

# Bennett's Fracture Repair—Which Method Results in the Best Functional Outcome? A Retrospective Cohort Analysis and Systematic Literature Review of Patient-Reported Functional Outcomes

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## Abstract

Surgical fixation of Bennett's fracture of the thumb is critical to prevent functional impairment; however, there is no consensus on the optimal fixation method. We performed an 11-year retrospective cohort analysis and a systematic literature review to determine long-term patient-reported outcomes following Bennett's fracture fixation. Retrospective cohort analysis identified 49 patients treated with Kirschner (K)-wire fixation, 85% returned to unrestricted movement during hand therapy. Forty-seven patients (96%) completed the disabilities of the arm, shoulder, and hand (DASH) questionnaires at a mean of 5.55 years from injury, with a mean score of 7.75. Systematic literature review identified 14 studies with a cumulative 541 patients. Fixation included open or percutaneous methods utilizing K-wires, tension band wiring, lag screws, T-Plates, external fixation, and arthroscopic screw fixation. Functional outcomes reported included DASH, quickDASH (qDASH), and visual analogue scores. Superficial wound infection occurred in 4 to 8% of percutaneous K-wire fixation. Open reduction internal fixation (ORIF) methods were associated with a 4 to 20% rate of reintervention and 5 to 28% rate of persistent paresthesia. Closed reduction with percutaneous K-wire fixation should be the first choice surgical method, given excellent, long-term functional outcomes, and low risk of complications. ORIF should be utilized where closed reduction is not achievable; however, the current evidence does not support one method of ORIF above another.

## Keywords

- ▶ Bennett's fracture
- ▶ hand surgery
- ▶ K-wire
- ▶ functional outcome
- ▶ long-term

## Introduction

Bennett's fractures are displaced intra-articular fractures of the base of the first metacarpal and were first described by Edward Bennett.<sup>1</sup> The volar ulnar aspect of the base of the thumb metacarpal separates and is subsequently held in place by its ligamentous attachment to the trapezium. However, the forces exerted by the abductor pollicis longus will displace the fragment from the rest of the thumb metacarpal.<sup>2</sup>

Bennett's fracture requires reduction and surgical fixation to prevent malunion and loss of function of the first carpometacarpal joint (CMCJ). Griffiths demonstrated that closed reduction and cast immobilization without fixation will result in fracture displacement and loss of function in many patients.<sup>3</sup> Gedda demonstrated that surgical fixation results in improved fracture reduction and return to functional baseline when compared with closed reduction and plaster cast immobilization.<sup>4</sup>

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While the need for surgical fixation is clear, the method of fixation varies by center, and due to the infrequency of this eponymous fracture, there is a paucity of data on long-term functional outcomes.<sup>5</sup> Fracture fixation is most commonly achieved through either Kirschner (K)-wire insertion, which can be open or percutaneous, or open reduction internal fixation (ORIF) with lag screws. Separately, some studies report the use of tension wiring around the base of the first metacarpal in addition to K-wire insertion, and others report using arthroscopy to assist screw insertion.

Optimal, evidence-based management of Bennett's fracture necessitates long-term patient-reported outcome measures. We present an 11-year retrospective analysis of the patient cohort treated at our institution, followed by a systematic review of the literature, to determine long-term patient-reported outcomes following surgical fixation of Bennett's fracture.

## Materials and Methods

### Retrospective Cohort Analysis

We conducted a retrospective analysis of our center's trauma database to identify patients with Bennett's fracture of the thumb who underwent surgical fixation. Our unit provides trauma care to a large urban center population. Standard preoperative radiographs include anteroposterior, lateral, and oblique views, with further imaging intraoperatively. Robert's view is not routinely included in preoperative imaging. Treatment at our institution consists of closed fracture reduction under anesthesia, percutaneous transmetacarpal K-wire fixation under X-ray image intensifier guidance, followed by postoperative hand therapy rehabilitation. Electronic medical records were reviewed to identify procedure type, mechanism of injury, smoking status, postoperative complications, postoperative range of movement, and length of hand therapy follow-up. Patients were excluded if their operative records were unavailable or they were lost to follow-up.

