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

La fracture de Bennett : étude comparative entre l'ostéosynthèse directe et ostéosynthèse percutaneé

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Abstract

Objectives

Aim of this study was to compare outcome after long term follow-up of Bennett fractures treated with Open Reduction and Internal Fixation (ORIF) or Closed Reduction Percutaneous Fixation (CRIF).

Material and methods

Patients treated between 1994 and 2010 were retrospectively assessed during an outpatient clinic appointment using a validated questionnaire (i.e. DASH, VAS), sensory tests, Grip- and Pinch-strength and Radiographic analysis for post-traumatic arthrosis.

Results

Fifty patients were included. Mean follow-up was 10 years. Mean age at trauma was 34 years. ORIF was applied in 35 patients. CRIF was used in 15 patients. No clinical difference in Grip- and Pinch-strength was found. Pain was significantly negatively correlated with decreased strength. Re-operations were performed in 5 ORIF treated patients. Change of sensation of the thumb was found in 13 patients, of which 11 had been treated by ORIF. High pain scores (VAS) were seen in ORIF patients. No correlation was found between post-traumatic arthrosis, surgical technique and functional outcome. A persistent Step-off or Gap larger than 2mm after surgery was significantly correlated with post-traumatic arthrosis.

Conclusion

The necessity to choose for anatomical reduction via open reduction and internal fixation seems to be less important in preventing post-traumatic arthrosis to develop as a persistent step-off or gap exceeding 2mm was found to be significantly correlated with the development of post-traumatic arthrosis. Secondly, both techniques give good functional results, although persistent pain was seen in the ORIF treated patients. Bennett fractures can therefore be safely treated with CRIF, when persistent step-off and gap after fixation does not exceed 2mm.

Level of Evidence: **Therapeutic study, Level III**

Introduction

Fractures at the base of the first metacarpal are classified using the 1972 Green and O'Brien classification. Five fractures can be recognized, i.e. Bennett's fracture, Rolando's fracture, Transverse extra-articular, Oblique extra-articular and Epiphyseal fracture (**Figure 1**) [11].

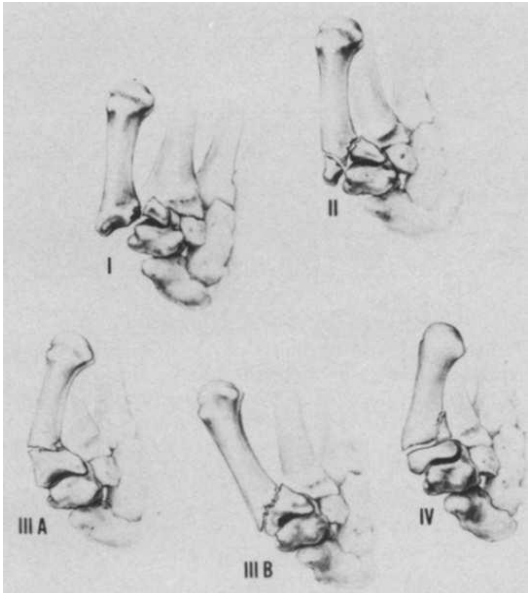

Figure 1. Classification of thumb fractures:
Type I Bennett's fracture
Type II Rolando's fracture
Type IIIA Transverse extra-articular fracture
Type IIIB Oblique extra-articular fracture
Type IV Epiphyseal fracture.
(Re-printed with kind permission from Elsevier Publisher® from "Fractures of the base of the first metacarpal bone: results of surgical treatment. J.L.M. van Niekerk, R. Ouwens; Injury, Vol 20, Issue 6, p359-262 (Nov) 1989.)

Bennett's fracture is named after Edward Hallaran Bennett, Professor of Surgery (1837–1907), who first described it in 1882 [74]. The specific fracture he described; "passed obliquely across the base of the bone, detaching the greater part of the articular surface and 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 muscle and adductor pollicis muscle which displace the larger fracture fragment, i.e. the first metacarpal shaft. The smaller, volar fracture fragment is transfixed to the palmar oblique ligament.

The result is an abduction of the first metacarpal shaft within the CMC joint and an adduction of the first metacarpal shaft towards the second metacarpal, making it an unstable fracture.

