SYSTEMATIC REVIEW

Comparing the Results of Total Ankle Arthroplasty Vs Tibiotalar Fusion (Ankle Arthrodesis) in Patients with Ankle Osteoarthritis since 2006 to 2020: A Systematic Review

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Abstract

Background: This study compares the outcomes of patients undergoing total ankle arthroplasty (TAA) and tibiotalar fusion (ankle arthrodesis) in patients with end-stage osteoarthritis. The primary outcome assessed was Patient Reported Outcome Measures (PROMS); secondary outcomes included the incidence of revision, re-operation, and complications.

Methods: A systematic review of studies examining the outcomes of patients undergoing TAA and/or tibiotalar fusion from 2006 to 2020 was conducted. Individual cohort studies and randomized control trials were included. Outcomes were assessed at two and five years.

Results: 21 studies were included: 16 arthroplasty (2,016 patients) and 5 arthrodesis (256 patients) studies. No significant difference in PROMS was evident two years post-surgery – American Orthopaedic Foot and Ankle Society (AOFAS) scores were 78.8 (95% CI-confidence interval: 76.6-80.8; n=1548) and 80.8 (95% CI: 80.1-81.5; n=206 patients) for the arthroplasty and arthrodesis groups respectively. Two years post-surgery the revision rates for the arthroplasty and arthrodesis groups were similar – 3.5% (n=9) and 3.7% (n=61) respectively (OR-odds ratio: 1.05; 95% CI: 0.51-2.13); however, the re-operation rate was 2.5 times higher for the arthroplasty group (12.2%) in comparison to the arthrodesis group (5.1%) (OR: 2.57; 95% CI: 1.43-4.62). Documented complications in the arthroplasty group were half those documented in the arthrodesis group two years post-surgery (OR: 0.53; 95% CI: 0.37-0.77). No arthrodesis studies were found which contained mean 5-year follow-up data within the study period.

Conclusion: Despite recent developments in TAA design, we found no clear evidence as to their superiority over ankle arthrodesis when considering patient outcomes two years postoperatively. However, this conclusion could be debatable in some types of patients such as diabetic patients, posttraumatic patients and patients with stiff hindfoot and midfoot.

Level of Evidence: I

Keywords: Ankle arthrodesis, Osteoarthritis, Tibiotalar fusion, Total ankle arthroplasty

Introduction

When medical therapy fails for patients suffering with end-stage ankle osteoarthritis, patients are left with one of two definitive operative options: ankle tibio-talar fusion (arthrodesis) or total ankle arthroplasty (TAA). The main indications for surgery are intractable pain and poor function indicating joint destruction. Traditionally, patients have been offered ankle fusions (arthrodesis) however, this procedure has since been linked with the development of osteoarthritis in adjacent joints and has a ~10% non-union rate

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(necessitating further surgery) (1). These factors have led to the development of the TAA, a procedure which has the potential to retain range of motion (ROM) and to protect adjacent joints from osteoarthritis. Concerns about the TAA wearing out have meant the procedure has primarily been used in older patients, with ankle arthrodesis still used in younger patients. Continued development of the TAA, however, has led to a newer, cementless, third generation of TAA's being introduced which may have the potential to be used in younger patients. Despite the availability of two operative procedures to treat patients with end-stage ankle osteoarthritis, there remains no conclusive evidence as to which intervention provides the best outcomes for patients.

The aim of this study, therefore, is to compare the outcomes and complications of the newer third generation TAA with ankle arthrodesis. The primary outcomes being patient reported outcomes measures (PROMS), re-operation rates, revision rate and complications.

Materials and Methods

Eligibility Criteria

Randomised control trials (RCTs) and cohort studies that included skeletally mature patients undergoing either TAA or ankle arthrodesis since 2006. Patients undergoing revision procedure or subtalar arthrodesis procedures were excluded. Studies in secondary or tertiary care were eligible. Only studies published in the English Language were included. The review only considered randomised control studies and cohort studies. Where studies used overlapping patient data (in the same sub-group) only the most recent study was used. Only studies with a mean follow-up of 2 years or more were included.

