

7-year follow-up after open reduction and internal screw fixation in Bennett fractures

Franck Marie Patrick Leclère · Achat Jenzer ·
Rolf Hüsler · David Kiermeir · Dietmar Bignion ·
Frank Unglaub · Esther Vögelin

Received: 9 January 2012 / Published online: 22 March 2012
© Springer-Verlag 2012

Abstract

Background Bennett fractures are unstable, and, with inadequate treatment, lead to osteoarthritis, weakness and loss of function of the first carpometacarpal joint. This study focuses on long-term functional and radiological outcomes after open reduction and internal fixation.

Methods Between June 1997 and December 2005, 24 patients with Bennett fractures were treated with open reduction and internal fixation with screws at our center. Radiological and functional assessments including range of motion of the thumb and pinch and grip strength were performed 4 months post-procedure and at the long-term follow-up, on average 83 months after surgery.

Results Reduction of the Bennett fracture was maintained as it was at the time of the procedure in 96 % of the cases when fixation with two lag screws was performed. At the 4-month follow-up, mean pinch and grip strength reached 92 ± 3 and 89 ± 4 % of the contralateral side, respectively. Long-term follow-up demonstrated no correlation between the accuracy of the fracture reduction and the development of post-traumatic arthritis.

Conclusion Good clinical results could be observed, if successful reduction of the fracture was achieved and

maintained. However, there was no correlation between the accuracy of the fracture reduction considering a gap and step < 2 mm and the development of arthritis.

Keywords Bennett fracture · Thumb · Open reduction · Traumatic arthritis

Introduction

Although described as early as in 1882 by Bennett [1], the intra-articular fracture of the base of the first metacarpal remains a therapeutic challenge for hand surgeons [2]. Its prevalence accounts for around one-third of all fractures of the first metacarpal in adults [3], predominates in adult males and usually occurs in the dominant hand [4]. Of significance in the Bennett fracture is the volar oblique ligament (beak ligament), which inserts at the base of the first metacarpal and opposes the action of the abductor pollicis longus (APL). When a fracture occurs, the fragment remains attached to this strong ligament, whereas the pull of the APL tendon, extensor pollicis brevis and longus tendons dislocate the remainder of the metacarpal dorsally, radially and proximally [5, 6].

Many treatments have been described for the treatment of Bennett fractures, including closed reduction with percutaneous pinning, open reduction with either pins or interfragmentary fixation, oblique traction pinning and external fixation [2, 7–9]. Recently, Culp and Johnson [10] also described an arthroscopically assisted percutaneous fixation of these fractures. Irrespective of the technique used, a correction as accurate as possible should be obtained to reduce the risk of osteoarthritis in the long-term.

Despite the number of short-term series and numerous treatments described in the literature, there is still a lack of

F. M. P. Leclère and A. Jenzer contributed equally to this study.

F. M. P. Leclère (✉) · A. Jenzer · R. Hüsler · D. Kiermeir ·
D. Bignion · E. Vögelin
Department of Plastic and Hand Surgery, University Hospital,
Inselspital University of Bern, 3010 Bern, Switzerland
e-mail: franckleclere@yahoo.fr

F. Unglaub
Department of Hand Surgery, Vulpiusklinik, Bad Rappenau,
Medical Faculty Mannheim, Mannheim, Germany

mid- and long-term follow-up studies of open reduction in Bennett fractures [11], which leave open the potential issue of early onset osteoarthritis. This study aims at assessing a 7-year outcomes after surgical treatment of Bennett fractures with open reduction and large screw fixation, with focus on the correlation between the accuracy of the fracture reduction and the development and/or the aggravation of arthritis.

Materials and methods

Patients

This retrospective study was performed following the ethical guidelines of the University of Bern and conducted on 28 patients. Inclusion criteria were: patients with a Bennett fracture, of all ages, of both sexes, operated on between June 1997 and October 2005 in our department. Exclusion criteria were the following: additional injury to the wrist, collagen disease, rheumatoid arthritis, osteomalacia and previous fracture of the first metacarpal bone. The patients, 5 women and 19 men, had a mean age of 40.1 years at the time of surgery (range of 24–64 years). There were 20 patients with injured dominant hands and 4 with non-dominant hands. Four patients were lost to follow-up about 2 months after surgery.

Bennett fracture

As reported in Table 1 and according to Gedda [6], Bennett fractures were classified into three types. Ten patients presented with Gedda Type 1 and 14 with Gedda Type 2 fractures. There was no Gedda Type 3 in our series.

