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ORIGINAL STUDY

A review of outcomes following surgical fixation of adult capitellum fractures : a six-year case series

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The aim of the study is to review post-operative outcomes following surgical fixation of capitellum fractures. This was a retrospective analysis of a 6 year period. We included fourteen patients with an average age of 56.6 years. We included Type 1 and Type 3 fractures as graded by the Bryan and Morrey classification. Post-surgical function was evaluated as per the Mayo Elbow Score. There were eleven Type 1 and three Type 3 fractures. All patients were treated with an ORIF. Our surgical approach was postero-lateral in five patients and antero-lateral in the remainder. Post-operatively more than half of our patients were mobilised within two weeks. Average time for radiological union was seven-weeks. Our average follow-up period was 34.5 months (range 6-75). The Mayo elbow score was excellent for seven, good for three and fair for another three of our patients. One subject could not be fully scored due to learning difficulties. We recommend ORIF for all Type 1 and Type 3 fractures so that early function can be regained. A single incision technique based either posteriorly or anteriorly with a screw in an anterior-to-posterior or posterior-to-anterior leads to good outcomes regardless of the type of hardware used.

Keywords : Capitellum ; fracture ; surgical outcome ; surgical fixation ; Mayo Elbow Performance Score.

INTRODUCTION

Isolated capitellum fractures are rare injuries mostly occurring in women and accounting for approximately 1% of all elbow fractures and 6% of distal humeral fractures *(6,38)*. The common mechanism of this injury is generally described as either the radial head undergoing direct axial compression in a hyper-extended or a partially flexed position, or following a postero-lateral subluxation or dislocation of the elbow *(25)*. Most orthopaedic surgeons have limited experience in treating fractures of the capitellum and trochlea ; the rarity and complexity of such injuries often means that only dedicated specialists treat them, usually with an operative form of management *(10,16)*. Surgically, most fracture types can be approached laterally ; however, fixation of small and sometimes entirely articular fragments may be necessary *(29)*. In case of a treatment failure, stiffness, instability and chronic pain may arise.

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Table 1. — Comparison of Capitellum Fracture Classifications

	Bryan & Morrey (14)	Ring et al (30)	Dubberly et al (6)
Type 1	A shear fracture in the coronal plane involving most of the capitellum and little or none of the trochlea – Hahn-Steinthal Lesion (11,34)	A single articular fragment consisting of the capitellum and the lateral portion of the trochlea	Fracture of the capitellum with or without the lateral trochlear ridge
Type 2	Involves a variable amount of articular cartilage of the capitellum with a minimal attachment of subchondral bone – Kocher-Lorenz Lesion (15,17)	Associated fracture of the lateral epicondyle	Fracture of the capitellum and trochlea as a single piece
Type 3	A comminuted/ multifragmentary or compression fracture of the capitellum	Impaction of the metaphyseal bone behind the capitellum,	Fracture of the capitellum and trochlea as separate pieces
Type 4	A shear fracture of the distal aspect of the humerus in the coronal plane including the capitellum and most of the trochlea – McKee et al (represented by a double arc sign on a plain lateral radiograph (20)	Fracture of the posterior aspect of the trochlea	
Type 5		Fracture of the medial epicondyle	
Sub-classified			Posterior comminution or impaction is **A** absent or **B** present

Table 2. — Comparison of Capitellum Fracture Management Strategies as reported in the literature in the last 10 years

	Number of patients	Treatment	Method	Approach	Direction
Vaishya R et al, JSES 2016	16	Surgical Fixation	Headless double-threaded compression screws (HDTCS)	Antero-lateral	Anterior-to-posterior
Bilsel K et al, Arch Orthop Trauma Surg 2013	18	Surgical Fixation	Variable pitch screws, HDTCS, cannulated screws	Lateral (16), posterior (2)	Anterior-to-posterior
Puloski S et al, J Orthop Trauma 2012	7	Non-operative	Closed reduction + splint at 90° of flexion & mobilised at 14 days	Not applicable	Not applicable
Brouwer et al, JHS (Am) 2011	30	Surgical Fixation	HDTCS, standard screws, plates	Not described	Not described
Ashwood N et al, JSES 2010	26	Surgical Fixation	HDTCS, bioabsorbable rods, plates	Postero-lateral	Anterior-to-posterior
Mighell M et al, JSES 2010	11	Surgical Fixation	HDTCS	Lateral	Anterior-to-posterior
Kuriyama K et al, JHS (am) 2010	2	Surgical Fixation	HDTCS	Arthroscopic assisted	Posterior-to-anterior and lateral to medial
Guitton TG et al, JBJS Am 2009	27	Surgical Fixation (25), Excision of fragment (2)	Cannulate screws, wires and plates	Lateral (22), Posterior (4), open wound (1)	Anterior-to-posterior and posterior-to-anterior
Cottalorda J et al, Orthop Traumatol Surg Res 2009	1	Excision of fragment	Not applicable	Lateral	Not applicable
Sodl JF et al, JBJS Am 2008	1	Surgical fixation	Suture fixation of chondral defect	Postero-lateral	Not applicable

