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Effectiveness of arthroscopically assisted surgery for ankle fractures: A meta-analysis

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ABSTRACT

Introduction: This meta-analysis was performed to determine whether the arthroscopically assisted open reduction and internal fixation (ORIF) for ankle fractures is more beneficial than the conventional ORIF.
Methods: Articles in electronic medial databases were searched between March 1983 and August 2016, including Pubmed and SCOPUS. We included the studies with comparative design comparing the surgical outcomes between the arthroscopically assisted ORIF for ankle fractures and the conventional ORIF. Finally, two RCTs and two retrospective comparative studies were included for analysis. Mean and standard deviation (SD) of postoperative functional scores, number of subjects, and P-values were extracted from the studies. In addition, postoperative follow-up period, fracture type, and study quality were collected.
Results: The pooled effect size of the four studies 0.535 (95% CI, 0.247–0.823) in Hedges's g, which favored the arthroscopically assisted ORIF over conventional ORIF. There was no evidence of publication bias in funnel plot and in Egger's test ($p = 0.534$).
Conclusion: The arthroscopically assisted ORIF for ankle fractures were more beneficial than the conventional ORIF in the current evidences. However, since it needs more medical cost and longer operation time, possible additional complications and cost effectiveness are to be validated in future studies.

Introduction

Ankle fractures are a very common orthopaedic injury requiring surgical treatment [1,2,3]. Although the surgical outcome using the conventional open reduction and internal fixation (ORIF) is generally favorable [4–7], some of the cases lead to unsatisfactory results even when the anatomical reduction has been achieved [8–10]. Since ankle arthroscopy has been introduced to ankle fractures, researchers found that concurrent occult injuries are very frequent in ankle fractures [11–15] and suggested that the poor surgical outcome is associated with the occult injuries [12,16] that cannot be adequately addressed by conventional diagnosis and treatment.

This has led to the introduction of arthroscopically assisted open reduction and internal fixation of ankle fractures. However, it has been reported to consititute only 1% of total number of ankle fracture surgeries in a recent study [17]. Although arthroscopic assisted management for ankle fractures have reported favorable outcomes, it is not gaining the popularity amongst the orthopaedic surgeons as would be expected. This is likely because the surgeons are not convinced that this management is superior to the 'already favorable' and more conventional ORIF especially when considering the cost-effectiveness of the procedure and the longer surgical time [17–19].

Furthermore, the arthroscopically diagnosed concurrent injuries with ankle fractures may heal spontaneously although future studies would be needed to further categorize those into spontaneously healing lesions and non-spontaneously healing lesions requiring arthroscopically assisted treatments. These concerns are beyond the scope of current evidences, and thus the focus should lie on the effectiveness of arthroscopically assisted ORIF compared with conventional ORIF in a more generalized realm. There have been a couple of systematic reviews on this proposed treatment issue [8,20,21], but in order to obtain

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the most current and best scientific evidences, the previous study results need to be quantitatively and statistically summarized via a meta-analysis.

Therefore, the aim is to compile a meta-analysis that investigates the effectiveness and postoperative functional scores of arthroscopically assisted ORIF for ankle fractures compared with the conventional ORIF without arthroscopy. We hypothesized that the arthroscopically assisted ORIF would result in more favorable surgical outcome compared with the conventional ORIF.

Materials and methods

Study selection

This study was approved by the institutional review board of our institute. We conducted a systematic literature search for all relevant articles through online databases, Pubmed and Scopus. The key searching terms were *ankle, distal fibula, distal tibia, fractures, and arthroscopy.* The combination of these terms were entered as medical subject headings. Other relevant articles were manually searched, and evaluated for their inclusion. Any additional articles were listed as references in other articles.

