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TRAUMA SURGERY

Surgical tips and tricks for coronal shear fractures of the elbow

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Abstract

Introduction Coronal shear fractures of the distal humerus represent an uncommon lesion and could be burdened by high complications. This complex lesion requires an accurate reduction and surgical fixation for a better outcome. Different techniques have been described, however no standard protocol have been proposed.
Purpose of this retrospective study, is to evaluate the clinical and radiological outcome with posterior cannulated self-tapping headless screws followed by an early-active-motion protocol and to outline the surgical tips and tricks for different fracture patterns.

Materials and methods From 2013 to 2019, a consecutive series of 24 patients with coronal shear fracture undergoing ORIF were included in the study. Fractures were classified according to Dubberley's classification. Cannulated self-tapping headless screws were used to fix the fragments.
When necessary, additional cannulated half-threaded screws on the lateral edge of the humerus were used, as well as bone chips and fibrin sealant on severe comminution. All patients underwent an assisted early-active-motion rehabilitation protocol. Mean follow-up was 30 months; patients underwent standard X-rays and clinical outcome assessment with range of motion, Broberg and Morrey score and MEPI score.

Results Surgical fixation with headless screw guaranteed complete healing of all shear fractures examined, no loss of reduction were reported. ROM assessment showed good results with an average arc of 113.1°. Excellent to good Broberg-Morrey and MEPI score were reported.
No cases of avascular necrosis nor post-traumatic osteoarthritis resulted in our series.
Complications occurred in 16.6% of the patients.

Conclusion Coronal shear fracture represents a challenging injury to treat. Anatomical reduction and the use of cannulated self-tapping headless screws from posterior provide a stable fixation, high union rates and good elbow function, with a low cartilage damage and risks of necrosis over 2 years of follow-up.

Level of evidence Therapeutic III

Keywords Coronal shear fracture · Distal humerus fracture · Capitellum · Elbow fracture · Headless screw

Introduction

Coronal shear fractures of the distal humerus represent less than 1% of all elbow fractures [1], but this uncommon lesion could be burdened by high complications. This kind of injury is usually caused by low-energy fall on an outstretched hand or results from a spontaneous reduction of a posterolateral dislocation, where an axial force through the radial head involves the capitellum, with a variable extension to the trochlea or to the posterior aspect of the distal humerus [2, 3]. Reported incidence is higher among females, especially associated with poor bone stock [4].

Almost 50% of shear fractures are associated with other lesions such as radial head fractures and disruption of the lateral collateral ligament (LCL) [5–7].

The complexity in surgical treatment is given by the small amount of subchondral bone available for a stable fixation [2], however conservative treatment with cast immobilization is no longer recommended because of the poor outcome and associated complications [8]. At present also the

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fragment excision is less used and can still be attempted for small unfixable fractures, despite a higher risk of residual instability, especially when the trochlea is involved [9, 10]. With the development of reconstructive techniques, better outcomes have been reported with surgical management based on open reduction and internal fixation [5, 12, 13]. The main purpose of surgery is to restore the congruity between articular surfaces through an anatomic reduction and stable fixation. Thanks to an early mobilization, this approach also reduces the incidence of elbow rigidity and secondary osteoarthritis. Though good-to-excellent results have been reported from several studies evaluating the functional outcomes of surgical treatment with internal fixation [11–13], no standard protocol has been proposed and limited data are available regarding outcomes and drawbacks. Purpose of this retrospective study is to evaluate the clinical and radiological outcome of coronal shear fractures treated with cannulated self-tapping headless screws, and to outline surgical tips and tricks for different fractures patterns.

Materials and methods

In a period between 2013 and 2018, a consecutive series of 24 patients with coronal shear fracture of the distal humerus, were included in this study.

Mean age was 50.2 years (range 18–71). All patients gave informed consent prior to being included in the study. This study was performed in accordance with the Ethical Standards of the 1964 Declaration of Helsinki as revised in 2000.

A 3D-CT scan has always been performed. Fractures were classified according to Dubberley's classification: a fracture of the capitellum with or without the lateral trochlear ridge (type 1), fracture involving the capitellum and the trochlea as one single piece (type 2) or as separate fragments (type 2) [5]. Absence (A) or presence (B), of posterior comminution was also assessed (Fig. 1).