In the 1950's the first reports were published showing better results when this unstable fracture is treated surgically [27, 28]. In the following years several surgical techniques have been suggested and new techniques have been introduced [11, 22, 27, 39, 41, 49, 56-59].

Open reduction and internal fixation (ORIF) is reported to give good results and has the advantage of anatomical reduction of the fracture under direct vision [22, 38, 61]. The anatomi-

cal reduction aims to prevent post-traumatic arthrosis [20]. Secondly, the advantage of open reduction and internal fixation is the possibility of early mobilisation [62].

Closed reduction and percutaneous fixation (CRIF) is also reported to give good clinical results [11, 56]. During CRIF fluoroscopy is used to assess fracture reduction. One study suggested fluoroscopy to be inadequate to assess step-off and gap during closed surgery [32]. Consequently, arthroscopy assisted surgery or ORIF is suggested for this fracture [59]. Fortunately, a more recent study confirmed that fluoroscopy can be safely used to assess Step-off and Gap in the closed surgical treatment of intra-articular fractures at the base of the first metacarpal [75].

Currently, no consensus is reached which type of surgery should be preferred in treating Bennett fractures. One reason for the ongoing discussion is the assumption that an anatomical reduction prevents the development of post-traumatic arthrosis. Some authors suggest a relationship while others were not able to correlate accuracy of fracture reduction with post-traumatic arthritis [20, 22, 56, 65]. To improve anatomical reduction arthroscopically assisted percutaneous techniques have even been suggested to combine visualisation of anatomical reduction with minimally invasive techniques [31, 59].

Lack of consensus also exists regarding the best surgical treatment as most outcome is based on research of only one technique or of very small groups of patients at short term follow-up [63, 64]. This paucity in evidence for one technique stresses the importance to evaluate ORIF and CRIF 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 [66]. Therefore, the purpose of the current study is to evaluate clinical and radiological outcome and report complications at 10-year follow-up of Bennett fractures treated by ORIF or CRIF.

Material and methods

This retrospective study was performed in two Level I Trauma Centres, after both institutions' ethical committee's approval was given to reassess all treated patients with Bennett fractures in the period 1994 and 2010. Procedures were performed in accordance with the 1975 Declaration of Helsinki.

An electronic search in 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 time follow up. All medical files were screened for eligibility (i.e. no other hand injuries). Previous radiological examinations were assessed to confirm type of fracture Bennett fractures. Inclusion criteria were Bennett fractures (Gedda type I); surgically treated with K-wire fixation or open reduction internal fixation; minimum age of 15 years at time of injury [42]. Patients who did not meet the inclusion criteria were excluded. When patients met all inclusion criteria they were invited to the outpatient clinic. Baseline characteristics were noted from the patient's medical record together with any additional injuries and the type of surgery applied.

During the outpatient's assessment subjective strength of the hand was scored. A scale from 0 to 10 was used to score the experienced strength as experienced by the patient in comparison with strength before trauma. 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 documented for each hand. To compare the Pinch- and Grip-strength between the injured and the non-injured hand, a percentage was calculated. A minimally clinically important difference (MCID) was set at a difference of 20%, compared with the Pinch- and Grip-strength of the contralateral side and adjusted for hand dominance as suggested by Crosby et al. and Greeven et al [35, 56].

Radiographic images were made in two separate directions to evaluate post-traumatic arthrosis of the first carpo-metacarpal 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 [11, 37].

All radiographs were examined by two researchers (SK and TG, respectively Consultant Orthopaedic Trauma Surgery, Level of Experience III and IV respectively). If no consensus could be reached, a third researcher had the deciding vote (MV, Consultant Trauma Surgeon, Level of Experience V) [76].

Statistical analysis

All statistical analysis and comparison have been performed by one of the authors, a professional in medical statics. 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 numbers with percentage. Statistical significance of difference between the ORIF and Percutaneous group was tested using Student's T-test or Mann-Whitney U-test (if normal or non-normal, respectively) or using a Chi-squared or Fisher's Exact test (for categorical variables). Correlation between outcome scores was tested using a Spearman rank correlation. A 2-sided p-value less than 0.05 was considered statistically significant.

