Xie, L.; Lin, K.; Zhao, L. (2023) A META-ANALYSIS OF CLOSED CANNULATED SCREW FIXATION VERSUS OPEN PLATE FIXATION FOR SANDERS II, III CALCANEAL FRACTURES IN FITNESS ENTHUSIASTS AND ATHLETES. Revista Internacional de Medicina y Ciencias de la Actividad Física y el Deporte vol. 23 (92) pp. 296-312.
DOI: https://doi.org/10.15366/rimcafd2023.92.023

ORIGINAL

META-ANALYSIS OF CLOSED CANNULATED SCREW FIXATION VERSUS OPEN PLATE FIXATION FOR SANDERS II, III CALCANEAL FRACTURES IN FITNESS ENTHUSIASTS AND ATHLETES

Lu Xie[1], Kailu Lin[1]*, Lujie Zhao[1]

[1]Ningbo yinzhou NO.2 Hospital Emergency Medical Center 315100, China

Recibido 28 de agosto de 2022 **Received** August 28, 2022
Aceptado 20 de julio de 2023 **Accepted** July 20, 2023

ABSTRACT

Objective: To compare closed cannulated screw fixation and open plate fixation in the treatment of Sanders Ⅱ, Ⅲ calcaneal fractures. **Methods:** Randomized controlled studies searching from PubMed, Embase and Cochrane library from the establishment of the database to September 2022. The retrieved literature was screened according to inclusion and exclusion criteria. And RevMan 5.3 software was used for Meta analysis. **Results:** A total of 10 studies were included with 1014 feet of 1010 cases, including 508 feet of 506 cases in the closed group (experimental group) and 506 feet of 504 cases in the open group (control group). Meta analysis results: the time to operation of the closed group was shorter than that of the open group [MD = -2.15, 95% CI (-3.62, -0.68), P < 0.05]; operation time of the closed group was shorter than that of the open group [MD = -14.95, 95% CI (-26.01, -3.90), P < 0.05]; bigger Gissane angle of the closed group [MD = 0.98, 95% CI (0.28, 1.67), P < 0.05]; higher calcaneus of the closed group [MD = 0.61, 95% CI (0.12, 1.11), P < 0.05]; less postoperative complications of the closed group [OR = 0.29, 95% CI (0.17, 0.52), P < 0.05]; No statistically significant differences in postoperative Bohler Angle [MD = 0.44, 95% CI (-0.50, 1.38), P > 0.05], calcaneus width [MD = 0.78, 95% CI (-0.17, 1.72), P > 0.05], and AOFAS scores [MD = 1.02, 95% CI (-3.46, 5.50), P > 0.05] were observed between the two groups. **Conclusions:** Closed cannulated screw fixation are superior to open plate fixation in the treatment of Sanders Ⅱ, Ⅲ calcaneal fractures with shorter operation time, and less postoperative complications. There is no significant difference between the two surgical methods in restoring ankle function.

KEYWORDS: Fitness Enthusiasts**;** Calcaneal fracture; Closed cannulated screw fixation; Athlete Surgery; Open plate fixation; Meta analysis

1. INTRODUCTION

Calcaneal fractures, particularly Sanders II and III fractures, represent a significant challenge in the realm of orthopedic trauma. Among those affected, fitness enthusiasts and athletes face unique considerations due to their active lifestyles and the critical role of the calcaneus in weight-bearing and ambulation. These fractures can severely impact mobility and athletic performance, making the choice of surgical intervention a critical decision (Howells, Hughes, Jackson, Atkins, & Livingstone, 2014; van Hoeve & Poeze, 2016) Two primary surgical approaches have been widely used in the treatment of Sanders II and III calcaneal fractures: closed cannulated screw fixation and open plate fixation. The choice between these surgical techniques remains a subject of debate within the orthopedic community, and the decision often depends on factors such as fracture severity, patient characteristics, and the desired postoperative outcomes (Dorr, Backes, Luitse, de Jong, & Schepers, 2016; Shirke et al., 2020).

This meta-analysis aims to comprehensively evaluate and compare the outcomes of closed cannulated screw fixation and open plate fixation specifically in the context of fitness enthusiasts and athletes with Sanders II and III calcaneal fractures (van der Vliet et al., 2020). By focusing on this unique patient population, we seek to provide valuable insights into which surgical approach may offer superior results in terms of postoperative recovery, return to athletic activities, and long-term functional outcomes. (Cao et al., 2015).(Hsu, Anderson, & Cohen, 2015).

The significance of this study lies in its potential to guide orthopedic surgeons, sports medicine practitioners, and athletes themselves in making informed treatment decisions (Mitchell, McKinley, & Robinson, 2009). Understanding the comparative effectiveness of these surgical techniques in the context of active individuals is essential for optimizing patient care and facilitating a successful return to sports and fitness activities(X.-J. Wang et al., 2016). As such, this meta-analysis contributes to the growing body of knowledge at the intersection of orthopedics and sports medicine, supporting evidence-based decision-making for those facing the challenges of calcaneal fractures in the pursuit of their athletic passions (Mesregah, Shams, Gamal, & Zaki, 2020).

2. METHODS

2.1 Literature retrieval

English databases such as PubMed, EMBASE and The Cochrane

Library were selected, and the retrieval date was up to September 2022. The search keywords were as follows: “Open reduction”, “Plate Fixation”, “Closed reduction”, “Percutaneous reduction”, “Screw Fixation”, “Calcaneal fracture”.

Inclusion criteria: (1) Research type: RCT (Randomized controlled study) published from the establishment of the database to September 2022; (2) Subjects: Patients with Sanders II and III calcaneal fractures diagnosed by CT; (3) Intervention measures: open plate fixation was used in the experimental group, and closed cannulated screw fixation was used in the control group; (4) Outcome indicators: time to operation, operation time, length of hospital stay, intraoperative blood loss, postoperative imaging parameters, visual analogue scale (VAS) scores, the American Orthopaedic Foot and Ankle Society (AOFAS) hindfoot scores, postoperative complications, one or more of these indicators.

Exclusion criteria: (1) Repeated studies and data; (2) Reviews, meta-analyses, case reports, letters and conference abstracts; (3) Defects in experimental design and low quality of literature; (4) Study of underage patients (<18 years old).

2.2 Data extraction

Basic information was extracted from the literature, including first author, year of publication, country, and number of patients in the experimental and control groups. The extracted information include: (1) the first author, year of publication, country, and number of patients in the experimental and control groups. (2) gender, age, and follow-up time. (3) main outcome indicators: time to operation, operation time, length of hospital stay, intraoperative blood loss, postoperative imaging parameters, VAS scores, AOFAS scores and postoperative complications.

2.3 Literature quality evaluation

Two researchers independently searched and screened the literature in strict accordance with the inclusion and exclusion criteria. The results of the two were cross-compared, and if there were differences, the third researcher would discuss and decide the final result. The quality of the included literature was evaluated according to Cochrane risk bias evaluation tool. The contents include: ① generation of random sequence; ② Whether correct allocation concealment is achieved: ③ whether subjects and performers are double-blind; ④ Whether blind method is used for result evaluation; ⑤ Intentionality analysis; ⑥ Select to publish; ⑦ Other biases. Finally, the risk of bias is assessed.

2.4 Method of statistics

Revman was used for analysis. The odds ratio (OR) and 95% confidence interval (CI) were used for the comparison between counting data groups, and the mean difference (MD) and 95% CI were used for the comparison between measurement data groups. The I^2 test was used to determine the heterogeneity of each study. If I^2 was less than 60%, all studies were considered homogeneous, and the included data were analyzed by the Fixed effect model.

