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Original article

Bennett's fracture: Comparative study between open and closed surgical techniques

Fracture de Bennett : étude comparative entre ostéosynthèse directe et ostéosynthèse percutanée

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ABSTRACT

The aim of this study was to assess long-term outcomes of surgically treated Bennett fractures, while comparing open reduction and internal fixation (ORIF) with closed reduction and percutaneous fixation (CRPF). Patients treated between 1994 and 2010 were assessed retrospectively during an outpatient visit using a validated questionnaire (i.e. DASH, pain assessed through VAS), sensory testing, grip- and pinch-strength and radiographic analysis for post-traumatic arthritis. Fifty patients were included. Mean follow-up was 10 years. Mean age at trauma was 34 years. ORIF was used in 35 patients. CRPF was used in 15 patients. No differences in grip- and pinch-strength were found. Re-operations were needed in five ORIF-treated patients. Higher Pain Scores (VAS) were seen in the ORIF-treated patients. No correlation was found between surgical technique and functional outcomes. A persistent step-off or gap larger than 2 mm after surgical fixation was significantly correlated with post-traumatic arthritis at 10 years' follow-up. The need to perform ORIF for anatomical reduction seems to be less important in preventing post-traumatic arthritis as a persistent step-off or gap of more than 2 mm was found to be significantly correlated with the development of post-traumatic arthritis. Secondly, both techniques lead to good functional outcomes, although persistent pain was seen in the ORIF-treated patients. Bennett fractures can therefore be safely treated with CRPF when the persistent step-off and gap after fixation do not exceed 2 mm.

Level of evidence: Therapeutic study, Level III.

Mots clés :
Fracture de Bennett
Traitement chirurgical
Reduction et ostéosynthèse à foyer ouvert
Ostéosynthèse percutanée
Arthrose post-traumatique

RÉSUMÉ

L'intérêt de ce travail était d'évaluer les résultats du traitement chirurgical de la fracture de Bennett par réduction et ostéosynthèse à foyer ouvert et ostéosynthèse percutanée. Il s'agissait d'une étude rétrospective de 50 cas de fracture de Bennett traitée par réduction et ostéosynthèse à foyer ouvert (ORIF) ou réduction et ostéosynthèse percutanées (CRPF), entre janvier 1994 et décembre 2010. Au recul moyen de 10 ans, tous les 50 patients ont pu être suivis, l'évaluation des résultats était basée sur le score DASH, la douleur évaluée sur une échelle visuelle analogique (EVA), la force de poigne et de pince et sur des critères radiologiques après l'analyse des radiographies spécifiques de la trapézo-métacarpienne. L'ORIF a été utilisée chez 35 patients et la CRPF a été utilisée chez 15 patients. Aucune différence clinique dans la force de poigne et de pince n'a été constatée. Des scores de douleur élevés (EVA) ont été seulement observés après ORIF. Une marche d'escalier ou un écart interfragmentaire supérieur à 2 mm

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était significativement corrélé à l'arthrose post-traumatique. Parce qu'une marche d'escalier ou un écart interfragmentaire supérieur à 2 mm était significativement corrélé à l'arthrose post-traumatique, la réduction anatomique par ORIF semble moins importante dans la prévention de l'arthrose post-traumatique. Les deux techniques donnent des bons résultats fonctionnels, bien que la persistance de douleur ait été observée chez les patients traités par ORIF. La réduction avec ostéosynthèse percutanée est donc la technique préférée dans le traitement de la fracture de Bennett si une marche d'escalier ou un écart interfragmentaire ne dépasse pas 2 mm.

1. Introduction

Fractures at the base of the first metacarpal are classified using the 1972 Green and O'Brien classification. Five fractures have been defined: Bennett's fracture, Rolando's fracture, transverse extra-articular, oblique extra-articular and epiphyseal (Fig. 1) [1].