Medical records were further analyzed to determine joint range of motion achieved by the end of hand therapy; this was classified into full range of motion and restricted range of motion. Patients were subsequently invited to complete the disabilities of the arm, shoulder and hand (DASH) questionnaire to gather long term patient-reported outcome measures of hand function. The overall DASH score out of 100 was calculated for returned questionnaires.

### Systematic Literature Review

Separately, a comprehensive, systematic literature review was conducted in adherence to the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines.<sup>6</sup> This literature search was performed using the electronic databases PubMed, SCOPUS, and The Cochrane Foundation. The search terms used are detailed in ► **Table 1**. Prespecified limits for study inclusion were that the study report primary evidence of functional outcomes following Bennett's fracture fixation in at least 10 patients. We extracted patient number, patient age, fixation method, length of follow-up, key

**Table 1** Systematic literature search strategy

Search strategy
1 = "Bennett's Fracture" OR "Bennetts Fracture"
2 = "Repair" OR "Fixation" OR "K-wire"
Limits
Publication date prior to March 7, 2019

Note: Search strings 1 and 2 were combined using the Boolean term AND, then the limits were applied.

functional outcomes including patient-reported outcomes, complication rates, and risk of bias using a structured proforma to ensure consistency of appraisal.

### Statistical Analysis

Data were analyzed using IBM SPSS statistics version 24. Descriptive statistics were reported and statistical analysis, including meta-analysis, performed where sufficient data were present. The Mann-Whitney *U*-test was used to compare independent groups which were nonnormally distributed. The Shapiro-Wilk test was used to assess for normality. One-way analysis of variance (ANOVA) was used to compare data among more than two groups. Correlations between categorical variables were examined using the Chi-squared test. Regression analysis was utilized to examine relationships between continuous variables. Two-tailed *p*-values were reported throughout and a *p*-value < 0.05 was considered statistically significant.

## Results

### Retrospective Cohort Analysis

A total of 61 patients were identified over an 11-year period (2006–2017) from our database analysis. Among 61 patients, 12 were excluded due to being lost to follow-up or subsequently being found not to meet the inclusion criteria. Among the 49 patients included in our study, 47 were male and 2 were female. Patients were classified radiographically using Gedda's classification; 91.8% (45) of patients presented with type 1 fractures, 2% (one) with type 2, and 6.1% (three) with type 3 fractures.<sup>4</sup>

### Postoperative Rehabilitation

Postoperatively, mean follow-up time in hand therapy clinic for rehabilitation and clinical assessment was 17.2 (range: 3–52) weeks. Postoperative range of movement values were documented; among 49 patients, 85.1% (40) returned to unrestricted movement within the hand therapy follow-up period, 7 patients (10.9%) had partial restriction of thumb movement, with data being unavailable for 2 patients. Restricted movement was defined as a Kapandji's score of less than 9, or where this was not stated, a first carpometacarpal flexion-extension range of less than 40 degrees.<sup>7</sup>

### Long-Term Patient-Reported Functional Outcomes

All 49 patients were invited to complete the DASH questionnaire to assess long-term functional outcomes from the

patient’s perspective, 47 patients responded (95.9%). The mean time between operative repair and patient completion of a DASH questionnaire was 5.55 (range: 1.41–11.2) years.

The mean DASH score amongst responding patients was 7.75 (range: 1.7–18.3; ▶Fig. 1); 14 patients (29.7%) had a DASH score of 10 or more, only 5 patients (10.6%) had a DASH score of 15 or more (15.0, 16.0, 17.0, 17.5, and 18.3, respectively).

**Fracture Fixation Method**

Among 49 patients, 91.8% (45) were managed with closed reduction with percutaneous of K-wire fixation. The remaining 8.2% (4) required open reduction with K-wire fixation where adequate anatomical reduction was not otherwise achievable. There was neither significant difference between open and closed K-wire fixations in terms of rehabilitation outcomes nor long-term DASH scores ( $p = 0.588$ ,  $p = 0.969$ , respectively).

**Mechanism of Injury**

Mechanisms of injury reported by patients on admission were: sports injuries (31.1%), violence (24.6%), falls (18%), road traffic accidents (16.4%), occupational (4.9%), and other miscellaneous accidents (4.9%). There was no significant difference in

rehabilitation outcomes nor long term DASH scores between the different mechanisms of injury ( $p = 0.124$ ,  $p = 0.610$ , respectively).

