

Bennett Fractures

A Review of Management

Michael S. Guss, M.D., I. David Kaye, M.D., and Michael Rettig, M.D.

Abstract

A Bennett fracture is a common injury that involves an intra-articular fracture at the base of the first metacarpal. This fracture typically results in a dorsally and radially displaced metacarpal shaft relative to the well-anchored volar ulnar fragment. Most Bennett fractures are treated with operative fixation, including closed reduction and percutaneous fixation, open reduction and internal fixation, or arthroscopically assisted fixation. However, the optimal surgical approach is controversial. There is a paucity of literature comparing the outcomes of the various treatments, leaving the surgeon without a clear treatment algorithm. Moreover, there is no consensus on acceptable reduction parameters, including articular gap or step-off, with some series stating that up to 2 mm of displacement is acceptable.

Edward H. Bennett described the intra-articular fracture-dislocation of the first metacarpal base in 1882.¹ He noted the thumb's functional importance, stating "no injury of it is to be lightly regarded."¹ Injury to the first metacarpal frequently occurs, accounting for 25% of all metacarpal fractures, 80% of which involve the base, the Bennett fracture being most common.² The goals of treatment are to maintain motion and the biomechanics of the trapeziometacarpal joint by restoring the joint's anatomic congruity and articular surface and correcting carpometacarpal subluxation or dislocation.³ Investigators postulate that accurate reduction of the CMC joint helps prevent

the development of arthritis in an articulation already at increased risk.^{4,5} For non-displaced fractures, treatment in a thumb-spica cast can be tried.^{1,6,7} For displaced fractures, closed reduction and percutaneous pinning (CRPP) is preferred for small fragments with minimal articular step-off.⁸⁻¹⁰ Open reduction and internal fixation (ORIF) is often indicated for large fracture fragments with displacement greater than 2 mm that are irreducible with closed methods.^{2,4,5,11,12} Recently, investigators have described arthroscopic osteosynthesis of displaced Bennett fractures.^{13,14} More than 20 methods of treatment have been described, reflecting the lack of clear consensus on optimal treatment.¹⁵ The purpose of this article is to review the relevant anatomy, biomechanics, clinical evaluation, classification, treatment options, and controversies that exist for treatment of the Bennett fracture. We also present our preferred treatment methods given the available literature.

Anatomy

The trapeziometacarpal joint is unique in that it is a double "saddle" joint.^{3,16} The articular surfaces of the thumb metacarpal base and trapezium resemble reciprocally interlocking saddles, allowing for flexion-extension, abduction-adduction, and rotation.^{3,16} Motion is coupled; pronation is combined with flexion and hyperextension with supination of the CMC joint. Metacarpal muscular insertions include the abductor pollicis longus (APL) at the proximal base, the adductor pollicis distal and ulnar, and the thenar muscles volarly. Ligamentous CMC joint stability is provided by the anterior-volar-oblique (beak) ligament, the posterior oblique, dorsal radial, and anterior and posterior intermetacarpal ligaments.¹⁷ Nearly half the stability of the joint is conferred by its biconcave nature. The beak ligament is the most significant capsular reinforcement and resists dorsal and radial subluxation during a key pinch by stabilizing the dorsal-radial capsule. In addition, it provides 40% of the

Michael S. Guss, M.D., I. David Kaye, M.D., and Michael Rettig, M.D., Department of Orthopaedic Surgery, Division of Hand Surgery, NYU Hospital for Joint Diseases, New York, New York. Correspondence: Michael S. Guss, M.D., Department of Orthopaedic Surgery, Division of Hand Surgery, NYU Hospital for Joint Diseases, 301 East 17th Street, New York, New York 10003; msg397@nyumc.org.

