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Review article

Sinus tarsi approach (STA) versus extensile lateral approach (ELA) for treatment of closed displaced intra-articular calcaneal fractures (DIACF): A meta-analysis

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ABSTRACT

Introduction: Our aim was to compare the effect of sinus tarsi approach (STA) vs extensile lateral approach (ELA) for treatment of closed displaced intra-articular calcaneal fractures (DIACF) is still being debated.
Materials and methods: A thorough research was carried out in the MEDLINE, EMBASE and Cochrane library databases from inception to December 2016. Only prospective or retrospective comparative studies were selected in this meta-analysis. Two independent reviewers conducted literature search, data extraction and quality assessment. The primary outcomes were anatomical restoration and prevalence of complications. Secondary outcomes included operation time and functional recovery.
Results: Four randomized controlled trials involving 326 patients and three cohort studies involving 206 patients were included. STA technique for DIACFs led to a decline in both operation time and incidence of complications. There were no significant differences between the groups in American Orthopedic Foot and Ankle Society scores, nor changes in Böhler angle.
Conclusions: This meta-analysis suggests that STA technique may reduce the operation time and incidence of complications. In conclusion, STA technique is reasonably an optimal choice for DIACF.

1. Introduction

Calcaneal fractures are one of the most common fractures, accounting for about 1–2% of all fractures in the human body and 75% of them are intra-articular [1]. Such fractures are mostly caused by a fall from a height and may cost patients a long period of time to back to their normal lives and recreation because of long-term pain, dysfunction, traumatic arthritis and ankyloses [2]. Recent studies have suggested that in DIACF treatment, anatomical structures of the calcaneus can be restored validly and get to better functional recovery if the surgery is performed correctly, though there is a high risk of complications [3,4].

The sinus tarsi approach (STA) try to decrease the risk of operative complications, through minimizing the soft tissue trauma, while still granting good reduction of fractures. However, STA still has several dilemmas including the restricted view of fracture region, technical difficulties and difficulty with manipulation [5]. However, their conclusions were based on single studies and inadequacy evidence to pinpoint the optimal choice in DIACF treatment.

Figuring out the advantages and disadvantages of sinus tarsi approach (STA) versus extensile lateral approach (ELA) for treatment of closed displaced intra-articular calcaneal fractures (DIACF) was the target of our meta-analysis, which was never discussed systematically before. We believe this is the very first meta-analysis that will draw stronger evidence to answer the question concerning surgical treatment of DIACF.

2. Materials and methods

To find studies comparing STA and ELA for the treatment of DIACF, we searched multiple comprehensive databases. We perform this study following the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines [6].

2.1. Study design and search strategy

Databases used for searching included Medline, EMBASE and Cochrane Central Register of Controlled Trails by two authors independently. There was no restriction to publication language.

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Quality assessment							№ of patients		Effect		Quality	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	STA	ELA	Relative (95% CI)	Absolute (95% CI)		
OPERATION TIME - operation time with STA and ELA technique in RCTs												
2	randomised trials	very serious [a,b,c,d]	not serious	not serious	serious [e]	very strong association all plausible residual confounding would reduce the demonstrated effect	64	86	-	MD **30.79 min fewer** (67.11 fewer to 5.53 more)	⊕⊕⊕⊕ HIGH	
OPERATION TIME - operation time with STA and ELA technique in retrospective cohort studies												
2	observational studies	serious [a,f]	not serious	not serious	serious [g]	very strong association all plausible residual confounding would reduce the demonstrated effect	77	69	-	MD **47.81 min fewer** (81.13 fewer to 14.49 fewer)	⊕⊕⊕◯ MODERATE	
complications - complications after STA and ELA treatment in RCTs												
4	randomised trials	very serious [b,c,d,h]	not serious	not serious	serious [e]	very strong association all plausible residual confounding would reduce the demonstrated effect	4/140 (2.9%)	25/130 (19.2%)	not estimable	**160 more per 1,000** (from 240 more to 90 more)	⊕⊕⊕⊕ HIGH	
complications - complications after STA and ELA treatment in retrospective cohort studies												
3	observational studies	serious [f,i]	not serious	not serious	serious [g]	strong association all plausible residual confounding would reduce the demonstrated effect	4/97 (4.1%)	35/165 (21.2%)	not estimable	**160 more per 1,000** (from 230 more to 80 more)	⊕⊕◯◯ LOW	
AOFAS - AOFAS after STA and ELA treatment in RCTs												
2	randomised trials	very serious [a,b,c,d]	not serious	not serious	serious [e]	all plausible residual confounding would reduce the demonstrated effect	49	49	-	MD **0.43 higher** (3.11 lower to 3.97 higher)	⊕⊕◯◯ LOW	
AOFAS - AOFAS after STA and ELA treatment in retrospective cohort studies												