Bennett's fracture is named after Edward Hallaran Bennett, professor of surgery (1837–1907), who first described it in 1882 [2]. The specific fracture he described "passed obliquely across the base of the bone, detaching the greater part of the articular surface; the piece of bone that was resting on this surface was projected toward the palm of the hand. The separated fragment was very large, and the deformity that resulted therefrom seemed more a dorsal subluxation of the first metacarpal".

This specific fracture-dislocation occurs as a result of the abductor pollicis longus muscle and adductor pollicis muscle displacing the larger fracture fragment, i.e. the first metacarpal shaft. The smaller, volar fracture fragment is transfixed to the palmar oblique ligament. Abduction of the first metacarpal shaft within the CMC joint and adduction of the first metacarpal shaft towards the second metacarpal result in an unstable fracture.

In the 1950's the first reports were published showing better results when this unstable fracture is treated surgically [3,4]. In the following years, several surgical techniques have been described and new techniques have been introduced [1,4–12].

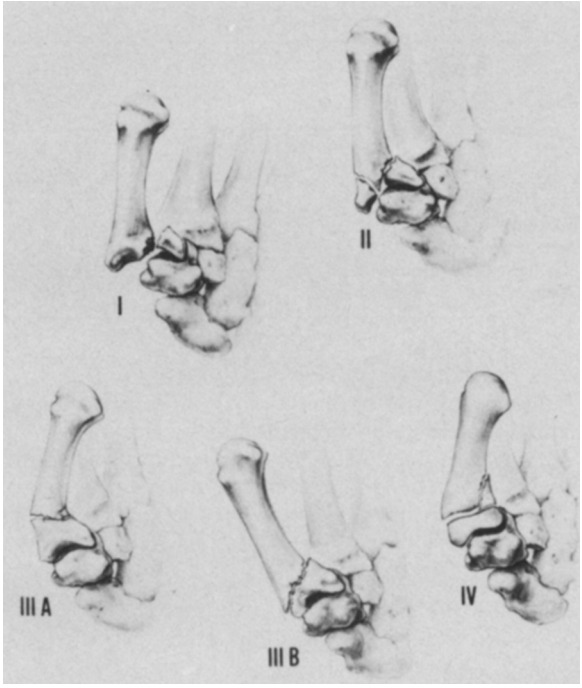

Fig. 1. Classification of first metacarpal base fractures (reprinted with kind permission of Elsevier from Van Niekerk and Ouwens [1]).

Open reduction and internal fixation (ORIF) is reported to give good results and has the advantage of anatomically reducing the fracture under direct vision [6,13,14]. Anatomical reduction aims to prevent post-traumatic arthritis [15]. Another advantage of ORIF is the possibility of early mobilization [16].

Closed reduction and percutaneous fixation (CRPF) is also reported to give good clinical results [1,7]. During CRPF, fluoroscopy is used to assess fracture reduction. One study suggested fluoroscopy was inadequate to assess step-offs and gaps during closed surgery [17]. Consequently, arthroscopy-assisted surgery or ORIF was suggested for this fracture [8]. Fortunately, a more recent study confirmed that fluoroscopy can be safely used to assess step-offs and gaps in the closed surgical treatment of intra-articular fractures at the base of the first metacarpal [18].

Currently, there is no consensus as to which type of surgery should be used for treating Bennett fractures. One reason for the ongoing debate is the assumption that anatomical reduction prevents the development of post-traumatic arthritis. Some authors suggest a relationship while others were not able to correlate the accuracy of fracture reduction with post-traumatic arthritis [6,7,15,19]. To improve anatomical reduction, arthroscopy-assisted percutaneous techniques have been proposed to combine viewing of anatomical reduction with minimally invasive techniques [8,20].

Lack of consensus also exists regarding the best surgical treatment, as most outcomes are based on research of a single technique or very small groups of patients at short term follow-up [21,22]. This paucity in evidence means there is a need to evaluate ORIF and CRPF in a large group of patients, after a long follow-up period in which post-traumatic changes have likely occurred and long-term complications can be detected [23]. Therefore, the purpose of the current study was to evaluate clinical and radiological outcomes and report complications at the 10-year follow-up of Bennett fractures treated by ORIF or CRPF.