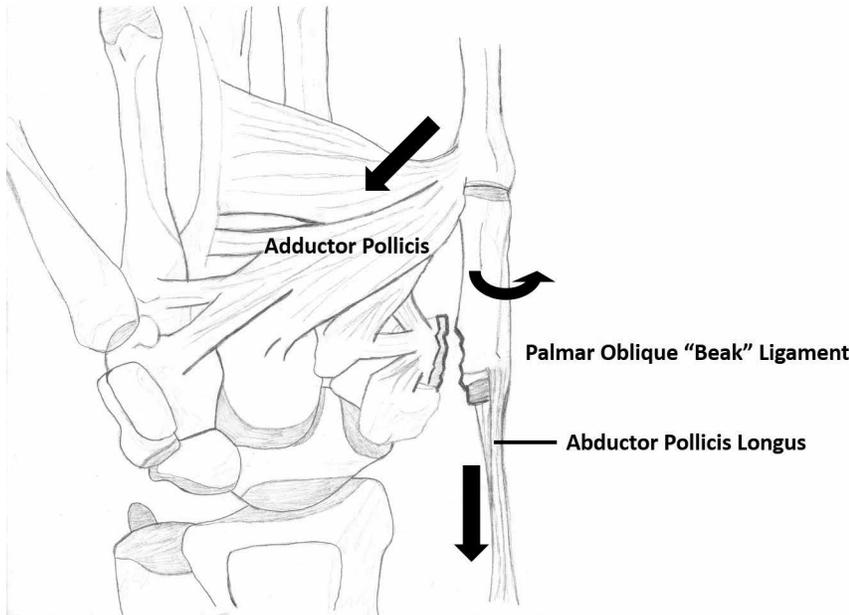


Figure 1 Bennett fracture subluxation of the first carpometacarpal joint. Deforming forces include adduction and supination of the first metacarpal by the adductor pollicis. The abductor pollicis longus displaces the first metacarpal proximally relative to the residual ulnar fragment, which is held in place by the palmar oblique ligament.

resistance to pronation.¹⁷ The beak ligament originates from the trapezium and inserts on the volar beak of the thumb metacarpal base. Resistance to supination is provided by the intermetacarpal ligament between the first and second metacarpals.

Biomechanics

The mechanism of injury is an axial load on the partially flexed thumb metacarpal leading to an intra-articular avulsion fracture of the volar ulnar metacarpal base from the remaining thumb metacarpal. The pull of the APL, the thumb extensors, and the adductor pollicis displaces the thumb metacarpal radially, dorsally, and proximally (Fig. 1). The volar ulnar corner of the metacarpal base remains in place, tethered by the strong volar oblique ligament.

Cooney and coworkers found that with a key pinch, the CMC joint sees compressive forces up to 12 times higher than the force being produced.¹⁸ High daily forces coupled with the relatively increased mobility of the trapeziometacarpal joint places increased stress on the articulation. This helps explain the CMC joints propensity for arthritis and the potential importance of surgical intervention in Bennett fractures.

Patient Evaluation

The majority of Bennett fractures occur in men, with more than half occurring in the dominant hand.^{1,2} The history and physical exam is an important part of the diagnostic

process. Patients will often report a fall onto the affected hand or direct axial load. They will report immediate pain and swelling at the base of the first metacarpal. On examination, they will have tenderness at the base of the CMC joint. Crepitus with attempted motion and decreased range of motion will be present. A palpable “shelf” deformity at the base of the metacarpal can result from displacement of the metacarpal shaft dorsally.

Imaging

Radiographs are essential for diagnosis. All patients should receive PA, lateral, and oblique images of the thumb. A true lateral view as described by Billing and Gedda is necessary to correctly view the articulation of the base of the first metacarpal at the first CMC joint.¹⁹ This view is obtained by pronating the hand 20° and then angling the beam 15° to 20° distally. In addition, traction radiographs have been described to help assess the effect of ligamentotaxis on the reduction.³ A computed tomography scan can be considered in comminuted fractures.

Classification

In 1952, Gedda published a series of Bennet fractures that had been treated non-operatively and proposed a classification system consisting of three types.²⁰ Type 1 is defined as a fracture with a large single ulnar fragment and subluxation of the metacarpal base. Type 2 is defined as an impaction fracture without subluxation of the thumb metacarpal. Type

Table 1 Gedda Classification of Bennett Fractures²

Type 1	Large single ulnar fragment and subluxation of the metacarpal base
Type 2	Impaction fracture without subluxation of the thumb metacarpal
Type 3	Small ulnar avulsion fracture fragment in association with metacarpal dislocation

3 represents a small ulnar avulsion fracture fragment in association with metacarpal dislocation (Table 1).²⁰