A slightly higher number of cases was reported in 1B group, accounting for six patients; four cases, respectively, for 1A; 2B; 3A; 3B group and only two patients were classified as 2A (Table 1).

The dominant side was affected in the 62.5% of cases (15/24). Surgical operation was performed with an average time of 5 days from the injury (range 1–8 days).

In one case a Type 1B capitellar fracture was associated with a Mason one radial head fracture, treated with headless screws.

The mean follow-up was 30 months (range 24–40 months). Radiological and clinical follow-up with standard AP and lateral view X-rays were performed monthly for the first 4 months postoperatively, then every 6 months, with a minimum long term follow-up of 24 months. All patients were interviewed and examined by the same observer (L.T.).

The clinical evaluation included analysis of passive and active range of motion (pROM; aROM), functional outcome, radiological evaluation of fracture healing and reduction maintenance, ligamentous stability, and the occurrence of possible adverse events.

Elbow function was assessed using the Mayo Elbow Performance Index (MEPI) and the Broberg and Morrey Functional Rating Index questionnaires. The MEPI consists of four parts: pain (with a maximum score of 45 points), ulnohumeral motion (20 points), stability (10 points) and the ability to perform five functional tasks (25 points). The total score ranges from 5 to 100 points, with higher scores indicating better function. If the total score is included between 90 and 100 points, it can be considered excellent; between 75 and 89 points, good; between 60 and 74 points, fair; and less than 60 points, poor [14].

The rating system of Broberg and Morrey is a 100-point system, which consists of four sections: motion (40 points), strength (20 points), stability (five points) and pain (35 points). In the categorical rating, 95–100 points indicates an excellent outcome; 80–94 points, a good outcome; 60–79 points, a fair outcome; less than 60 points, a poor outcome. The outcome can be considered satisfactory if the result is rated as good or excellent, and unsatisfactory if it is fair or poor [14].

Cannulated self-tapping headless screws (Acutrak, Acumed—Hillsboro, Oregon) were used to fix the fragments. Sometimes additional cannulated half-threaded screws on the lateral edge of the humerus were used, as well as bone chips and fibrin sealant on severe comminution. All patients underwent an assisted early-active-motion rehabilitation protocol. Mean follow-up was 2 years; patients underwent standard X-rays and clinical outcome assessment with Range of Motion, Broberg and Morrey score and MEPI score.

Surgical technique

An extensile lateral Kocher approach was performed in all cases. The incision was centered over the lateral epicondyle and extended from the anterior aspect of the lateral column, to approximately 2 cm distal to the radial head. Proceeding through the subcutaneous tissues and dissection of the anterior capsule, the distal humerus was exposed. Reduction was attempted and the fragments were temporarily stabilized with K-wires pinning. Definitive fixation was obtained through Mini or Micro Acutrak headless self-tapping compression screws (Acumed, Hillsboro, OR, USA), inserted from posterior to anterior (Fig. 2).

An insertion of the screw from anterior [15] produces a not negligible injury to the cartilage surface and can collapse