Searches

With the help of the Institutional Library - Medline, Embase and Cochrane databases were searched. Searches were performed on May 10th 2019 for Embase and Medline and May 14th 2019 for Cochrane. The complete electronic search strategies are detailed in [Table 1]. All studies identified were imported into Endnote to facilitate the selection process by removing duplicate studies. The remaining studies were imported into Mendeley and screened by two authors. The titles and abstracts were then reviewed to exclude any studies that did not meet the inclusion criteria. Following this, the full text of the remaining studies were reviewed to determine final inclusion. The results of the two independent searches were then compared.

Results of Individual Studies

2274 studies were originally identified as meeting the search criteria. 901 of these were identified as duplicates leaving 1373 studies. Following review of the paper's title and abstract, 75 studies remained between the two authors. The full papers were then reviewed leaving 36 studies. These remaining studies were reviewed and discussed a final time with 23 studies meeting the inclusion criteria. Four studies were subsequently found to include overlapping patient data sets; two of these studies were therefore excluded leaving a final count of 21 studies included in the systematic review. This is displayed in [Figure 1].

Data Extraction

Two authors independently extracted data using an

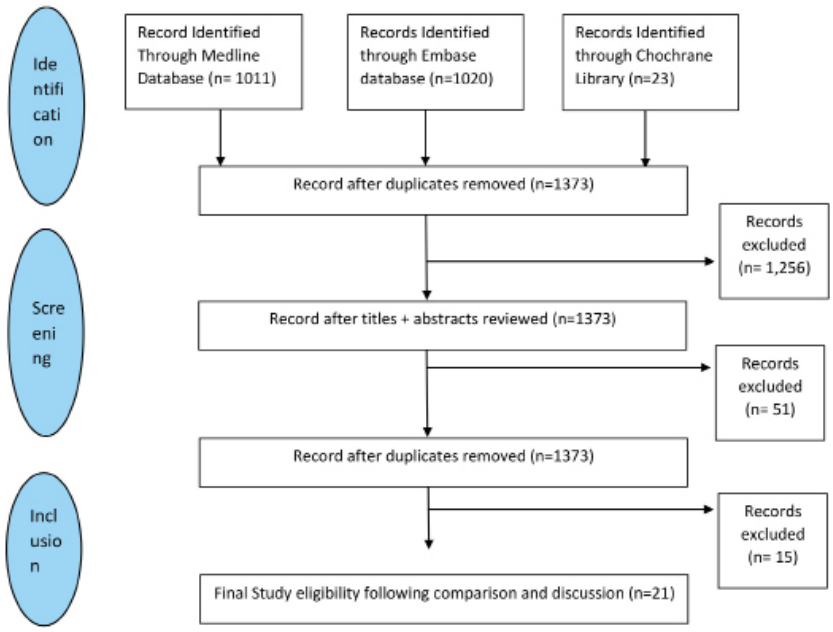

Figure 1. PRISMA Flow diagram for search strategy and study selection.