Non-Operative Treatment

Historically, the majority of these injuries were treated with closed reduction and casting for 4 to 6 weeks.^{1,6,7,21} Reduction is obtained by applying axial traction, palmar abduction, and pronation to the thumb metacarpal while providing pressure over the dorsal-radial metacarpal base (Fig. 2). The hand is then placed into plaster immobilization in a thumb-spica splint in an attempt to maintain reduction. During the 1960s, long-term studies analyzing non-operative management showed frequent loss of reduction with resulting posttraumatic arthritis, shifting management toward operative fixation.^{6,7} Gedda and Moberg reported a series of 54 patients, 49 of which were asymptomatic after non-operative treatment.² However, they became early proponents of open fixation due to evidence of loss of reduction and radiographic findings of arthrosis in 41 of these patients.² Despite the radiographic arthrosis seen on imaging and clinical findings of loss of motion in abduction and extension, patient satisfaction remained high in some series.^{6,21} However, in 1990, Livesey reported a series of 17 Bennett fractures treated with casting with 26-year follow-up.²² Six patients had severe pain, 12 had persistent gross deformity, and 13 had persistent subluxation of the CMC joint. All patients had loss of thumb abduction and extension and a decrease

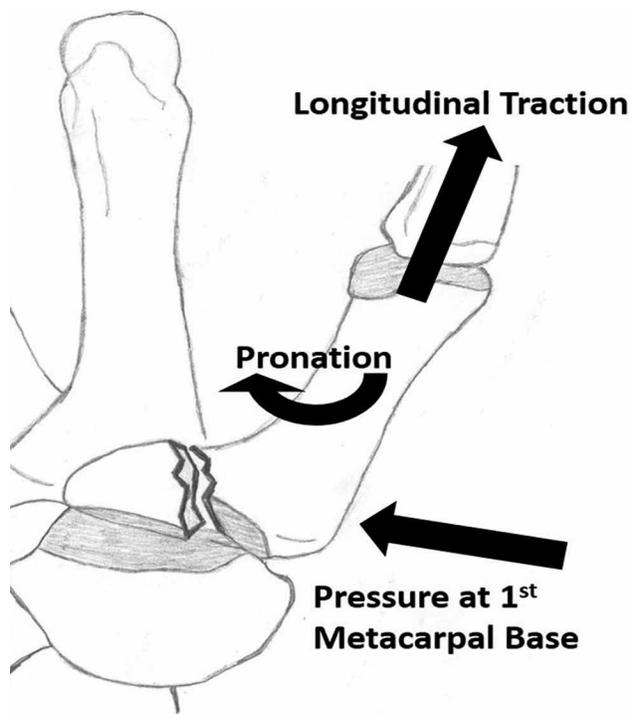


Figure 2 Closed reduction of Bennett fractures is obtained by applying axial traction, palmar abduction, and pronation to the thumb metacarpal while providing pressure over the dorsal-radial metacarpal base.

in grip strength. They concluded operative means should be employed. Non-operative treatment is now mainly reserved for non-displaced Bennett fractures.²²

Operative Treatment

Percutaneous pinning is one operative option to maintain articular reduction and correction of metacarpal subluxation and has the advantage of avoiding associated complications of open surgery, including tendon adhesions and bone necrosis. In 1950, Wagner reported 38 cases treated with CRPP across the trapeziometacarpal joint and found “uniformly good results.”¹⁰ Van Nierk recommended transmetacarpal pinning to spare the already threatened CMC joint articular cartilage.⁹ He found no limitations in daily activities, work, or sporting hobbies. In 2012 Greeven reported on seven Bennett fractures with 2-year follow-up treated with transmetacarpal pinning.⁸ Surgical time ranged from 6 to 20 minutes, no complications were reported, and none of the patients experienced “any functional limitations.”⁸

While series have shown acceptable results with CRPP, the ability to obtain an anatomic reduction using closed methods has been questioned.^{23,24} Capo and colleagues simulated Bennett fractures in eight cadaveric specimens and then compared the articular reduction using fluoroscopy and direct visualization of the joint after CRPP.²³ Fractures were created through an open incision, skin closed, and CRPP performed. They found a significant difference in articular step-off (< 0.001) and displacement (< 0.01) measured using fluoroscopy versus subsequent open examination.²³ However, Greeven and associates could not replicate these findings and did not find differences in displacement or fracture step-off between fluoroscopy, plain radiographs, and direct visualization.²⁴