2. Patients and methods

2.1. Study design

This retrospective study was performed in two Level I trauma centers, after both hospitals' research ethics committees approved reviewing all treated patients with Bennett fractures between 1994 and 2010. Procedures were performed in accordance with the 1975 Declaration of Helsinki.

An electronic search of the Digital Patients Medical Database was performed using diagnostic codes, treatment codes and (erroneous) spelling varieties of "Bennett". Only patients treated between 1994 and 2010 were included to guarantee long-term follow-up. All medical records were screened for eligibility (i.e. no other hand injuries). Previous radiological examinations were assessed to confirm the presence of Bennett fractures. Inclusion criteria were Bennett fractures (Gedda type I) surgically treated with K-wire fixation or ORIF; minimum age of 15 years at the time

of injury [24]. Patients who did not meet the inclusion criteria were excluded. When patients met all the inclusion criteria, they were invited to return the outpatient clinic. Baseline characteristics were compiled from the patient's medical record together with any additional injuries and the type of surgery performed.

2.2. Outcome assessment

During the outpatient assessment, subjective hand strength was determined using a Scale from 0 to 10 to Score the patient's self-reported strength in comparison with strength before the injury event. To evaluate pain, we used a Visual Analog Scale (VAS) ranging from 0 cm (no pain) to 10 cm (worst imaginable pain). Post-operative complications and re-operations were documented.

Sensory examination of the radial side of the operated thumb was compared with the patient's non-injured hand and classified as normal intact sensation, tingling or numbness.

Grip- and pinch-strength of both hands was assessed. Grip- and pinch-strength were expressed in kilograms (Baseline® Hydraulic Hand Dynamometer and Baseline® Mechanical Pinch Gauge, Fabrication Enterprises, White Plains, NY, USA). The mean of three separate measurements was recorded for each hand. A percentage was calculated to compare the pinch- and grip-strength between the injured and non-injured hand. The minimal clinically important difference (MCID) was set at 20%, compared with the pinch- and grip-strength of the contralateral side and adjusted for hand dominance [7,25].

Radiographic images were taken in two separate view to evaluate post-traumatic arthritis of the first carpometacarpal joint using the Van Niekerk and Owens modifications of the Eaton and Littler classification: stage I – no clear arthritic changes; stage II – osteophytes smaller than 2 mm; stage III – osteophytes larger than 2 mm or joint narrowing and stage IV – joint space more or less disappeared [1,26].

All radiographs were examined by two researchers (SK and TG, Consultants in Orthopedic Trauma Surgery, Level of Experience III and IV respectively). If no consensus was reached, a third researcher had the deciding vote (MV, Consultant Trauma Surgeon, Level of Experience V) [27].

2.3. Statistical analysis

All statistical tests and comparisons were performed by one of the authors, a professional in biomedical statistics. Normality of data was evaluated using a Shapiro–Wilk test. Continuous data are shown as mean with standard deviation (if normally distributed) or as median with P_{25}–P_{75} (if non-normal). Categorical data are shown as counts with percentage. Statistical significance of the difference between the ORIF and CRPF groups was tested using Student's *t*-test or the Mann–Whitney *U*-test (if normal or non-normal, respectively) or using a Chi^2 or Fisher's exact test (for categorical variables). Correlation between outcome Scores was tested using a Spearman rank correlation. A two-tailed *P*-value less than 0.05 was considered statistically significant.

3. Results

The electronic search of the Digital Patients Medical Database identified 83 candidate patients. After assessing the injury date, eligibility and radiological examination, 50 patients with a Gedda I fracture met the inclusion criteria and were invited for the outpatient review. All 50 patients were clinically and radiologically assessed during the outpatient review visit. Mean follow-up time was 10 (± 4) years. The average age at the time of injury was 34 (± 12) years. Forty-two patients were male and eight were female.