Surgical technique

Patients were operated under tourniquet on average 1.4 days and never more than 6 days after trauma. The procedure was performed using a longitudinal incision over the dorso-radial aspect of the first metacarpal and radiopalmarly curved at the CMC I joint. The superficial radial nerve was identified and preserved. The joint capsule was exposed between the APL tendon and the radial palmar insertion of the thenar muscles.

Table 1 Gedda's classification

Types	Description
I	Intra-articular fragment with subluxation of the metacarpal
II	Fracture through the palmar tip without dislocation or subluxation of the metacarpal
III	Small avulsion fragments, the trapeziometacarpal joint is dislocated

The thenar muscles were partially released subperiosteally and retracted in the palmar direction. The joint capsule was incised transversely to visualize the joint surfaces. Reduction was performed using an inside-out technique: A drill hole of 1.1 mm was placed centrally in the Bennett fragment. The corresponding hole was drilled opposite at the base of the supinated metacarpal with the 1.1-mm drill; The fracture was reduced by pronation of the metacarpal and held with reduction forceps and fixed with an additional 1.0 K-wire. Both drill holes of the Bennett fragment and the metacarpal were conjoined and the core hole of the metacarpal prepared with the 1.3- or 1.5-mm drill bit. The lag screw was then passed over the pre-drilled hole from the metacarpal bone to the Bennett fragment. 1.3- or 1.5-mm lag screws (Synthes, Oberdorf, Switzerland) were used for fixation. A second screw was placed more distally in the outside-in technique and the K-wire removed. Post-operatively, the patients were immobilized in a cast for 2 weeks. The average time required for the procedure was 79 min (range of 20–150 min).

Objective assessment

A clinical checkup was performed 4 months post-procedure and at the long-term follow-up, on average 83 months after surgery. This included the assessment of range of motion of the thumb and pinch and grip strength. Grip strength was measured using the Jamar dynamometer (level 2).

The pre- and post-operative standard two planes X-rays were assessed for signs of arthritis in the carpometacarpal (CMC) joint and the scapho-trapezo-trapezoidal (STT) joint. The patients were then radiologically controlled at 4 months post-procedure (Figs. 1, 2) and at the long-term follow-up. Two independent surgeons not involved in the surgical procedure reviewed the X-rays with respect to the reduction of the joint surface. The results were classified according to the presence and extent of a gap or step. Arthritis was scored according to the arthritis classification of the CMC I joint by van Niekerk and Ouwens' [12] modification of the Eaton and Littler classification [13]. During the 4-month and last checkup, patients were examined with an image intensifier in order to more precisely evaluate the joint surfaces. The difference in magnification between the image intensifier and the X-ray was taken into account by positioning a 1 mm K-wire on the image intensifier exposure, which was then used as an exact reference for the measurement. The step or gap in the image intensifier was measured and the difference in size correlated.

Subjective assessment

At the long-term follow-up checkup, patients were asked to score the pain on a visual scale (VAS: 0 = no pain; 10 = excruciating pain). Moreover, a grind test was performed