In a cadaveric biomechanical study, Cullen and coworkers measured the contact area and pressures of the first CMC joint after artificial Bennett fracture, with fragments fixed with a 2 mm joint step-off.²⁵ They found an overall increase in CMC joint contact area; however, there was no pathological pressure increases. In fact, there was a decrease in palmar contact forces with a slight increase in dorsal forces. They concluded that a Bennett fracture with a 2 mm step-off should not precipitate a post-traumatic arthritis and may actually be protective, and therefore, CRPP to restore articular surface with up to 2 mm of step-off should be the first treatment of choice.²⁵

Classically, ORIF has been recommended when the fracture fragment is greater than 15% to 25% of the articular surface and when the articular surface cannot be reduced to less than 2 mm of displacement with closed methods.^{2,4,11,26,27} If open reduction is going to be performed, a Wagner incision is generally utilized.¹⁰ This incision follows the thenar eminence in a gentle curve toward its palmar aspect. In general, studies evaluating ORIF have produced favorable results.^{2,4,11,26,27} ORIF allows for anatomic reduction, which prevents the development of radiographic arthritis associated

with malreduction. In 2012, Leclere and colleagues reported a series of 24 patients undergoing ORIF with an average of 83 month follow-up.²⁸ Reduction with less than 1 mm step or gap was obtained in all patients and was maintained in 96% of cases. Pinch and grip strength measured at 4 months was 92% and 89% of the unaffected side, respectively, and did not increase significantly at long-term follow-up. The average visual analog scale pain score was 1.4 (scale range: 0 to 10), and all but one patient could “practice daily life and sports activity at the same level as before surgery.”²⁸

It is unclear if the radiographic changes seen in Bennett fractures are clinically significant. Leclere and colleagues could not find a correlation between “accuracy of the fracture reduction considering a gap and step less than 2 mm and development of arthritis.”²⁸ Kjaer-Peterson and associates and Thurston and coworkers reported medium- to long-term follow-up (average 7.3 and 7.6 years, respectively) showing superior radiographic results could be obtained when there was less than 1 mm of displacement.^{4,5} Only Kjaer-Peterson and associates could correlate this finding clinically.⁴

Studies comparing ORIF and CRPP are limited. In 1994, Timmenga and colleagues compared 18 patients (7 CRPP, 11 ORIF) with mean follow-up of 10.7 years.²⁹ There was no correlation between the method of treatment and the development of arthritis, but there was a significant correlation between the degree of reduction and the development of arthritic changes. However, there was no correlation between the extent of radiographic arthritis and symptoms as five of seven patients with exact reduction still proceeded to develop arthritis.²⁹ In 1990, Kjaer-Peterson and associates reported on 41 patients treated with either casting (9), CRPP (6) or ORIF (26).⁴ Excellent reduction (< 1 mm step-off) was obtained in 5, 4, and 18 patients, respectively. At a mean

follow-up of 7.3 years, 31 patients were reviewed. Fifteen of 18 patients with excellent reduction were asymptomatic, as opposed to 6 of the 13 with residual displacement. As stated previously, this correlated with radiographic results. The investigators advocated “exact reduction, if necessary by open reduction.”⁴ Lutz and coworkers in 2003 compared 15 patients treated with ORIF and 17 with CRPP with mean follow-up of 7 years, excluding patients with greater than 1 mm of step-off.³⁰ They found no difference in clinical or radiographic arthritic outcomes between treatments but did find a significantly higher incidence of adduction deformity with pinning. The investigators prefer CRPP for Bennett fractures with a large fragment, with ORIF “reserved for irreducible fractures and cases when a Kirschner wire cannot be placed in the uninjured bone at the base of the thumb metacarpal.”³⁰

Recently, arthroscopic reduction and internal fixation of Bennett fractures was described.^{13,14} Theoretical advantages to ORIF include decreased damage to surrounding soft tissues and vascular supply while direct visualization of the joint surface provides an advantage over CRPP. Zemirline reported a series of seven patients treated arthroscopically, concluding this technique facilitates “joint reduction but does not guarantee stability of fixation.”¹⁴ There is no data supporting the utilization of arthroscopic fixation in favor of CRPP and ORIF at this time.

