JPRAS Open 38 (2023) 206–216

Contents lists available at ScienceDirect

JPRAS Open

journal homepage: www.elsevier.com/locate/jpra

Review Article

Management of Bennett's fracture: A systematic review and meta-analysis

Mohammad Daher[a], Sami Roukoz[a,b], Ali Ghoul[b], Jean Tarchichi[b], Marven Aoun[a], Amer Sebaaly[a,b,*]

[a] Saint Joseph University, Faculty of medicine, Beirut, Lebanon
[b] Department of Orthopedic Surgery, Hotel Dieu de France Hospital, Beirut, Lebanon

ARTICLE INFO

Article history:
Received 26 August 2023
Accepted 23 September 2023
Available online 30 September 2023

Keywords:
Bennett's fracture
Closed reduction
Open reduction internal fixation
Thumb
Carpometacarpal joint

ABSTRACT

Background: First described in 1882, Bennett's fracture is an intra-articular fracture of the first metacarpal associated with a dislocation of the carpometacarpal joint. Usually, open reduction internal fixation is used to manage such fractures. However, closed reduction has shown good outcomes recently. This meta-analysis compares closed reduction to open reduction internal fixation in the management of Bennett's fracture.
Methods: PubMed, Cochrane, and Google Scholar (pages 1–20) were searched until August 2023. The clinical outcomes consisted of post-traumatic arthritis, grip and pinch strengths, range of motion, functional scores, and mean adduction deformity.
Results: Six retrospective studies were included in this meta-analysis. Our results show higher grip and pinch strengths, better extension and flexion of the thumb, and lower mean adduction deformity in the open reduction internal fixation group.
Conclusion: Higher grip and pinch strengths, better extension and flexion of the carpometacarpal joint, and a smaller mean adduction deformity of the thumb in the open reduction internal fixation group. No differences were seen in the remaining outcomes. However, a higher rate of complications is associated with open reduc-

* Corresponding author at: Department of Orthopedic Surgery Spine Unit, Hotel Dieu de France Hospital, Alfred Naccache Boulevard, School of Medicine, Saint Joseph University, Beirut, Lebanon.
E-mail address: amer.sebaaly@usj.edu.lb (A. Sebaaly).

https://doi.org/10.1016/j.jpra.2023.09.010

tion internal fixation. Nevertheless, more randomized controlled studies are needed to confirm such results.

Level of evidence: III

Introduction

The fracture known as Bennett's fracture was first described in 1882 by Edward Hallaran Bennett.[1] The first metacarpal shaft, which is the largest fracture fragment, is displaced by the muscles of the abductor pollicis longus and adductor pollicis.[2] The palmar oblique ligament is attached to the smaller, volar fracture fragment.[2] An unstable fracture results from adduction of the first metacarpal shaft toward the second metacarpal and abduction of the first metacarpal shaft within the carpometacarpal (CMC) joint.[2]

Studies at first demonstrated better outcomes when this unstable fracture is treated surgically.[3,4] Open reduction and internal fixation (ORIF) has the benefit of anatomically reducing the fracture under direct view and is said to produce positive results,[5,6] avoid post-traumatic arthritis,[7] and has a potential for early mobilization.[8] However, closed reduction (CR) and percutaneous fixation is known to result in positive clinical outcomes.[9,10] Fluoroscopy is utilized during CR to evaluate fracture reduction. Furthermore, it was shown that fluoroscopy can be used safely to evaluate step-offs and gaps in the closed surgical treatment of intra-articular fractures at the base of the first metacarpal.[11]

Until now, there has been no consensus regarding the management of Bennett's fracture. Therefore, this meta-analysis consists of comparing CR (with percutaneous fixation by K wires, screws, and an external fixator) to ORIF when facing such a fracture.

Material and methods

Search strategy

This study followed the PRISMA guidelines. PubMed, Cochrane, and Google Scholar (pages 1–20) were searched and updated to August 2023 using the following keywords and Boolean terms "Bennett" and "Fracture" for the qualified studies in order to compare CR to ORIF in the management of Bennett's fracture. Literature was also identified by tracking reference lists from papers and Internet searches. One investigator (MD) extracted the data, and another investigator (AS) confirmed the choice of the articles. The process is summarized in the PRISMA flowchart (Figure 1).

