

Functional Outcomes and Fusion Rates Following Arthroscopic Subtalar Arthrodesis: A Systematic Review and Meta-analysis

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ABSTRACT

Background: Subtalar arthritis presents as severe pain, inability to walk on uneven ground, and instability which hampers the normal gait biomechanics in patients. Arthrodesis is considered the gold standard to alleviate these symptoms. Over time, arthroscopic subtalar arthrodesis has established itself as a viable method of treatment for isolated subtalar arthritis without significant deformity. This systematic review analyzes the functional outcomes and fusion rates following arthroscopic subtalar arthrodesis for subtalar arthritis.

Materials and Methods: The systematic review was conducted according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analysis) guidelines from peer-reviewed journals published in English between June 2000 and March 2021. Quality appraisal of all selected articles was done and data was subsequently extracted and analyzed.

Results: After a thorough literature search, 13 studies were included for analysis. A total of 361 patients (376 feet) undergoing subtalar arthrodesis using arthroscopic technique have been described in literature. Pooled data showed improvement in AOFAS score from 44.2 to 79.6 ($p < 0.001$) and a fusion rate of 94.6%. Mean time to fusion was 9.9 weeks (± 0.9 week) with no significant increase in complication rates with use of the arthroscopic technique.

Conclusion: Based on available literature, arthroscopic subtalar arthrodesis appears to be a reliable and safe technique. This study showed promising results for isolated arthroscopic subtalar arthrodesis with good fusion rates and improved functional outcomes. The authors recommend further studies for exploring use of this approach for subtalar arthritis.

Level of evidence: Level IV.

Keywords: AOFAS, Arthrodesis, Arthroscopic, Fusion rate, Subtalar.

Journal of Foot and Ankle Surgery (Asia-Pacific) (2022): 10.5005/jp-journals-10040-1218

INTRODUCTION

The subtalar joint complex is formed from three distinct parts of the calcaneus namely the anterior, middle, and posterior facets which articulate with the talus. This configuration provides complex motion biomechanics to the subtalar complex. Any condition that affects this joint leads to significant changes in gait biomechanics.¹ Various symptoms arising from altered joint mechanics include pain, decreased joint motion, deformity, and instability. Symptomatic patients often tend to have difficulty walking on uneven surfaces, episodes of instability, and eventually a restriction of movement at ankle and subtalar joints. Posttraumatic osteoarthritis, congenital deformities, primary osteoarthritis, and inflammatory arthropathy are among the major causative factors for subtalar arthritis. Subtalar arthrodesis remains the gold standard management for symptomatic relief and provides the best results among the available treatment modalities.²

Conventional open methods to approach the subtalar joint include a classical lateral approach to the subtalar joint and a less invasive sinus tarsi approach. Technical advancements over time have made it easier to approach the subtalar joint using smaller incisions. All these provide a good exposure and overall results and are thus considered established approaches to the subtalar joint to achieve subtalar fusion. Complications with the conventional open technique include wound complications, non-union, malunion, and rarely pseudoarthrosis.³

Arthroscopic procedures provide an alternative to the open techniques by providing a much less invasive option. Over the

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How to cite this article: Singh MS, Harna B, Khurana A, *et al.* Functional Outcomes and Fusion Rates Following Arthroscopic Subtalar Arthrodesis: A Systematic Review and Meta-analysis. *J Foot Ankle Surg (Asia-Pacific)* 2022;9(S-1):S173–S178.

Source of support: Nil

Conflict of interest: None

past few years, arthroscopic arthrodesis of the subtalar joint has been used increasingly in patients with isolated subtalar arthritis with considerable success in the available literature.^{4,5} However, the arthroscopic approach is contraindicated in cases that requires major deformity correction, such as, malunited calcaneum fractures

and postinfective arthritis. Open procedures are better advocated in such cases.⁶ Given the recent enthusiasm over arthroscopic techniques in foot and ankle, a thorough literature search was performed evaluating the functional outcomes and fusion rates with arthroscopic techniques of subtalar arthrodesis, and the results were summarized in the form of a systematic review.