Table 1. Embase, Medline and Cochrane Search Strategies

Database	Embase	Medline	Cochrane
Date	10/05/19	10/05/19	14/05/19
#1	1 Arthroplasty, Replacement, Ankle/ (240)	1. Arthroplasty, Replacement, Ankle/ (628)	MeSH descriptor: [Arthroplasty, Replacement, Ankle] explode all trees
#2	2 total ankle arthroplast*.ti,ab. (711)	2 total ankle arthroplast*.ti,ab. (585)	total ankle arthroplast*:ti,ab
#3	3 total ankle replacement*.ti,ab. (855)	3 total ankle replacement*.ti,ab. (670)	total ankle replacement*:ti,ab
#4	4 (ankle* adj5 (arthroplast* or replace* or prosthe* or implant* or endoprosthe*)).ti,ab. (2401)	4 (ankle* adj5 (arthroplast* or replace* or prosthe* or implant* or endoprosthe*)).ti,ab. (1849)	ankle* NEAR/5 (arthroplast* OR replace* OR prosthe* OR implant* OR endoprosthe*):ti,ab
#5	5 Ankle Joint/ or Ankle/ (30628)	5 Ankle Joint/ or Ankle/ (22431)	MeSH descriptor: [Ankle] explode all trees
#6	6 "prostheses and implants"/ or joint prosthesis/ (21846)	6 "prostheses and implants"/ or joint prosthesis/ (54137)	MeSH descriptor: [Ankle Joint] explode all trees
#7	7 5 and 6 (332)	7 5 and 6 (628)	MeSH descriptor: [Joint Prosthesis] explode all trees
#8	8 1 or 2 or 3 or 4 or 7 (2585)	8 1 or 2 or 3 or 4 or 7 (2070)	#1 or #2 or #3 or #4
#9	9 Arthrodesis/ (11566)	9 Arthrodesis/ (8881)	#5 or #6
#10	10 Ankle Joint/ or Ankle/ (30628)	10 Ankle Joint/ or Ankle/ (22431)	#7 AND #9
#11	11 9 and 10 (783)	11 9 and 10 (1477)	MeSH descriptor: [Arthrodesis] this term only
#12	12 ((ankle or tibio-talar or tibiotalar) adj (arthrodes* or fusion)).ti,ab. (1397)	12 ((ankle or tibio-talar or tibiotalar) adj (arthrodes* or fusion)).ti,ab. (1082)	#9 AND #11
#13	13 11 or 12 (1963)	13 11 or 12 (1940)	(ankle* or tibio-talar or tibiotalar) NEXT (arthrodes* or fusion):ti,ab
#14	14 8 or 13 (4006)	14 8 or 13 (3542)	#8 or #10 or #12 or #13
#15	15 randomized controlled trial/ (546496)	15 randomized controlled trial.pt. (481288)	(ankle or tibio-talar or tibiotalar) NEXT (arthrodes* or fusion)
#16	16 controlled clinical trial.tw. (17207)	16 controlled clinical trial.pt. (93052)	#14 or #15
#17	17 randomi?ed.tw. (809802)	17 randomi?ed.tw. (568253)	#12 and #16
#18	18 randomly.tw. (407929)	18 randomly.tw. (310831)	limit to reviews, 2006-2019
#19	19 trial.tw. (769955)	19 trial.tw. (540911)	
#20	20 group*.tw. (4726680)	20 group*.tw. (3440272)	
#21	21 15 or 16 or 17 or 18 or 19 or 20 (5573530)	21 15 or 16 or 17 or 18 or 19 or 20 (4124949)	
#22	22 (exp animals/ or nonhuman/) not human/ (6218901)	22 exp animals/ not humans.sh. (4576104)	
#23	23 21 not 22 (4610364)	23 21 not 22 (3507650)	
#24	24 exp cohort analysis/ (461268)	24 exp Cohort Studies/ (1851659)	
#25	25 exp longitudinal study/ (124822)	25 cohort*.tw. (510809)	
#26	26 exp prospective study/ (515592)	26 (Follow up adj (study or studies)).tw. (46746)	
#27	27 exp follow up/ (1391966)	27 (observational adj (study or studies)).tw. (91463)	
#28	28 cohort*.tw. (859157)	28 Retrospective.tw. (467645)	
#29	29 (Follow up adj (study or studies)).tw. (59469)	29 followup.tw. (20052)	
#30	30 (observational adj (study or studies)).tw. (142778)	30 24 or 25 or 26 or 27 or 28 or 29 (2258649)	
#31	31 Retrospective.tw. (766335)	31 23 or 30 (4999514)	
#32	32 followup.tw. (47057)	32 14 and 31 (1506)	
#33	33 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 (3074918)	33 limit 32 to (english language and yr="2006 -Current") (1011)	
#34	(or 33 (6590683 23 34		
#35	(and 34 (1782 14 35		
#36	(limit 35 to (english language and yr="2006 -Current") (1361 36		
#37	Conference abstracts 37		
#38	NOT 37 36 38		

Table 2. Risk of Bias Assessment Using the Newcastle-Ottawa Scale for Cohort Studies