Fig. 1. The quality of evidence graded by the GRADE system.

Keywords used for searches were: calcaneal fractures, heel fracture, sinus tarsi approach, minimally invasive, limited invasive, extensile lateral approach. Data were last updated on December 26, 2016. Reference lists of the relevant articles were also searched.

2.2. Selection criteria

Comparative studies that compared STA with ELA groups for DIACF were taken into consideration. Selected studies must meet the following principles:

- studies were designed comparing the STA and ELA technique prospectively or retrospectively;
- surgical complications or clinical outcome were recorded;
- clinical scores were demonstrated in the form of a mean value with a standard deviation or with a clear range when reported.

2.3. Study identification

Two reviewers screened titles of all articles collected independently. Abstract was reviewed if the study was potentially related to the topic; a full text was scanned when the information was deficient from the abstract; if there were any divergence, it will be solved by consensus after discussion with the corresponding author; means with clear ranges were converted into standard deviation using reported method [7].

2.4. Data extraction

Two reviewers extracted valid data from all relevant studies individually. Disagreement was resolved by discussion, a third reviewer made the final decision if not resolved. Valid data collected from all studies included patient information, methodology, surgery details and reported outcomes.

2.5. Methodological assessment

The assessment of RCTs was made using The Cochrane Collaboration's "Risk of Bias" tool [8] with seven particular domains including sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective outcome reporting and other issues. After assessed above, the risk of bias was categorized as low, unclear or high for each of the included studies.

Methodological qualities of all prospective or retrospective cohort studies appraised individually by two reviewers using the Newcastle-Ottawa Quality Assessment scale [9] the Newcastle–Ottawa scale is a tool used for assessing the quality of cohort studies. Each study is judged on eight terms, classified into three groups using the tools: selection; comparability and outcome. Stars were given if the article met the condition, more stars suggest higher quality.

2.6. Outcomes for meta-analysis

Outcomes were classified as anatomical restoration, functional recovery and incidence of complications. anatomical restoration represented by changes in Böhler angle functional recovery mainly contains AOFAS score meta-analysis of operation time as a major influencing factor has also been proceed.

Table 1
Main characteristics of included studies.

Author	Study type	Study population				Mean age (years)		Follow-up (months)		Implant		Outcome assessment
		STA group	ELA group	Total	Lost to follow-up	STA group	ELA group	STA group	ELA group	STA group	ELA group	
Li LH	RCT	31	29	64	4	40	41	12		Screw and plate	Screw and plate	VAS pain score AOFAS Böhler angle Poor reduction Reduction loss Wound complications
Chen Z	RCT	32	32	64	0	36.7	37.1	24		Screw and plate	Screw and plate	Motion range subtalar joint Lateral displacement of footplate pressure center Instep index Calcaneal width Wound complications
Xia S	RCT	59	49	127	19	38	39	8–28		Screw and plate	Screw and plate	Böhlers angle Gissanes angle Calcaneal heights Calcaneal widths Calcaneal lengths Wound complications
Basile A	RCT	18	20	45	7	41.89	31.55	>24		Screw and plate	Screw and plate	AOFAS score VAS pain score FFI score Quality of reduction of the posterior subtalar joint (PSJ) Böhler angle Wound complications
Kline AJ	Cohort study	33	79	112	NA	42.2	46.4	>6		Screw	Screw and plate	FFI SF-36 VAS pain score Böhlers angle Gissanes angle Wound complications
Yeo JH	Cohort study	40	60	100	NA	46	42	46	57	Screw	Screw and plate	Böhlers angle Gissanes angle Calcaneal heights Calcaneal widths Calcaneal lengths wound complications
Weber M	Cohort study	24	26	61	11	42.67	40.04	24.65	21.29	Screw	Screw and plate	AOFAS score CRPS (minor form) Wound complications