Results

The electronic search in the Digital Patients Medical Database identified eighty-three possible patients. After assessment of date of trauma, eligibility and radiological examination fifty patients, with a Gedda I fracture, met the inclusion criteria and were included for outpatient assessment. All fifty patients were clinically and radiologically assessed during the outpatient clinic visit. Mean follow-up time was 10 (±4) years. The average age at trauma was 34 (±12) years. Forty-two patients were male.

The dominant hand was injured in 34 patients. Mechanism of injury varied from sports injuries, (motor) cycle accidents, 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's fracture.

ORIF was performed in 35 patients and consisted of mini-fragment screw fixation via a radio-palmar approach, followed by a release of the thenar. CRIF was performed in 15 patients and consisted of trans-metacarpal fixation between metacarpal I and II or with metacarpo-trapezoidal K-wires.

The average time between trauma and surgery was 7 days; ORIF was done in 6 days and CRIF in 8 days after trauma. Post-operative management varied from cast immobilization and removable splint to functional after treatment. Significantly more often the right side was treated with CRIF (p = 0.011, **Table I**)

Table I Patient characteristics

ID	Sex	Age	Follow up (yr.)	Fracture side	Trauma mechanism	Fixation type	Additional injury	Days to Surgery	Cast immobilization
1	M	18	8	R	(motor)cycle accident	ORIF	none	6	another#
2	M	38	18	R	sports	ORIF	none	14	none
3	M	24	17	R	(motor)cycle accident	ORIF	none	1	none
4	M	31	17	L	(motor)cycle accident	ORIF	none	1	cast immobilization
5	M	41	17	L	sports	ORIF	none	1	none
6	M	42	12	R	(motor)cycle accident	ORIF	metatarsal fracture	4	cast immobilization
7	M	32	17	L	(motor)cycle accident	ORIF	trapezium fracture	1	none
8	M	37	13	L	(motor)cycle accident	ORIF	none	6	none
9	M	19	14	R	(motor)cycle accident	ORIF	none	2	removable splint
10	F	28	14	R	fall	ORIF	metacarpal II-IV fracture	0	cast immobilization
11	F	26	12	R	sports	ORIF	none	21	cast immobilization
12	F	54	12	R	(motor)cycle accident *	ORIF	cerebral contusion	7	cast immobilization
13	M	15	10	R	fighting	ORIF	none	9	none
14	M	23	9	R	sports	ORIF	none	11	none
15	M	17	10	L	(motor)cycle accident	CRIF	none	0	cast immobilization

Table I Patient characteristics (continued)

ID	Sex	Age	Follow up	Fracture	Trauma mechanism	Fixation type	Additional injury	Days to	Cast immobilization
16	M	45	9	R	sports	ORIF	none	4	cast immobilization
17	M	32	9	R	fall	ORIF	none	4	cast immobilization
18	F	54	9	L	fall	CRIF	cerebral contusion	20	cast immobilization
19	M	46	8	R	(motor)cycle accident *	CRIF	tib fib fracture, lung contusion	6	cast immobilization
20	M	33	8	R	fighting	ORIF	IP displacement	3	cast immobilization
21	M	36	8	R	fighting	ORIF	none	10	cast immobilization
22	M	43	6	L	sports	CRIF	none	8	cast immobilization
23	M	23	6	R	fighting	ORIF	none	9	none
24	M	38	7	R	fall	ORIF	none	7	removable splint
25	M	26	6	R	sports	ORIF	none	1	cast immobilization
26	M	34	6	L	(motor)cycle accident	ORIF	none	3	cast immobilization
27	M	20	6	L	fall	ORIF	none	5	cast immobilization
28	M	18	6	R	(motor)cycle accident *	CRIF	clavicle fracture	23	cast immobilization
29	M	48	7	R	fall	ORIF	none	1	cast immobilization
30	M	45	6	R	(motor)cycle accident	ORIF	none	2	cast immobilization
31	M	21	5	R	fighting	ORIF	none	0	cast immobilization
32	M	47	5	L	fighting	CRIF	none	3	cast immobilization
33	M	24	16	R	(motor)cycle accident	ORIF	none	10	none
34	F	27	18	L	(motor)cycle accident	ORIF	none	4	none
35	F	19	7	R	hockey ball versus hand	ORIF	none	20	none
36	M	50	12	L	fall	ORIF	none	1	removable splint
37	M	54	10	L	sports	CRIF	none	0	none
38	M	22	10	R	(motor)cycle accident	ORIF	none	10	cast immobilization
39	M	30	8	R	(motor)cycle accident	CRIF	none	3	cast immobilization
40	F	46	7	R	sports	ORIF	none	8	none
41	M	55	8	L	(motor)cycle accident	CRIF	none	5	cast immobilization
42	M	22	7	R	fall	ORIF	none	7	cast immobilization
43	F	39	9	L	(motor)cycle accident	CRIF	none	1	cast immobilization
44	M	34	6	L	(motor)cycle accident	ORIF	none	6	cast immobilization
45	M	28	7	L	car accident	CRIF	cerebral contusion	3	cast immobilization
46	M	38	14	R	fighting	CRIF	head wound	27	cast immobilization
47	M	64	7	R	fall	CRIF	subdural haematoma	7	cast immobilization
48	M	35	6	R	(motor)cycle accident	ORIF	none	14	cast immobilization
49	M	28	18	L	fall	CRIF	shoulder displacement	4	cast immobilization
50	M	17	11	L	(motor)cycle accident	CRIF	none	7	cast immobilization