The inclusion criteria were human studies with comparative design (arthroscopically assisted ORIF vs conventional ORIF), those investigating arthroscopic surgeries concurrently performed with ORIF for ankle fractures, and articles written in English. The exclusion criteria were 1) studies investigating pilon fractures or talar fractures, 2) those where arthroscopy was used only for the detection of concurrent injuries with ankle fractures (diagnostic studies), 3) those investigating pediatric ankle fractures, 4) case reports or systematic reviews, 5) those without surgical outcomes as quantitative clinical scores, and 6) delayed arthroscopic procedure performed for sequalae of ankle fractures.

Quality assessment and data extraction

Two authors independently assessed all potential articles for eligibility. Quality assessment of the studies were performed using Jadad scale for randomized controlled trials [22] and Newcastle-Ottawa scale for retrospective comparative studies [23]. Discrepancies between the two independent authors were resolved by discussion and final consensus. Data were extracted from the included studies including patients' demographics, follow-up period, ankle fracture type and outcome measures. Functional outcome scores from the included four studies were physical function subscale of SF-36 [24], AOFAS score [25], Olerud-Molander score [26], and physical functional subscale of PROMIS [27,28], respectively.

Data analysis

Effect sizes were calculated from the postoperative functional scores of the studies. To evaluate the effectiveness of arthroscopic assisted ORIF compared with conventional ORIF, standardized mean difference was calculated. The difference of postoperative functional scores between arthroscopic ORIF and conventional ORIF was divided by pooled standard deviation in three studies, and standardized mean difference was calculated from the mean and *p*-value in one study. All effect sizes (Cohen's d) were multiplied by a correction factor depending on the sample size to reduce bias, which produced Hedges' g [29]. A random effects model was adopted to pool the effect sizes based on the heterogeneity of the studies, which tends to produce more conservative estimates than the fixed effects model. Meta-regression analysis was not performed because four studies was not considered to be sufficient for the analysis.

Publication bias was tested using a funnel plot and the Egger's test [30]. A funnel plot is a scatter plot of the intervention effect estimates from individual studies against some measure of each study's size or precision. A funnel plot graphed the Hedges' g for a study on the horizontal axis and the standard error on the vertical axis. The asymmetry in the funnel plot suggested the possible bias. Egger et al. proposed a test for asymmetry of the funnel plot. This is a test for the Y intercept = 0 from a linear regression of a normalized effect estimate (estimate divided by its standard error) against precision (reciprocal of the standard error of the estimate) [30]. Egger's test was performed by regressing the effect size on the inverse of the study variance, where the bias was considered to be present if the intercept for the regression was different from null at $p < 0.1$. All statistical analyses were performed using comprehensive meta-analysis software version 2.0.

Results

Seven studies were found to meet our inclusion criteria. Of these, one study only reported radiographic outcome [31] and another study reported postoperative clinical outcome as a qualitative value [32]. Another study reported a protocol of a randomized controlled trial without postoperative outcomes [33]. Therefore, four studies were available for final inclusion and analyzed in the meta-analysis (Fig. 1).

Of the four studies included, two were retrospective comparative studies and two were randomized controlled trials. This meta-analysis included a total of 188 patients. Mean number of subjects in each study ranged from 19 to 72. Mean age of the patients ranged from 29 years to 42 years, and mean follow up ranged from 21 months to 67 months (Table 1).

The pooled effect size of the four studies was 0.546 (95% confidence interval [CI], 0.253–0.839) and Hedges's g was 0.535 (95% CI, 0.247–0.823), which favored arthroscopically assisted ORIF over conventional ORIF (Fig. 2). Arthroscopically assisted ORIF showed better outcomes than the conventional in both subgroups of lateral malleolar fracture and medial malleolar fracture in terms of the effect size (Fig. 2).

A funnel plot showed the asymmetric distribution of the dots was not evident (Fig. 3), and Egger's test also suggested that there was no publication bias ($p = 0.534$)

Discussion

The results of this meta-analysis showed that arthroscopic assisted ORIF for ankle fractures were more beneficial with respect to functional outcomes when compared to conventional ORIF, which is considered to be the best quantitative current evidence on this treatment modality. To the best of our knowledge, this study is the first meta-analysis investigating the effectiveness of the concurrent arthroscopic treatment for concomitant intraarticular injuries at the time of ankle fracture surgeries. Although the number of available articles were small, no publication bias was observed among the articles.