Discussion

Bennett fractures have been treated since 1882, yet optimal management is still unknown. Definitive treatment recommendations are difficult to make because of limited follow-up and lack of prospective randomized studies. For the majority of fractures, operative fixation to restore articular

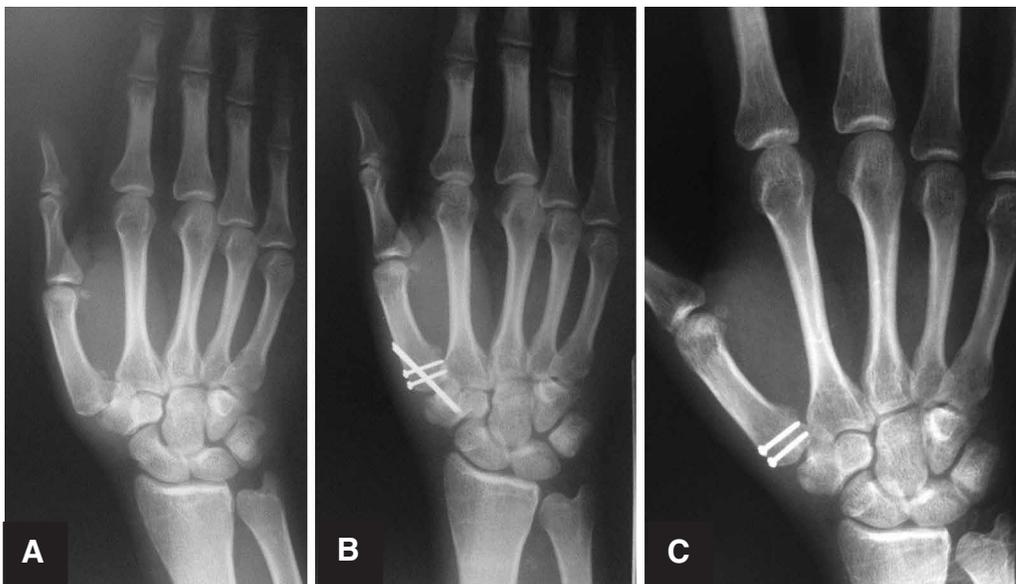


Figure 3 A, Bennett fracture with large ulnar fragment. B, Same fracture status after open reduction and internal fixation with two 2.0 mm interfragmentary screws, augmented with Kirschner wire fixation. C, 4 week's after surgery with removal of the Kirschner wire.

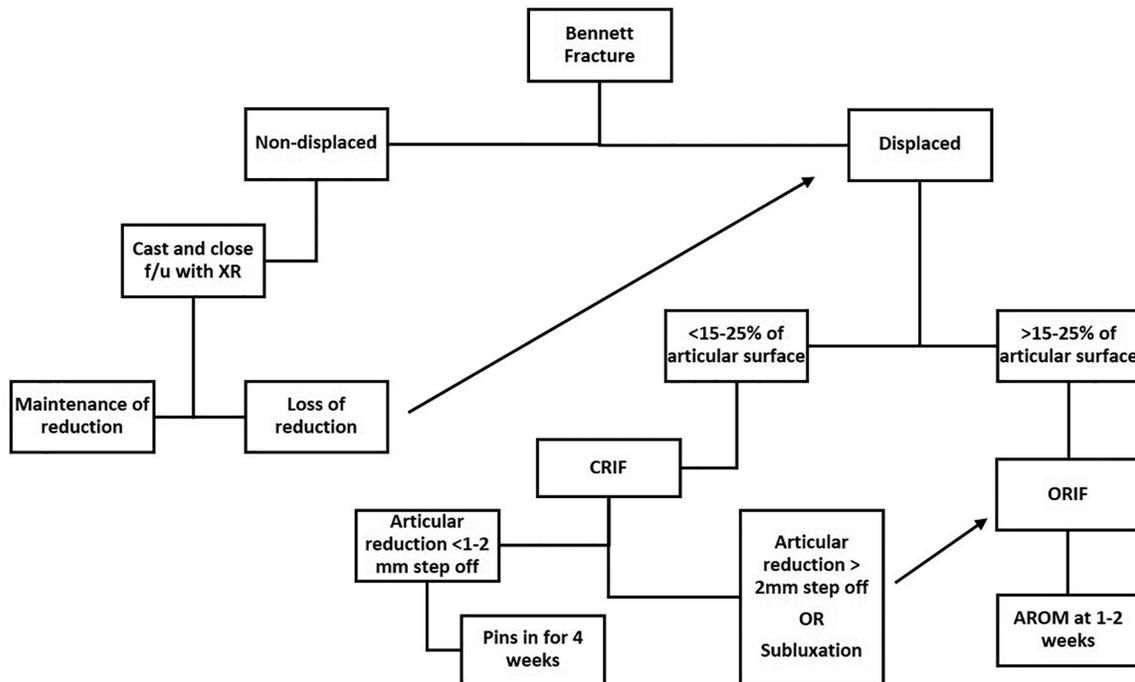


Figure 4 Bennett fracture: proposed treatment algorithm.