MATERIALS AND METHODS

Study Identification

Following the PRISMA guidelines (Preferred Reporting Items for Systematic Reviews and Meta-analyses) format (Fig. 1), literature searches were done up to April 2021 for the last 20 years on search databases. These included Medline, Embase, and Cochrane databases where various search-related terms and combinations were used. This study was registered on PROSPERO before the initiation of the search (CRD42021269017).

The search string used for the present review included "Subtalar joint," "isolated subtalar arthritis," "subtalar arthritis," "posttraumatic subtalar arthritis," "arthroscopy or arthroscopic or arthroscopically," "subtalar arthrodesis," "arthroscopic subtalar arthrodesis." We also used Boolean operators "AND" & "OR" to maximize the search results. All possible combinations were searched. MeSH terms as appropriate for the search results were also utilized for adding to the pool of data. Additional articles were identified through evaluation of bibliography of related articles which were already pooled to maximize the results. All relevant full texts were acquired and were thoroughly scrutinized in accordance with inclusion and exclusion criteria as provided in the text further. Full-text articles were acquired after the screening of the title and abstract.

Eligibility Criteria

Studies which were shortlisted based on predefined inclusion criteria that included (1) Original article, (2) Published in the English language, (3) Citing the functional outcomes and fusion rates, (4) Using arthroscopic technique for subtalar arthrodesis. The criteria for exclusion were articles which were (1) Technical notes without a patient cohort, (2) Review articles without any patient data, (3) Commentaries and editorials, (4) Conference presentations.

Quality Appraisal

All the studies were assessed by the authors. Quality appraisal of all the studies was done in accordance with the MINORS (Methodological Index for Non-randomized Studies) criteria.

Data Extraction

The full articles of all selected manuscripts were reviewed independently by the authors (BH, SS) to confirm study eligibility, to assess the quality of study, and to extract data using a predesigned extraction form. Disagreement between reviewers was resolved by the senior author (MS). Patients included for evaluation were those with isolated subtalar arthritis due to various causes who underwent arthroscopic subtalar arthrodesis. Data included various demographic details, duration from disease to surgery, follow-up duration, functional outcome scores, fusion rates, duration till fusion, and complications. Studies fulfilling the inclusion criteria were scored for quality in accordance with the guidelines of Oxford Centre for Evidence-based Medicine. For each outcome variable such as AOFAS, total number of patients enrolled and the mean (SD) or median (range/IQR), length of follow-up (in months) were recorded. Prevalence of post-traumatic arthritis was extracted in the form of percentages and 95% Confidence Interval (CI).

Statistical Methods

Categorical variables were presented as number of cases or percentages. Continuous variables were reported as mean \pm SD. The heterogeneity among different articles was assessed by using the χ^2 and I^2 squared indexes. The statistical significance threshold was set to 5% for effect size and heterogeneity. Pooled fusion rates were obtained from a meta-analysis using a random effects model with the method of Higgins and Thompson (2002), to take into account the heterogeneity. A summary odds ratio with 95% confidence intervals (CI) was calculated using a random effects model (Review Manager Software, Version 5; Oxford, UK: Cochrane Collaboration) for gender. Heterogeneity was calculated using the Chi-squared test of studies contributing to the meta-analysis.