* multi trauma patient

bandage for 1 week

M = male, F =female, R =right, L = left, ORIF = Open Reduction Internal Fixation; CRIF = Closed Reduction and Percutaneous Fixation

Functional outcome

The median DASH score for all patients was 5 (P_{25}-P_{75} 0-8). Selected by treatment type the DASH score was 0 (P_{25}-P_{75} 0-6) and 4 (P_{25}-P_{75} 0-12), for ORIF and CRIF respectively. Grip- and Pinch-strength were good in majority of patients in comparison to the non-injured hand for both techniques. A MCID of 20% in Grip- and Pinch-strength in comparison with the uninjured hand was found in 7 patients (**Table II and III**). Four had been treated with ORIF and three with CRIF.

In total eleven patients reported pain at follow-up. Four patients were found to report a VAS of 3 or higher. All 4 patients had been treated with ORIF. Statistical analysis showed a significant correlation between 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 also with loss of strength.

Table II Overall outcome

Item	Overall N=50	ORIF N=35	CRIF N=15	p-value
Age	34 (12)	32 (10)	39 (15)	0.123*
Male	42 (84)	29 (83%)	13 (87%)	1.000#
Right side affected	31 (62%)	26 (74%)	5 (33%)	0.011#
Right side dominant	41 (82%)	29 (83%)	12 (80%)	1.000#
Dominant side affected	16 (32%)	9 (26%)	7 (47%)	0.191#
Eaton Littler class				
1	24 (48%)	19 (54%)	5 (33%)	0.078^
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#
Re-operation	27 (54%)	12 (34%)	15 (100%)	<0.001#
VAS	0 (0-0)	0 (0-0)	0 (0-0)	0.285~
DASH	0 (0-8)	0 (0-6)	4 (0-12)	0.135~
DASH work	0 (0-0)	0 (0-0)	0 (0-10)	0.257~
DASH hobbies	0 (0-10)	0 (0-6)	0 (0-16)	0.893~
Strength	10 (9-10)	10 (8-10)	10 (9-10)	0.949~
Pinch (kg) affected side	11 (9-12)	11 (10-12)	10 (8-12)	0.112~
Pinch (kg) contralateral side	10 (8-12)	10 (9-11)	10 (7-13)	0.86~
Pinch difference	0 (-1 to 1)	1 (0-1)	-1 (-1 to 0)	0.012~
Grip (kg) affected side	47.9 (11.0)	48.6 (10.4)	46.3 (12.7)	0.516∞
Grip (kg) contralateral side	47.7 (11.5)	48.6 (11.0)	45.4 (12.9)	0.366∞
Grip difference	0.2 (6.4)	-0.1 (7.1)	0.9 (4.8)	0.612∞