The dominant hand was injured in 34 patients. Mechanism of injury varied from sports injuries, motorcycle accidents and car accidents, to involvement in a fight and a fall on an outstretched hand. Medical history showed no relevant injuries or illnesses prior to the treatment of the Bennett fracture.

ORIF was performed in 35 patients and consisted of mini-fragment screw fixation through a radiopalmar approach, followed by release of the thenar muscles. CRPF was performed in 15 patients and consisted of transmetacarpal fixation between metacarpal I and II or with metacarpotrapezoidal K-wires.

The average time between the injury and surgery was 7 days; ORIF was done in 6 days and CRPF in 8 days after the injury event. Post-operative management varied from cast immobilization and removable splint to functional rehabilitation. The right side was significantly more often treated with CRPF ($P = 0.011$, Table 1).

3.1. Functional outcomes

The median DASH Score for all patients was 5 (P_{25}–P_{75} 0–8). The DASH Score was 0 for ORIF (P_{25}–P_{75} 0–6) and 4 for CRPF (P_{25}–P_{75} 0–12). Grip- and pinch-strength were good in the majority of patients in comparison to the non-injured hand for both techniques. A MCID of 20% in grip- and pinch-strength relative to the uninjured hand was found in seven patients (Table 2). Four had been treated with ORIF and three with CRPF.

In total, 11 patients reported pain at follow-up. Four patients had a pain level of 3 or higher. All 4 patients had been treated with ORIF. Statistical analysis showed a significant correlation between the DASH and Pain Score (Spearman's rho = 0.540, $P < 0.001$) and also a significant correlation between pain (VAS) and strength (Spearman's rho = −0.533, $P < 0.01$). A higher Pain Score correlated significantly with a higher DASH and lower strength.

Table 1
Overall outcomes.

Item	Overall *n* = 50	ORIF *n* = 35	CRPF *n* = 15	*P*-value
Age	34 (12)	32 (10)	39 (15)	0.123[a]
Male	42 (84)	29 (83%)	13 (87%)	1.000[b]
Right side affected	31 (62%)	26 (74%)	5 (33%)	0.011[b]
Right side dominant	41 (82%)	29 (83%)	12 (80%)	1.000[b]
Dominant side affected	16 (32%)	9 (26%)	7 (47%)	0.191[b]
Eaton–Littler CMC arthritis stage				
1	24 (48%)	19 (54%)	5 (33%)	0.078[c]
2	18 (36%)	11 (31%)	7 (47%)	
3	6 (12%)	5 (14%)	1 (7%)	
4	2 (4%)	0 (0%)	2 (13%)	
Sensory dysfunction	13 (26%)	11 (31%)	2 (13%)	0.294[b]
Re-operation	27 (54%)	12 (34%)	15 (100%)	< 0.001[b]
Pain level (VAS)	0 (0–0)	0 (0–0)	0 (0–0)	0.285[d]
DASH	0 (0–8)	0 (0–6)	4 (0–12)	0.135[d]
DASH work	0 (0–0)	0 (0–0)	0 (0–10)	0.257[d]
DASH hobbies	0 (0–10)	0 (0–6)	0 (0–16)	0.893[d]
Strength	10 (9–10)	10 (8–10)	10 (9–10)	0.949[d]
Pinch (kg) affected side	11 (9–12)	11 (10–12)	10 (8–12)	0.112[d]
Pinch (kg) contralateral side	10 (8–12)	10 (9–11)	10 (7–13)	0.86[d]
Pinch difference	0 (−1 to 1)	1 (0–1)	−1 (−1 to 0)	0.012[d]
Grip (kg) affected side	47.9 (11.0)	48.6 (10.4)	46.3 (12.7)	0.516[e]
Grip (kg) contralateral side	47.7 (11.5)	48.6 (11.0)	45.4 (12.9)	0.366[e]
Grip difference	0.2 (6.4)	−0.1 (7.1)	0.9 (4.8)	0.612[e]

ORIF: open reduction and internal fixation; CRPF: closed reduction and percutaneous fixation; CMC: carpometacarpal; DASH: disability for arm, shoulder and hand; VAS: visual analog scale.
Data are shown as mean (SD), median (P25-P75) or *n* (%).
[a] Student's *t*-test with unequal variance assumed.
[b] Fisher's Exact test.
[c] Chi^2 test.
[d] Mann-Whitney U-test.
[e] Student's *t*-test with equal variance assumed.