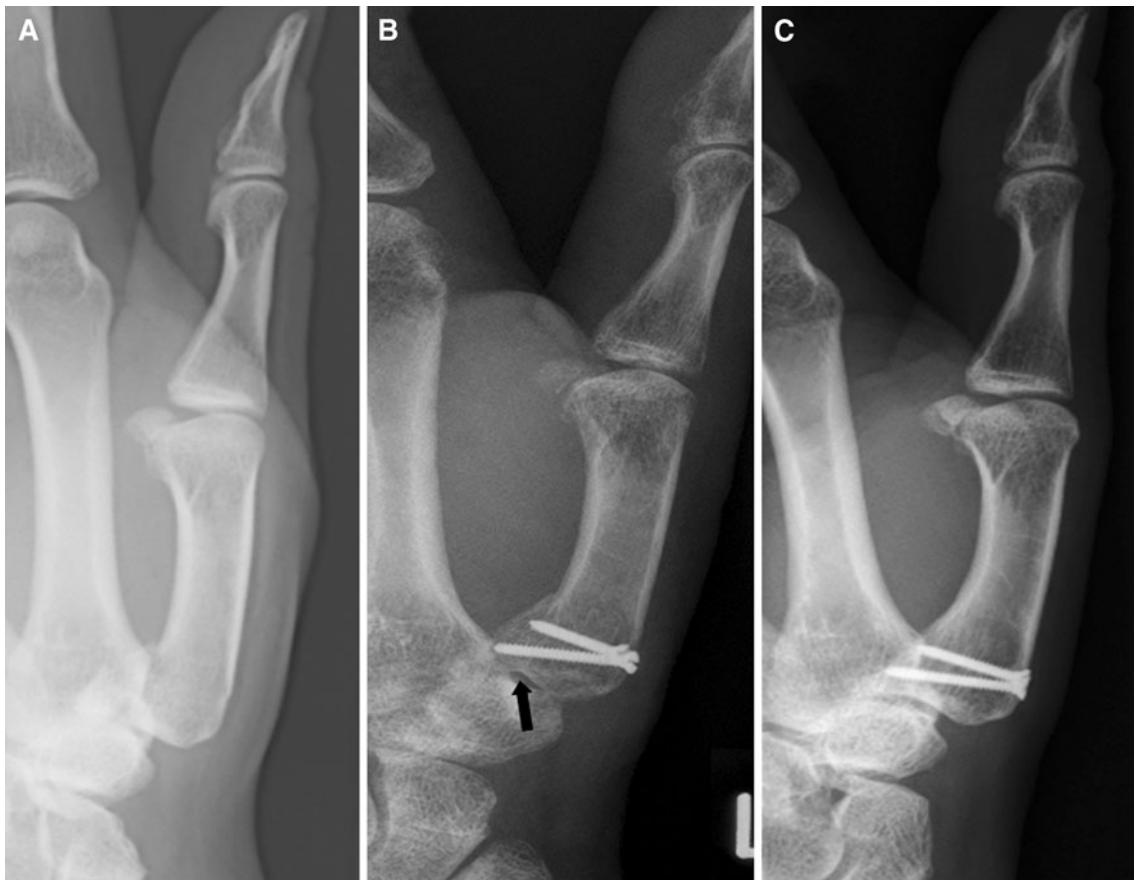


Fig. 1 Examples of a Gedda Type II fracture: pre-operative (a), 4 months (b) and 71 months (c) after operation. The step presents in (b black arrow) has been completely remodeled with time



Fig. 2 Example of gap with no step (black arrow)

in order to mimic everyday stress exerted on the joint (0–10). The patients were asked if their daily life or sports activity had been negatively impacted as a consequence of the procedure.

Statistical analysis

The mean follow-up was 83.4 ± 27.6 months after surgery (54–154 months follow-up). End point of the study was April 2010. Radiological and functional assessments including range of motion of the thumb and pinch and grip strength were performed 4 months after the operation and during the long-term follow-up, on average 83 months after surgery. Data are presented as mean. Student's test (two samples) is used to calculate the *P* values, and $P < 0.05$ is considered to be statistically significant (Table 2).

Results

24 patients with Bennett fracture were controlled. Among them 21 patients did not present arthritis in the pre-operative X-rays, whereas arthritis stage II of the CMC joint was pre-operatively diagnosed in three patients.

Table 2 Comparison of the functional results in our series

	4 months	83 months	<i>P</i> values
Palmar abduction*/radial abduction** of the thumb (mean)	88-0-7°	93-0-5°	0.2158* 0.8262**
MP flexion*/extension** of the thumb (mean)	55-0-12°	59-0-6°	0.3125* 0.2405**
IP flexion*/extension** of the thumb (mean)	72-0-21°	67-0-31°	0.6178* 0.1019**
Intermetacarpal angle (mean)	37.7°	34.5°	0.0537
Grip strength (kg)	40.9	48.6	0.013
Pinch strength (kg)	10.1	10.2	0.8809

*indicate MP flexion

**indicate MP extension

p* value for MP flexion is 0.3125*p* value for MP extension is 0.2405

Complications

There were no infections or development of a complex regional pain syndrome. In one patient, reduction was lost with a dorso-radial subluxation of the trapeziometacarpal joint with only two-thirds of the trapeziometacarpal joint surfaces remaining congruent. In this case, the Bennett fragment was initially reduced with only one lag screw, leading to secondary dislocation 9 weeks after surgery. Revision surgery using a plate and screws was unsuccessful because of plate failure and questionable patient compliance. This patient ended up with the worst overall results with respect to range of motion and pain when compared with the other patients at the long-term follow-up.