**Age at Injury**

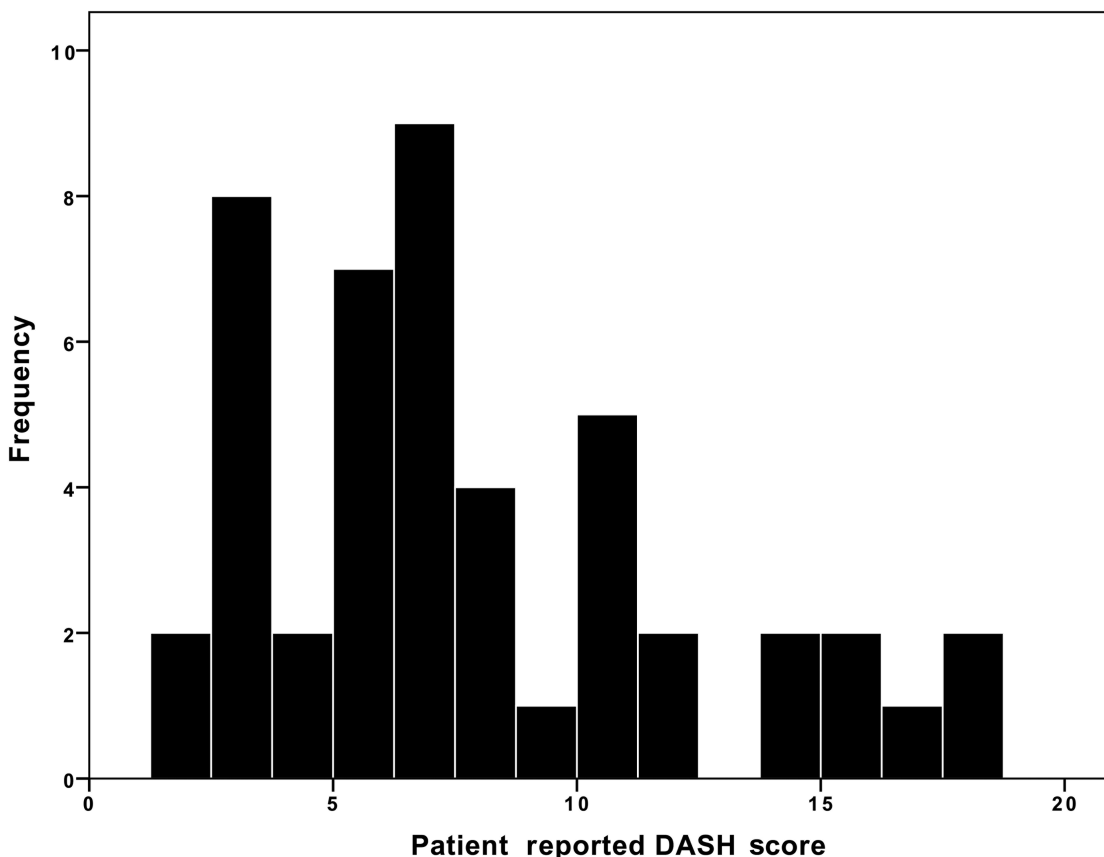
The mean age at time of injury was 32.4 (range: 14–74) years (▶Fig. 2). Patient age at the time of injury was neither correlated with postoperative recovery nor patient-reported long-term DASH scores ( $p = 0.510$ ,  $p = 0.631$ , respectively).

**Time to Fixation**

The mean time to surgery following Bennett’s fracture was 6 (range: 1–17) days. Time to surgery was neither correlated with postoperative recovery nor long-term patient-reported DASH scores ( $p = 0.424$ ,  $p = 0.44$ , respectively).

**Smoking Status**

Of the 49 patients, 19 (38.7%) were smokers and 5 did not have a recorded smoking status. There was no significant association between smoking status and postoperative rehabilitation, nor long-term DASH scores ( $p = 0.576$ ,  $p = 0.352$ , respectively). There was no significant relationship between smoking and complication rates ( $X^2$ ,  $p = 0.178$ ).