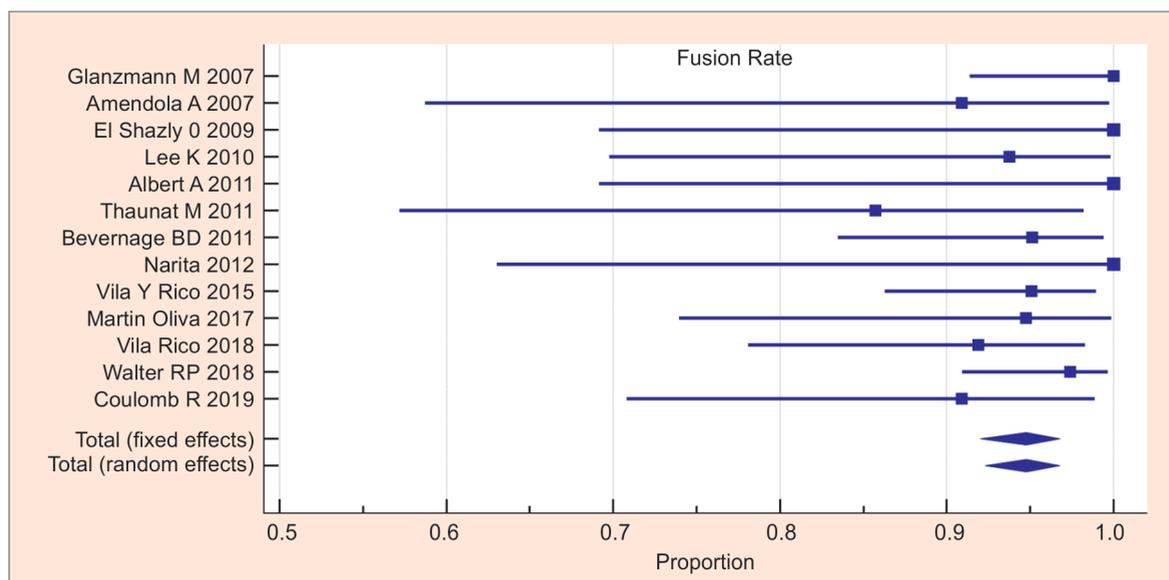


Fig. 1: Forest plot showing pooled fusion rate

RESULTS

A total of 211 studies were identified following an initial search (Fig. 1). After thorough scrutiny of the studies, 23 studies were identified by authors which were included for final evaluation and data extraction. A total of 367 feet in 361 patients from the mentioned 13 studies were included for analysis. Pooled estimate of age using random effect model was found to be 46.4 years (95% CI: 41.2–51.6) with 0% heterogeneity (Table 1).

Detailed analysis showed significantly larger proportion of male patients as compared to females who underwent arthroscopic subtalar arthrodesis (OR = 5.32; 95% CI: 1.93–14.69). About 75.7% (95% CI: 56.11–90.89) of the patients included had post-traumatic arthritis in the included patient cohort. The remaining causes included primary arthritis, secondary arthritis due to coalition, inflammatory arthritis. The mean follow-up time was 30 months (95% CI: 25–34.5).

AOFAS hindfoot score was the main functional outcome measured in most studies. AOFAS score improved significantly from preoperative value to the score at final follow-up postoperatively using paired t-test (mean value improved 44.2 preoperative to 79.6 at final follow-up $p < 0.001$) After pooling 12 studies, average of difference in preoperative and final AOFAS score was found to be 37.55 (95% CI: 32.15–42.93)

using random effect model with 20% of heterogeneity using generic inverse variance meta-analysis ($p < 0.001$).

Fusion rate was found to be 94.76% (95% CI: 92.30–96.77) with 0% of heterogeneity after pooling data from all available literature (Forest plot, Flowchart 1). There was no evidence of publication bias as Egger’s intercept was -0.828 (p -value = 0.308). Overall mean of fusion time was found to be 9.92 ± 0.86 weeks using random-effect model with 68% heterogeneity.