	Selection (Max 1)				Comparability (Max 2)	Outcomes (Max 1)		
	Representativeness of exposed cohort	Selection of non-exposed cohort	Ascertainment of exposure	Outcome not present at the start of the study	Comparability of cohorts based on design analysis	Assessment of outcomes	Length of follow-up	Adequacy of follow-up
Bianchi et al., 2019 (2)	*		*	*	*	*	*	*
Gaudot et al., 2013 (3)	*		*	*	*	*	*	*
Summers et al., 2012 (4)	*		*	*	*	*	*	*
Gross et al., 2015 (5)	*		*	*	*	*	*	*
Rosello et al., 2014 (6)	*		*	*	*	*	*	*
Usuelli et al., 2019 (7)	*		*	*	*	*	*	*
Kerkhoff et al., 2016 (8)	*		*	*	*	*	*	*
Tan et al., 2018 (9)	*		*	*	*	*	*	*
King et al., 2018 (10)	*		*	*	*	*	*	*
Cottom et al., 2019 (11)	*		*	*	*	*	*	*
Queen et al., 2014 (12)	*		*	*	*	*	*	*
Ramaskandhan et al., 2014 (13)	*		*	*	*	*	*	*
Lampley et al., 2016 (14)	*		*	*	*	*	*	*
Balaji et al., 2017 (15)	*		*	*	*	*	*	*
Li et al., 2017 (16)	*		*	*	*	*	*	*
Jain et al., 2015 (17)	*		*	*	*	*	*	*
Duan et al., 2016 (18)	*		*	*	*	*	*	*
Morasiewicz et al., 2019 (19)	*		*	*	*	*	*	*
Harston et al., 2017 (20)	*		*	*	*	*	*	*
Johnson et al., 2018 (21)	*		*	*	*	*	*	*
Gramlich et al., 2018 (22)	*		*	*	*	*		*

excel data extraction template. Any disagreements were resolved with a third author where necessary. Data extraction was unblinded. Extracted information included: author(s), study title, type of intervention, type of study, study duration, number of patients, patient gender, patient age, patient body mass index (BMI), mean follow-up time, PROMS, number of revisions and re-operations and any documented complications.

Bias Assessment

Risk of bias was unblinded and assessed using the Newcastle Ottawa assessment tool by two independent reviewers. Any disagreements were resolved by a third reviewer. The quality of evidence was assessed using the GRADE (Grading of Recommendations, Assessment, Development and Evaluations) criteria, this is displayed in [Table 2] (2-22).

Statistical Analysis

Binary outcomes were expressed as odds ratios (OR) with 95% confidence intervals (CIs) and p-values of less than .05 considered significant. Results from the individual studies were pooled using a random-effects meta-analysis using inverse variance weighting.

Results Analysis

To assess medium and longer-term outcomes the arthroplasty studies were split into two subgroups – those with a mean follow-up time of less than 5 years (13 studies) and those with a mean follow-up time of 5+ years (3 studies). Two of the studies in the >5-year group contained data from patients in the <5-year group and the results of those studies were separated out so that a fair comparison could be made between the two groups. All the studies in the arthrodesis group had a follow-up period of less than 5 years, and thus were not divided into subgroups. Where studies compared separate patient

cohorts within a study the results were combined.

Results

A total of 21 studies met the inclusion criteria, including 16 studies which focussed on arthroplasty and 5 which addressed arthrodesis [Table 3]. All studies were retrospective or prospective cohort studies; no randomised control studies met the inclusion criteria, and no studies were found which directly compared the outcomes of TAA with ankle arthrodesis. The number of patients and demographic data of each cohort can be seen in [Table 4]. 11 studies included information about patient BMI; in the arthroplasty group with <5 year follow-up (F/U) 1062 patients were included with mean BMI of 29 (18.8-49.9) in the 5 year F/U group 109 patients were included with mean of 26.9. In the arthrodesis group 136 patients were included with a mean of 28.