Inclusion criteria were (1) comparative randomized controlled trials, retrospective comparative studies, and prospective clinical trials; (2) patients who suffered Bennett's fracture; (3) CR was used in one group compared to a second group treated by ORIF. Excluded studies were (1) case reports, narrative or systematic reviews, theoretical research, conference reports, meta-analysis, expert comments, and economic analysis; (2) non-relevant outcomes.

Data extraction

Two reviewers determined the eligibility of the studies independently. Extraction of the analyzed data was made from the included studies and it consisted of two parts. The first part consisted of the basic information containing the name of the authors, the title, the publication year, the journal, the volume, the issue, the pages, the study design, the sample size along with the size of each group of management, and the different types of bias suspected in each study. The second part consisted of post-operative arthritis, pinch and grip strengths, thumb range of motion, functional scores, and

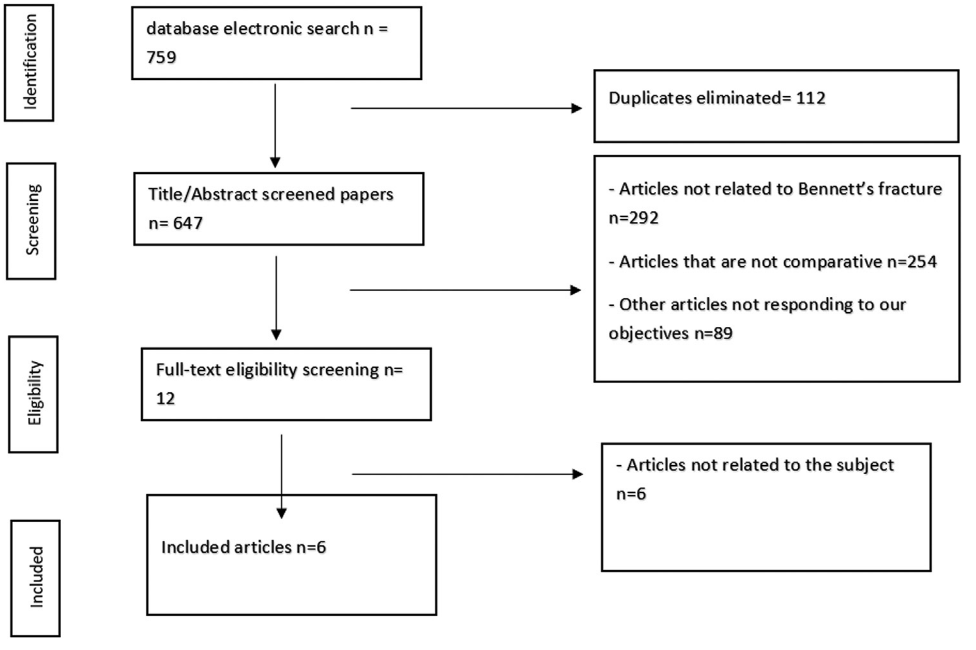

Figure 1. PRISMA flowchart for the article selection process.

the mean of adduction deformity. Any arising difference between the investigators was resolved by discussion.

Risk of bias assessment

Two authors (MD and AS) independently assessed the risk of bias using the ROBINS-I tool for assessing risk of bias in non-randomized studies of interventions.[12] Studies that had a critical risk of bias were excluded.

Statistical analysis

The statistical analysis was performed using Review Manager 5.4 (The Cochrane Collaboration, 2020). For continuous data, 95 % confidence intervals (CI) and standardized mean differences were utilized, while risk ratio with 95 % CI was used for dichotomous data. Q tests and I2 statistics were used to evaluate heterogeneity, indicating considerable heterogeneity if $p \leq 0.10$ or $I2 > 50$ %. High levels of variability in the variables were handled by the random-effects model. On the other hand, the fixed-effect model was chosen if $p > 0.10$ or $I2 < 50$ %. statistically significant is shown by $p = 0.05$.