If $I^2 \geq 60\%$, it is considered that there is heterogeneity among the studies, and then random effects model will be used to analyze the included data. $P < 0.05$ indicated that the difference was statistically significant. The analysis results were represented by drawing forest maps. And the funnel plot drawn by RevMan is used to evaluate the potential publication bias for the articles.

3. RESULTS

According to the principle of retrieval strategy and manual inclusion of references, a total of 220 articles were obtained, and 165 articles remained after removing the duplicate articles. The inclusion and exclusion criteria were used to screen the articles, and 10 articles were finally included (Fig 1). The basic information of the literatures included in the meta-analysis was summarized (Tables 1). As can be seen from the risk of bias map, the included articles have low bias (Fig 2).

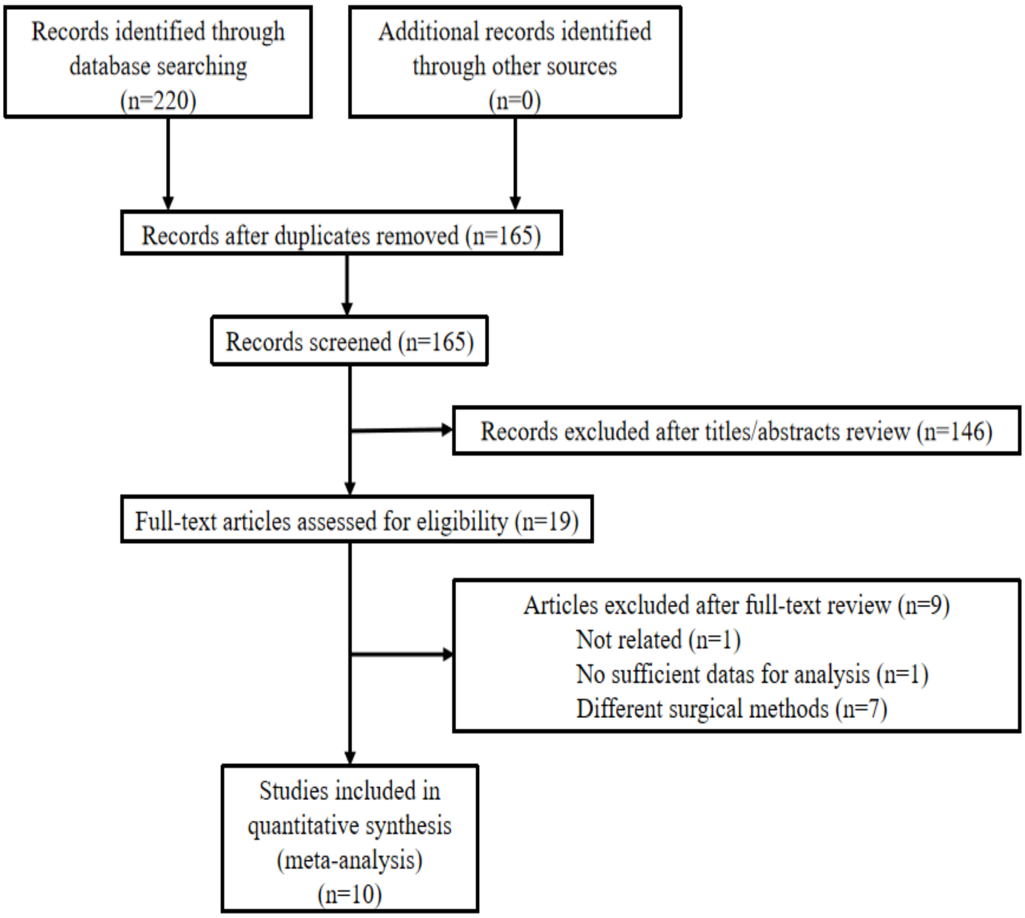


Figure 1: Inclusion process of literature

Table 1: The basic information of the literatures

SOURCE	COUNTRY	N		AGE	YEAR	SEX%		Outcome	Follow-up time（month）
		EXP GROUP	CONTROL GROUP	EXP GROUP	CONTROL GROUP	EXP GROUP	CONTROL GROUP		
Chen, (Chen, Zhang, Hong, Lu, & Yuan, 2011)	China	38	40	31.1	32.7	60.0	52.6	④⑤⑪⑫	18-30
Feng, (Feng et al., 2016)	China	42	38	39.5±10.5	40.7±10.3	81.0	84.2	①②⑤⑥⑦⑧⑨⑪⑫	20-29
Khurana,(Khurana, Dhillon, Prabhakar, & John, 2017)	Indian	12	9	30.6	34.3	-	-	⑤⑪⑫	1-6
Kir,(Kir et al., 2018)	Turkey	29	31	39.62±13.41	38.87±12.64	86.2	90.3	①②③⑤⑥⑦⑧⑨⑪⑫	12
Li,(Li et al., 2020)	China	31	28	39.3±9.6	39.1±8.6	77.4	75	①②③④⑤⑥⑦⑧⑨⑩⑪⑫	12-24
Rastegar, (Rastegar, Ravanbod, Moradi, & Moradi, 2021)	Iran	15	15	41.61±7.46	35.33±11.69	73.3	80	②⑤⑥⑫	12
Wang,(Q. Wang et al., 2015)	China	246	246	40.1±7.0	39.2±6.0	56.9	57.7	⑤⑥⑧⑨⑫	12-24
Zhai, (Zhai et al., 2021)	China	30	30	36.85±7.42	37.26±7.38	70.0	76.7	②④⑤⑥⑫	3-15
Zhang,(J. Zhang, Ebraheim, Lausé, Xiao, & Xu, 2012)	China	47	52	41.0±14.8	40.0±13.7	74.5	73.1	②⑤⑥⑪⑫	15-32
Zhang, (T. Zhang, Yan, Xie, & Mu, 2016)	China	16	15	35.8±12.5	37.1±12.3	75	66.67	①⑤⑥⑪⑫	10-36

-, not given.

1, Exp group mean experimental group. 2, Data were mean ages or imputed mean ages from all groups. 3, Data were proportions of men.

4,①Time to operation; ②operation time; ③length of hospital stay; ④intraoperative blood loss; ⑤Bohler angle; ⑥Gissane angle; ⑦calcaneal length; ⑧calcaneal width; ⑨calcaneal height; ⑩VAS score; ⑪AOFAS scores; ⑫postoperative complications.