2.7. Statistical analysis

The quality of evidence of outcome measures was graded by the international general evidence quality classification system GRADE [10] of which were included the RCT tests and cohort studies (Fig. 1).

The RCT trial was set to be the highest level of evidence, with 5 factors that could reduce the quality of the evidence: limitations of the study, publication bias, imprecision of the study, inconsistencies in the study, and indirect findings.

The cohort study had a lower level of evidence, but with 3 factors that can increase the quality of the evidence: large magnitude of an effect, dose-response gradient and effect of plausible residual confounding.

3. Results

3.1. Literature search

We initially identified a total of 714 potentially compatible articles: 268 from Medline, 338 from Embase, 118 from the Cochrane database. After screened to titles, abstracts and even full texts, four published RCTs contain 326 patients and 3 cohort studies covers 206 patients met all inclusion criteria [11–17]. Four articles were excluded because of using minimally invasive without STA technique and two articles excluded as there were open fractures in STA group [18–23]. Characteristics of general studies and participants were listed in Table 1.

3.2. Methodological quality assessment

The methodological quality of the four RCTs was evaluated according to The Cochrane Collaboration's "Risk of Bias" tool (Fig. 2).

Newcastle Ottawa Scale used for cohort studies indicates that the quality of most trials was good (Table 2).

3.3. Meta-analysis

3.3.1. Böhler angle

Three trials compared the recovery of Böhler angle after STA and ELA techniques [14,16,17]. The pooling of outcomes showed the similar scores were recorded in follow-up between the 2 groups [MD = 0.06, 95% CI = (−1.00 to 1.12), $P = 0.92$] (Fig. 3). Chenonly reported the Böhler angle after the surgery thus, excluded from the meta-analysis [12].

3.4. American Orthopedic Foot and Ankle Society

Regarding to AOFAS after both treatments, outcome reported by two RCTs suggested that no significant difference was found between the groups [MD = 0.43, 95% CI= (−3.11 to 3.97), $P = 0.81$]