Results

Characteristics of the included studies

Six studies were included in this meta-analysis.[2,13–17] All of them were retrospective studies. This study involved 155 subjects in the CR group compared to 185 subjects in the ORIF group. The main characteristics of the included studies are summarized in Table 1. The results of the bias assessment are summarized in Table 2.

Table 1
Main characteristics of the included studies.

	Methods	Participants		Mean age (SD)		Measured outcomes	Follow-up time
		CR	ORIF	CR	ORIF		
Kamphuis et al. 2019	Retrospective comparison	15	35	39 15	32 10	Eaton-Littler carpometacarpal arthritis, complications (reoperations, sensory dysfunction,), pain, pinch strength, grip strength, and DASH	10 years
Lutz et al. 2003	Retrospective comparison	17	15	37 NA	28 NA	Pain, arthritis, grip power, pinch power, range of motion, mean loss of reduction, and mean adduction deformity	7 years
Pomares et al. 2016	Retrospective comparison	11	10	37 NA	30 NA	QuickDASH, kapandji, grip strength, pinch strength, tourniquet duration, immobilization, sick leave, complications, return to former activities, Fracture healing, anatomical reduction, joint remodeling, and intra-articular fixation material	33 months
Zhang et al. 2011	Retrospective comparison	21	56	35 NA	32 NA	Pinch strength, grip strength, range of motion, and pain	39 months
Zhang et al. 2019	Retrospective comparison	35	37	34 6	32 5	Gap, step-off, bone healing, satisfaction, DASH, Kapandji opposition score, grip strength, key pinch, thumb abduction, extension, and flexion	16 months
Zhongzhe et al. 2011	Retrospective comparison	56	32	37 NA	34 NA	Range of motion, reduction, arthritis, grip power, pinch power, and deformity	7 years

Table 2
Bias assessment of the included studies.

Studies	Confounding bias	Selection bias	Classification bias	Bias due to deviation from interventions	Bias due to missing data	Bias in measurement of outcomes	Bias in selection of reported results	Results
Kamphuis et al. 2019	Low risk	Low risk	Low risk	Low risk	Low risk	Moderate risk	Low risk	Moderate risk
Lutz et al. 2003	Low risk	Low risk	Low risk	Low risk	Low risk	Moderate risk	Low risk	Moderate risk
Pomares et al. 2016	Low risk	Low risk	Low risk	Low risk	Low risk	Moderate risk	Low risk	Moderate risk
Zhang et al. 2011	Low risk	Low risk	Low risk	Low risk	Low risk	Moderate risk	Low risk	Moderate risk
Zhang et al. 2019	Low risk	Low risk	Low risk	Low risk	Low risk	Moderate risk	Low risk	Moderate risk
Zhongzhe et al. 2011	Low risk	Low risk	Low risk	Low risk	Low risk	Moderate risk	Low risk	Moderate risk