**Fig. 1** Long-term patient reported functional outcomes after Bennett’s fracture fixation using the disabilities of the arm, shoulder, and hand (DASH) questionnaire.

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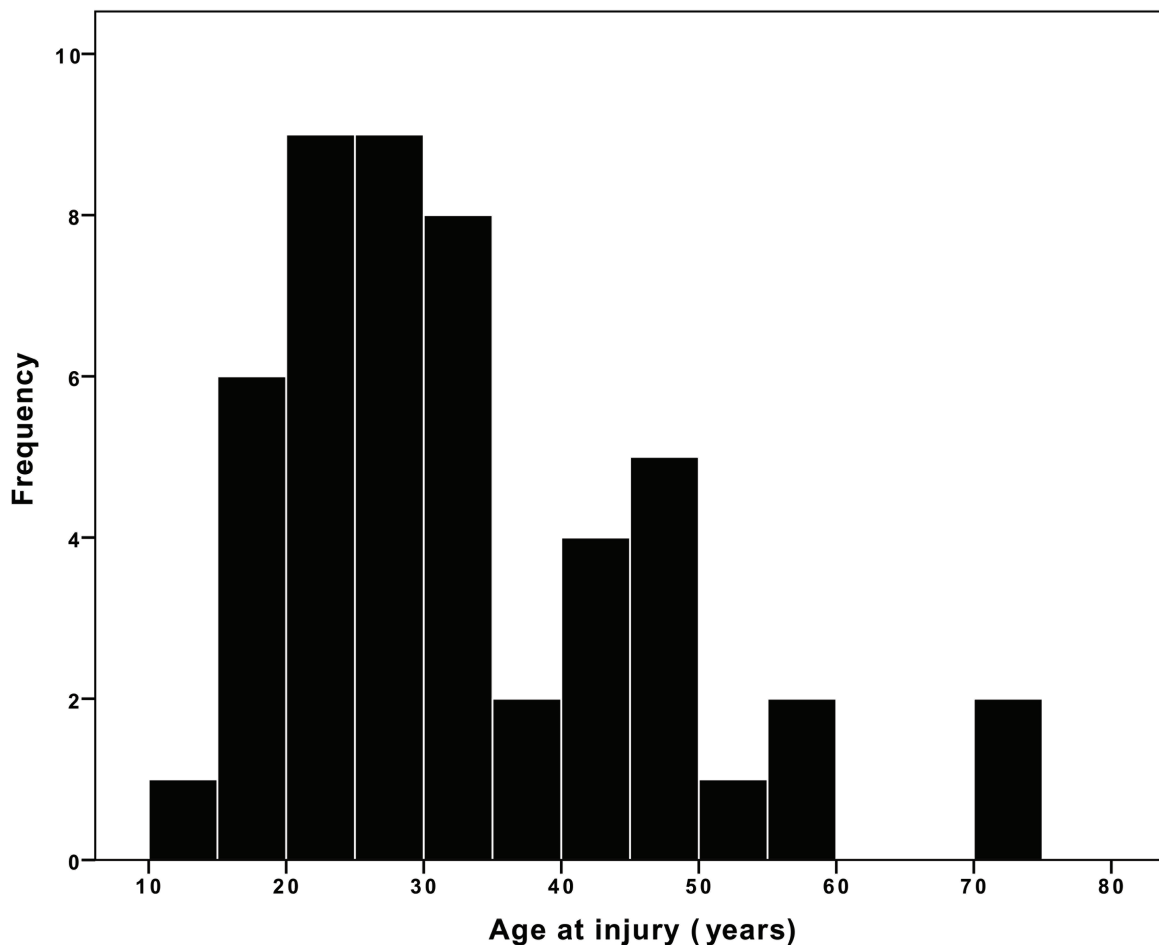


Fig. 2 Patient age at the time of fracture.

### Complications

Complication rates amongst these patients were low. Five patients had documented postoperative complications (10.2%) of which three were wound infections (►Table 2). Patients with documented wound infections were all successfully treated with oral antibiotics as an outpatient, and there was no significant difference in the long-term reported DASH scores ( $p = 0.205$ ).

### Systematic Literature Review

Systematic review of the literature identified 124 papers after duplicate removal; after full text review, 14 papers met the predetermined inclusion and exclusion criteria (►Fig. 3).