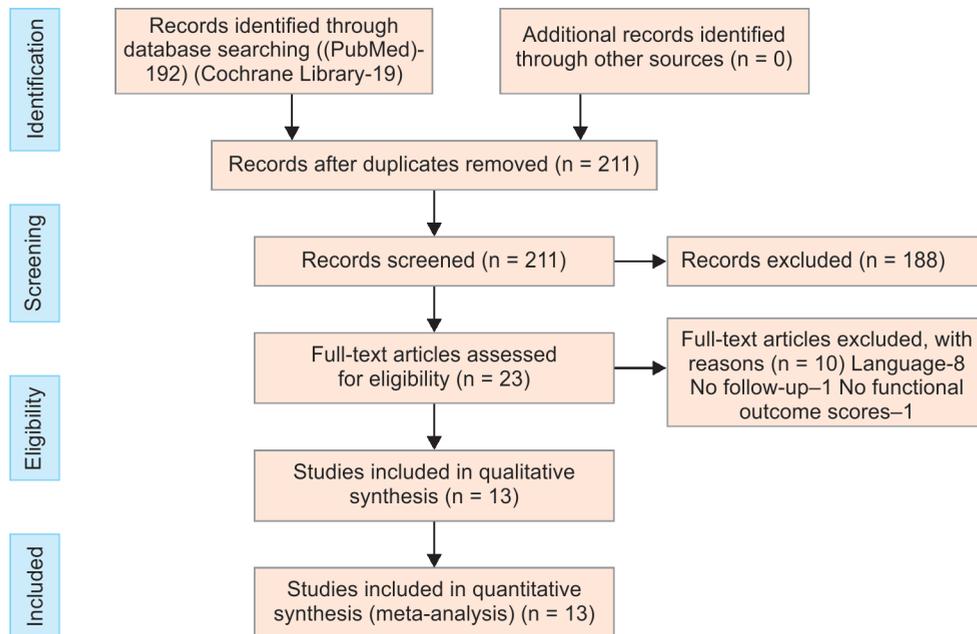
Questions for Quality assessment

The items are scored 0 (not reported), 1 (reported but inadequate) or 2 (reported and adequate)

- Clearly stated aim: The question addressed should be precise and relevant in the light of available literature
- Inclusion of consecutive patients: All patients potentially fit for inclusion (satisfying the criteria for inclusion) have been included in the study during the study period (no exclusion or details about the reasons for exclusion)
- Prospective collection of data: Data were collected according to a protocol established before the beginning of the study
- Endpoints appropriate to the aim of the study: Unambiguous explanation of the criteria used to evaluate the main outcome which should be in accordance with the question addressed by the study. Also, the endpoints should be assessed on an intention-to-treat basis.
- Unbiased assessment of the study endpoint: Blind evaluation of objective endpoints and double-blind evaluation of subjective endpoints. Otherwise, the reasons for not blinding should be stated
- Follow-up period appropriate to the aim of the study: The follow-up should be sufficiently long to allow the assessment of the main endpoint and possible adverse events
- Loss to follow-up less than 5%: All patients should be included in the follow-up. Otherwise, the proportion lost to follow-up should not exceed the proportion experiencing the major endpoint
- Prospective calculation of the study size: Information of the size of detectable difference of interest with a calculation of 95%

Table 1: Demographic data

Total studies	13
Total patients	361 (367 feet)
Pooled mean age	46.4 (95% CI: 41.2–51.6) years
Etiology	75.7% (95% CI: 56.11–90.89) post- traumatic arthritis
Mean follow-up	30 months (95% CI: 25–34.5).
Pooled fusion rate	94.76% (95% CI: 92.30–96.77)
Scoring systems	AOFAS, Angus well scoring, SF-12, Odom criteria, VAS scoring, NAS pain score



Flowchart 1: Forest plot PRISMA flowchart

confidence interval, according to the expected incidence of the outcome event, and information about the level for statistical significance and estimates of power when comparing the outcomes.

DISCUSSION

This systematic review analyses the various parameters for the efficacy of arthroscopic subtalar arthrodesis for isolated subtalar arthritis with minimal deformity. The open technique is considered the gold standard for the subtalar arthrodesis with recent interest increasing in arthroscopic methods.⁷ Isolated subtalar arthritis following trauma was one of the main etiological factors accounting for almost 75% of overall patients in the current analysis. Analysis of pooled data showed an average age of 46.4 years with approximately five times more male patients as compared to female. Four included studies have mentioned the smoking data of patients. Six studies have discussed the mean duration from symptom onset to arthrodesis (range 15–67 months).^{4,5,8-11}

Majority of the authors have utilized two posterior portal technique with 4 mm 30° arthroscope. About 4.5 mm, 3 mm, 3.5 mm arthroscopes were also used with 30° angle being common in all. Three portal technique was also used with sinus tarsi portal added on to standard procedure.^{5,6,8-14} Duration of surgery and length of hospital stay was specified by only three groups of authors.^{4,15,16} Postoperative rehabilitation included immobilization in a below knee cast for a mean of 5.2 weeks (range 2–8 weeks) and subsequently gradual progressive weight bearing.