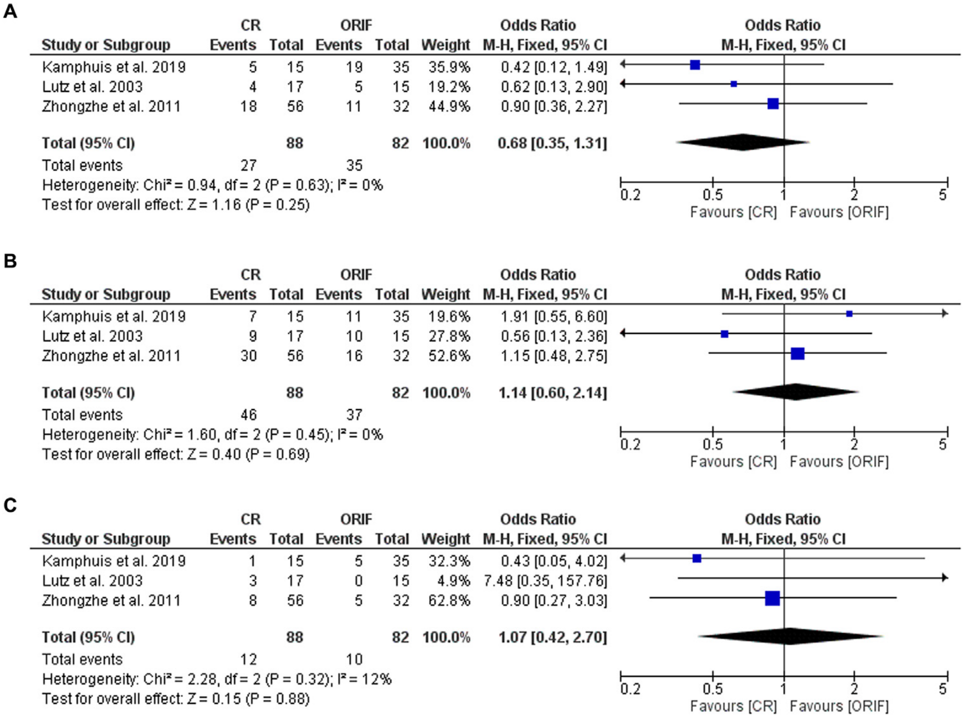

Figure 2. (A): Forest plot showing Eaton–Littler CMC stage 1 arthritis in CR and ORIF. (B): Forest plot showing Eaton-Littler CMC stage 2 arthritis in CR and ORIF. (C): Forest plot showing Eaton-Littler CMC stage 3 arthritis in CR and ORIF.

Arthritis

Three studies (with a mean follow-up ranging from 7 to 10 years) on 170 subjects (88 CR vs 82 ORIF) reported data on post-operative arthritis according to Eaton-Littler. The results showed no differences between CR and ORIF in stage 1 arthritis (odds ratio= 0.68; 95 % CI= 0.35–1.31, $p = 0.25$, Figure 2A), stage 2 arthritis (Odds Ratio= 1.14; 95 % CI= 0.6–2.14, $p = 0.69$, Figure 2B), and stage 3 arthritis (Odds Ratio= 1.07; 95 % CI= 0.42–2.7, $p = 0.88$, Figure 2C).

Strengths

Six studies on 340 subjects (155 CR vs 185 ORIF) reported data on both grip and pinch strengths post-operatively. The results showed that when compared to ORIF, CR had significantly lower post-operative grip strength (mean difference= −3.01; 95 % CI= −4.01– −2.01, $p < 0.00001$, Figure 3A), as well as pinch strength (mean difference= −1.07; 95 % CI= −1.64– −0.5, $p = 0.0002$, Figure 3B)

Range of motion

Adduction

Two studies on 120 subjects (73 CR vs 47 ORIF) reported data on post-operative thumb adduction. The results showed no differences between CR and ORIF (mean difference= 2.04; 95 % CI= −1.07–5.14, $p = 0.2$, Figure 4A).

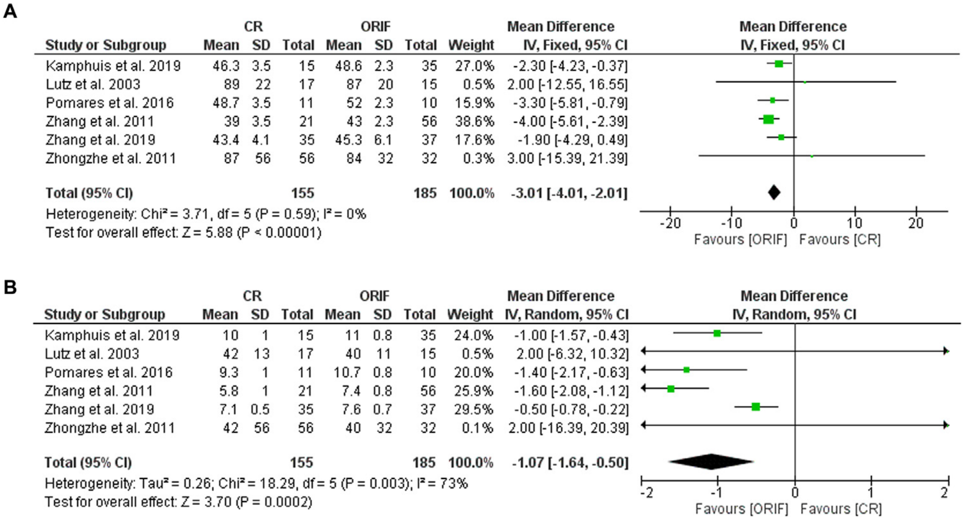

Figure 3. (A): Forest plot showing post-operative grip strength in CR and ORIF. (B): Forest plot showing post-operative pinch strength in CR and ORIF.