4-month checkup

The functional results at the 4-month follow-up are reported in Table 2. The palmar abduction/radial abduction of the thumb was on average 88-0-7°. The intermetacarpal angle between the first and second ray, using the Lister tubercle as the pivot point, measured on average $37.7 \pm 2^\circ$. The MP and IP joints flexion/extension range was on average 55-0-12° and 72-0-21°, respectively. The pinch strength averaged 10.1 kg, which corresponded to

$92 \pm 3\%$ of the unaffected side. The mean grip strength was 40.9 kg or $89 \pm 4\%$ of the unaffected side.

The radiological results are listed in Table 3 (Figs. 1, 2). Of the 21 patients with no pre-operative signs of CMC joint arthritis, anatomical reduction was achieved in 10 (48 %) patients. Reduction with a joint surface step with <1 mm but without a gap was achieved in seven patients (33 %). A joint surface gap of <1 mm and without a step was present in three patients (14 %). A 1-mm joint surface step and gap was seen in one patient (5 %).

In the three patients with pre-operative arthritis, one was reduced anatomically, one showed a gap (<1 mm) with no step and one a step (<1 mm) with no gap.

Long-term follow-up

Neither joint instability nor hypesthesia in the area around the scar was found. As reported in Table 2, the functional results were slightly improved at the time of the last checkup, but there was no statistical difference with the 4-month follow-up.

No screw dislocation or loosening was observed in all of the 24 patients. The gap and steps disappeared over time with restoration of the anatomy due to the phenomenon of remodeling (Tables 3, 4). The only patient showing a joint surface incongruence was the one in whom the initial reduction had been lost and who now presented with a joint surface step of 2 mm and no gap.

Despite a complete remodeling of the joint surfaces at the 4-month follow-up in all but one case, we found signs of arthritis in ten of the cases (Table 5). In three patients, osteoarthritis Grade II [12] was present initially and did not worsen. For the seven other patients, arthritis Grade II (six patients) or III (one patient) developed after surgery. Only one patient, who was initially anatomically reduced, developed trapeziometacarpal arthritis. The arthritis always developed in the dominant hand. The patients who developed arthritis were not manual workers.

Subjective assessment

The average VAS score was 1.4 ± 0.4 . There was no statistical difference between the arthritis and non-arthritis

Table 3 Radiological remodeling over time

	Step/no gap		Gap/no step		Gap and step	
	4 months	83 months	4 months	83 months	4 months	83 months
<1 mm	7	0	3	–	–	–
1–2 mm	–	–	–	–	1	–
≥2 mm	–	1	–	–	–	–
Total	7	1	3	0	1	0

Table 4 Radiological joint remodeling in the 21 patients without pre-existing CMC joint arthritis

Follow-up	4 months	83 months
Anatomical	10	20
Step/no gap	7	1
Gap/no step	3	0
Gap and step	1	0

group ($P = 0.7$). The mean grind test was 0.8 ± 0.3 in the non-arthritis group ($n = 14$) compared to 1.8 ± 0.5 in the arthritis group ($n = 10$). Considering pain during the grind test, there was no statistical difference between the arthritis and non-arthritis group ($P < 0.01$). All but one patient was able to practice daily life and sports activity at the same level as before surgery.

Discussion

As shown in the numerous articles published, the intra-articular fracture of the base of the first metacarpal is still a therapeutic challenge for hand surgeons [2, 14]. In his original article, Bennett [1] described treating two patients with a 4-week cast immobilization. Although the closed reduction remained the preferred method of treatment until the 1970s, many studies have shown unsatisfactory functional results with this therapy [15]. Surgical treatment is varied and includes closed reduction with percutaneous pinning or open reduction with either pins or interfragmentary fixation. The literature has shown that good clinical results, independent of the operative procedure employed, can be observed, if successful reduction of the fracture was achieved and maintained [2]. Culp and Johnson [10] advocate the assistance of endoscopy to best reduce the fracture. The portals used are 1R (just radial to

the APL tendon at the level of the CMC joint) and 1U (just ulnar to the extensor pollicis brevis tendon, at the level of the CMC joint) [10, 16]. In our series, the initial reduction was maintained in 96 % of cases. This is a marked difference with the published literature, with reported loss of reduction in ~ 30 % of cases, irrespective of the technique used [3, 17, 18]. This loss of reduction has also led some authors to consider other techniques such as tension band wiring [19]. But the wire loop used to lasso the Kirschner wire may conflict with the articular surfaces and lead to an increased incidence of osteoarthritis in the long-term. Furthermore, the wires and the K-wire are more prominent than screws and can easily provoke soft tissue or superficial radial nerve irritation. In the one patient in our series for whom reduction was lost, only one lag screw was used to hold the reduction, illustrating the fact that at least two screws be used to maintain the reduction, if possible. Furthermore, by using two screws, the rotational stability of the reduced fragment can be better secured. This reduction allowed a proper joint stability and a significant improvement of the grip and pinch strength, which reached 89 and 92 % of the contralateral side, respectively.