Patient related outcome measures (PROMS)

Only studies reporting American Orthopaedic Foot and Ankle Society (AOFAS) scores were included in the following analysis, as this indicator was the most frequently reported outcome. Other PROMS were excluded as they were not directly comparable and were only reported by a small number of studies. 10 of the 18 studies in the <5-year arthroplasty subgroup reported AOFAS scores. In the arthrodesis group 4/5 studies included AOFAS scoring however only two of the studies included both preoperative and postoperative scores. In the 5-year group only one study included AOFAS scores. Other outcome measures used included the "Visual Analog Scale" (VAS), "The 36-Item Short Form Survery" (SF-36), The "Foot and Ankle Outcome Score" (FAOS) and "The Foot Function Index" (FFI).

The results show the mean preoperative scores in the arthroplasty subgroup 38.8 and 40.1 were much lower than in the arthrodesis subgroup 46.94. Improvement was higher in the arthroplasty group than in the arthrodesis group at all time points and was clinically and statistically significant [Table 5]. We were unable to generate a measure of spread as full data sets were unavailable. Confidence intervals were calculated from mean results, sample size and standard deviation.

Revisions

15 studies in the arthroplasty subgroups, and all 5 studies in the arthrodesis subgroup, included data regarding the number of revisions that were undertaken.

Table 3. Characteristics for the 21 studies included in the Systematic Review (2-22).

No	Study	Prosthesis	Study Type	Country	Study Duration	Patients	BMI	Mean F/U (months)
1	Bianchi *et al.*, 2019 (2)	Zimmer TM	Retrospective	Italy	2013 - 2016	30		30
2	Gaudot *et al.*, 2013 (3)	Salto-Talaris (ST)	Retrospective	France	2006 - 2009	32	28	24
3	Summers *et al.*, 2012 (4)	Mobility	Prospective	Australia	2006 - 2009	58		32
4	Gross *et al.*, 2015 (5)	Inbone/STAR/SALTO	Prospective	USA	2007 - 2013	455		45
5	Rosello *et al.*, 2014 (6)	Hintegra	Retrospective	Spain	2006 - 2011	17		37
6	Usuelli *et al.*, 2019 (7)	Hintegra	Prospective	Italy	May 2011 -	81	28.3	46
7	Kerkhoff *et al.*, 2016 (8)	Mobility system	Retrospective	Netherlands	2008 - 2013	67	27	40
8	Tan *et al.*, 2018 (9)	Mobility	Retrospective	Singapore	2007 - 2013	41	27	29
9	King *et al.*, 2018 (10)	Infinity	Prospective	England	2014 - 2015	19		32
10	Cottom *et al.*, 2019 (11)	STAR/ST/Cadence/ Infinity	Retrospective	USA	2012 - 2016	97	29.6	26
11	Queen *et al.*, 2014 (12)	Salto-Talaris/ STAR	Prospective	USA	2007-	90		24
12	Ramaskandhan *et al.*, 2014 (13)	Mobility TAS	Prospective	England	2006 - 2009	106	28.2	24
13	Lampley *et al.*, 2016 (14)	Inbone/ST/STAR	Retrospective	USA	2007 - 2014	638	29.5	24
14	Balaji *et al.*, 2017 (15)	Arthrodesis	Retrospective	India	2009 - 2014	29		33
15	Li *et al.*, 2017 (16)	Arthrodesis (ex-fix/IF)	Retrospective	China	2011 - 2015	59	25	29
16	Jain *et al.*, 2015 (17)	Arthrodesis	Retrospective		2007 - 2013	50	29.1	32
17	Duan *et al.*, 2016 (18)	Arthrodesis	Retrospective		2007 - 2012	68		32
18	Morasiewicz *et al.*, 2019 (19)	Arthrodesis	Retrospective		2007 - 2015	47		46
19	Harston et al 2017 (20)	INBONE 1	Retrospective	USA	2007 - 2011	149		71
20	Johnson-Lynn *et al.*, 2018 (21)	Mobility	Retrospective	England	2006 - 2009	76	28.5	60
21	Gramlich *et al.*, 2018 (22)	ST + Tornier	Prospective	Germany	2008 - 2013	60	29.4	60