Fractures of the capitellum often display more complexity than that of their first appearance and may involve the trochlea, lateral epicondyle and the posterior aspect of the lateral column *(10,29)*.

Furthermore, capitellum fractures may have concomitant ligamentous injuries (medial collateral ligament or lateral ligamentous complex tears) and ipsilateral radial head fractures *(6,21)*.

A number of classifications exist attempting to describe such injuries from Bryan and Morrey's original descriptive version *(4)* to more recent attempts by Ring et al *(30)* and Dubberly et al *(6)* (Table 1). The latter being prognosis orientated and it signifies the importance of posterior comminution and medial extension of the fracture.

The aim of our retrospective study was to evaluate the functional and radiographic outcomes of open reduction and internal fixation of capitellum fractures specifically, Type 1 and Type 3 fractures according to the Bryan and Morrey classification *(4)* in light of current trends reported in the literature (Table 2).

MATERIALS AND METHODS

We carried out a retrospective study analysing patient case notes, physiotherapy notes, theatre records and the relevant radiographs for a period of 6 years. Fourteen patients with an average age of 56.6 years (range 19-88) with capitellum fractures were included in the study (twelve females and two males).

For the purposes of our study, we preferred the Bryan and Morrey classification system *(4)* and thus included Type 1 and Type 3 fractures treated with open reduction and internal fixation (ORIF). Type 2 fractures were not included as the Kocher-Lorenz *(15,17)* osteochondral sleeve fracture can initially be treated with physiotherapy or surgical removal of an isolated fragment rather than an ORIF.

The decision to treat these fractures non-operatively is an option but otherwise it is a challenge faced by most upper limb surgeons dealing with such injuries. Non-operative management in certain circumstances can be an acceptable form of treatment, whether this is due to patient related factors such as co-morbidities or the fracture configuration itself and should always be taken into consideration during the decision making process. However, as the purpose of our study was to assess post-surgical outcomes, all fractures treated non-operatively were excluded as well as those with trochlear involvement (lateral mass fractures) due to their complex injury pattern.

Mayo Elbow Performance Score
Function
Pain (max., 45 points)
None (45 points)
Mild (30 points)
Moderate (15 points)
Severe (0 points)
Mean
Range of motion (max., 20 points)
Arc > 100 degrees (20 points)
Arc 50 to 100 degrees (15 points)
Arc < 50 degrees (5 points)
Mean
Stability (max., 10 points)
Stable (10 points)
Moderately unstable (5 points)
Grossly unstable (0 points)
Mean
Function (max., 25 points)
Able to comb hair (5 points)
Able to feed oneself (5 points)
Able to perform personal hygiene tasks (5 points)
Able to on shirt (5 points)
Able to put on shoes (5 points)
Mean
Mean total (max., 100 points)

Morrey BF, An KN, Chao EYS: Functional evaluation of the elbow. *In The Elbow and Its Disorders*, edited by B. F. Morrey. Ed. 2, pp. 86-89. Philadelphia, W. B. Saunders, 1993.

Figure 1. — Mayo Elbow Performance Score.

Patients were assessed in the outpatient setting and followed up with regular antero-posterior and lateral views of the elbow along with a clinical examination and a functional outcome measurement. Manual goniometry was employed to assess the angle of flexion and extension of elbow movements. At the final follow-up all patients were reviewed by senior clinicians with a special interest in upper limb surgery at a busy district general hospital. The Mayo Elbow performance score (MEPS) *(22)* was the tool of choice for documenting outcomes (Figure 1).

Nine patients had a postero-lateral approach and while the rest had an antero-lateral approach performed. For the postero-lateral approach, the incision was centred over the lateral epicondyle, extending from the anterior side of the lateral column of the distal part of the humerus to approximately 2 cm distal to radial head. Whereas for the antero-lateral approach, we utilised the interval between brachialis and brachioradialis proximally and brachioradialis and pronator teres distally. The radial nerve was identified and protected for each case. Additionally, if small fragments of radial head were noted, they were excised and if a medial collateral ligament (MCL) repair was necessary then a direct medial incision was used.