Data are shown as mean (SD), median (P_{25}-P_{75}) or N (%).
*Student's T-test with unequal variance assumed
Fisher's Exact test ^ Chi-squared test
~ Mann-Whitney U-test ∞ Student's T-test with equal variance assumed

Table III Minimally Clinically Important Difference (MCID) of Pinch- and Grip-strength

ID	Surg.	Injured	Dominant	Pain	DASH	Work	Hobby	Strength	Pinch	Pinch	Grip	Grip	Diff.	Diff.	Arthritis
				(VAS)		DASH	DASH		R (kg)	L (kg)	R (kg)	L (kg)	%Pinch	% Grip	Eaton-Littler
															class
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							

Minimally Clinically Important Difference (MCID) was set at a difference of 20% versus contralateral side and adjusted for hand dominance (*after Crosby et al. & Greeven et al.* [35, 56], MCID larger than 20% are underlined in table.
Surg. = type of surgery, i.e. ORIF or CRIF
ORIF = Open Reduction Internal Fixation
CRIF = Closed Reduction and Percutaneous Fixation
L = Left
R = Right
VAS = Visual Analogue Score
Diff. = Difference (in % Pinch and % Grip)

Complications

Complications were reported in 12 (34%) ORIF treated patients and 4 (27%) CRIF treated patients (**Table IV**). Loss of reduction was reported in one ORIF and one CRIF patient. Both patients were successfully re-operated with the same technique.

Pin-tract infection occurred in one CRIF treated patient and was successfully treated with oral antibiotics and K-wire removal after fracture healing.

Sensory examination of the operated hand in comparison to the patient's non-injured hand showed normal sensation in 37 patients. Tingling was found in 4 patients and numbness was found in 9 patients (**Table IV**). Of these 13 patients, 11 were treated with ORIF and 2 had been treated with CRIF.

Seven ORIF patients (20%) were re-operated. Reasons for re-operation were loss of reduction, functional impairment and complaints of osteosynthesis material. One CRIF patient was re-operated because of loss of reduction. All other CRIF patients were re-operated for K-wire removal after fracture consolidation.

Radiographs

In 13 patients the radiographs showed an Eaton Littler Grade III or IV at follow-up. Seven patients had been treated by ORIF and 6 patients had been treated by CRIF.

Table IV Complications at follow-up

Surgical ID		Sex	Age	Injured	Days to	Re-operations	Complications
Technique				side	Surgery		
ORIF	1	M	18	R	6	yes	tingling
(N=12, 34%)	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
CRIF	22	M	43	L	8	yes	pin-tract infection
(N=4, 27%)	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

M= male, F= female, R= right, L= left

A persistent Step-off or Gap after surgical fixation larger than 2mm showed a significantly correlation with the development of post-traumatic arthrosis (**Table V**).

No statistically significant association could be found between the modified Eaton Littler classification and reported pain (VAS), functional outcome, or treatment type.

(**For detailed outcome please see *Supplement: Pinch- & Grip strength and Eaton-Littler Classification for all 50 patients***)

Table V Post-Traumatic Arthrosis and Quality of Reduction

		Eaton Littler classification			
Fracture reduction*		I	II	III	IV
0-2 mm	(n=43)	12	24	6	1
> 2mm	(n=7)	1	0	6	0
total	(n=50)	13	24	12	1

* = Step-off or Gap
Chi-Square test, p=0.001

Discussion

The first important finding of the current study is the significant correlation between a persistent Step-off and Gap of 2mm and the development of post-traumatic arthrosis. This warrants the question how much importance should be given to an anatomical reduction during surgery in an attempt to prevent these post-traumatic changes from developing [61, 73].

Previous research has shown that with fluoroscopy fracture reduction after percutaneous fixation can be adequately assessed [75]. The necessity for anatomical reduction via open reduction and internal fixation or even arthroscopy might be of less importance. Previous smaller studies also reported good results when step-off was smaller than 2mm [20, 77]. Furthermore, without the dissection necessary for ORIF the patient is less at risk to develop 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 of osteosynthesis material.