Table 4. Patient Demographic and follow-up length (F/U, follow-up)

	Arthroplasty		Arthrodesis
	<5 Year F/U	>5 year F/U	
No. of patients	1731	285	253
Mean patient age (range)	62.1 (22-89)	61.8	52.6 (17-83)
Male: Female (%)	49:51	64:36	62:38
Mean F/U time (months)	31.9	65.6	34

Table 5. Studies including patient reported outcome measures (PROMS). F/U, follow-up

	American Orthopaedic Foot and Ankle Society (AOFAS)			
	Arthroplasty <5 year	Arthrodesis	Arthroplasty >5 year	Arthroplasty <5 year 1 excluded
Studies	10	4	1	9
Patient Number	1548	206	149	910
Mean F/U time months)	31.9	31.2	71	37.5
Average Pre-op score	38.8	46.9	40.1	37.3
Average post-op score	78.6	80.8	76.2	78.2

Note, two of the three 5+year studies have some patients in common with the <5-year group.

The total number of revisions undertaken in each subgroup can be found in [Table 6]. No statistically significant difference in the number of revisions was found between the <5-year arthroplasty subgroup and the arthrodesis group (OR: 1.0467; 95% CI: 051 – 2.13). No comparison has been made between the >5-year subgroup and the arthrodesis group, due to the longer follow-up period (which is likely to increase the number of revisions undertaken irrespective of the operative intervention). Indications for revision are displayed in [Table 7].

Re-operation

11 studies in the arthroplasty subgroups, and all 5 studies in the arthrodesis subgroup, included data regarding the number of re-operations that were undertaken. Note, two of the three 5+year studies included patient data from the <5-year group. The total number of reoperations undertaken in each subgroup can be found in [Table 8]. The <5-year arthroplasty group had a 2.5 times higher rate of re-operation when compared to the arthrodesis group (OR: 2.57; 95% CI: 1.43 – 4.62). The most common reason for re-operation was pain/impingement [Table 9]. No comparison has been made between the >5-year subgroup and the arthrodesis group, due to the longer follow-up period (which is likely to increase the number of reoperations undertaken irrespective of the operative intervention).

Complications

8 studies in the arthroplasty subgroups, and all 5 studies in the arthrodesis subgroup, included data regarding the number of complications this can be seen [Table 10]. Only one study in the >5 years subgroup included complication data (please note, this study included patient data from the <5-year group). The total number of medical complications in each subgroup can be found in [Table 11].

The <5-year arthroplasty group was found to have nearly half as many (60%) documented complications

Table 6. Studies looking at revision rates (F/U, follow-up; CI, confidence interval)

	Arthroplasty <5 years	Arthrodesis	Arthroplasty >5 years	Arthroplasty <5 years excluding 2 Studies
Total patient numbers	1641	253	285	897
Mean age	62.2 (22-89)	52.6 (17-83)	61.8 (30-87)	62.1 (22-88)
Mean F/U time (Months)	32.4	34.0	65.6	39.2
Revision	61 (3.7% CI 2.8-4.75)	9 (3.5% CI 1.64 – 6.65%)	29 (10.1% CI 6.92 – 14.3%)	40 (4.4% CI 3.2- 6.0%)

Table 7. Reasons for Revision

Arthroplasty <5 years		Arthroplasty >5 years		Arthrodesis	
Aseptic Loosening	16	Aseptic Loosening	8	Non-Union	9
Hindfoot Deformity	1	Instability	2		
Infection	20	Osteonecrosis	5		
Non-Union	1	Pain	1		
Osteonecrosis	5	Trauma	1		
Pain	8	Unknown	11		
Skin Irritation	2	Total	28		
Trauma	1				
Unknown	7				
Total	61				

Table 8. Studies looking at re-operations. F/U, follow-up

	Arthroplasty <5 year	Arthrodesis	Arthroplasty >5 years	Arthroplasty <5 years excluded 2 Studies
Total patient numbers	1032	253	285	288
Mean age	62.8 (22-89)	52.6 (17-83)	61.8 (30-87)	64.3
Average F/U	26.2	37.8	65.5	32.0
Re-operation	126 (12.2%)	13 (5.1%)	47 (16.5%)	33 (11.5%)