In the long run, however, there was no significant correlation between the accuracy of reduction considering a step or gap < 2 mm and the development of post-traumatic arthritis. Despite a complete remodeling of the joint surfaces in all but one case, signs of arthritis were found in ten of the cases. Cullen et al. [20] suggested that there is no predisposition to post-traumatic arthritis in the trapezio-metacarpal joint after a Bennett fracture, which has healed with a 2-mm step in the articular surface. He suggested that the reduction of the metacarpal shaft to the trapezium and the beak fragment should be the priority in treatment. If our findings appear contradictory to the assertions of Cullen et al. [20], however, this can be easily explained by the following two arguments:

Table 5 Initial type of fracture and quality of reduction in patients with arthritis at the long-term follow-up

N	Fracture type	Arthritis	4-month checkup		8-month checkup	
			Reduction	Arthritis	Reduction	Arthritis
1	II	II	Anatomically reduced	II	Anatomically reduced	II
2	II	II	Gap and no step	II	Anatomically reduced	II
3	II	II	Step and no gap	II	Anatomically reduced	II
4	II	–	Step and no gap	–	Anatomically reduced	II
5	I	–	Step and no gap	–	Anatomically reduced	II
6	II	–	Step and no gap	–	Anatomically reduced	II
7	II	–	Step and no gap	–	Anatomically reduced	II
8	II	–	Gap and secondary dislocation	–	Secondary dislocation	III
9	II	–	Gap and no step	–	Anatomically reduced	II
10	I	–	Anatomically reduced	–	Anatomically reduced	II

- (1) Cullen made his conclusion after a mechanical study on cadavers, and it is possible that in a clinical situation, the results would have been different. In this context, it is important to remember that other studies set the limit at 1 mm [21]. In our studies, the seven patients who developed signs of arthritis were adequately reduced with a gap and step of 2 mm or less. However, only one patient who was anatomically reduced developed arthritis. According to our results, it may be postulated that small joints like the trapeziometacarpal joint are less tolerant to joint surface imperfections compared to larger joints, even if this observation has little or no clinical significance. In this context, it would be meaningful to evaluate the use of low intensity pulsed ultrasound bone stimulators (LIPUS) on this small joint fracture. In their critical review of the literature, Riboh and Leversedge [22] have suggested that the evidence supporting LIPUS for the treatment of acute fractures might, in fact, be better than that evaluating its use for the treatment of delayed unions or non-unions of fractures, based on a comparison of the relative quality of study methodologies and fracture union rates.
- (2) A second hypothesis is that the development of arthritis in our series was not post-traumatic but degenerative. Cannon et al. [21] made the hypothesis that if little displaced fractures do go on to develop symptomatic arthritic changes, a significant number should be present to the surgeon in middle life for surgical treatment. In his review of 456 patients operated for arthritis of the first carpometacarpal joint, only 7 out of 456 patients had arthritis associated with a Bennett fracture. In other words, in most of the patient, arthritis was degenerative and not post-traumatic.

Despite the long-term outcomes, our series presents both methodological and technical limits:

- (1) First, the diversity of surgeons makes the series not homogeneous, although this is offset by the standardization of the technique of the same surgical school, as confirmed by the overall good results in terms of reduction.
- (2) Second, with the small case number in this series, the correlation of post-operative joint incongruence and the development of post-traumatic arthritis in the trapeziometacarpal joint remain unclear.
- (3) Third, because it is ethically difficult to justify, we do not perform a CAT scan to evaluate the joint reduction and arthritis. The CAT scan remains, however, the gold standard in evaluating joint surface details. In this context, it has to be born in mind that Capo et al. [23] underlined how fluoroscopic and

plain radiographic evaluation can be erroneous in assessing incongruities in joint reduction compared to direct measurement in a simulated Bennett fracture. For this reason, we tried to objectively assess the image intensifier results with the positioned K-wire.

- (4) Finally, the absence of a control group did not allow us to compare the long-term outcomes of our technique with other surgical approaches. However, our overall results in terms of reduction are a marked difference to the published literature, with reported loss of reduction in ~30 % of cases whatever the technique used [3, 17, 18].