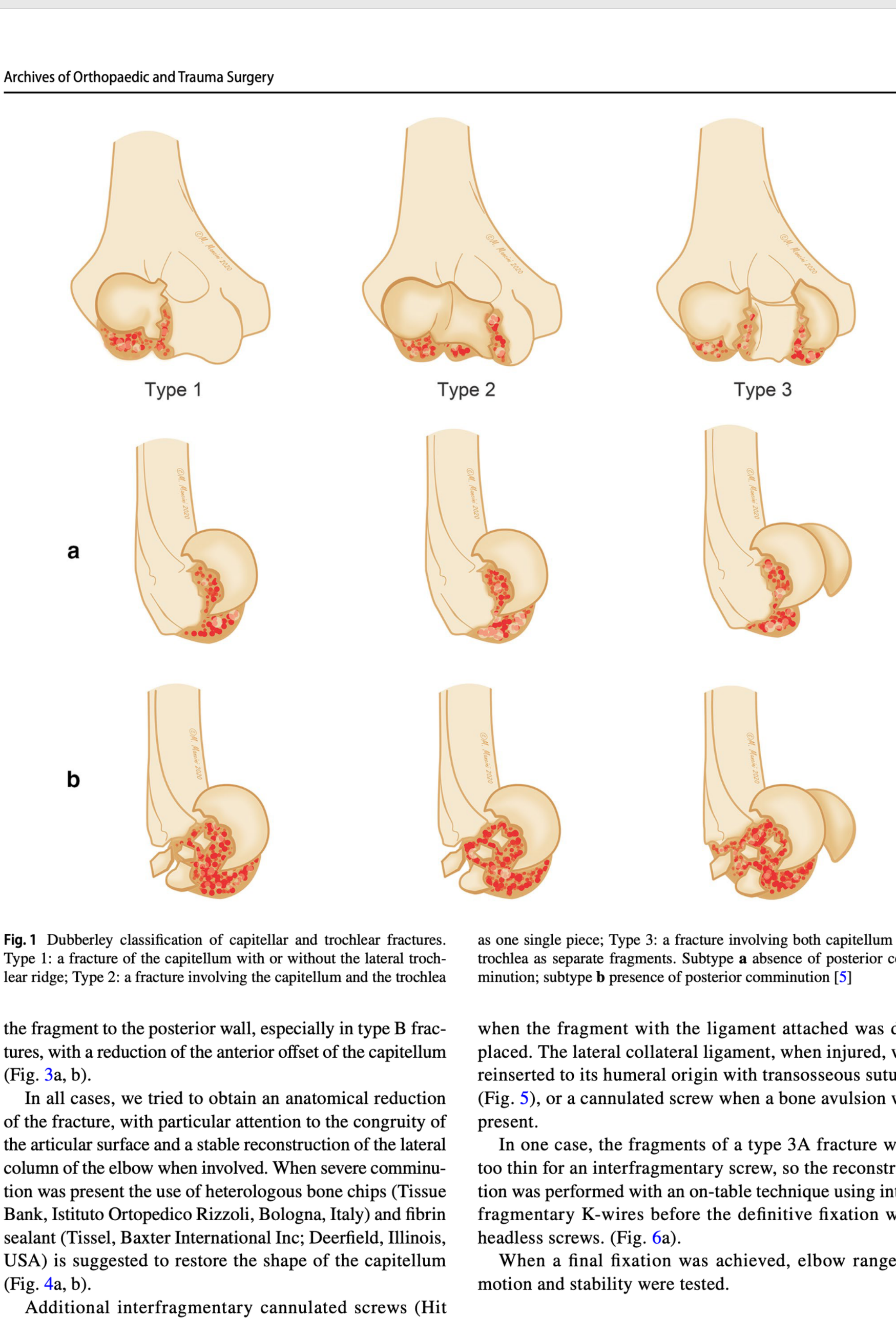

Fig. 1 Dubberley classification of capitellar and trochlear fractures. Type 1: a fracture of the capitellum with or without the lateral trochlear ridge; Type 2: a fracture involving the capitellum and the trochlea as one single piece; Type 3: a fracture involving both capitellum and trochlea as separate fragments. Subtype **a** absence of posterior comminution; subtype **b** presence of posterior comminution [5]

the fragment to the posterior wall, especially in type B fractures, with a reduction of the anterior offset of the capitellum (Fig. 3a, b).

In all cases, we tried to obtain an anatomical reduction of the fracture, with particular attention to the congruity of the articular surface and a stable reconstruction of the lateral column of the elbow when involved. When severe comminution was present the use of heterologous bone chips (Tissue Bank, Istituto Ortopedico Rizzoli, Bologna, Italy) and fibrin sealant (Tissel, Baxter International Inc; Deerfield, Illinois, USA) is suggested to restore the shape of the capitellum (Fig. 4a, b).

Additional interfragmentary cannulated screws (Hit Medica, Serravalle, Repubblica di San Marino) were used when the fragment with the ligament attached was displaced. The lateral collateral ligament, when injured, was reinserted to its humeral origin with transosseous sutures (Fig. 5), or a cannulated screw when a bone avulsion was present.