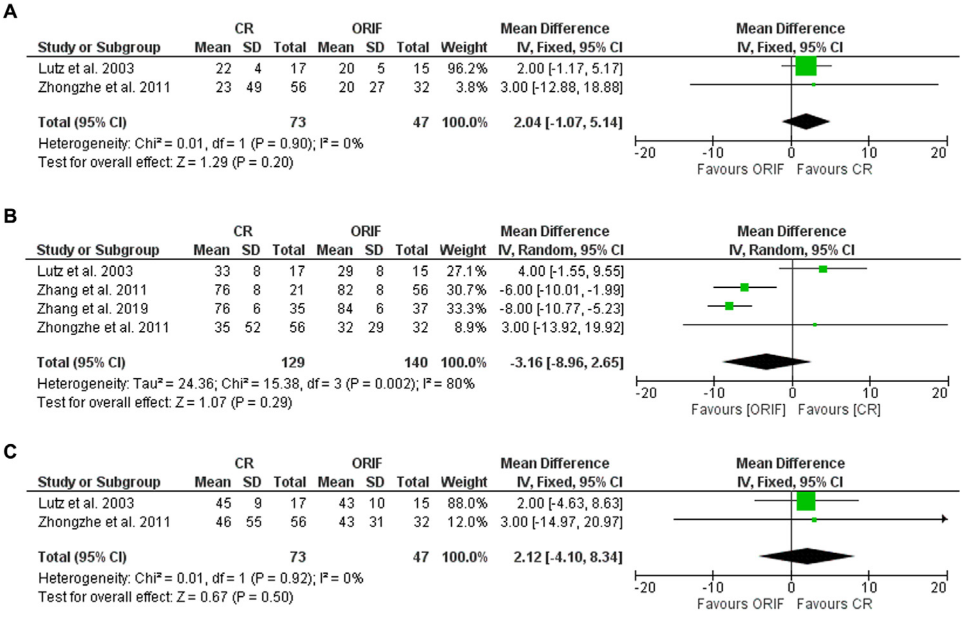

Figure 4. (A): Forest plot showing post-operative adduction in CR and ORIF. (B): Forest plot showing post-operative abduction in CR and ORIF. (C): Forest plot showing post-operative opposition in CR and ORIF. (D): Forest plot showing post-operative extension-flexion in CR and ORIF. (E): Forest plot showing post-operative Kapandji opposition score in CR and ORIF.

Abduction

Four studies on 269 subjects (129 CR vs 140 ORIF) reported data on post-operative thumb abduction. The results showed no differences between CR and ORIF (mean difference= −3.16; 95 % CI= −8.96–2.65, $p = 0.29$, Figure 4B)