Key data extracted during the literature review are summarized in ►Table 3, for clarity. The 14 included papers reported 541 patients with Bennett's fracture that underwent surgical fixation. Retrospective cohort studies were the most common study design, providing level-III evidence. Key data extracted included procedure type, patient number, follow-up length, outcome metrics, and complications (►Table 3).

DASH, quickDASH (qDASH), and visual analogue scales (VAS) were reported in 10 of the 14 included studies,

Table 2 Documented postoperative complications for all included patients

Complication	Number	Outcome
Wound infection	3	All resolved with oral antibiotics
Broken K-wire	1	Surgically removed
K-wire displaced	1	K-wire removed

providing patient-reported outcomes measures of long-term functional recovery. Where these metrics were unavailable, any other functional outcome metrics that were available were extracted.

### Discussion

The optimal management of Bennett's fracture is still a topic of debate. Studies have demonstrated the need for surgical fixation, given the inherent instability of the fracture, to achieve good functional outcomes.<sup>3,8,9</sup> However, the use of a variety of surgical fixation methods continue to be reported in the literature, including the use of K-wires with either open or closed reduction and fixation, external fixation devices, tension band wiring, lag screws, miniature T-Plates,

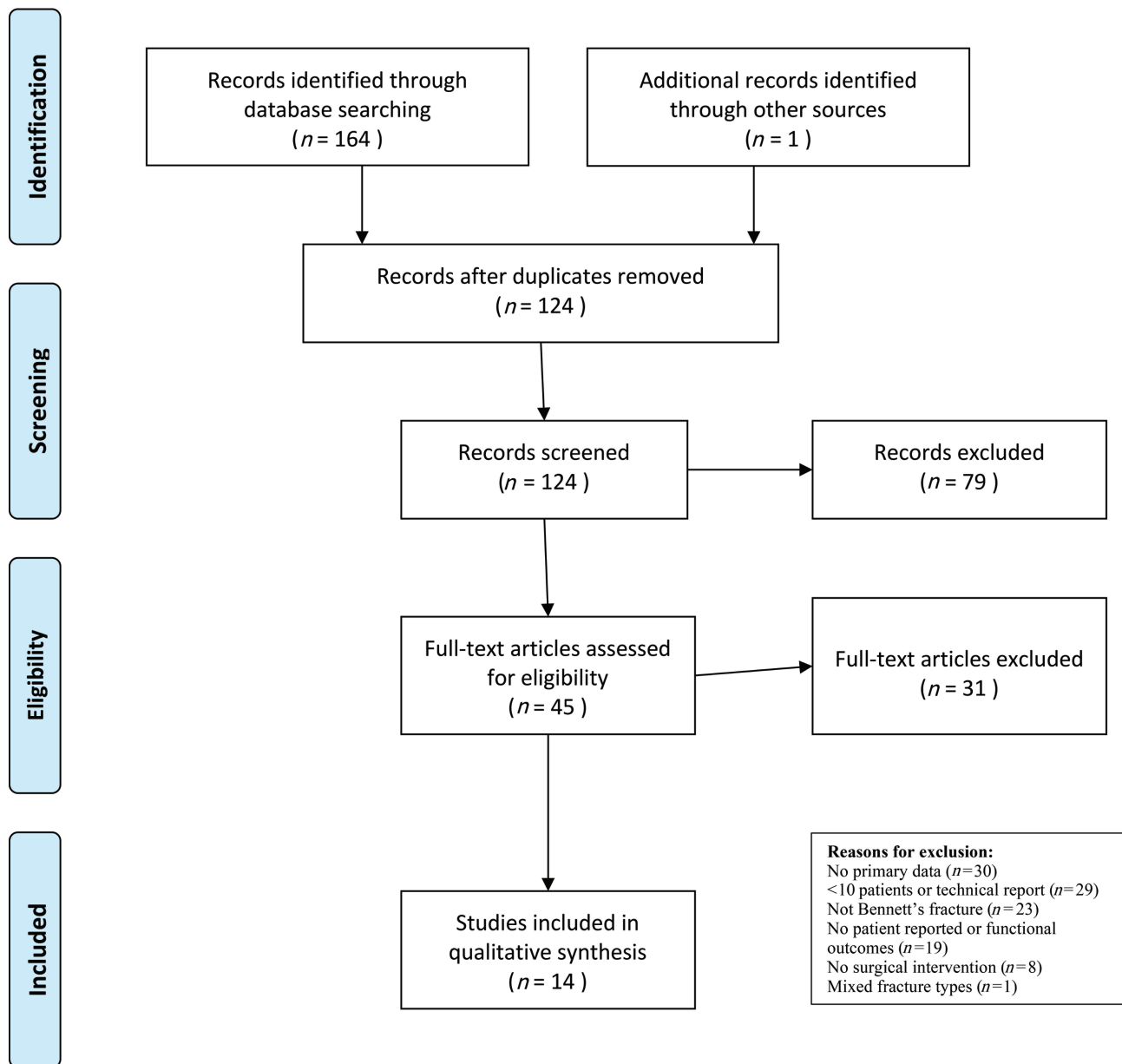


Fig. 3 PRISMA literature search flow diagram. PRISMA, preferred reporting items for systematic reviews and meta-analyses.