RESULTS

The mechanism of the injury was a direct blow in eleven patients (79%) and a fall onto an outstretched hand (FOOSH) in three patients (21%).

There were eleven Type 1 and three Type 3 fractures (Figures 2 & 3). Also, associated injuries included two dislocations with one MCL injury and two radial nerve injuries noted at the time of presentation.

The waiting time for surgery was a mean of 3.0 days (range 0-7). All patients had an ORIF with a screw and additionally, two patients had supplementation of fixation with wires. With regards to fixation, nine patients received a Mini Acutrak® Headless Compression Screw, whilst four had Herbert™ (Zimmer®) Cannulated Bone Screws and the other one had a mini lag screw (AO - Synthes®). Eleven operations were performed by a consultant and the remainder by a senior registrar. Based on the fracture morphology, the approach was antero-lateral for five patients and postero-lateral in nine patients. All Type 3 fractures were operated through a postero-lateral approach. The direction of screws was anterior-to-posterior in thirteen patients and posterior-to-anterior in the other one. The average tourniquet time was 66.28 minutes (range 47-110 minutes) which also reflected the operative time.

Nine patients had early mobilisation (all were Type 1 injuries) however, three required up-to four-weeks and the other two had a six-week immobilisation period in either a hinged brace or a plaster cast. The difference in post-operation protocol was anecdotally determined by the surgeon based on the robustness of the fixation at the time of surgery. All the patients were subsequently assessed both clinically and radiologically. Average time for radiological union was 7 weeks ; union was regarded as the obliteration of the fracture line and cortical continuity on at least 3 out of 4 cortices on two radiographic views – antero-posterior and lateral *(23)*. Average follow-up was noted to be 34.5 months (range 6-75). At their last follow-up no patient demonstrated avascular necrosis or heterotopic ossification of their elbow.

Mayo Elbow score was excellent for seven patients, good for three patients, and fair for three patients. One patient could not be assessed due to learning difficulties. One of the three patients with a fair outcome developed capsular contractions post surgery whereas the other two included a Type 3 injury with a protruding screw post-operatively and a radial nerve palsy associated with the original injury.

Figure 2. — Type 1 fracture (post op radiographs).

Figure 3. — Type 3 fracture (post op radiographs).

Eight out of fourteen (57%) patients had full flexion (140 degrees or more) during their last follow up. Moreover, six patients had 10 degrees extension deformity while one had full extension (Table 2).

With regards to complications, one patient had revision fixation due to metalwork failure. Despite the fracture being fixed with 2 headless compression

Table 3. — Range of motion in patients at last follow-up

Patient No.	Range of motion from extension to flexion (degrees)
1	10 – 135
2	20 – 140
3	10 – 130
4	45 – 140
5	10 – 140
6	30 – 140
7	20 – 100
8	0 – 140
9	20 – 140
10	10 – 140
11	20 – 135
12	20 – 120
13	10 – 140
14	10 – 100

screws, at the point of failure it was felt that the fracture compression was inadequate and therefore a revision fixation with a lag screw and supplemental wires was performed at approximately 3 months after the original injury.

One patient required a capsular release for contractions despite the advice to to mobilise immediately after surgery ; we were unable to give an exact explanation as to this problem however the elbow's range of motion was noted to be 30-140 degrees at discharge.

Furthermore, one screw was removed for being prominent in patient who had a type 3 fracture. Due to the complexity of the fracture pattern four screws were placed in an anterior-to-posterior fashion. However, due to collapse of one of the fragments during the healing process, the correlating screw was then removed on the basis that it was prominent and painful.

DISCUSSION

Hahn was the first to report on capitellum fractures on the basis of an autopsy finding in 1853 and whilst Kocher provided the first clinical observation in 1896 *(11,15)*, these injuries are still rare and therefore optimum management of these fractures is a matter of ongoing debate due to a shortage of large cohort comparative studies.

Guitton et al. reported that the vast majority of what appear to be capitellum fractures are actually complex fractures of the articular surface involving both the capitellum and the trochlea ; increased complexity of these fractures lead to worse functional outcomes *(10)*. Furthermore, the capitellum is susceptible to shear forces because of its centre of rotation being 12-15 mm anterior to the humeral shaft and fractures are seen with greater frequency in females than in males as seen in our case series. This may be partly explained by the greater carrying angle and an increased susceptibility of osteoporosis in females *(10)*.