Table 9. Reasons for re-operation

Arthroplasty <5 year		Arthroplasty >5 years		Arthrodesis	
Indication/Procedure	**Number**	**Indication/Procedure**	**Number**	**Indication/Procedure**	**Number**
Bone cyst	9	Bone cyst	4	Infection/Wound Breakdown	6
Fracture	5	Fracture	1	Removal Metal	6
Infection/Wound Breakdown	27	Infection	2	Subtalar Arthrodesis	1
Instability	1	Malalignment	4		
Pain + Exchange	1	Pain/ Impingement	20		
Pain/ Impingement	111	Subtalar arthrodesis	1		
Poly liner exchange	5	Unknown	14		
Subtalar arthrodesis	4				
Subsidence	1				

Table 10. Studies looking at complications. F/U, follow-up; CI, confidence interval

	Arthroplasty <5 year	Arthrodesis	Arthroplasty <5 years excluded 1 Studies	Arthroplasty >5 years
Total patient numbers	475	253	369	76
Mean age	62.4 (22-89)	52.6 (17-83)	62.6	63 (32-80)
Average F/U	32.5	37.8	35	60
Complications	76 (16% CI 12.8 – 19.6)	67 (26.5% CI 21 – 32.3)	64 (17.3% 13.6 - 21.6)	6 (7.9% CI 3.0 – 16.4)

Table 11. Documented complications

Arthroplasty <5 years		Arthroplasty >5 years		Arthrodesis	
Complication	**Number**	**Complication**	**Number**	**Complication**	**Number**
Fractures/Dislocation	12	Fractures/Dislocation	2	Fractures/Dislocation	0
Pain	37	Pain	1	Pain	27
Superficial Infection	19	Superficial Infection	3	Superficial Wound Infection	29
Deep infection	6			Deep Infection	2
Non-unions	2			Non-unions	9
Total	76				

when compared with the arthrodesis subgroup (OR: 0.53; 95% CI: 0.37 – 0.77). The most frequently documented complications in both subgroups were pain and superficial infection. No comparison has been made between the >5-year subgroup and the arthrodesis group, due to the longer follow-up period.

The rate of non-union at 2 years in the arthrodesis group was found to be 3.6%.

Discussion

End-stage ankle osteoarthritis is a disabling condition with limited treatment options. Despite the development of new and "improved" ankle arthroplasty devices, our study shows that there is a considerable lack of recent high-quality research comparing the outcomes of these newer ankle arthroplasty's with ankle arthrodesis. Much of the clinical evidence used today is based on studies done over 30 years ago. An example of one such study is a recent systematic review performed by Lawton et al 2017 (23). Which despite including studies published after 2006, included patients operated on in 1993. By including patients from so long ago it does not account for development of newer prosthesis and therefore possible improvement in outcomes.

Our data showed similar postoperative PROMS at 2 years between the arthroplasty and arthrodesis groups at 78.8 and to 80.1 respectively. This compares similarly to Haddad et al 2007 who reported postoperative scores of 78.2 and 75.6 (1). Notably, although the mean patient reported outcome was slightly higher in the arthrodesis subgroup, the improvement in outcomes post-operatively was higher in the arthroplasty group, a fact that has not been noted by other studies, including Haddad et al (1). Due to the non-standardised use of a single patient reported outcomes measure in foot and ankle surgery it is difficult to compare studies. Our results showed that AOFAS scoring was by far the most popular PROMS used with other measures including VAS, SF-36, FAOS, FFI but with only a small number of studies using each it was not possible to fairly compare the studies. The use of AOFAS scoring was recently highlighted by Lakey and Hunt 2019 who stated clinicians should not be overly reliant on AOFAS scores due to its poor validity (24). AOFAS released a statement in 2018 stating they no longer endorse its use and other measures such as the recently developed patient reported outcomes measurement information system (PROMIS) should be used instead (25). The use of the newer PROMIS scoring has been shown to be highly predictive in identifying patients who would or who wouldn't benefit from foot and ankle surgery (26). The use of these scores have the potential to improve the validity and consistency in measuring patient reported outcomes and determining who would be most likely to benefit from surgery in future years.