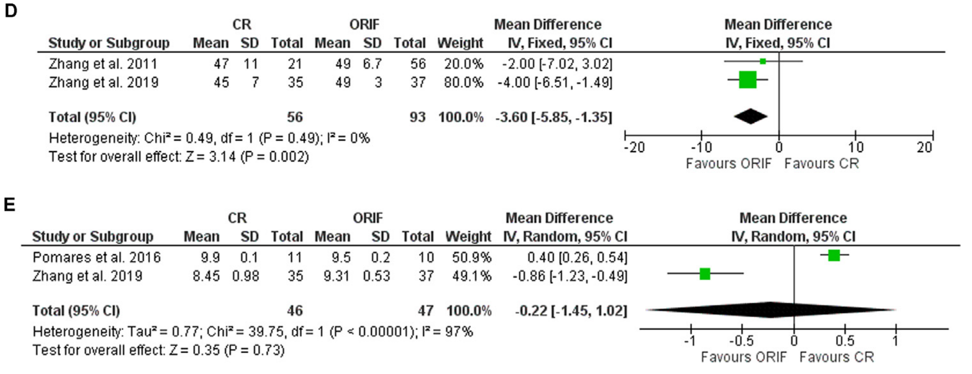

Figure 4. Continued

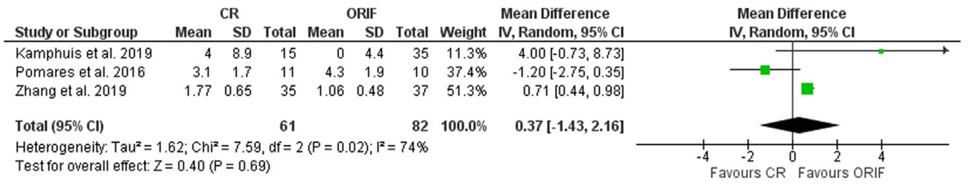

Figure 5. Forest plot showing post-operative DASH score in CR and ORIF.

Opposition

Two studies on 120 subjects (73 CR vs 47 ORIF) reported data on post-operative thumb opposition. The results showed no differences between CR and ORIF (mean difference= 2.12; 95 % CI= −4.1–8.34, $p = 0.5$, Figure 4C)

Extension-flexion

Two studies on 149 subjects (56 CR vs 93 ORIF) reported data on post-operative thumb extension-flexion. The results showed that when compared to ORIF, CR had lower post-operative CMC extension-flexion (mean difference=−3.6; 95 % CI= −5.85– −1.35, $p = 0.002$, Figure 4D)

Kapandji opposition score

Two studies on 93 subjects (46 CR vs 47 ORIF) reported data on post-operative Kapandji opposition score. The results showed no differences between ORIF and CR (mean difference= −0.22; 95 % CI= −1.45– 1.02, $p = 0.73$, Figure 4D)

DASH score

Three studies on 143 subjects (61 CR vs 82 ORIF) reported data on post-operative DASH score. The results showed no differences between ORIF and CR (mean difference= 0.37; 95 % CI= −1.43– 2.16, $p = 0.69$, Figure 5).

Mean adduction deformity

Two studies on 138 subjects (71 CR vs 67 ORIF) reported data on post-operative mean adduction deformity. The results showed that when compared to ORIF, CR showed a higher mean adduction deformity (mean difference= 4.68; 95 % CI= 1.44–7.91, $p = 0.005$, Figure 6).

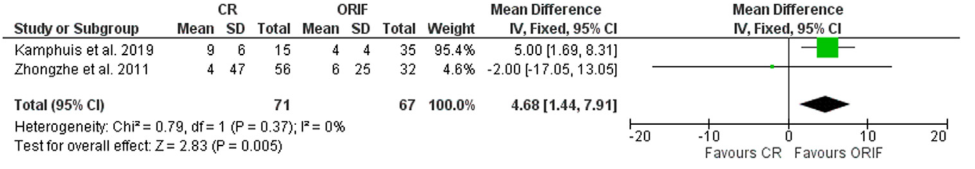

Figure 6. Forest plot showing post-operative mean adduction deformity in CR and ORIF.

Discussion

First described in 1882, Bennett's fracture is an intra-articular fracture of the first metacarpal with a dislocation of the CMC joint. ORIF is usually preferred in such an unstable fracture in order to attain anatomical reduction and prevent the occurrence of post-traumatic arthritis. However, CR was shown to result in good outcomes. Data regarding the management of this fracture are still unclear. For that reason, this meta-analysis compares CR to ORIF in the treatment of Bennett's fracture. When comparing CR to ORIF, the latter showed better post-operative grip and pinch strengths, better extension and flexion of the CMC joint, and smaller mean adduction deformity. No difference was seen in the remaining outcomes.