and arthroscopic screws. We review the evidence for each of these in turn.

K-wires are the most commonly used method of fixation, being utilized in our cohort and 12 of 14 studies reported in the literature. Study design varies from the use of percutaneous K-wires only, open K-wire fixation, to direct comparison with other fixation methods. Along with our cohort, 10 further studies report the use of percutaneous K-wire fixation with a total of 251 patients (►Table 3). Mean follow-up of these patients ranged from 15 months to 11.5 years. DASH scores were predominantly reported in more recent studies, with mean scores of 1.77 to 4.0, and 7.75 in our cohort. Franchignoni et al demonstrated that the minimum clinically

significant score with the DASH questionnaire is approximately 10 to 15 points.<sup>10</sup> Patients rarely reported DASH scores greater than 15, even at very long follow-up times; for instance, in our cohort fewer than 10% of patients reported a DASH score of more than 15. This demonstrates that percutaneous K-wire fixation reliably results in excellent long-term patient outcomes.

Complication rates with percutaneous K-wire fixation are low; superficial wound or wire tract infection was the most commonly reported in approximately 4 to 8% of patients. In our cohort, these infections were superficial, resolved with oral antibiotic treatment, and had no substantial impact on long-term functional outcomes.

**Table 3** Systematic literature review results. Studies reporting outcomes after Bennett's fracture fixation in at least 10 patients