incongruity and correct joint subluxation is recommended. However, this is based on data consisting of small retrospective case series or cohort studies and is conflicting on the preferred type of operative treatment. The literature is unclear regarding what is considered an acceptable articular reduction and whether a small articular step-off (< 2 mm) will have long-term clinical effects, even with evidence of radiographic arthrosis. It is yet to be determined if the benefits of ORIF outweigh the risks when compared to CRPP in order to prevent potentially clinically insignificant radiographic changes of the CMC joint.

Randomized prospective trials with long-term follow-up comparing CRPP versus ORIF in patients with Bennett fractures would help us understand the difference between the clinical outcomes of the two treatments. This would help assess the relationship between residual articular step-off and the development of first CMC joint radiographic arthrosis, and whether such arthrosis has any clinical significance. In addition, further studies of arthroscopic fixation are needed to determine its indications and effectiveness.

Author's Preferred Treatment

For patients with non-displaced Bennett fracture, we recommend a trial of closed reduction by applying axial traction, palmar abduction, and pronation to the thumb metacarpal while providing pressure over the metacarpal base followed by immobilization in a thumb-spica splint or cast for 4 to 6 weeks. These patients require close radiographic follow-up to ensure adequate reduction. Patients with displaced Bennett fractures with CMC subluxation require operative

intervention. We recommend CRPP with 0.045 Kirschner wires placed from the metacarpal into the trapezium after performing the above reduction maneuver and confirming reduction on fluoroscopy. If CRPP achieves correction of the CMC subluxation, even in the setting of incomplete articular reduction, we would not convert to ORIF. If CRPP cannot achieve an intraoperative reduction with less than 2 mm of articular step off, we would proceed to ORIF utilizing a Wagner incision to expose the metacarpal base. If a large fragment is present, then two 2.0 mm screws can be used for interfragmentary fixation along with Kirschner wires, as described previously, for increased stability (Fig. 3). If the fragment is small, multiple Kirschner wires can be used to maintain reduction. After CRPP and ORIF, the patient should be placed into a thumb-spica cast for 4 to 6 weeks. Patients are advised to expect some stiffness and loss of motion in abduction and extension as well as loss of grip strength and post-traumatic arthritis.

Conclusion

The optimal treatment of Bennett fractures continues to be controversial among orthopaedic surgeons. The lack of randomized, long-term studies with large patient numbers means there are no definitive treatment algorithms available. While most physicians would agree that displaced fractures require operative intervention, the treatment option of choice continues to be debated. Regardless of the ultimate treatment method decided on, the treating physician must make sure that the fracture is well reduced without residual subluxation prior to leaving the operating room.

Disclosure Statement

None of the authors have a financial or proprietary interest in the subject matter or materials discussed, including, but not limited to, employment, consultancies, stock ownership, honoraria, and paid expert testimony.