Most of the studies utilized AOFAS as the major functional outcome score for the analysis postoperatively (Table 2).¹⁶ Overall, the improvement in AOFAS score was statistically significant. It improved from a mean value of 44.2 to 79.6 ($p < 0.001$). Angus well score, SF-12, Odom criteria, VAS score, NAS pain score were other scores utilized in the included studies for functional evaluation.^{12-14,17,18} Fusion rate following arthroscopic arthrodesis was found to be 94.6% (92.3–96.7).

Bone grafting is a preferred technical addition to prevent nonunion of subtalar arthrodesis and four author groups have

utilized bone grafting in their cases while others have not used any kind of grafting.^{4,8,15,18} Glanzmann et al. described a series of 37 patients with bone grafting with 100% union rate (Table 2).⁴ Ten patients treated with arthroscopic subtalar arthrodesis and bone grafting by Albert et al. documented 100% union rate in a mean follow-up of just 7 weeks.¹⁵

In a series of 11 patients, Amendola et al. described just one union failure with a mean follow-up of 10 weeks. Union had occurred in all cases within 9 weeks, without complication.⁸ Bevernage also utilized bone grafting but only in eight out of a total of 41 patients. There was no statistical difference as such in union rates in both the groups with only two cases of nonunion in patients not receiving bone graft and an overall 95% fusion rate. In view of the nonsignificant fusion advantage with the use of bone graft in the available literature, we believe further studies are required to compare the effect of bone grafting with due consideration given to other confounding factors like smoking, diabetes etc. on union rates.¹⁸ Mean time to achieve union was 9.9 weeks with a mean follow-up of 30 months as determined from pooled data.

Overall data showed no significant percentage of complications, nonunion, hardware-related complications, or rate of revision surgery following or during surgery. Arthroscopic subtalar arthrodesis is indicated mainly in patients with isolated subtalar arthritis without any component of malalignment. Albert et al. commented that, since arthroscopy cannot be used for structural bone grafting, it would be better to treat significant deformities of the hindfoot with the open procedure.¹⁵ But with advancing experience, more cases have been included with a wide range of pathologies and deformities which were previously avoided. Indications have thus been expanded to include increasingly severe deformities and a range of different pathologies.

The safest and most reliable technique for subtalar arthrodesis is still controversial,¹⁹ despite excellent results having been documented with arthroscopic arthrodesis. Rungprai et al. conducted a retrospective review of patients who underwent subtalar arthrodesis comparing open with arthroscopic technique.³ A total of 121 patients (129 feet) were identified from the records out

Table 2: Study characteristics

Study	No. of patients	No. of feet	Mean age (in years)	Mean follow-up (in months)	AOFAS (Mean)		Arthroscope used
					Preop	Postop	
Glanzmann M 2007	37	41	42	55	53	84	3.5 mm
Amendola A 2007	10	11	41	34	36	86	3.0 mm 30°
El Shazly O 2009	10	10	42.1	28.4	38	74	NS
Lee K 2010	16	16	44	30	35	85	2.9 mm 30°
Albert A 2011	10	10	37.8	21.5	47	78	4.0 mm 30°
Thaunat M 2011	13	14	55	>12 months (mean NS)	51	77	4.5 mm 30°
Bevernage BD 2011	41	41	NS	>20 months (Mean NS)	49	80	4.0 mm 30°
Narita 2012	8	8	51.5	26.6	32	75	NS
Vila Y Rico 2015	61	61	49.1	57.5	51.1	81.2	4.0 mm 30°
Martin Oliva 2017	19	19	50.9	42.9	42.9	80.2	4.5 mm 30°
Vila Rico 2018	37	37	38.2	57.5	49	76	4.0 mm 30°
Walter RP 2018	77	77	53.4	NS	NS	NS	4.5 mm
Coulomb R 2019	22	22	49.5	>12 months (Mean NS)	46.4	76.3	4.5 mm 30°