Given the baseline differences between the groups, we would like to mention that the improvement in PROMs was better in the arthroplasty group than in the arthrodesis group. Whilst the overall figure was similar the degree of improvement was better.

The rates of revision at 2 years remained similar between the two groups at 3.7% for arthroplasty group and 3.5% in the arthrodesis group. At just over 5 years the rate of revision in the arthroplasty group was 10.1% (6.9 – 14.3) which again compares similarly to Haddad et al who reported a revision rate of 7% (5.5-11.6) (1). Haddad study was a systematic review of the literature addressing the intermediate and long-term outcomes of interest in TAA and ankle arthrodesis. When reporting revision rates there were discrepancies between studies with some studies reporting all re-operations as revisions when other studies only included implant failure/ exchange as revision. This has previously been raised by Lieb et al 2015 who analysed joint registry data and highlighted that definitions of revisions differed from one registry to another (27).

Our results showed a significant increase in the number of re-operation required for patients undergoing ankle arthroplasty, with the primary reason being due to pain and impingement following surgery. The rate of re-operation at two years following ankle arthroplasty was 12.2% and was 2.5 times the rate when compared to arthrodesis 5.5%. This compares similarly to SooHoo et al 2007 who reported rates of 9% and 5% at 1 year (28). Complications were documented in 16% of patients with arthroplasty and 26.5% of patients undergoing arthrodesis. This compares similarly to results of Lawton et al who reported rates of 19.7% and 26.9% (23).

The main limitation of our study was that we were unable to directly compare the outcomes of patients undergoing TAA with patients undergoing arthrodesis. The study

was also limited due to the lack of randomised control trials published in the literature. Due to limited number of studies looking at arthrodesis, all forms of arthrodesis were included open, closed and external fixation. There were also difficulties in determining the exact follow-up time for a patient in each study and when the outcomes were assessed, therefore the mean F/U time for each study was used. Finally it became apparent during our review that certain studies had used overlapping patient cohorts we have tried to account for this by performing a sensitivity analysis by excluding those cohorts from the 2 year F/U if some of those patients were again used in the 5 year follow-up data.

We are currently aware of two multi-site RCTs comparing ankle arthroplasty vs ankle arthrodesis. "Comparing Ankle Fusion to Ankle Replacement" which was first registered in 2012 and due to complete in 2027 (29). The second RCT "Total ankle replacement versus ankle arthrodesis" (TARVA) first registered in 2014 and is due to finish in 2020 (30). These studies may finally provide the answers many clinicians have been searching for. Until then there remains no clear evidence as to which procedure is superior despite the recent advances in arthroplasty design.

In June 2012 Schu et al compared the participation in sports and recreational activities in patients who underwent either ankle arthrodesis or TAA for end-stage osteoarthritis of the ankle (31). They found no significant difference between the groups concerning activity levels, participation in sports activities, UCLA (University of California at Los Angeles) and AOFAS score. After ankle arthrodesis the number of patients participating in sports decreased. However, this change was not statistically significant".

Taking into account that our search did not include 2021 we would like to mention some important recent studies on the topic: In January 2021 Ross et al compared outcomes following ankle arthrodesis versus TAA for primary ankle osteoarthritis using a large patient database (level III of evidence study) (32). The ankle arthrodesis cohort exhibited higher rates of postoperative joint complications in the short and medium-term, namely, subsequent fusions or osteotomies, periprosthetic fractures, and hardware removal. In March 2021 Sanders et al compared 3-dimensional foot and ankle kinetics and kinematics and determine the ankle power that is generated during level walking and stair ascent between TAA and ankle arthrodesis patients (level III of evidence study) (33). There were significant differences during level walking and stair ascent between patients with TAA and ankle arthrodesis. TAA patients generated greater peak plantarflexion power and sagittal motion within the foot and ankle compared to patients with an ankle arthrodesis.

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