Conclusion

Good clinical results could be observed, if successful reduction of the fracture was achieved and maintained. However, there was no correlation between the accuracy of the fracture reduction considering a gap and step <2 mm and the development of arthritis.

Conflict of interest There are no conflicts of interest.

References

1. Bennett EH (1882) Fractures of the metacarpal bones. *Dublin J Med Sci* 73:72–75
2. Carlsen BT, Moran SL (2009) Thumb trauma: Bennett fractures, Rolando fractures, and ulnar collateral ligament injuries. *J Hand Surg Am* 34:945–952
3. Hove LM (1993) Fractures of the hand. Distribution and relative incidence. *Scand J Plast Reconstr Surg Hand Surg* 27:317–319
4. Dial WB, Berg E (1972) Bennett's fracture. *Hand* 4:229–235
5. Demir E, Unglaub F, Wittemann M, Germann G, Sauerbier M (2006) Surgically treated intraarticular fractures of the trapeziometacarpal joint—a clinical and radiological outcome study. *Unfallchirurg* 109:13–21
6. Gedda KO (1954) Studies on Bennett's fracture; anatomy, roentgenology, and therapy. *Acta Chir Scand Suppl* 193:1–114
7. Lutz M, Sailer R, Zimmermann R, Gabl M, Ulmer H, Pechlaner S (2003) Closed reduction transarticular Kirschner wire fixation versus open reduction internal fixation in the treatment of Bennett's fracture dislocation. *J Hand Surg Br* 28:142–147
8. Surzur P, Rigault M, Charissoux JL, Mabit C, Arnaud JP (1994) Recent fractures of the base of the 1st metacarpal bone. A study of a series of 138 cases. *Ann Chir Main Memb Super* 13:122–134
9. Fornander P, Kongsholm J (1990) Simultaneous Bennett's and distal radius fractures treated with external fixation. *Acta Orthop* 61:84–85
10. Culp RW, Johnson JW (2010) Arthroscopically assisted percutaneous fixation of Bennett fractures. *J Hand Surg Am* 35:137–140
11. Timmenga EJ, Blokhuis TJ, Maas M, Raaijmakers EL (1994) Long-term evaluation of Bennett's fracture. A comparison between open and closed reduction. *J Hand Surg Br* 19:373–377
12. van Niekerk JL, Ouwens R (1989) Fractures of the base of the first metacarpal bone: results of surgical treatment. *Injury* 20:359–362

13. Eaton RG, Littler JW (1969) A study of the basal joint of the thumb. Treatment of its disabilities by fusion. *J Bone Joint Surg Am* 51:661–668
14. Strömberg L (1977) Compression fixation of Bennett's fracture. *Acta Orthop* 48:586–591
15. Livesley PJ (1990) The conservative management of Bennett's fracture-dislocation: a 26-year follow-up. *J Hand Surg Br* 15: 291–294
16. Furia JP (2010) Arthroscopic debridement and synovectomy for treating basal joint arthritis. *Arthroscopy* 26:34–40
17. Kjaer-Petersen K, Langhoff O, Andersen K (1990) Bennett's fracture. *J Hand Surg Br* 15:58–61
18. Gedda KO, Moberg E (1952) Open reduction and osteosynthesis of the so-called Bennett's fracture in the carpo-metacarpal joint of the thumb. *Acta Orthop Scand* 22:249–257
19. Zhang X, Shao X, Zhang Z, Wen S, Sun J, Wang B (2012) Treatment of a Bennett fracture using tension band wiring. *J Hand Surg Am*
20. Cullen JP, Parentis MA, Chinchilli VM, Pellegrini VD Jr (1997) Simulated Bennett fracture treated with closed reduction and percutaneous pinning. A biomechanical analysis of residual incongruity of the joint. *J Bone Joint Surg Am* 79:413–420
21. Cannon SR, Dowd GS, Williams DH, Scott JM (1986) A long-term study following Bennett's fracture. *J Hand Surg Br* 11: 426–431
22. Riboh JC, Leversedge FJ (2011) The use of low-intensity pulsed ultrasound bone stimulators for fractures of the hand and upper extremity. *J Hand Surg Am* (Epub Oct 24)
23. Capo JT, Kinchelow T, Orillaza NS, Rossy W (2009) Accuracy of fluoroscopy in closed reduction and percutaneous fixation of simulated Bennett's fracture. *J Hand Surg Am* 34:637–641