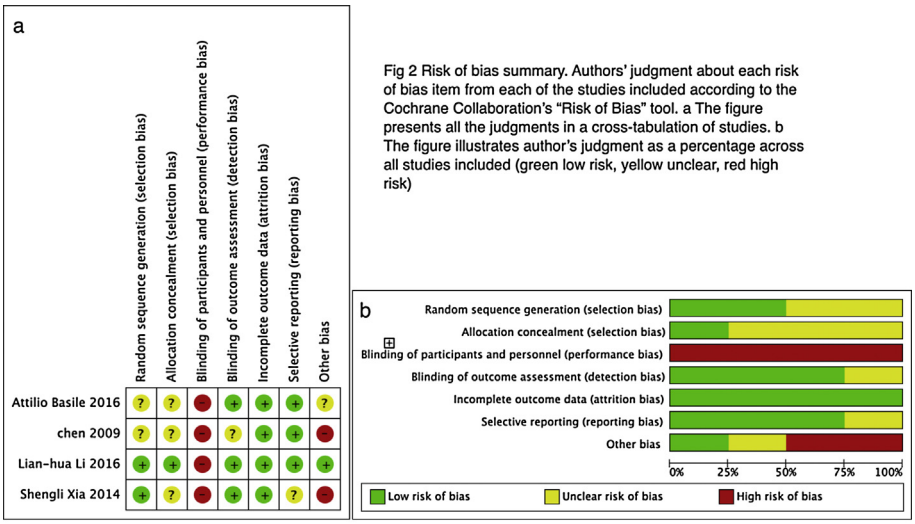

Fig 2 Risk of bias summary. Authors' judgment about each risk of bias item from each of the studies included according to the Cochrane Collaboration's "Risk of Bias" tool. a The figure presents all the judgments in a cross-tabulation of studies. b The figure illustrates author's judgment as a percentage across all studies included (green low risk, yellow unclear, red high risk)

Fig. 2. The methodological quality of the four RCTs evaluated according to Cochrane risk of bios tool.

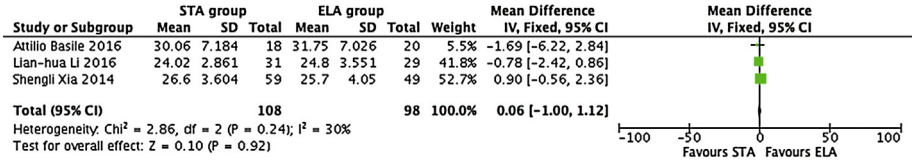

Fig. 3. Böhler angle after STA and ELA techniques.

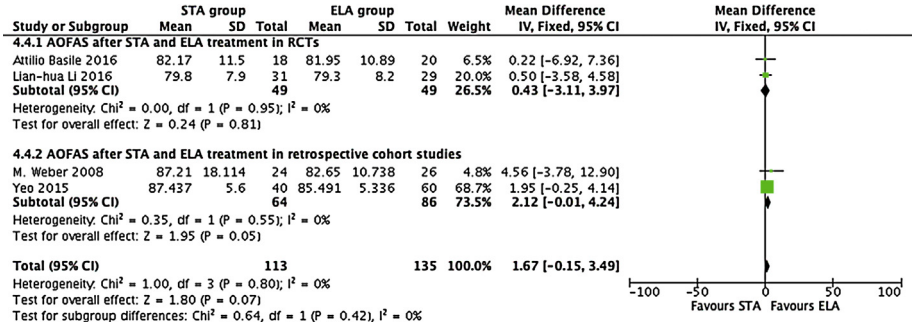

Fig. 4. AOFAS after STA and ELA techniques.

Table 2
The New castle-Ottawa Quality Assessment scale for cohort studies.

Author	Selection of the study groups	Comparability of the groups	Outcome	Total score
Kline AJ	****	*	**	7
Yeo JH	****	**	**	8
Weber M	****	*	**	7

A asterisk represents one point, usually 6 points or more shows that the quality of the article is high and credible.

[16,17]. As in two cohort studies, [11,12] outcome reported suggested the STA group might have a larger AOFAS than the ELA group, but the relationship was "borderline significant"; [MD = 2.12, 95% CI = (−0.01 to 4.24), $P = 0.05$] (Fig. 4).

3.5. Visual analog scale

Visual analog scale (VAS) pain scores was reported in both Basile and Li a similar VAS pain score was observed whether with STA or ELA technique [16,17] [MD = −0.28, 95% CI = (−0.65 to 0.10), $P = 0.15$] (Fig. 5).

3.6. Incidence of wound complications

A total of 4 of 140 STA treated patients compared with 25 of 130 ELA treated patients had complications in four RCTs (2.86% versus 19.23%) and 4 of 97 compared with 35 of 165 in three cohort studies (4.1% versus 21.21%) [11–17]. The significant difference indicated a higher complication rate in the ELA group [RR −0.16, 95% CI (−0.24 to −0.09), $P < 0.0001$ in RCTs; RR −0.16, 95% CI (−0.23 to −0.08), $P < 0.0001$ in cohort studies] (Fig. 6).