Before discussing the study results in detail, there are some limitations to be addressed. First, the overall number of the subjects was relatively small; thus, the study results might not be generalized. Second, all of the four studies did not indicate the operation time or whether the arthroscopic surgeons were the same as the non-arthroscopic surgeons. The experience of the surgeons could possibly cause a bias in the study results. Therefore, the results need to be clinically interpreted with caution.

Arthroscopic assisted ORIF for ankle fractures is a very reasonable approach considering that a considerable portion of ankle fractures have concomitant intraarticular injuries. Previous

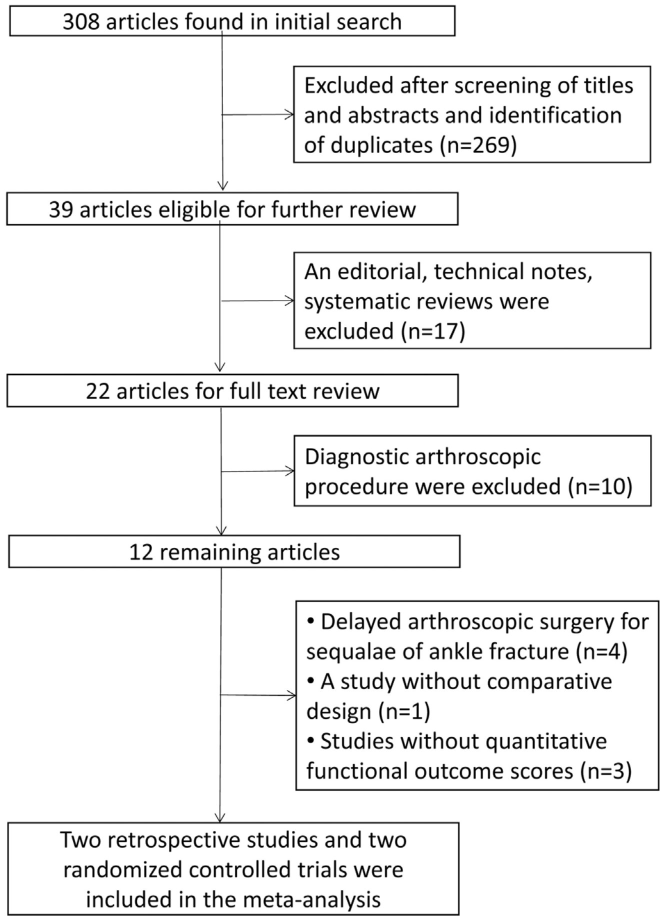

Fig. 1. Flowchart showing the inclusion and exclusion process of the studies.

studies reported that the concomitant intraartiular cartilage injuries with ankle fractures were found in upto 79.2% of the cases, more often on the talus than on the distal tibia, the fibula, or the medial malleolus [12]. Although arthroscopic diagnosis of occult intraarticular lesions associated with ankle fractures is clearly useful, the effectiveness of arthroscopic assisted ankle fracture treatment has not been sufficiently proven. Due to this lack of evidence, arthroscopic assisted ankle fracture surgeries have failed to obtain treatment popularity among surgeons treating these injuries.

In addition, arthroscopic assisted ORIF requires longer surgical time and carries possible additional complication rates. Previous studies reported that arthroscopic assisted ankle fracture surgeries required an additional 15–20 min of operation time compared with conventional ORIF [18,19]. There have been no reported complications associated with arthroscopic assisted ORIF. However, various known complications of elective ankle arthroscopic procedures could possibly still occur such as superficial peroneal neuritis, saphenous neuritis, damage to the neurovascular bundle and even wound complications [34]. Compartment syndrome

Table 1
Summary of the included studies with comparative design.