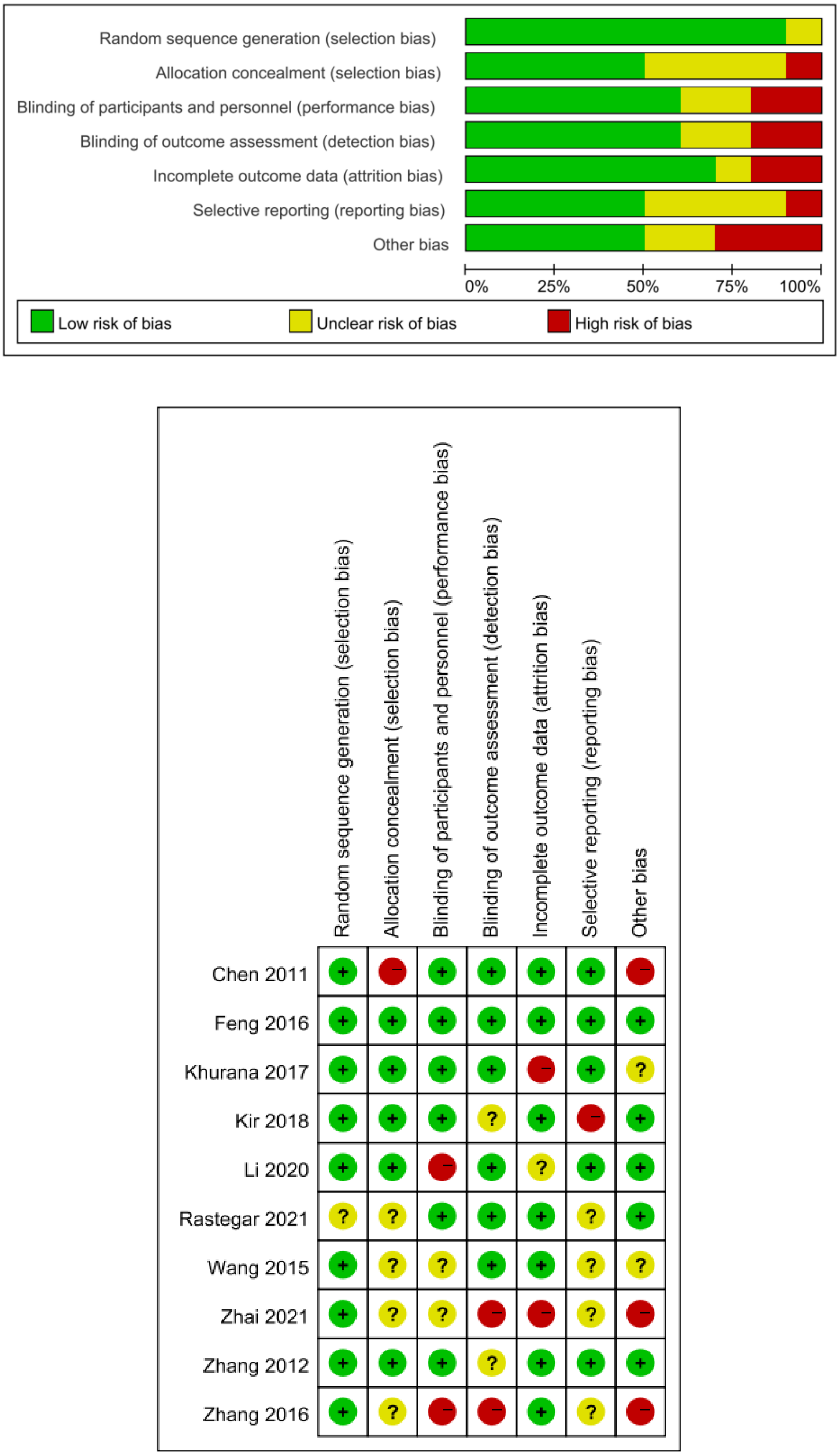
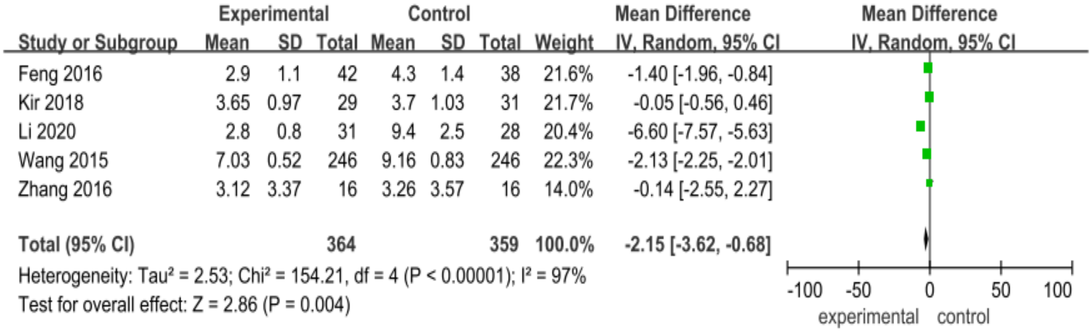


Figure 2: Risk of Bias map

3.1 Time to operation

A total of 5 articles studied the time to operation. We used RevMan to make forest map, because of the large heterogeneity, so the random effects model was used. The results showed that the time to operation of the experimental group was shorter than that of the control group (P < 0.05) (Fig 3). It can be seen from the funnel plot that the included literature is less biased (Fig 3-1).



Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI
Feng 2016	2.9	1.1	42	4.3	1.4	38	21.6%	-1.40 [-1.96, -0.84]
Kir 2018	3.65	0.97	29	3.7	1.03	31	21.7%	-0.05 [-0.56, 0.46]
Li 2020	2.8	0.8	31	9.4	2.5	28	20.4%	-6.60 [-7.57, -5.63]
Wang 2015	7.03	0.52	246	9.16	0.83	246	22.3%	-2.13 [-2.25, -2.01]
Zhang 2016	3.12	3.37	16	3.26	3.57	16	14.0%	-0.14 [-2.55, 2.27]
Total (95% CI)			**364**			**359**	**100.0%**	**-2.15 [-3.62, -0.68]**

Heterogeneity: Tau² = 2.53; Chi² = 154.21, df = 4 (P < 0.00001); I² = 97%
Test for overall effect: Z = 2.86 (P = 0.004)

Figure 3: Forest map of time to operation comparison (days ± SD)

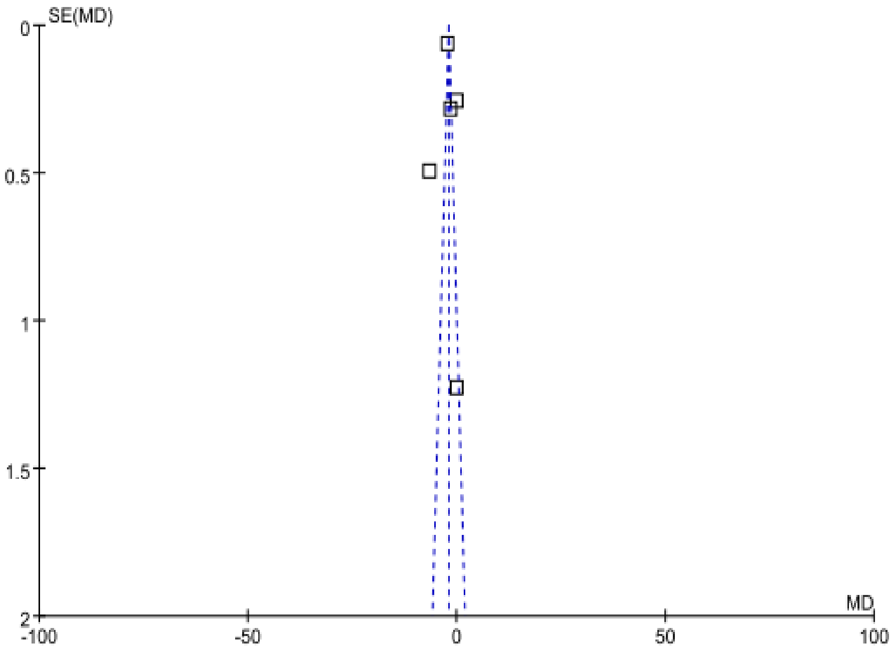


Figure 3-1: Funnel plot for comparison of time to operation comparison

3.2 Operation time

A total of 6 articles studied the operation time. The operation time of the closed group was shorter than that of the open group [MD = -14.95, 95% CI (-26.01, -3.90), P < 0.05] (Fig 4). It can be seen from the funnel plot that the included literature is less biased (Fig 4-1).