3.7. Operation time

Operation time was mentioned in two cohort studies [11,15] patients managed by STA had a underlying trend shorter operation time than the ELA patients, but no statistical significance was attained [MD = −30.79, 95% CI = (−67.11 to 5.53), $P = 0.10$]. However, in two RCTs [14,16] outcome indicated that the two

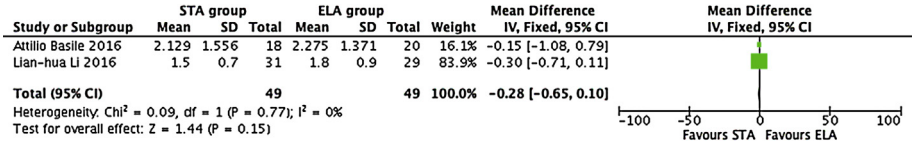

Fig. 5. Visual analog scale (VAS) pain scores after STA and ELA techniques.

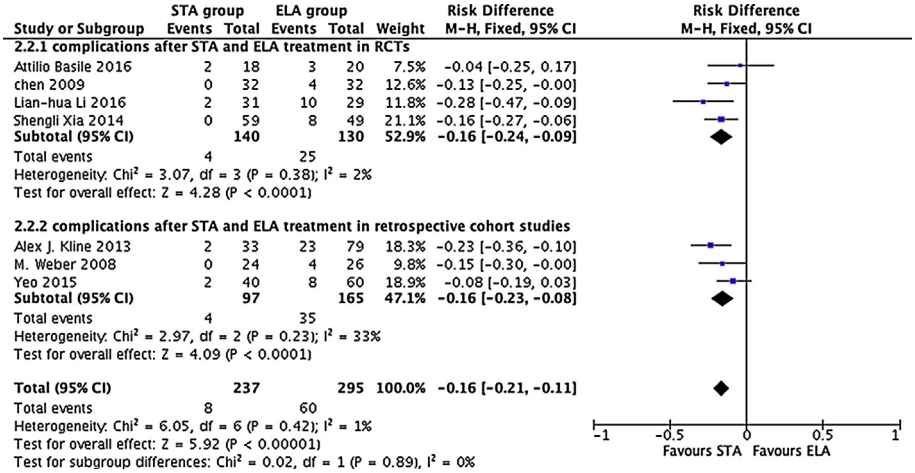

Fig. 6. Incidence of wound complications after STA and ELA techniques.

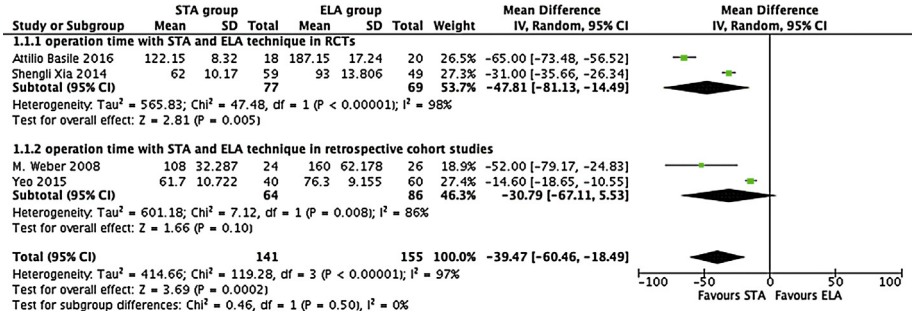

Fig. 7. Operation time after STA and ELA techniques.

groups had a significant difference [MD = −47.81, 95% CI = (−81.13 to −14.49), $P = 0.005$]. The diversity may due to insufficient sample size in both RCTs and cohort studies (Fig. 7).