Author/Year	Type of study	No. of AAORIF	No. of ORIF	Fracture type	Mean Age (years)	M:F	Mean follow-up (months)	Outcome measure tools	PostOp score (AAORIF)	PostOp score (ORIF)	Study quality
Thordarson/2001 [15]	RCT	9	10	16 SER, 3 PER (intact MM)	29	17:2	21	SF 36	97	96	Jadad 3
Takao/2004 [36]	RCT	41	31	22 SER, 50 PAb (intact MM)	36 (AAORIF), 38 (ORIF)	48:24	40 (AAORIF), 41 (ORIF)	AOFAS	91	87.6	Jadad 3
Turhan/2013 [19]	Retrospective comparative	21	26	MM fracture	34 (AAORIF), 42 (ORIF)	28:19	26 (AAORIF), 38 (ORIF)	Olerud-Molander	92.3	86.3	NOS 5/8
Fuchs/2016 [18]	Retrospective comparative	24	27	AO/OTA 33 type B, 18 type C (intact MM)	38 (AAORIF), 40 (ORIF)	31:20	67	PROMIS	57.8	54.5	NOS 6/8

AAORIF, arthroscopically assisted open reduction & internal fixation of fracture; ORIF, conventional open reduction & internal fixation of fracture; RCT, randomized controlled trial; SER, supination-external rotation injury in Lauge-Hansen classification; PER, pronation-external rotation in Lauge-Hansen classification; MM, medial malleolus; PAb, pronation-abduction injury in Lauge-Hansen classification; NOS, Newcastle-Ottawa scale.

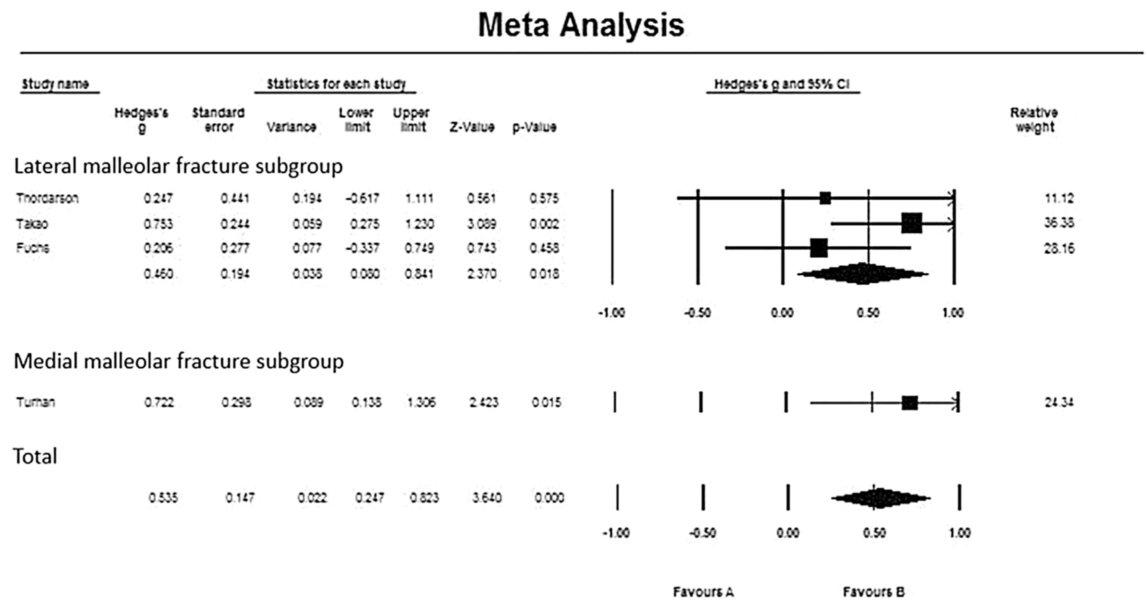

Fig. 2. Forest plot showing the pooled effect sizes as Hedges's g (A, the conventional ORIF and B, the arthroscopically ORIF), where overall effect size favors the arthroscopically assisted ORIF. Lateral and medial malleolar fracture subgroups also favor arthroscopically assisted ORIF.