Our results showed no difference in the development of arthritis between CR and ORIF. In fact, Kamphuis et al. showed that there was a correlation between the occurrence of post-traumatic arthritis and a step-off/gap of 2 mm.[2] This leads us to consider how much importance anatomical reduction should receive during surgery in an effort to stop these post-traumatic modifications from occurring.[5,18] Furthermore, other studies reported good outcomes with a step-off/gap smaller than 2 mm.[7]

Our results have shown no difference between CR and ORIF in the DASH score and the range of motion except for the extension and flexion of the CMC joint. It was shown as well that pain was mostly seen in patients treated with ORIF and that these patients were often reoperated in order to remove the hardware due to functional impairments and complaints.[2,14] In fact, studies have shown that even with ORIF, failure, as well as redislocation, can occur in around 30 % of the cases due to failed osteosynthesis.[3,19]

Even though higher grip and pinch strengths were seen in the ORIF group, there remains to be seen the clinical significance of this statistical difference. Moreover, the complications associated with ORIF must be taken into consideration such as persistent pain, paresthesia, loss of strength, and malunion which can potentially affect the return to work.[14] Actually, Pomares et al.[14] showed that the post-operative course was simpler, the immobilization time was shorter, the rate of complications was lower, and the tourniquet time was shorter in the CR group.

However, a higher mean of adduction deformity was seen in the CR group. This might be due to the placement of the Kirschner wire near the fracture line resulting in the loss of reduction.[20] Therefore, ORIF can still have a place in cases where the Kirschner wire cannot be placed in the uninjured bone at the base of the thumb metacarpal or in irreducible fractures.[13]

Strengths and limitations

This study is the first meta-analysis comparing CR to ORIF in Bennett's fracture. Moreover, this metanalysis involved only comparative studies, which decreased the risk of operative matching, as well as other bias types. Finally, the selection process was more selective which makes the study less heterogenous and decreases the risk of bias. However, this study presents some limitations: Few comparative studies in the literature were included; the inclusion and exclusion criteria for patients were different and the rehabilitation programs were different in each particular study; the number of included studies is limited and the data used for analysis was pooled because individual patients' data were unavailable, which could limit more comprehensive analyses.

Conclusion

This study is the first meta-analysis comparing CR to ORIF in the management of Bennett's fracture. Our results showed higher grip and pinch strengths, better extension and flexion of the CMC joint, and a smaller mean adduction deformity of the thumb in the ORIF group. No differences were seen in the remaining outcomes. However, studies have shown that ORIF is associated with a higher rate of complications and the clinical significance of the statistically higher grip and pinch strengths is still unknown. Nevertheless, additional randomized controlled studies are needed to confirm our results.

Declaration of Competing Interest

We declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

We received no financial support for the research, authorship, and/or publication of this article.

Informed consent

Not applicable.

Ethical approval

Not applicable.

Acknowledgments

None.

Contributorship

MD and MA researched literature and conceived the study. AG and JT were involved in protocol development. AS and SR were involved in data analysis as well as supervising the whole work. MD wrote the first draft of the manuscript. All authors reviewed and edited the manuscript and approved the final version of the manuscript.