The second important finding of the current study is that similar functional outcome was found for both types of surgery after long term follow-up. In line with previous publications with shorter follow up, the current study confirms good clinical results for ORIF as well as for CRIF in the treatment of Bennett's fracture at 10-year follow up [22, 41, 56, 61, 62].

An important other finding in the current study are the high pain scores (VAS > 3) which were only seen in ORIF patients. A higher pain score was significantly correlated with a higher DASH and also with loss of strength. This makes these findings clinically important.

The authors are not aware of any previous research in which pain after surgical treatment of Bennett's fracture are reported at 10-year follow-up. The reported pain was not correlated with post-traumatic arthrosis (Eaton-Littler score). Other metacarpal studies have shown difference in complications between CRIF and ORIF techniques in the surgical treatment of second to fifth metacarpal fractures [16]. This was explained by the surgical dissection necessary for open reduction and internal fixation resulting in a higher chance of unintended damage to vital anatomical structures [16, 34]. This might be explanatory for the current study's finding, that all patients with a pain score (VAS) of 3 or higher had been treated by open technique. Future research should focus on persistent pain after surgical treatment of Bennett fractures.

Strengths/Limitations

One strength of the current study is the long term follow up of the included patients and the clinical and radiological assessment of outcome. But because of its retrospective nature, this study has several limitations. Selection bias will be present because the type of treatment was based on the personal preference of the surgeon. Secondly, the post-operative management is different between ORIF and CRIF. Thirdly, within the CRIF patients two types of percutaneous pinning was used, introducing extra bias.

In conclusion, the necessity to choose for anatomical reduction via open reduction and internal fixation seems to be less important in preventing post-traumatic arthrosis. And although both techniques result in similar functional outcome after 10-year follow-up, pain was only seen in ORIF patients. Based on these findings, a Bennett fracture can be safely treated with CRIF, when persistent step-off and gap after fixation does not exceed 2mm.

Supplement: Overall Functional Outcome and Eaton-Littler Classification

ID	Sex	Age	Fracture side	Dominant side	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 class
1	M	18	R	R	0	0	0	0	10	11,7#	12,3	50#	49	-5,1%	2,0%	1
2	M	38	R	R	0	0	0	0	10	12.0#	10,3	52#	50	14,1%	3,8%	1
3	M	24	R	R	0	0	0		10	12.7#	9,7	59#	69	23,6%	-16,9%	1
4	M	31	L	R	0	0	0		10	10.3	11.7#	52	50#	12,0%	-4,0%	1
5	M	41	L	R	0	0	0	0	10	11.0	11.0#	36	39#	0,0%	7,7%	2
6	M	42	R	R	0	0	0	0	9	10,3#	9,3	39#	41	9,7%	-5,1%	3
7	M	32	L	R	0	0	0		10	11,3	11,3#	43	47#	0,0%	8,5%	1
8	M	37	L	R	3	4	0	0	8	12,3	10,0#	43	31#	-23.0%	-38,7%	2
9	M	19	R	R	0	0	0		10	11,2#	11,3	53#	53	-0,9%	0,0%	1
10	F	28	R	R	0	3	0	13	8	4,7#	6	29#	27	-27,7%	6,9%	2
11	F	26	R	R	0	0	0		10	8,0#	7,3	35#	33	8,8%	5,7%	1
12	F	54	R	R	3	22		13	5	7,3#	7	31#	31	4,1%	0,0%	2
13	M	15	R	R	0	0	0	0	10	10,7#	10	61#	59	6,5%	3,3%	1
14	M	23	R	R	0	4	0	13	9	12,0#	10,7	59#	59	10,8%	0,0%	2
15	M	17	L	L	0	0	0	0	10	8,2	8,0#	52	55#	-2,5%	5,5%	1
16	M	45	R	R	0	8	6	6	10	13,7#	12	60#	39	12,4%	35,0%	2
17	M	32	R	R	0	0	0	0	10	10,8#	11,2	53#	57	-3,7%	-7,5%	3
18	F	54	L	R	0	0		0	10	6,7	2,7#	31	25#	-148,0%	-24,0%	4
19	M	46	R	R	0	11	0	19	9	10,7#	12,8	58#	51	-19,6%	12,0%	3
20	M	33	R	L	0	0	0		10	10,3	12,0#	40	49#	14,2%	18,4%	1
21	M	36	R	R	1	8	13		8	11,5#	12,2	43#	42	-6,1%	2,3%	2
22	M	43	L	R	0	0	0	0	10	13,2	11,7#	49	51#	-12.8%	3,9%	2