In one case, the fragments of a type 3A fracture were too thin for an interfragmentary screw, so the reconstruction was performed with an on-table technique using interfragmentary K-wires before the definitive fixation with headless screws. (Fig. 6a).

When a final fixation was achieved, elbow range of motion and stability were tested.

Table 1 Epidemiological data of coronal sear fracture of the elbow

Patient	Age	Sex	Dubberley classification	Procedure	Associated injuries	Complications
1	52	F	3B	HS	LCL	
2	80	F	2B	HS + P		
3	63	F	1B	HS		
4	43	M	2B	HS + IS		
5	59	F	1B	HS	LCL	
6	68	F	3A	HS	LCL	
7	73	F	3A	HS + IS + KW	LCL	KW migration: percutaneous removal
8	18	M	1B	HS	Radial head fracture	
9	20	F	1A	HS		
10	60	F	1B	HS		Elbow stiffness: arthroscopic release
11	66	M	3B	HS	LCL	
12	60	M	1A	HS	LCL	
13	55	F	1A	HS	LCL	
14	59	F	2A	HS + IS		
15	60	F	2A	HS	LCL	
16	43	M	3A	HS + IS	LCL	Instability; LCL revision surgery
17	45	F	1B	HS		
18	18	F	1A	HS		
19	19	M	2B	HS		
20	71	F	3B	HS + IS		CRPS
21	44	F	3A	HS + IS		
22	43	M	3B	HS + IS	LCL	
23	37	M	2B	HS + IS		
24	49	F	1B	HS		

HS head-less screw, *IS* additional Inter-fragmentary cannulated screw, *KW* Kirschner wires, *LCL* lateral collateral ligament

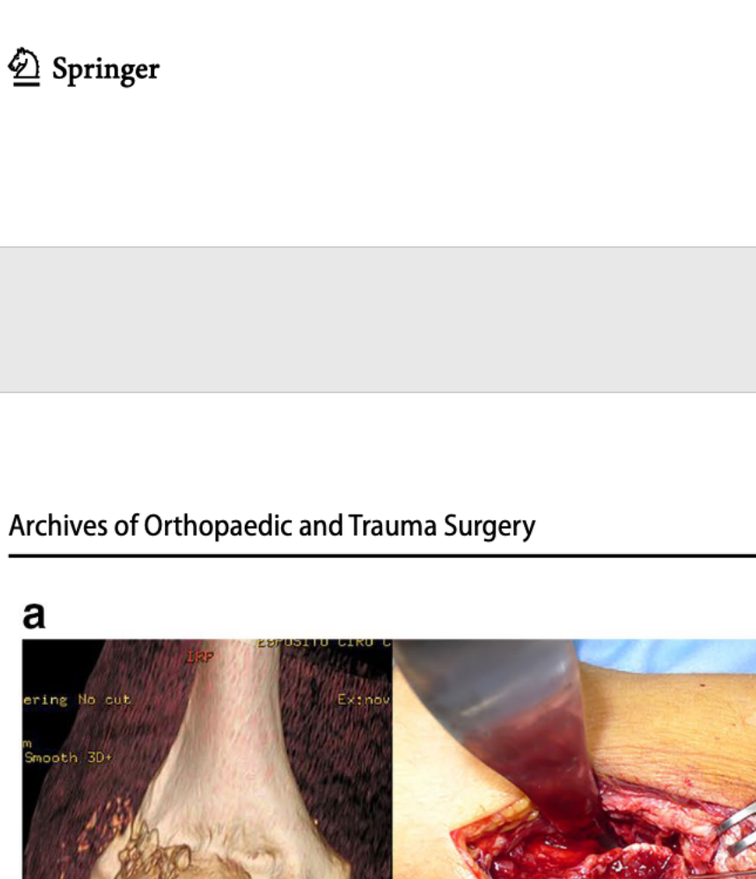

Fig. 2 Capitellar fracture reduction and a headless cannulated screw inserted from posterior to anterior

Fig. 3 Illustration represents a posterior-to-anterior fixation with a headless screw (**a**) and a possible dislocation of the capitellum reducing the anterior offset (especially in posterior comminution cases), when fixation is performed from anterior (**b**)

Postoperative management and rehabilitation protocol

Postoperatively, the elbow was splinted at 90° of flexion for 1 week, and then an early-active-motion was allowed using a dynamic splint: a program of gravity-aided and active-assisted exercises was undertake up 2 months post-operative. Assisted passive motion and physical therapy for edema reabsorption were performed the first 2 weeks post-operatively.