	Experimental			Control				Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Feng 2016	39.7	7.6	42	64.2	8.6	38	16.8%	-24.50 [-28.07, -20.93]
Kir 2018	54.65	7.39	29	54.41	7.51	31	16.8%	0.24 [-3.53, 4.01]
Li 2020	34	3.1	31	60	7.6	28	16.9%	-26.00 [-29.02, -22.98]
Rastegar 2021	61.33	3.5	15	68.66	11.8	15	16.3%	-7.33 [-13.56, -1.10]
Zhai 2021	60.32	10.19	30	91.04	13.85	30	16.3%	-30.72 [-36.87, -24.57]
Zhang 2012	70.6	8.4	47	72.2	9.6	52	16.9%	-1.60 [-5.15, 1.95]
Total (95% CI)			**194**			**194**	**100.0%**	**-14.95 [-26.01, -3.90]**

Heterogeneity: Tau² = 185.44; Chi² = 226.63, df = 5 (P < 0.00001); I² = 98%
Test for overall effect: Z = 2.65 (P = 0.008)

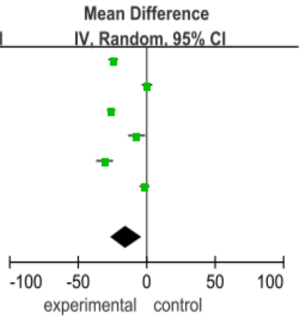


Figure 4: Forest map of operation time comparison (min ± SD)

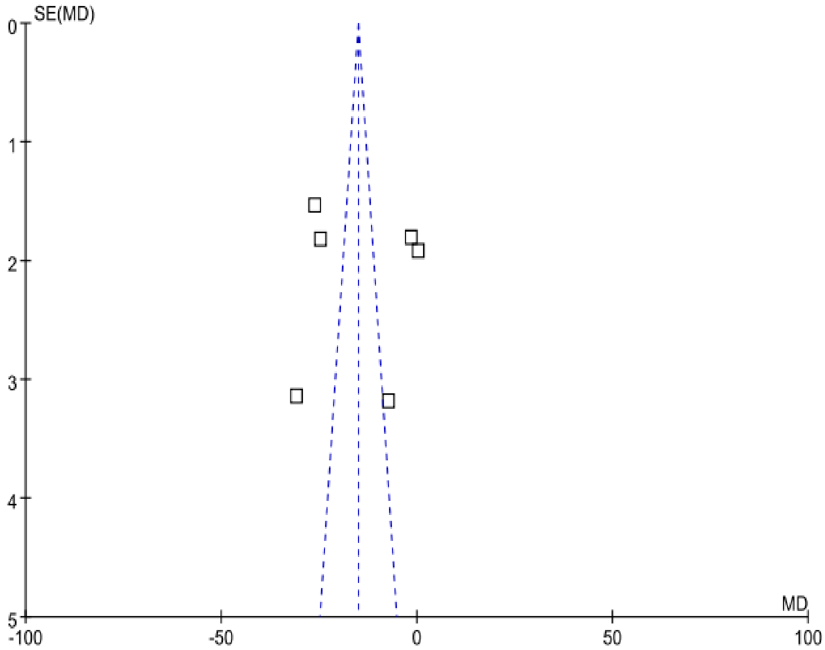


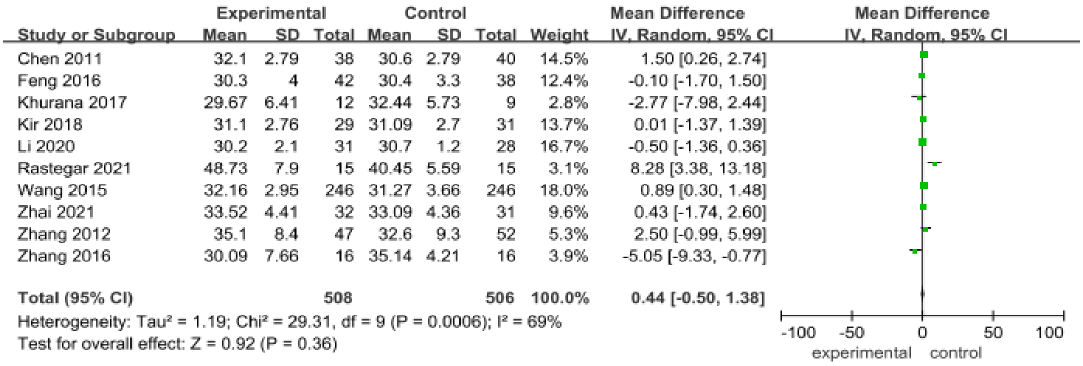
Fig 4-1: Funnel plot for comparison of operation time

3.3 Length of hospital stay, intraoperative blood loss and VAS scores

A total of 3 articles studied the length of hospital stay. There are also 3 articles that have studied intraoperative blood loss. Only one research [14] reported the VAS scores. Due to the lack of research literature, we have not made relevant forest maps and funnel plots. More articles are needed to study these aspects in the future.

3.4 Postoperative imaging parameters

A total of 10 articles studied the Bohler Angle. The results showed that there is no statistically significant differences in postoperative Bohler Angle (P > 0.05) between the two groups (Fig 5). A total of 10 articles studied the Gissane angle. The results showed that Gissane angle of the closed group is bigger than that of the open group (P < 0.05) (Fig 6). Four articles studied the calcaneus width, which showed that no statistically significant differences in calcaneus width (P > 0.05) (Fig 7). A total of 4 articles studied the calcaneus height, which showed higher calcaneus in the closed group (P < 0.05) (Fig 8). It can be seen from the funnel plot that the included literature is less biased (Fig 5-1, Fig 6-1, Fig 7-1, Fig 8-1).



Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI
Chen 2011	32.1	2.79	38	30.6	2.79	40	14.5%	1.50 [0.26, 2.74]
Feng 2016	30.3	4	42	30.4	3.3	38	12.4%	-0.10 [-1.70, 1.50]
Khurana 2017	29.67	6.41	12	32.44	5.73	9	2.8%	-2.77 [-7.98, 2.44]
Kir 2018	31.1	2.76	29	31.09	2.7	31	13.7%	0.01 [-1.37, 1.39]
Li 2020	30.2	2.1	31	30.7	1.2	28	16.7%	-0.50 [-1.36, 0.36]
Rastegar 2021	48.73	7.9	15	40.45	5.59	15	3.1%	8.28 [3.38, 13.18]
Wang 2015	32.16	2.95	246	31.27	3.66	246	18.0%	0.89 [0.30, 1.48]
Zhai 2021	33.52	4.41	32	33.09	4.36	31	9.6%	0.43 [-1.74, 2.60]
Zhang 2012	35.1	8.4	47	32.6	9.3	52	5.3%	2.50 [-0.99, 5.99]
Zhang 2016	30.09	7.66	16	35.14	4.21	16	3.9%	-5.05 [-9.33, -0.77]
Total (95% CI)			**508**			**506**	**100.0%**	**0.44 [-0.50, 1.38]**

Heterogeneity: Tau² = 1.19; Chi² = 29.31, df = 9 (P = 0.0006); I² = 69%
Test for overall effect: Z = 0.92 (P = 0.36)