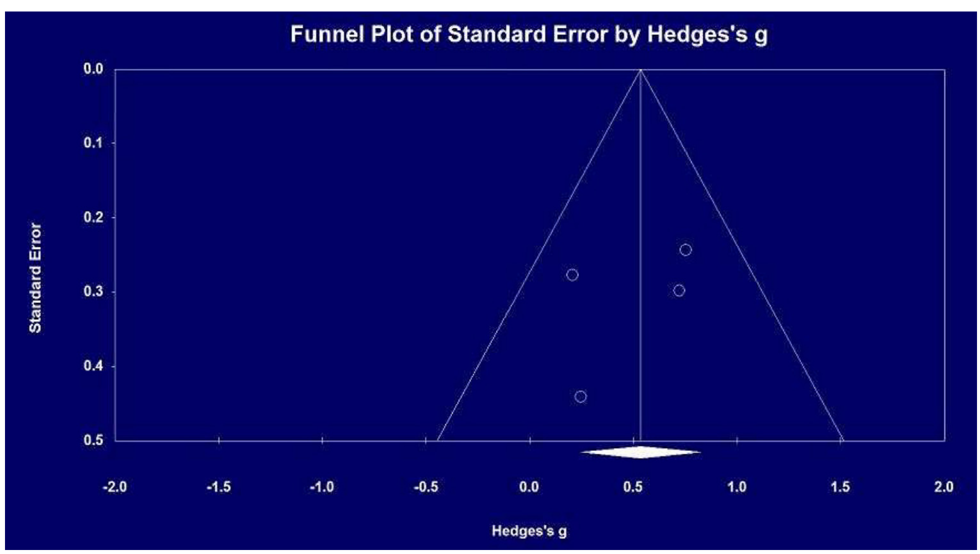

Fig. 3. Funnel plot where the asymmetry of distribution of dots is not evident.

secondary to fluid extravasation from the arthroscopy could be a concern as well with this procedure when performed in the setting of an acute injury [35] although this disastrous complication has never been reported in arthroscopic assisted ORIF. These concerns over additional complication rates, additional cost and added time has impeded generalized use of arthroscopic assisted ORIF for ankle fractures.

Of the four studies included in the meta-analysis [15,18,19,36], one RCT and one retrospective study found no significant difference in clinical outcome between the arthroscopic ORIF and the conventional ORIF, although they reported considerable incidence of concomitant intraarticular injuries with ankle fractures [15,18]. Moreover, there were a relative lack of explanations as to why the arthroscopic assisted ORIF failed to achieve better functional outcome than the conventional ORIF. The RCT, although it was the first comparative study on this issue, included a very small number of procedures (19 patients) and might have failed to reach statistical significance [15]. In addition, they performed minimal arthroscopic treatments with only one out of the nine patients requiring a small cartilaginous loose body removal, which might have been insufficient to lead to a significantly improved surgical outcome.

From the results of this meta-analysis, it should be considered that the arthroscopic assisted ORIF for ankle fractures is more effective with minimal additional risk compared to the conventional ORIF in terms of postoperative functional scores. In addition, delayed diagnosis and investigation with noninvasive evaluations such as magnetic resonance imaging for patients complaining of postoperative pain might be more difficult due to the artifact of the metal implants [37]. This alone should support the arthroscopic treatment of concomitant injuries with ankle fracutres at the time of ORIF. Furthermore, the cost-effectiveness of this procedure and possible additional complication rates need to be further elucidated in future studies and weighed against proposed benefits. Previous studies reported that the more severe ankle fractures have higher incidence of concomitant cartilage injuries [13] and patients with ages under 30 years and over 60 years had more severe cartilage injuries associated with ankle fractures [12]. Hopefully with the accumulation of more detailed data and evidence, we will be able to predict the specific features of patients that would best benefit from arthroscopic assisted ORIF while still maintaining cost effect.

Conflict of interest

The authors have no conflict of interest.

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