Table 2
Minimal clinically important difference (MCID) in pinch and grip strength.

ID	Technique	Fracture side	Hand dominance	Pain (VAS)	DASH	Work DASH	Hobby DASH	Strength (subj.)	Pinch R (kg)	Pinch L (kg)	Grip R (kg)	Grip L (kg)	Difference % pinch	Difference % grip	Arthritis Eaton-Littler stage
8	ORIF	L	R	3	4	0	0	8	12.3	10.0#	43	31#	−18.7%	−38.7%	2
10	ORIF	R	R	0	3	0	13	8	4.7#	6.0	29#	27	−27.7%	6.9%	2
18	CRIF	L	R	0	0		0	10	6.7	2.7#	31	25#	−148%	−4%	4
29	ORIF	R	L	0	0	0	0	10	13.7	11.3#	59	52#	−21.2%	−13.5%	1
36	ORIF	L	R	6	28	19		6	11.2	9.0#	51	33#	−19.6%	−54.50%	3
41	CRIF	L	R	0	3	0	0	7	12.7	9.8#	41	41#	−29.6%	0%	2
50	CRIF	L	R	0	4	0		10	12.7	8.7#	74	73#	−31.4%	1.4%	1
							average	8							

ORIF: open reduction and internal fixation; CRPF: closed reduction and percutaneous fixation; DASH: disability for arm, shoulder and hand; VAS: visual analog scale. Minimal clinically important difference (MCID) was defined as a 20% difference versus contralateral side and adjusted for hand dominance (after Crosby et al. and Greeven et al.; 4.21), MCID larger than 20% underlined in the table.

3.2. Complications

Complications were reported in 12 (34%) ORIF treated patients and 4 (27%) CRPF-treated patients (Table 3). Loss of reduction was reported in one ORIF and one CRPF patient. Both patients were successfully re-operated with the same technique. Pin-tract infection occurred in one CRPF-treated patient who was successfully treated with oral antibiotics and K-wire removal after the fracture healed.

Sensory examination of the operated hand found normal sensation in 37 patients. Tingling was found in 4 patients and numbness in 9 patients (Table 3). Of these 13 patients, 11 were treated with ORIF and 2 had been treated with CRPF.

Seven ORIF patients (20%) were re-operated. Reasons for re-operation were loss of reduction, functional impairment and discomfort related to the fixation hardware. One CRPF patient was re-operated because of loss of reduction. All the other CRPF patients were re-operated for K-wire removal after fracture union.

3.3. Radiographs

In 13 patients, the radiographs showed Eaton–Littler Grade III or IV carpometacarpal arthritis at follow-up. Seven patients had been treated by ORIF and six patients had been treated by CRPF. There was a significant correlation between a persistent step-off or gap after surgical fixation larger than 2 mm and the development of post-traumatic arthritis (Table 4).

No statistically significant association could be found between the modified Eaton–Littler classification and reported pain (VAS), functional outcome, or treatment type. For detailed outcomes (pinch- and grip strength and Eaton–Littler classification for all 50 patients) please see the Supplement.

4. Discussion

The first important finding of our study is the significant correlation between a persistent step-off and gap of 2 mm and the development of post-traumatic arthritis. This leads us to question how much importance should be placed on anatomical reduction during surgery in an attempt to prevent these post-traumatic changes from developing [13,28]. Previous research has shown that fracture reduction after percutaneous fixation can be adequately assessed with fluoroscopy [18]. The need for anatomical reduction via ORIF or even arthroscopy might be less important since previous smaller studies also reported good outcomes when the step-off was smaller than 2 mm [15,29]. Furthermore, without the dissection associated with ORIF, patients are less at risk of developing complications such as reported in the current study. Pain was mostly seen in ORIF patients as well as re-operations because of functional impairment and complaints about the fixation hardware.