References

1. Bennett EH. On fracture of the metacarpal bone of the thumb. *Br Med J*. 1886 Jul 3;2(1331):12-3.
2. 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):249-57.
3. Soyer AD. Fractures of the base of the first metacarpal: current treatment options. *J Am Acad Orthop Surg*. 1999 Nov-Dec;7(6):403-12.
4. Kjaer-Petersen K, Langhoff O, Andersen K. Bennett's fracture. *J Hand Surg Br*. 1990 Feb;15(1):58-61.
5. Thurston AJ, Dempsey SM. Bennett's fracture: a medium to long-term review. *Aust N Z J Surg*. 1993 Feb;63(2):120-3.
6. Griffiths JC. Fractures at the base of the first metacarpal bone. *J Bone Joint Surg Br*. 1964 Nov;46:712-9.
7. Pollen AG. The conservative treatment of Bennett's fracture-subluxation of the thumb metacarpal. *J Bone Joint Surg Br*. 1968 Feb;50(1):91-101.
8. Greeven AP, Alta TD, Scholtens RE, et al. Closed reduction intermetacarpal Kirschner wire fixation in the treatment of unstable fractures of the base of the first metacarpal. *Injury*. 2012 Feb;43(2):246-51.
9. van Niekerk JL, Ouwens R. Fractures of the base of the first metacarpal bone: results of surgical treatment. *Injury*. 1989 Nov;20(6):359-62.
10. Wagner CJ. Method of treatment of Bennett's fracture dislocation. *Am J Surg*. Aug 1950;80(2):230-1.
11. Gelberman RH, Vance RM, Zakaib GS. Fractures at the base of the thumb: treatment with oblique traction. *J Bone Joint Surg Am*. 1979 Mar;61(2):260-2.
12. Jupiter JB, Hastings H 2nd, Capo JT. The treatment of complex fractures and fracture-dislocations of the hand. *Instr Course Lect*. 2010;59:333-41.
13. Culp RW, Johnson JW. Arthroscopically assisted percutaneous fixation of Bennett fractures. *J Hand Surg Am*. 2010 Jan;35(1):137-40.
14. Zemirline A, Lebailly F, Taleb C, et al. Arthroscopic assisted percutaneous screw fixation of Bennett's fracture. *Hand Surg*. 2014;19(2):281-6.
15. Liverneaux PA, Ichihara S, Hendriks S, et al. Fractures and dislocation of the base of the thumb metacarpal. *J Hand Surg Eur Vol*. 2015 Jan;40(1):42-50.
16. Day CS, Stern PJ. Fractures of the metacarpals and phalanges. *In: Green DP, Wolfe SW (eds): Green's Operative Hand Surgery* (6th ed). Philadelphia: Elsevier, Churchill Livingstone, 2011, pp. 239-290.
17. Imaeda T, An KN, Cooney WP 3rd. Functional anatomy and biomechanics of the thumb. *Hand Clin*. 1992 Feb;8(1):9-15.
18. Cooney WP 3rd, Chao EY. Biomechanical analysis of static forces in the thumb during hand function. *J Bone Joint Surg Am*. 1977 Jan;59(1):27-36.
19. Billing L, Gedda KO. Roentgen examination of Bennett's fracture. *Acta Radiol*. 1952 Dec;38(6):471-6.
20. Gedda KO. Studies on Bennett's fracture; anatomy, roentgenology, and therapy. *Acta Chir Scand Suppl*. 1954;193:1-114.
21. Cannon SR, Dowd GS, Williams DH, Scott JM. A long-term study following Bennett's fracture. *J Hand Surg Br*. 1986 Oct;11(3):426-31.
22. Livesley PJ. The conservative management of Bennett's fracture-dislocation: a 26-year follow-up. *J Hand Surg Br*. 1990 Aug;15(3):291-4.
23. Capo JT, Kinchelov T, Orillaza NS, et al. Accuracy of fluoroscopy in closed reduction and percutaneous fixation of simulated Bennett's fracture. *J Hand Surg Am*. 2009 Apr;34(4):637-41.
24. Greeven AP, Hammer S, Deruiter MC, et al. Accuracy of fluoroscopy in the treatment of intra-articular thumb metacarpal fractures. *J Hand Surg Eur Vol*. 2013 Nov;38(9):979-83.
25. Cullen JP, Parentis MA, Chinchilli VM, et al. Simulated Bennett fracture treated with closed reduction and percutaneous pinning. A biomechanical analysis of residual incongruity of the joint. *J Bone Joint Surg Am*. 1997 Mar;79(3):413-20.
26. Salgeback S, Eiken O, Carstam N, et al. A study of Bennett's fracture. Special reference to fixation by percutaneous pinning. *Scand J Plast Reconstr Surg*. 1971;5(2):142-8.
27. Spangberg O, Thorten L. Bennett's fracture. A method of treatment with oblique traction. *J Bone Joint Surg Br*. 1963 Nov;45(4):732-6.
28. Leclere FM, Jenzer A, Husler R, et al. 7-year follow-up after open reduction and internal screw fixation in Bennett fractures. *Arch Orthop Trauma Surg*. 2012 Jul;132(7):1045-51.
29. Timmenga EJ, Blokhuis TJ, Maas M, et al. Long-term evaluation of Bennett's fracture. A comparison between open and closed reduction. *J Hand Surg Br*. 1994 Jun;19(3):373-7.
30. Lutz M, Sailer R, Zimmermann R, et al. Closed reduction transarticular Kirschner wire fixation versus open reduction internal fixation in the treatment of Bennett's fracture dislocation. *J Hand Surg Br*. 2003 Apr;28(2):142-7.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.