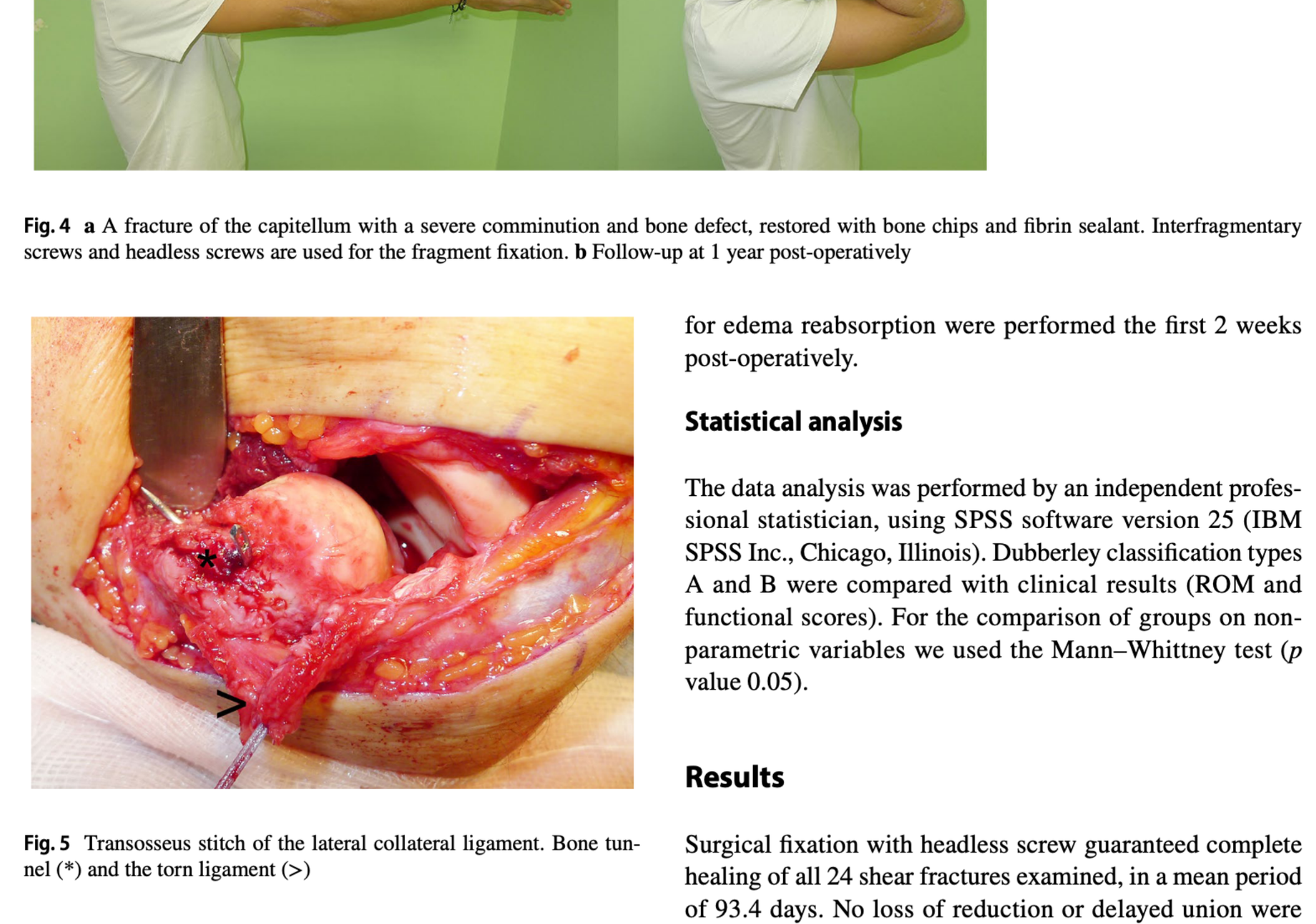

Fig. 4 **a** A fracture of the capitellum with a severe comminution and bone defect, restored with bone chips and fibrin sealant. Interfragmentary screws and headless screws are used for the fragment fixation. **b** Follow-up at 1 year post-operatively