Supplement: Overall Functional Outcome and Eaton-Littler Classification (continued)

ID	Sex	Age	Fracture	Dominant	Pain	DASH	Work	Hobby	Strength	Pinch	Pinch	Grip	Grip	Difference	Difference	Arthritis
23	M	23	R	R	3	11	13		8	11,7#	11,2	45#	43	4,3%	4,4%	1
24	M	38	R	R	0	0	0		10	11,2#	10,2	51#	59	8,9%	-15,7%	3
25	M	26	R	R	0	0	0	0	10	11,8#	11,3	63#	55	4,2%	12,7%	1
26	M	34	L	R	0	0	0	0	10	10	12,7#	59	57#	21,3%	-3,5%	2
27	M	20	L	L	1	1		25	10	9	10,2#	36	41#	11,8%	12,2%	2
28	M	18	R	R	0	8	19	25	10	11,2#	11,8	50#	50	-5,4%	0,0%	2
29	M	48	R	L	0	0	0	0	10	13,7	11,3#	59	52#	-21,2%	-13,5%	1
30	M	45	R	R	0	0	0	0	10	12,0#	11,3	56#	58	5,8%	-3,6%	1
31	M	21	R	L	1	13	6	44	8	8,3	10,0#	60	60#	17,0%	0,0%	1
32	M	47	L	L	1	26	0		10	24,7	23,0#	50	48#	-7,4%	-4,2%	2
33	M	24	R	R	0	0	0	0	10	24,3#	23,3	55#	65	4,1%	-18,2%	1
34	F	27	L	L	0	4	0	0	5	6,7	5,8#	37	33#	-15,5%	-12,1%	2
35	F	19	R	R	0	33	0	0	10	6,0#	5,7	34#	35	5,0%	-2,9%	1
36	M	50	L	R	6	28	19		6	11,2	9,0#	51	33#	-24,4%	-54,5%	3
37	M	54	L	R	0	2	0	0	10	10	11,7#	52	56#	14,5%	7,1%	2
38	M	22	R	R	0	1	0	6	10	12,3#	10,3	59#	55	16,3%	6,8%	2
39	M	30	R	R	0	0	0	0	10	9,3#	7	29#	31	24,7%	-6,9%	1
40	F	46	R	R	0	3		0	10	9,7#	8,7	46#	39	10,3%	15,2%	3
41	M	55	L	R	0	3	0	0	7	12,7	9,8#	41	41#	-29,6%	0,0%	2
42	M	22	R	R	0	7	0	0	10	12,0#	12,2	60#	67	-1,7%	-11,7%	1
43	F	39	L	L	0	11	13	0	8	10	10,0#	32	33#	0,0%	3,0%	2
44	M	34	L	L	1	6			10	10,5	10,8#	51	59#	2,8%	13,6%	1
45	M	28	L	R	0	12	13	13	9	11,7	13,7#	63	53#	14,6%	-18,9%	2
46	M	38	R	R	1	16		25	8	7,3#	7	33#	28	4,1%	15,2%	1

Supplement: Overall Functional Outcome and Eaton-Littler Classification (continued)

ID	Sex	Age	Fracture	Dominant	Pain	DASH	Work	Hobby	Strength	Pinch	Pinch	Grip	Grip	Difference	Difference	Arthritis
47	M	64	R	R	0	12	6	0	10	9,3#	8	47#	41	14,0%	12,8%	4
48	M	35	R	R	1	1	0	6	8	8,7#	7,2	56#	51	17,2%	8,9%	1
49	M	28	L	R	0	0	0	0	10	6,2	5,7#	36	43#	-8,8%	16,3%	1
50	M	17	L	R	0	4	0		10	12,7	8,7#	74	73#	-46.0%	1,4%	1
Average		34			0	5	2	6	9	10,9	10,4	48	47			