4. Discussion

The most significant point confirmed by our meta-analysis is that STA group may leads to a decreased operation time and a smaller probability of complications in DIACF. Moreover, there were no significant differences between the 2 groups in the changes in Böhler angle, or AOFAS score. In practical clinic application, the real outcomes depend often enough on the expertise of the operative team and their learning curve. The best approach is always the one you know well. To promote the sinus tarsi approach, surgeons need to standardize the reduction and share the expertise.

Weber et al. [11] reported the number of patients marked as excellent, good, fair and poor using the AOFAS. Scores of 90 + indicates excellent scores of 80–90 donates good, scores of 70–80 represented as fair and scores 70–was poor similar results between two groups was obtained.

Apart from the measures to estimate the efficacy between STA and ELA technique, some data not available for meta-analysis were also reported in the eligible studies. Basile et al. [16] and Kline at al. [13] reported that the average foot function index (The FFI was a self-administered index with questionnaires of 23 items divided into 3 sub-scales developed to evaluate the extent of foot pain, disability and activity restriction. The possible score range for FFI is 0–100, with lower scores denoting better outcomes) in the STA group was similar to the ELA group, no significant difference was detected [24].

Maryland foot score (MFS) was mentioned in two articles, Chen et al. and Xia et al. [12,14]. Chen reported the MFS postoperative, one year after surgery and two years after surgery, was found no significant difference between two groups. However, in Xia's article, the outcome of 76.56% fractures were excellent (90–100 points), 17.19% good (75–89 points) and 6.25% fair (50–74 points), with excellent/good rate of 93.8% (60/64) in STA group, while with excellent/good rate of 86.8% (46/53) in ELA group, which was statistically significant between two groups ($P < 0.01$). Such statistical differences may be due to the developed new plate which may has the advantages of simple structure, small size and perfect shape. It cannot only provide enough strength to support the fracture of calcaneus, but also reduce the tension of skin and soft tissue.

Many different kinds of assessment scores or scales were adopted for comparisons, such as, Motion range of subtalar joint, Calcaneal length, Calcaneal width, Calcaneal height, Gissane angle,

Short Form 36 [SF-36] The restoration of the height of the calcaneus is a key factor evaluating the outcome of DIACF, but there was only one RCT [14] and one retrospective study [15] mentioned in our study, so it is no enough medical data to make a meta-analysis. Correction of the valgus of the hind foot and disappearance of the conflict between the external malleolus and the calcaneus were also important for assessing the outcomes, but there was no article referring to it in our study.

Weber et al. also reported ten patients complained of tenderness of the postero-inferior scar at three months [11]. After removal of the screws the tenderness resolved in all ten patients. It may result from the fixation with screws only without a plate. There were also four further patients diagnosed as having complex regional pain syndrome (CRPS) because of having continued diffuse moderate hind-foot pain on weight-bearing without swelling or delayed osseous healing.

After searching in databases, only 4 RCTs matched our selection criteria [12,14,16,17] considering the sample size of RCTs was limited, we also searched for cohort studies related to the topic. The leading limitations of the studies we enrolled are small sample size and the lack of a uniform criterion to appraise postoperative clinical outcome, especially function and pain. As a result, the different criterion found in the available RCTs, only a few studies could be included in the meta-analysis, which may lead to loss of ample data for meta-analysis. The recruitment of cohort studies might be the main weakness of our meta-analysis, as they may have brought to our results a certain degree of selection bias. Therefore, cohort studies-related results and conclusions should be treated cautiously.

5. Conclusions

In general, our meta-analyses confirm that the STA technique can result in shorter operation time and lower complication rate, but their restoration of anatomical structures and functional recovery may seems similar. Consequently, STA technique may be superior to ELA with a view to complication rate. We hope there will be more multicenter, large-scale and high quality RCTs with consistent assessment systems comparing DIACF surgery strategies.

Disclosure of interest

The authors declare that they have no competing interest.

Acknowledgments

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org.10.1016/j.otsr.2017.12.015.

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