Figure 5: Forest map of Bohler angle comparison (°± SD)

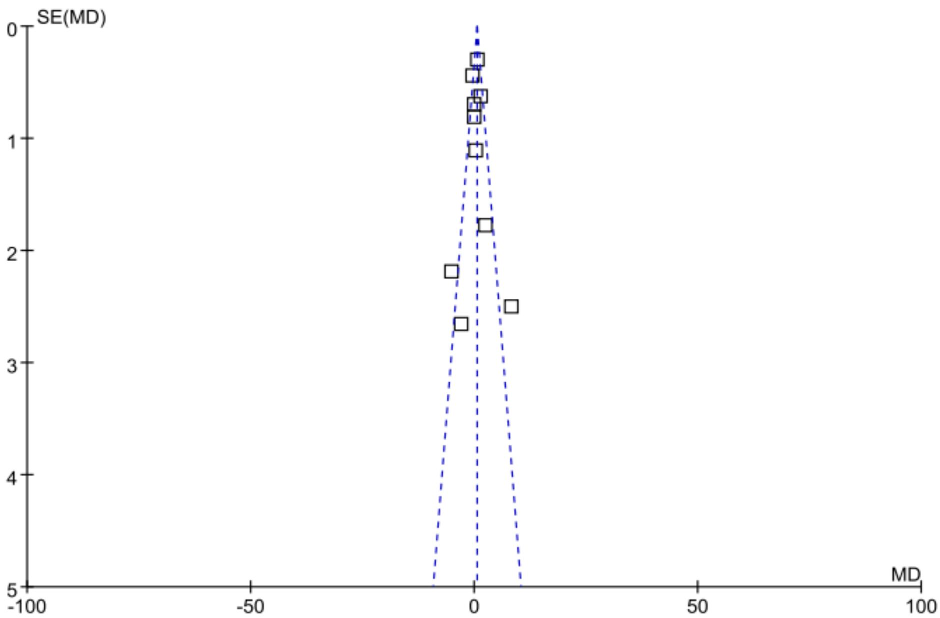
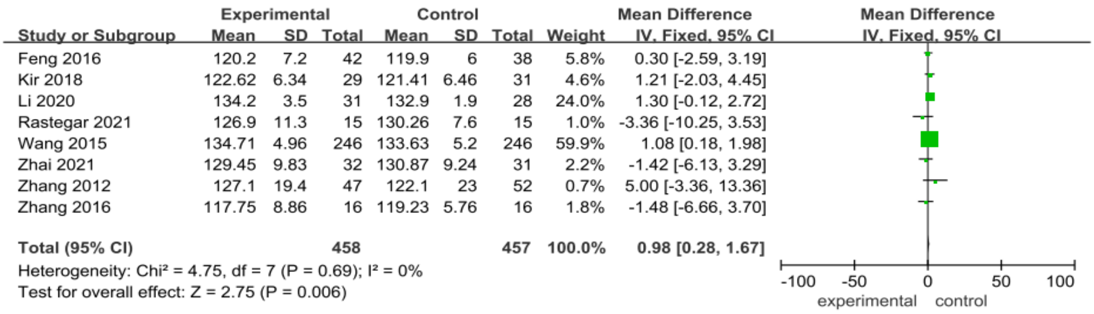


Figure 5-1: Funnel plot for comparison of Bohler angle



Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Fixed, 95% CI
Feng 2016	120.2	7.2	42	119.9	6	38	5.8%	0.30 [-2.59, 3.19]
Kir 2018	122.62	6.34	29	121.41	6.46	31	4.6%	1.21 [-2.03, 4.45]
Li 2020	134.2	3.5	31	132.9	1.9	28	24.0%	1.30 [-0.12, 2.72]
Rastegar 2021	126.9	11.3	15	130.26	7.6	15	1.0%	-3.36 [-10.25, 3.53]
Wang 2015	134.71	4.96	246	133.63	5.2	246	59.9%	1.08 [0.18, 1.98]
Zhai 2021	129.45	9.83	32	130.87	9.24	31	2.2%	-1.42 [-6.13, 3.29]
Zhang 2012	127.1	19.4	47	122.1	23	52	0.7%	5.00 [-3.36, 13.36]
Zhang 2016	117.75	8.86	16	119.23	5.76	16	1.8%	-1.48 [-6.66, 3.70]
Total (95% CI)			**458**			**457**	**100.0%**	**0.98 [0.28, 1.67]**

Heterogeneity: Chi² = 4.75, df = 7 (P = 0.69); I² = 0%
Test for overall effect: Z = 2.75 (P = 0.006)

Figure 6: Forest map of Gissane angle comparison (°± SD)

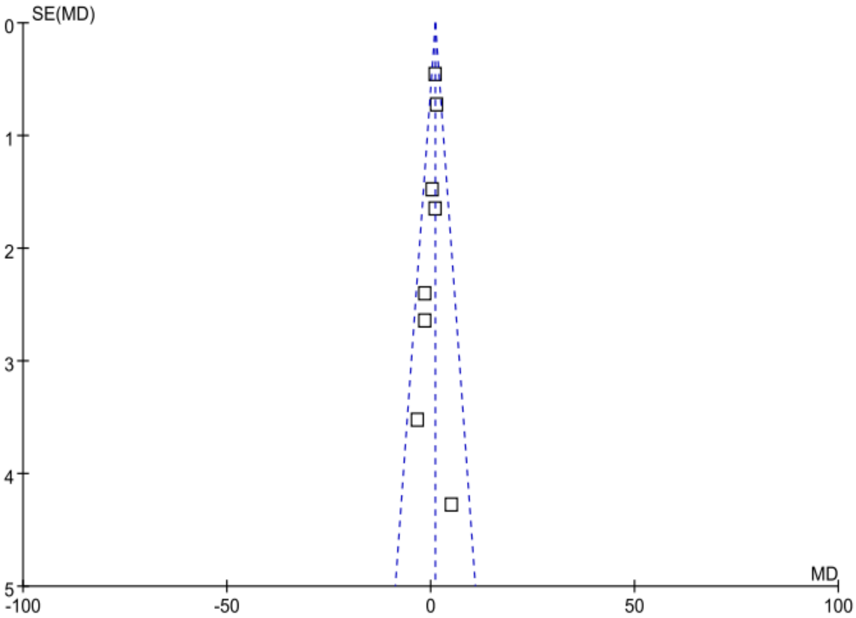


Figure 6-1: Funnel plot for comparison of Gissane angle

	Experimental			Control				Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Feng 2016	34.7	2.2	42	33	1.8	38	23.9%	1.70 [0.82, 2.58]
Kir 2018	34.13	1.86	29	32.77	1.45	31	24.2%	1.36 [0.51, 2.21]
Li 2020	42.9	1.9	31	42.5	1.5	28	24.0%	0.40 [-0.47, 1.27]
Wang 2015	36.82	2.74	246	37.02	2.85	246	27.8%	-0.20 [-0.69, 0.29]
Total (95% CI)			**348**			**343**	**100.0%**	**0.78 [-0.17, 1.72]**

Heterogeneity: Tau² = 0.77; Chi² = 18.87, df = 3 (P = 0.0003); I² = 84%
Test for overall effect: Z = 1.61 (P = 0.11)