References

1. Bennett EH. *Fractures of the Metacarpal Bones*; 1882 *Dublin*Published online.
2. Kamphuis SJM, Greeven APA, Kleinveld S, Gosens T, Van Lieshout EMM. Bennett's fracture: Comparative study between open and closed surgical techniques. *Hand Surg Rehabil*. 2019;38(2):97–101 Published online. doi:10.1016/j.hansur.2018.11.003.
3. Gedda KO, Moberg E. Open reduction and osteosynthesis of the so-called Bennett's fracture in the carpo-metacarpal joint of the thumb. *Acta Orthop Scand*. 1952;22(1-4):249–257. doi:10.3109/17453675208989009.
4. Levy V, Mazzola M, Gonzalez M. Intra-articular fracture of the base of the first metacarpal bone: Treatment through a volar approach. *Hand*. 2018;13(1):90–94. doi:10.1177/1558944716685828.
5. Liverneaux PA, Ichihara S, Hendriks S, Facca S, Bodin F. Fractures and dislocation of the base of the thumb metacarpal. *J Hand Surg Eur*. 2015;40(1):42–50 *Vol*. doi:10.1177/1753193414554357.
6. Büren C, Gehrmann SV, Windolf J, Lögters T. [Direct screw osteosynthesis of a Bennett's fracture by radiopalmar incision after Gedda and Moberg]. *Z Orthop Unfall*. 2016;154(2):195–197. doi:10.1055/s-0041-107941.
7. Timmenga EJF, Blokhuis TJ, Maas M, Raaijmakers ELFB. Long-term evaluation of Bennett's fracture A comparison between open and closed reduction. *J Hand Surg Br*. 1994;19(3):373–377. doi:10.1016/0266-7681(94)90093-0.
8. Uludag S, Ataker Y, Seyahi A, Tetik O, Gudemez E. Early rehabilitation after stable osteosynthesis of intra-articular fractures of the metacarpal base of the thumb. *J Hand Surg Eur*. 2015;40(4):370–373 *Vol*. doi:10.1177/1753193413494035.
9. Greeven APA, Alta TDW, Scholtens REM, de Heer P, van der Linden FM. Closed reduction intermetacarpal Kirschner wire fixation in the treatment of unstable fractures of the base of the first metacarpal. *Injury*. 2012;43(2):246–251. doi:10.1016/j.injury.2011.10.038.
10. van Niekerk JLM, Ouwens R. Fractures of the base of the first metacarpal bone: Results of surgical treatment. *Injury*. 1989;20(6):359–362. doi:10.1016/0020-1383(89)90014-4.

11. Greeven APA, Hammer S, Deruiter MC, Schipper IB. Accuracy of fluoroscopy in the treatment of intra-articular thumb metacarpal fractures. *J Hand Surg Eur*. 2013;38(9):979–983 *Vol*. doi:10.1177/1753193412468565.
12. Sterne JA, Hernán MA, Reeves BC, et al. Robins-I: A tool for assessing risk of bias in non-randomised studies of interventions. *BMJ*. 2016;355:i4919. doi:10.1136/bmj.i4919.
13. Lutz M, Sailer R, Zimmermann R, Gabl M, Ulmer H, Pechlaner S. Closed reduction transarticular Kirschner wire fixation versus open reduction internal fixation in the treatment of Bennett' S fracture dislocation. *J Hand Surg Br*. 2003;28(2):142–147.
14. Pomares G, Strugarek-Lecoanet C, Dap F, Dautel G. Bennett fracture: Arthroscopically assisted percutaneous screw fixation versus open surgery: Functional and radiological outcomes. *Orthop Traumatol Surg Res*. 2016;102(3):357–361. doi:10.1016/j.otsr.2016.01.015.
15. Zhang X, Dhawan V, Zhao S, Yu Y, Shao X, Zhang G. Treatment of Bennett fractures with tension-band wiring through a small incision under loupes and a headlight. *Phys Sportsmed*. 2019;47(1):122–128. doi:10.1080/00913847.2018.1530576.
16. Zhang X, Shao X, Zhang Z, Wen S, Sun J, Wang B. Treatment of a Bennett fracture using tension band wiring. *J Hand Surg Am*. 2012;37(3):427–433. doi:10.1016/j.jhsa.2011.12.025.
17. Zhongzhe L, Yang G, Wen T, Guanglei T. closed reduction external fixation fixation versus open reduction internal fixation in the patietns with Bennett fracture dislocation. *Med Assoc Publ house*. 2011:35–44 Published online.
18. Adi M, Miyamoto H, Taleb C, et al. Percutaneous fixation of first metacarpal base fractures using locked K-wires: A series of 14 cases. *Tech Hand Up Extrem Surg*. 2014;18(2):77–81. doi:10.1097/BTH.0000000000000040.
19. Kjaer-Petersen K, Langhoff O, Andersen K. Bennett's fracture. *J Hand Surg Br*. 1990;15(1):58–61. doi:10.1016/0266-7681_90_90049-a.
20. Sawaizumi T, Nanno M, Nanbu A, Ito H. Percutaneous leverage pinning in the treatment of Bennett's fracture. *J Orthop Sci*. 2005;10(1):27–31. doi:10.1007/s00776-004-0856-6.