	Kamphuis (2019) <sup>24</sup>	Zhang et al (2019) <sup>17</sup>	Levy et al (2018) <sup>12</sup>	Pomares et al (2016) <sup>19</sup>	Middleton et al (2015) <sup>25</sup>	Li et al (2014) <sup>11</sup>	Leclere (2012)	Zhang et al (2012) <sup>16</sup>	Demir et al (2006) <sup>21</sup>	Lutz et al (2003) <sup>22</sup>	Brüske et al (2001) <sup>13</sup>	Timenga (1994)	Van Niekerk and Ouwens (1989)	Salgeback 1971	
Age (y)	34 (±12) years	32 (range: 24–54)	32 (range: 22–52)	30.2 (range: 16–42) vs. 37.4 (range: 18–59)	33.2 (range: 18–75)	37 (no range)	40.1 (range: 24–64)	32 (range: 19–51)	36.4 (range: 20–75)	28 (no range) vs. 37 (no range)	42 (range: 23–58)	43 (SD = 13.36)	25 (range: 16–34)	39 (range: 16–81)	
Fixation method	Closed K-wire (n = 15) vs. ORIF screw (n = 35)	Open K-wire + tension band (n = 37) vs. closed K-wire (n = 35)	ORIF mixed screws or K-wire (n = 21)	ORIF screw (n = 10) vs. arthroscopic screw (n = 11)	Closed K-wire (n = 62)	External fixator (n = 56) vs. ORIF mixed screw and K-wire (n = 32)	ORIF screw (n = 24)	Open K-wire + tension band (n = 56) vs. closed K-wire (n = 21)	ORIF screw closed K-wire (n = 4)	ORIF screw vs. closed K-wire (n = 17)	Closed K-wire (n = 14) vs. open K-wire (n = 5)	Closed K-wire (n = 7) vs. ORIF (n = 11)	Closed K-wire (n = 8) Open K-wire (n = 2) "Other methods" (n = 2)	Closed K-wire (n = 23) vs. open K-wire (n = 5)	
Average follow-up (range)	10 (6–14) y	15 (12–18) mo	8 (3–10) mo	33.3 (28–36) vs. 27.6 (24–31) mo	11.5 (3.4–18.5) y	7 (2–10) y	83 (54–154) mo	39 (36–42) vs. 35 (31–41) months	38.9 (6.4) mo	7 (3–18) y	1.5 (0.5–3) y	10.7 (7–16) y	6.25 (1.5–9) y	6 (1–14) y	
Outcome (range)	DASH, 4 (0–12) vs. 0 (0–6) Pain VAS, 0 (0–0) vs. 0 (0–0)	DASH, 1.06 (0–2) vs. 1.77 (0–3) The Kapandji, 9.31 (8–10) vs. 8.45 (7–10)	Quick-DASH, 15 (no range) VAS score, median: 0 (IQR: 0–1.5)	QuickDASH, 4.3 (0–18.18) vs. 3.1 (0–18.18) Kapanjji, 9.5 (8–10) vs. 9.9 (9–10)	DASH, 3.0 (0–38)	VAS pain, "No significant difference between groups" (values not stated)	VAS score, 1.4 (1–1.8) ("pain," 0–10 scale) Mean palmar abduction 93–0–5 degrees	VAS (0–5) vs. 0 (0–2) vs. 0 (0–5) Mean CMCJ flexion extension 49 (45–54) vs. 47 (38–53) degrees	DASH 5.6 (1.9) (No subgroup results)	Pain 27% (n = 4) vs. 12% (n = 2) Mean active position (SD) 43 degrees (10) vs. 45 degrees (9)	Pain 27% vs. 12% (n = 2) Mean active position (SD) 43 degrees (10) vs. 45 degrees (9)	"Full opposition" in 100% of patients VAS score, 1.2 (1.1–1.5) ("Disability," scale 1–5) Pain 33% (n = 7) no subgroup	Full range of movement, 100% of patients No perceived handicap: 100% of patients "Mild stiffness" 43% (n = 3) vs. 27% (n = 3)	"No complaints" 67% (n = 8) "Slight complaints" 33% (n = 4)	Closed: 87.5% "No complaints" 12.5% "normal working capacity, slight discomfort" vs. Open, 100% "No complaints"
Complication	Revision, 6% (n = 1) vs. 20% (n = 7) Infection, 6% (n = 1) vs. 0% Paresthesia, 13% (n = 2) vs. 28% (n = 11)	None reported	Revision: 10% (n = 2)	60%: 6 pain, 1 weakness, 1 malunion, 1 paresthesia vs. 9%: 1 complex regional pain syndrome	Wound infection 4.2%	Wound infection, 5 (n = 3) vs. 0% Delayed union, 0 vs. 6% (n = 2)	Revision: 4% (n = 1)	None reported	None reported	None reported	None reported	None reported	None reported	None reported	None reported

Abbreviations: K, Kirschner; ORIF, open reduction internal fixation; QuickDASH, a shortened version of disabilities of the arm, shoulder, and hand; SD, standard deviation; VAS, visual analog scale.

Our cohort was further analyzed for factors associated with inferior long-term outcomes following K-wire fixation and found no statistically significant association with patient age, mechanism of injury, time to repair, and nonsmoking status. The four patients that reported DASH scores greater than 15 were representative of the overall cohort, with no evidence of differences pre- or postoperatively.

One study reported the use of external fixation devices in 56 patients with a mean follow-up time of 7 years.<sup>11</sup> Li et al compared the use of external fixation devices to open reduction internal fixation; however, we can draw little in the way of conclusions from their study given the limited outcomes data provided, and their comparison to a mixed ORIF group of K-wires and lag screws.