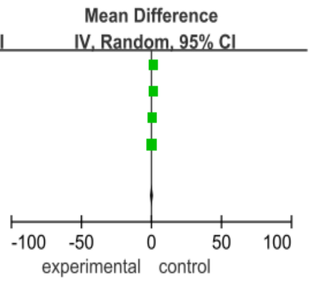


Figure 7: Forest map of calcaneal width comparison (mm ± SD)

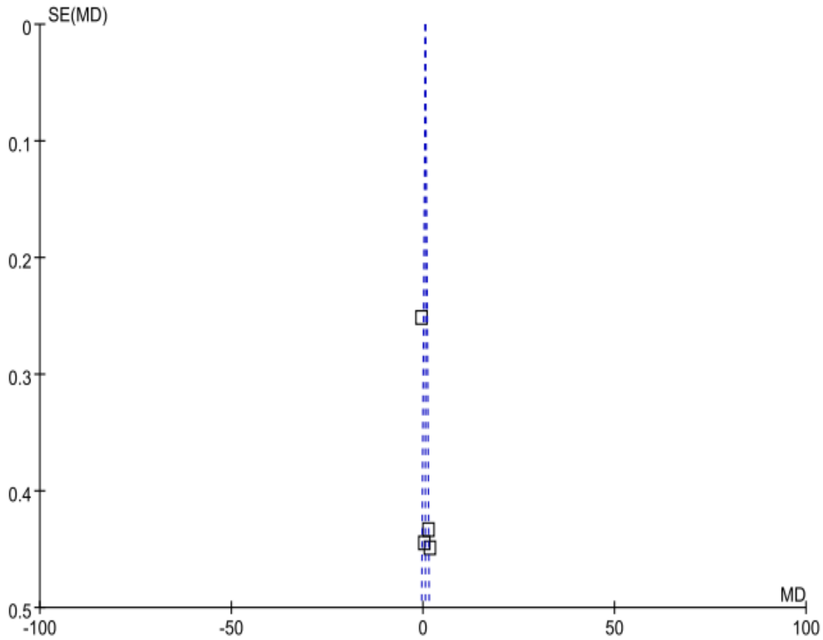


Figure 7-1: Funnel plot for comparison of calcaneal width

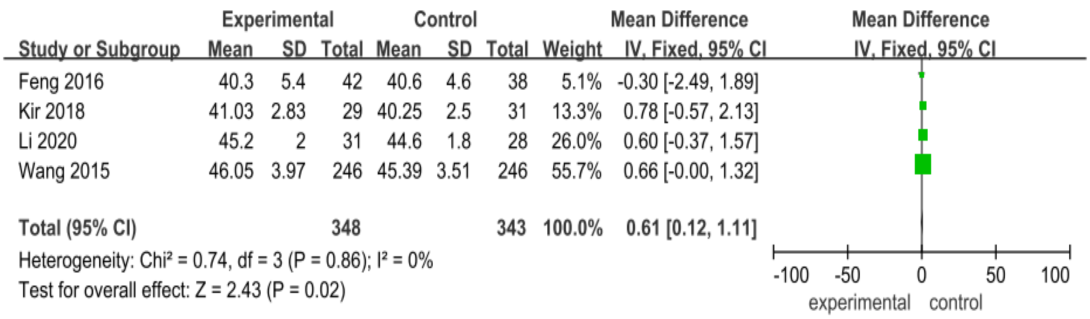


Figure 8: Forest map of calcaneal height comparison (mm ± SD)

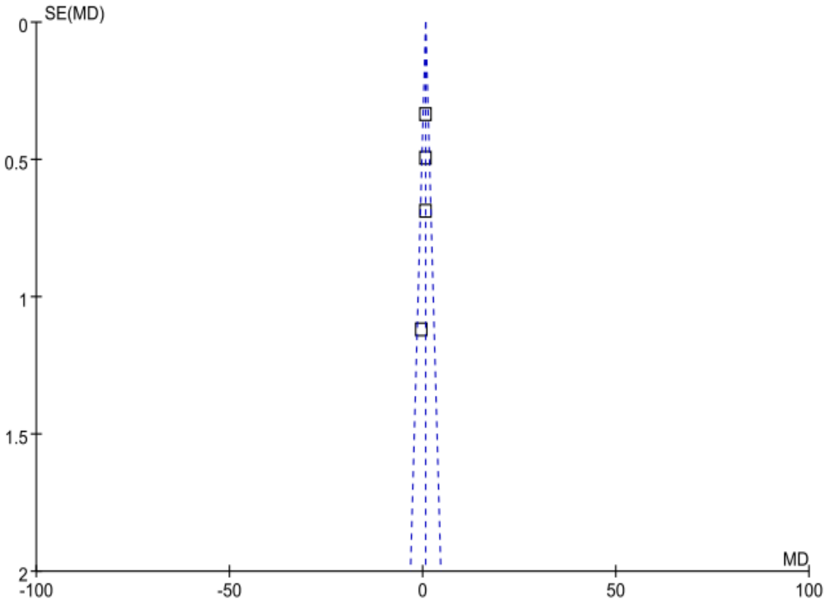


Figure 8-1: Funnel plot for comparison of calcaneal height

3.5 AOFAS scores

Four articles investigated the AOFAS scores. It was found that AOFAS scores was not significantly different from that of open group (P > 0.05) (Fig 9). It can be seen from the funnel plot that the included literature is less biased (Fig 9-1).

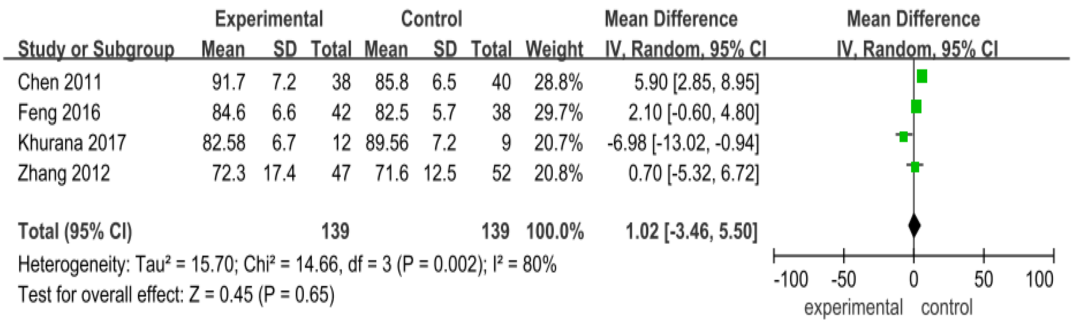


Figure 9: Forest map of AOFAS scores comparison

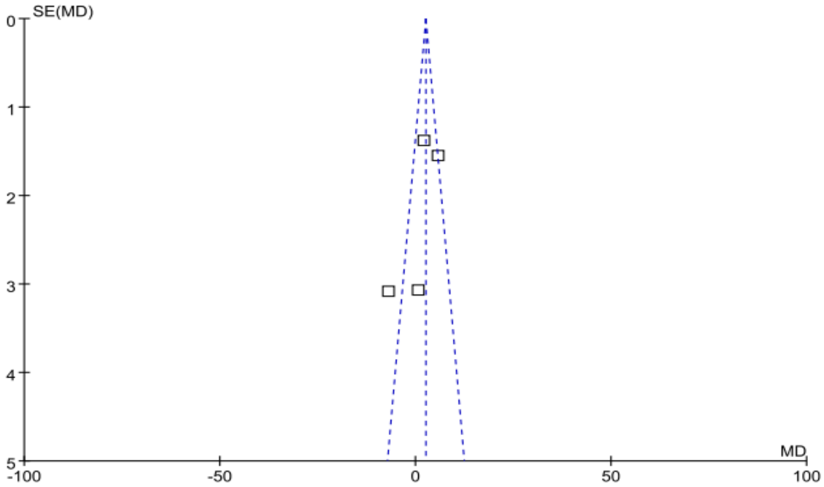


Figure 9-1: Funnel plot for comparison of AOFAS scores

3.6 Postoperative complications

Ten articles investigated the postoperative complications. We used RevMan to make forest maps. It was found that postoperative complications of the closed group are less than that of the open group (P < 0.05) (Fig 10). It can be seen from the funnel plot that the included literature is less biased (Fig 10-1).

