risk factors for complications after AA and TAA.[21,26] For example, a previous study by Whalen et al[28] found that smoking significantly increased the risk for wound breakdown after TAA. Interestingly, our data indicated that smoking was not significantly correlated with complications or reoperation in either group. Although, it was found that TAA patients with comorbid osteoporosis were at significantly higher risk of reoperation. Additionally, patients in the TAA group with comorbid hematologic disorders or coagulopathies were at significantly higher risk for both POCs and reoperation. Our results, along with historical evidence, show that specific comorbidities play a significant role in the risk for complications and reoperation after TAA or AA and should be holistically considered by the surgeon when determining if a patient is a safe candidate for surgery.

This study has several limitations that should be acknowledged. First, given the inadequate study power of 50.2%, this study should be considered exploratory and not definitive. Further studies should incorporate a prospective design to enroll more patients in each group; assuming the reoperation rates remain the same between the groups, the study must include at minimum 253 patients in each group to reach power and conclusively determine differences. Also, being retrospective in nature, it may not completely reflect recent advances in materials and construction of TAA implants. Additionally, there was a possible selection bias given that the study is underpowered and favoring younger patients for AA over TAA, thus creating a significant difference in age and other demographics between both groups. Lastly, many of the adjunctive procedures included in our study were categorized as “minor” as they did not require additional incisions, dissections, or operative time, and were not directly aimed at correcting deformity (eg, hardware removal). These minor adjunctive procedures may cloud a true correlation between major adjunctive procedures and outcomes following TAA or AA. Thus, future studies evaluating TAA and AA including only major deformity-correcting adjunctive procedures with demographically matched grouping is recommended. Finally, being a retrospective review from a single institution, our selected sample population may not be entirely representative of the population as a whole.

Conclusion

This preliminary study found that the presence of adjunctive procedures during either a TAA or AA in this patient group did not significantly increase the risk of major complications or reoperation. Several preexisting comorbidities were identified to be associated with higher rates of POCs or reoperation, including osteoporosis and coagulopathies. This study demonstrates a need for further research into this subject, with larger, better-defined cohorts needed to draw conclusive findings. Thus, our conclusions should not be viewed as definitive.

Ethical Approval

Ethical approval for this study (ID: 23-002960) was waived by the IRB as it was determined to be exempt from the requirement for IRB approval (45 CFR 46.104d, category 4).

Declaration of Conflicting Interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: Edward T. Haupt, MD, reports disclosures relevant to manuscript from Exactech, Treace, Arthrex: consulting fees; Exactech: research support; and AOFAS: small grant research support. Disclosure forms for all authors are available online.

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Supplementary Table 1. Details of Index Procedure, Both Groups.

Total Ankle Arthroplasty (TAA) (n = 136)		Ankle Arthrodesis (AA) (n = 110)	
Type of Implant Used	n (%)	Procedure Type	n (%)
Exactech Vantage Total Ankle	8 (5.9)	Open, screws only	67 (60.9)
STAR	12 (8.8)	Open, plate-supported	39 (35.5)
Wright Medical Inbone Total Ankle	19 (14.0)	Arthroscopic, screws only	4 (3.6)
Wright Medical Infinity Total Ankle	64 (47.1)	Arthroscopic, plate-supported	0 (0.0)
Wright Medical Infinity Tibial Tray + Inbone Talar Dome	26 (19.1)		
Wright Medical Inbone Tibial Tray + Inbone II Talar Dome	1 (0.7)		
Wright Medical Inbone Tibial Tray + Invision Talar Dome	1 (0.7)		
Zimmer Biomet Trabecular Metal Total Ankle	4 (2.9)		
Unspecified	1 (0.7)		

Supplementary Table 2. Frequency of Adjunctive Procedures.

	TAA, n (%)	AA, n (%)
Major adjunctive procedures		
Adjacent joint arthrodesis	0 (0)	22 (20)
Fibular osteotomy	2 (1.47)	12 (10.91)
Tibia or talus osteotomy	0 (0)	5 (4.55)
ORIF	4 (2.94)	1 (0.91)
External fixator application	1 (0.74)	3 (2.73)
Lateral ankle ligament repair	3 (2.21)	0 (0)
First metatarsal osteotomy	0 (0)	3 (2.73)
Irrigation and debridement	0 (0)	2 (1.82)
Arthrotomy with excision of loose intra-articular bodies	1 (0.74)	1 (0.74)
Plantar fasciotomy	0 (0)	2 (1.82)
"Cotton" osteotomy	1 (0.74)	0 (0)
Midfoot arthrodesis	1 (0.74)	0 (0)
Calcaneus osteotomy	1 (0.74)	0 (0)
Hammertoe correction	0 (0)	1 (0.91)
Partial talectomy	0 (0)	1 (0.91)
Minor adjunctive procedures		
Hardware removal	17 (12.50)	13 (11.82)
Achilles tendon lengthening / gastrocnemius recession	21 (15.44)	6 (5.45)
Bone graft harvesting	1 (0.74)	20 (18.18)
Prophylactic screw fixation, medial malleolus	8 (5.88)	0 (0)
Onlay live fibular strut graft	0 (0)	7 (6.37)
Deltoid ligament release	4 (2.94)	0 (0)
Ankle cheilectomy	2 (1.47)	1 (0.91)
Exostectomy	0 (0)	2 (1.82)
Posterior tibial tendon release	0 (0)	1 (0.91)
Other[a]	4	14

Abbreviations: AA, ankle arthrodesis; ORIF, open reduction internal fixation; TAA, total ankle arthroplasty.
[a]TAA: other procedures included toe injection (1) and talus debridement (2). AA: other procedures included resection of ruptured peroneus brevis tendon (1), peroneus longus to brevis tendon transfer (1), osteochondral fragment removal (1), heterotopic ossification resection (1), and tibial cyst debridement (1).