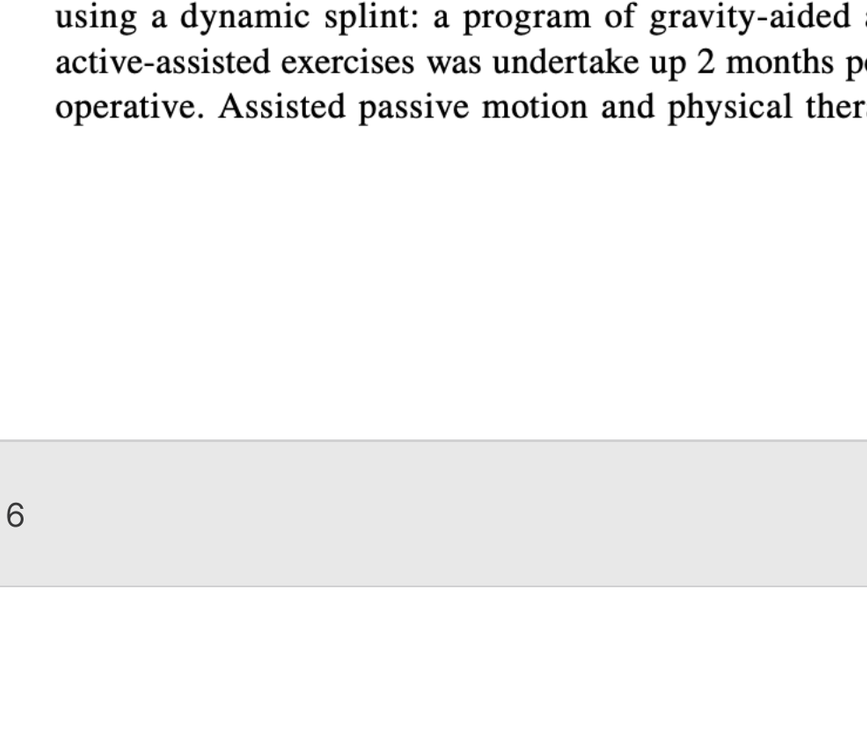

Fig. 5 Transosseus stitch of the lateral collateral ligament. Bone tunnel (*) and the torn ligament (>)

Statistical analysis

The data analysis was performed by an independent professional statistician, using SPSS software version 25 (IBM SPSS Inc., Chicago, Illinois). Dubberley classification types A and B were compared with clinical results (ROM and functional scores). For the comparison of groups on non-parametric variables we used the Mann–Whitney test (*p* value 0.05).

Results

Surgical fixation with headless screw guaranteed complete healing of all 24 shear fractures examined, in a mean period of 93.4 days. No loss of reduction or delayed union were reported. ROM assessment showed good results with an overall average arc of 113.1°. Mean arc of motion for each Dubberley's type, resulted: 1A (123.7°); type 1B (111.6°); type 2A (115°); type 2B (120°); type 3A (110°); type 3B (100°) (Table 2).

Pronation and supination arc of movement was complete in almost every patient, so it was not included in the statistical analysis. Good and Excellent Broberg and Morrey and MEPI scores were reported, with an overall satisfactory result (Mean MEPI 92.1; Mean Broberg 90.7). Scores value for each type of fracture are reported in Table 2.

From the collected data, we reported a worsening trend in mobility of the elbow from Dubberley's type 1A fractures to type 3B, by about 25° of arc of motion.

However, statistical analysis does not reveal a significant correlation (*p* value < 0.05) between type A and B, with the three outcome indicators: arc of motion, MEPI and Broberg–Morrey score.

Fig. 6 **a** Restoring the joint anatomy with on-table technique and thin interfragmentary K-wires when fragments are too thin for a transverse lag screw. **b** K-wires subcutaneous migration found at X-ray follow-up. It was removed with a percutaneous procedure