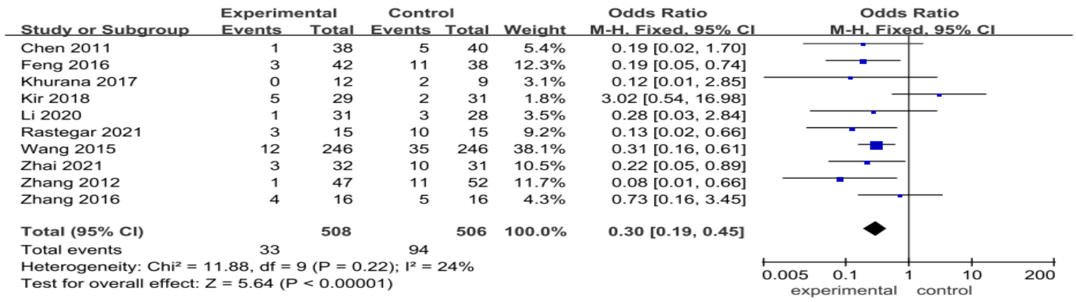


Figure 10: Forest map of postoperative complication comparison

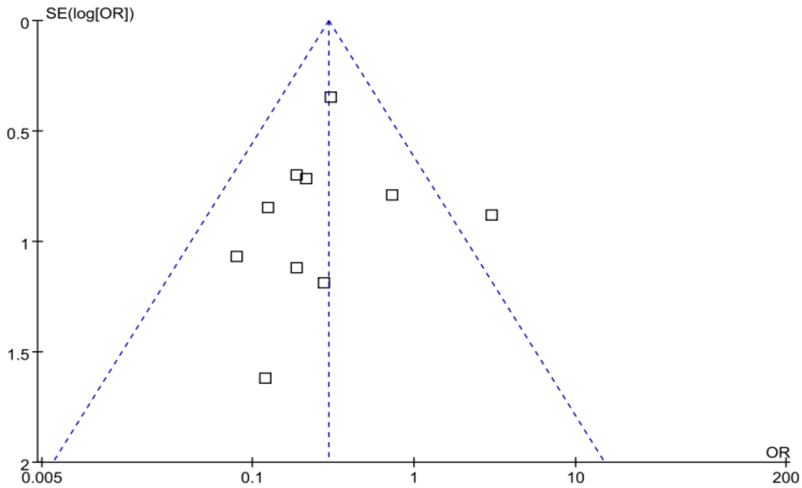


Figure 10-1: Funnel plot for comparison of postoperative complication

4. DISCUSSION

Calcaneal fracture accounts for about 2% of human fracture, which is the most common type of tarsal fracture in adults (Chen et al., 2011; Feng et al., 2016). Calcaneal fracture leads to subtalar joint fusion and malunion, seriously affecting normal life and work (Khurana et al., 2017; Kir et al., 2018). Sanders Ⅱ~III fractures are mostly treated by surgery, which can restore the integrity and anatomical angle of posterior talus articular surface to the greatest extent(Li et al., 2020; Rastegar et al., 2021) [18]. Open plate fixation is the gold standard for anatomical reduction, which can effectively restore calcaneal anatomical parameters and posterior talar articular surface (Q. Wang et al., 2015; Zhai et al., 2021). However, with the rapid development of calcaneal fracture treatment in recent years, the disadvantages of traditional surgical methods have become increasingly apparent. The blood supply of the soft tissues around the calcaneus is poor, while the traditional operation requires extensive stripping of the soft tissues, and the local blood supply is severely damaged. Not only is there a high requirement for the affected soft tissues, but also complications such as local skin necrosis and incision infection often occur after the operation (J. Zhang et al., 2012). In recent years, with the rapid development of the concept of rapid rehabilitation, closed reduction and external fixation for calcaneal fracture has gradually become known to the public. This technique has many advantages, such as less soft tissue peeling, less postoperative complications and convenient removal (T. Zhang et al., 2016). However, this technique also has defects, such as complicated needle path nursing and high requirements for the clinical experience of the operator (Fan et al., 2016).

The results suggest that the closed cannulated screw fixation has certain advantages in waiting for operation time and operation time. The incidence of postoperative complications was lower than that of open plate fixation group. Open plate fixation can reduce the articular surface under direct vision, and can effectively restore the calcaneus height, width, and calcaneus tuberosity varus alignment. However, the larger incision and more lateral soft tissue peeling lead to damage to the blood supply of the soft tissue, which is very likely to cause infection or necrosis of the incision margin, and even lead to calcaneus osteomyelitis in severe cases (Kaur, Sondhi, & Kaur, 2017).

Percutaneous cannulated screw fixation is relatively simple, with short operation time and small trauma. It can avoid related complications caused by excessive stripping of soft tissue, effectively reduce the risk of soft tissue necrosis or infection in the surgical incision, and also reduce the incidence of complications such as peroneal tendonitis and lateral ankle impact syndrome. Bohler angle is an important evaluation index of the therapeutic effect of calcaneal fracture. The angle reduction indicates that the posterior articular surface of the calcaneus bearing weight collapses, resulting in the relative forward movement of the body's center of gravity. Gissane angle is another important therapeutic index for bone fracture treatment. This index can reflect whether the distal articular surface is flat. When Gissane angle increases abnormally, it indicates that the posterior articular surface of the patient is displaced. This study suggested that the Gissane angle of the closed group is large, which indicates that this surgical method is more likely to lead to articular surface collapse than open surgery, and the effect of joint reduction is poor. The width and height of calcaneus are indicators to judge the severity of fracture, and their recovery after operation is closely related to the recovery of ankle function.

The closed reduction and external fixation technique follows the triangle mechanics between the tibia, calcaneus and forefoot, adjusts the calcaneus length by controlling the prying angle of the round needle, and compresses the calcaneus laterally to restore the calcaneus width. Through analysis and comparison, it is found that the closed group is superior to the open group in restoring calcaneal height. Both methods have good effects in restoring calcaneal width.

AOFAS score is a commonly used quantitative index to evaluate the living ability and foot function after calcaneal fracture surgery. This study showed that there was no significant difference in AOFAS scores between the two techniques, indicating that the two methods had similar effects on restoring calcaneal stability and daily living ability. Although it is generally believed that open plate fixation can achieve better reduction, some studies have shown that closed screw fixation can achieve the same or similar results for joint reduction. Extensive incisions will expose more soft tissue and destroy local blood supply, which may lead to skin necrosis and wound dehiscence.

Therefore, in order to enable patients to perform functional exercise early and better prevent postoperative complications, percutaneous hollow screw fixation may be a better method for calcaneal fractures. This study has certain limitations: First, 10 studies were included, totaling 1014 feet, lacking large sample randomized controlled trials and statistical efficacy. Second, no comparison was made between the two techniques for the treatment of calcaneal fractures of different Sanders classifications, and no subgroup analysis was available.