NS, Not specified

Table 3: MINORS quality appraisal

Authors	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
Glanzmann M 2007	2	2	2	2	1	2	2	2
Amendola A 2007	2	2	1	1	1	2	2	2
El Shazly O 2009	2	2	1	1	0	1	2	2
Lee K 2010	2	2	2	2	1	2	2	2
Albert A 2011	2	2	2	2	2	2	2	1
Thaunat M 2011	2	2	2	2	1	2	2	1
Bevernage BD 2011	1	1	2	1	0	1	1	1
Narita 2012	1	1	2	1	0	2	1	1
Vila Y Rico 2015	2	1	1	2	2	2	2	2
Martin Oliva 2017	2	2	1	2	0	2	2	2
Vila Rico 2018	2	2	2	2	1	2	2	2
Walter RP 2018	2	2	2	2	1	2	2	2
Coulomb R 2019	1	2	2	2	1	2	2	2

of which open technique was done in 60 feet in 57 patients and arthroscopic technique in 69 feet in 64 patients between 2001 and 2014. There was no significant difference recorded between the groups in terms of the fusion rates and time to union (p -value-0.858). Return to work or activities of daily living were however earlier in the arthroscopic arthrodesis group (p -value-0.045). Based on this study, a prospective analysis is required comparing between open and arthroscopic techniques with a more comprehensive protocol for avoiding various confounding factors. However, conducting such a study is likely to require a strong protocol and prolonged follow-up due to limited patient numbers.

Previously arthrodesis of subtalar and talonavicular or arthrodesis of all three joints (subtalar, talonavicular, and calcaneocuboid) were the favored procedures for subtalar arthritis with large deformity. However, as the talonavicular joint affects the function of the hindfoot and overall gait of the individual, isolated subtalar arthrodesis is preferred to avoid secondary degeneration of neighboring joints and simultaneously allow hindfoot mobility.²⁰

In summary, analysis of the studies showed an improved AOFAS score, good union rates with minimal complications associated with an arthroscopic subtalar arthrodesis. However, generalization of the findings is difficult as there is heterogeneity in the included cohort and in the surgical technique used such as difference in size of arthroscope, posterior 2 portal or 3 portal, lateral position or prone position etc. All these factors may directly or indirectly affect the overall outcomes. Nonetheless, a minimal invasive option appears to be a better option compared to opening whenever possible in a carefully selected patient.

Critical appraisal of the studies shows low risk for bias and overall provides the results for individual studies which comes out to be satisfactory for the systematic review (Table 3). There are various limitations in the current review with various missing links to be able to recommend the universal acceptance of arthroscopic subtalar arthrodesis for isolated subtalar arthritis. Comorbidities have not been described properly in the studies like smoking, diabetes, renal diseases which tend to increase complications and affect union rates. The definition of a union is different according to authors and union is defined clinically in a few studies while others have relied on radiological criteria. AOFAS has been discontinued as such and is no longer validated for foot and ankle scoring. Studies utilizing a more recent scoring system are required to clearly describe the better picture of patient satisfaction outcomes. Studies have utilized various

portals for approaching the joint which can be a potential factor in changing the outcomes. Return to sports or daily living activities, gait analysis is missing variables that provide better information on effects of subtalar arthrodesis on neighboring joints as well as the generalized perception of the procedure by the patient.

CONCLUSION

Arthroscopic approach for isolated subtalar arthrodesis is a minimally invasive technique that has shown to achieve a fusion rate comparable or better than open techniques. Careful selection of patient with mild deformities and isolated condition is ideal for achieving better results. Prospective randomized studies comparing open with arthroscopic technique in a prospective cohort are required to further clarify the advantages of the arthroscopic approach for fusing the subtalar joint.

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