The second important finding of our study is that similar functional outcomes were found for both types of surgery after long-term follow-up. In line with previous publications with shorter follow-up, our study confirms good clinical results for ORIF as well as for CRPF for treating Bennett's fracture at 10 years of follow-up [6,7,12,13,16].

Another important finding in our study is the High Pain Scores (VAS > 3) in some ORIF patients. A higher Pain Score was significantly correlated with a higher DASH and lower strength,

Table 3
Complications at follow-up.

Surgical ID technique		Sex	Age	Injured side	Days to surgery	Re-operation	Complication(s)
ORIF (*n* = 12, 34%)	1	M	18	R	6	yes	tingling
	6	M	42	R	4	no	numbness
	9	M	19	R	2	no	numbness
	10	F	28	R	0	yes	numbness
	23	M	23	R	9	yes	tingling
	24	M	38	R	7	yes	loss of reduction/numbness
	27	M	20	L	5	yes	tingling
	30	M	45	R	2	no	numbness
	34	F	27	L	4	no	numbness
	35	F	19	R	20	yes	adhesiolysis
	38	M	22	R	10	no	tingling
	48	M	35	R	14	yes	numbness
CRPF (N = 4, 27%)	22	M	43	L	8	yes	pin-tract infection
	46	M	38	R	27	yes	numbness of thumb
	47	M	64	R	7	yes	loss of reduction
	50	M	17	L	7	yes	numbness of thumb

ORIF: open reduction and internal fixation; CRPF: closed reduction and percutaneous fixation; DASH: disability for arm, shoulder and hand; VAS: visual analog scale; M: male; F: female; R: right; L: left.

Table 4
Post-traumatic arthritis and quality of reduction.

Fracture reduction[a]		Eaton–Littler carpometacarpal arthritis stage			
		I	II	III	IV
0–2 mm	(n = 43)	12	24	6	1
> 2 mm	(n = 7)	1	0	6	0
Total	(n = 50)	13	24	12	1

Chi^2 test, P = 0.001.
[a] Step-off or gap.

which makes these findings clinically important. We are not aware of any previous research in which pain after surgical treatment of Bennett's fracture is reported at the 10-year follow-up. The reported pain was not correlated with post-traumatic arthritis (Eaton–Littler stage). Other metacarpal studies have shown a difference in complications between CRPF and ORIF techniques in the surgical treatment of second to fifth metacarpal fractures [30]. This was explained by the surgical dissection associated with ORIF resulting in a higher chance of unintended damage to vital anatomical structures [30,31]. This might be relevant to our study's findings, since all patients with a Pain Score of 3 or higher had been treated with ORIF. Future research should focus on persistent pain after surgical treatment of Bennett fractures.

One of our study's strengths is the long-term follow-up of the included patients and the clinical and radiological outcomes. However, this study has several limitations because of its retrospective nature. Selection bias is likely because the type of treatment was based on the surgeon's personal preference. Secondly, the post-operative management was different between ORIF and CRPF. Thirdly, within the CRPF patients, two types of percutaneous pinning methods were used, introducing extra bias.

5. Conclusion

The need to perform ORIF for anatomical reduction seems to be less important for preventing post-traumatic arthritis. And although both techniques result in similar functional outcomes after 10 years of follow-up, persistent pain was only seen in ORIF patients. Based on these findings, a Bennett fracture can be safely treated with CRPF when the persistent step-off and gap after fixation does not exceed 2 mm.

Ethical approval

This research was performed in compliance with ethical requirements.

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Disclosure of interest

The authors declare that they have no competing interest.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at https://doi.org/10.1016/j.hansur.2018.11.003.

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