5. Conclusion

In conclusion, the meta-analysis comparing closed cannulated screw fixation and open plate fixation for Sanders II and III calcaneal fractures in fitness enthusiasts and athletes highlights the importance of personalized treatment decisions. Both surgical approaches offer comparable overall outcomes in terms of fracture reduction and long-term functional recovery.

However, individual patient factors, fracture characteristics, and surgeon expertise should guide the choice of surgical technique.

The study underscores the significance of tailoring treatment to meet the specific needs and goals of athletes and fitness enthusiasts, with the ultimate aim of facilitating a successful return to athletic activities. It also emphasizes the need for continued research in orthopedics and sports medicine to further refine treatment strategies and optimize outcomes for this active patient population. In the dynamic field of orthopedic trauma and sports medicine, this meta-analysis contributes valuable insights that support evidence-based decision-making and enhance the care provided to individuals with calcaneal fractures, allowing them to pursue their athletic passions while minimizing the impact of these complex injuries.

REFERENCE

Cao, L., Weng, W., Song, S., Mao, N., Li, H., Cai, Y., . . . Su, J. (2015). Surgical treatment of calcaneal fractures of Sanders type II and III by a minimally invasive technique using a locking plate. *The Journal of Foot and Ankle Surgery, 54*(1), 76-81.

Chen, L., Zhang, G., Hong, J., Lu, X., & Yuan, W. (2011). Comparison of percutaneous screw fixation and calcium sulfate cement grafting versus open treatment of displaced intra-articular calcaneal fractures. *Foot & ankle international, 32*(10), 979-985.

Dorr, M. C., Backes, M., Luitse, J. S., de Jong, V. M., & Schepers, T. (2016). Complications of Kirschner wire use in open reduction and internal fixation of calcaneal fractures. *The Journal of Foot and Ankle Surgery, 55*(5), 915-917.

Fan, B., Zhou, X., Wei, Z., Ren, Y., Lin, W., Hao, Y., . . . Feng, S. (2016). Cannulated screw fixation and plate fixation for displaced intra-articular calcaneus fracture: a meta-analysis of randomized controlled trials. *International Journal of Surgery, 34*, 64-72.

Feng, Y., Shui, X., Wang, J., Cai, L., Yu, Y., Ying, X., . . . Hong, J. (2016). Comparison of percutaneous cannulated screw fixation and calcium sulfate cement grafting versus minimally invasive sinus tarsi approach and plate fixation for displaced intra-articular calcaneal fractures: a prospective randomized controlled trial. *BMC Musculoskeletal Disorders, 17*(1), 1-10.

Howells, N. R., Hughes, A. W., Jackson, M., Atkins, R. M., & Livingstone, J. A. (2014). Interobserver and intraobserver reliability assessment of calcaneal fracture classification systems. *The Journal of Foot and Ankle Surgery, 53*(1), 47-51.

Hsu, A. R., Anderson, R. B., & Cohen, B. E. (2015). Advances in surgical management of intra-articular calcaneus fractures. *JAAOS-Journal of the American Academy of Orthopaedic Surgeons, 23*(7), 399-407.

Kaur, K., Sondhi, S., & Kaur, P. S. (2017). Statistical Optimization of the production of protease from Bacillus sp. MSK-01 in submerged fermentation. *Journal of Commercial Biotechnology, 23*(4).

Khurana, A., Dhillon, M. S., Prabhakar, S., & John, R. (2017). Outcome evaluation of minimally invasive surgery versus extensile lateral approach in management of displaced intra-articular calcaneal fractures: a randomised control trial. *The Foot, 31*, 23-30.

Kir, M. C., Ayanoglu, S., Cabuk, H., Dedeoglu, S. S., Imren, Y., Karslioglu, B., . . . Gurbuz, H. (2018). Mini-plate fixation via sinus tarsi approach is superior to cannulated screw in intra-articular calcaneal fractures: A prospective randomized study. *Journal of Orthopaedic Surgery, 26*(3), 2309499018792742.

Li, M., Lian, X., Yang, W., Ding, K., Jin, L., Jiao, Z., . . . Chen, W. (2020). Percutaneous reduction and hollow screw fixation versus open reduction and internal fixation for treating displaced intra-articular calcaneal fractures. *Medical Science Monitor: International Medical Journal of Experimental and Clinical Research, 26*, e926833-926831.

Mesregah, M. K., Shams, A., Gamal, O., & Zaki, E. M. (2020). Clinical and radiological outcomes of minimally invasive reduction and percutaneous K-wire fixation for intra-articular calcaneal fractures. *Orthopedics, 43*(2), 97-101.

Mitchell, M., McKinley, J., & Robinson, C. (2009). The epidemiology of calcaneal fractures. *The Foot, 19*(4), 197-200.

Rastegar, S., Ravanbod, H., Moradi, M., & Moradi, N. (2021). Extensile approach versus minimally invasive technique in management of calcaneus fractures. *International Journal of Burns and Trauma, 11*(1), 27.

Shirke, S., Musaliyarakam, N., Varghese, S., Hatha, M., Sukham, M., & Lakshmanaperumal, R. (2020). Novel records of three remoras from Andaman and Nicobar waters, India. *FishTaxa, 18*, 30-38.

van der Vliet, Q. M., Potter, J. M., Esselink, T. A., Houwert, R. M., Hietbrink, F., Leenen, L. P., & Heng, M. (2020). Open versus closed operative treatment for tongue-type calcaneal fractures: case series and literature review. *The Journal of Foot and Ankle Surgery, 59*(2), 264-268.

van Hoeve, S., & Poeze, M. (2016). Outcome of minimally invasive open and percutaneous techniques for repair of calcaneal fractures: a systematic review. *The Journal of Foot and Ankle Surgery, 55*(6), 1256-1263.

Wang, Q., Li, X., Sun, Y., Yan, L., Xiong, C., & Wang, J. (2015). Comparison of the outcomes of two operational methods used for the fixation of calcaneal fracture. *Cell Biochemistry and Biophysics, 72*, 191-196.

Wang, X.-J., Su, Y.-X., Li, L., Zhang, Z.-H., Wei, X.-C., & Wei, L. (2016). Percutaneous poking reduction and fixation versus open reduction and fixation in the treatment of displaced calcaneal fractures for Chinese patients: A systematic review and meta-analysis. *Chinese Journal of*

Traumatology, 19(6), 362-367.

Zhai, L., Huang, K., Lin, B., Guo, Q., Liu, Y., Shen, L., & Ma, G. (2021). Application Comparison of Closed Reduction with Hollow Screw Internal Fixation and Open Reduction with Special Shaped Plate Internal Fixation in Calcaneal Fracture. *Indian Journal of Pharmaceutical Sciences*, 155-160.

Zhang, J., Ebraheim, N., Lausé, G. E., Xiao, B., & Xu, R. (2012). A comparison of absorbable screws and metallic plates in treating calcaneal fractures: a prospective randomized trial. *Journal of Trauma and Acute Care Surgery, 72*(2), E106-E110.

Zhang, T., Yan, Y., Xie, X., & Mu, W. (2016). Minimally invasive sinus tarsi approach with cannulated screw fixation combined with vacuum-assisted closure for treatment of severe open calcaneal fractures with medial wounds. *The Journal of Foot and Ankle Surgery, 55*(1), 112-116.