ORIF methods are an alternative to percutaneous fixation, with several distinct methods reported including the use of K-wires, tension band wiring, lag screws, miniature T-Plates, and arthroscopic screw placement. In total, 13 of 14 papers reported patient cohorts after ORIF with a total of 279 patients, distinct procedure methods are discussed subsequently. While different functional outcome measures have been reported, it is evident that open fixation methods also result in excellent long-term outcomes, with mean DASH and qDASH scores (range: 0–15) and VAS scores (range: 0–1.4 out of 10), comparable to that of percutaneous K-wire fixation. Complication rates and types do differ between open and closed methods; however, the need for operative revision is reported not uncommonly in 4 to 20% of cases, persistent paresthesia in 5 to 28% of cases, along with one report of chronic regional pain syndrome. Wound infections, by contrast, are not reported in open fixation methods.

Among those studies reporting on open reduction methods, five studies reported on the use of K-wires for ORIF<sup>11–15</sup>; however, the conclusions that can be drawn from these data are limited. Two studies grouped open K-wire fixation with other open methodologies without providing subgroup analysis, while the other three studies reported mixed outcomes in small cohort sizes (combined  $n = 12$ ). Overall, there is insufficient data to draw conclusions on the use of K-wire fixation during open procedures, as compared with other ORIF methods.

Two studies reported ORIF with K-wires and tension banding in a total of 93 patients, as compared with percutaneous K-wire fixation.<sup>16,17</sup> The addition of tension banding aimed to improve anatomical reduction, however, resulted in no difference in patient-reported DASH scores, pain scores, or joint range of motion; it did, however, permit earlier postoperative mobilization. Complications were not reported in these studies; however, this would be a realistic concern given the higher rates of some complications in other open fixation methods.

Subgroup outcomes following ORIF with lag screws were reported by six studies with a combined 110 patients.<sup>18–23</sup> Long-term mean DASH and qDASH scores (range: 0–5.6) are comparable to other percutaneous and ORIF methods; complication rates are also comparable to other ORIF methods, including paresthesia and the need for surgical revision. One

study compared the use of ORIF with screws to the use of arthroscopically placed screws, which require less soft tissue dissection.<sup>19</sup> Arthroscopic procedures resulted in comparable qDASH and Kapandji's scores but with a lower rate of complications (9 vs. 60%); however, conclusions are limited by the small number of patients in the arthroscopic group ( $n = 11$ ). Miniature T-Plate ORIF did not have sufficient distinct data to support subgroup analysis, with only a small number of cases in mixed ORIF patient groups.

Our study demonstrates that closed reduction with percutaneous K-wire fixation results in excellent long-term functional outcomes, comparable to those with ORIF, yet with a reduced risk of significant complications. In some instances, where anatomical reduction cannot be achieved, open reduction may be necessary; the strict threshold for this decision is unclear, however. Some studies suggest the target of a <2 mm intra-articular step deformity to minimize the risk of osteoarthritis; however, there are conflicting results in the literature with some studies finding a correlation between a step deformity >2 mm and increased osteoarthritis, and others finding no correlation.<sup>18,21–23</sup> Furthermore, several studies have found little correlation between the extent of joint arthritis and patient-reported symptoms.<sup>3,9,13,15,22</sup>

## Limitations

There are some limitations to the interpretation of our results. First, given the uncommon nature of Bennett's fracture, the current evidence base is predominantly composed of retrospective cohort studies with variable follow-up periods. As it is recognized that joint changes can later become apparent if a fracture is not carefully aligned, future studies should specifically evaluate these patients after several years of follow-up to ascertain whether these late changes correlate with deteriorating patient-reported outcomes. Second, the scope of our study is intentionally limited to all surgical fixation methods; while nonsurgical management is rare due to the instability of Bennett's fracture, it may be appropriate in some circumstances. Finally, present studies have variable design, surgical technique, and outcome metrics; this prohibits meaningful meta-analysis. To enhance the robustness of the conclusions drawn from our study, future research should be conducted through multicenter prospective studies to minimize the risk of bias and to ensure that they are adequately powered.

## Conclusion

The optimal management of Bennett's fracture requires fracture reduction and surgical fixation to avoid long-term loss of hand function and quality of life. Closed reduction with percutaneous K-wire fixation should be the first choice surgical method given its excellent, long-term functional outcomes and its low risk of complications. ORIF should be reserved for cases where closed reduction is not achievable; however, the current evidence base does not support one method of ORIF above another.

**Conflict of Interest**

None declared.

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