To date a number of small series (Table 2) have been published reporting a variety of solutions to managing these injuries. Points of interest to surgeons include :

1. *To operate or not?*
2. *Does the fracture heal and what is the rate of avascular necrosis (AVN)?*
3. *Which approach, type of screw to use, and whether to compress or not? Also, is it better to go antero-posterior (AP) or postero-anterior (PA)?*
4. *Does rotation of the fragment need addressing?*
5. *Is it safe to strip off the posterior blood supply to the lateral column?*
6. *What to do with lateral ligament complex at time of surgery?*
7. *Is it safe to mobilise early and what can the patient expect from range of motion (ROM)?*

Surgical management of capitellum fractures has substantial support in the literature although most of the studies are retrospective in nature *(16,24)*. Previous publications have debated between fragment excision and internal fixation as viable options for the appropriate fracture presentations. Regarding the risk of AVN Alvarez et al reported better results with excision of a large fragment or multiple small fragments in comparison to closed reduction, or by open reduction and fixation *(1)*. However, later studies often recommended open reduction and internal fixation as the treatment of choice with better results, particularly less stiffness and instability *(5,9,20,31)*. Scaninelli recommended a fibrin sealant method for fresh displaced fractures of the capitellum in a small case series

Table 4. — Outcomes of Capitellum Fractures

Patient	Age	Gender	Days to Operation	Mechanism	Fracture Type	Assoc. Injuries/ Factors	Approach	Type of Fixation	Fixation Method	Mayo Score	Immobilization	Follow-up	Complications
1	55	F	2	Direct	3	Ulna Nerve Neuritis	Postero-lateral	Ant.-to-Post.	K-wire + Herbert Screw	85	2 weeks	22 months	
2	62	F	4	FOOSH	1		Antero-lateral	Ant.-to-Post.	K-wire + Acutrak Screw	-	None	1.5 months	
3	81	F	1	Direct	1		Postero-lateral	Post.-to-Ant.	2x Lag Screw	100	4 weeks	9 months	
4	26	F	1	Direct	3		Postero-lateral	Ant.-to-Post.	K-wires + 4x Herbert Screws	60-65	2 weeks	24 months	Screw Protrusion
5	83	F	0	FOOSH	1		Postero-lateral	Ant.-to-Post.	2x Acutrak Screws	85	None	17 months	
6	37	F	7	Direct	1		Postero-lateral	Ant.-to-Post.	2x Acutrak Screws	70	None	11 months	Contracture
7	60	F	3	Direct	1		Postero-lateral	Ant.-to-Post.	Herbert Screw	100	None	3 months	
8	47	F	2	Direct	1	MCL Injury	Postero-lateral	Ant.-to-Post.	3x Acutrak Screws + MCL Repair	100	6weeks (Hinge Brace)	3 months	
9	19	F	3	Direct	1	Pregnant	Antero-lateral	Ant.-to-Post.	2x Acutrak Screw	100	4 weeks	7 months	Failure: Re-do with Lag Screw + K-Wires
10	77	F	3	Direct	1		Postero-lateral	Ant.-to-Post.	2x Acutrak Screw	100	None	1.5 months	
11	77	F	4	Direct	3		Postero-lateral	Ant.-to-Post.	Acutrak Screw	100	6 weeks (Plaster Cast)	2.5 months	
12	43	M	6	FOOSH	1	Radial Nerve Symptoms	Antero-lateral	Ant.-to-Post.	K-wire + Herbert Screw	85	4 weeks	9 months	
13	38	M	5	Direct	1		Antero-lateral	Ant.-to-Post.	2x Acutrak Screws	100	None	3 months	
14	88	F	5	Direct	1	Radial Nerve Symptoms	Antero-lateral	Ant.-to-Post.	2x Acutrak Screws	60-70	None	Ongoing	

with three patients having good clinical results at approximately four years post treatment *(32)*.

The need for surgical intervention itself can also be debated as Trinh et al demonstrated no statistically significant difference in pain and functional outcomes following non-operative vs operative management of Type 1 (over 80%), 2 and 3 fractures *(35)*. Closed reduction and immobilisation for a period of time is a popular non-operative strategy, however, maintaining anatomical reduction of the fracture fragments may be difficult and requires an extended period of immobilisation which, conversely may be a cause of stiffness secondary to early post-traumatic arthritis and thus ORIF may prove to be more ideal especially in terms of early mobilization *(20,33)*.

Puloski et al demonstrated anatomical or near anatomical reduction and union with good outcomes having no AVN rates in their small series of conservatively managed fractures *(26)* however, mal-union and instability are likely outcomes when the fragments have healed in a displaced manner *(1,10)*.

In operatively treated fractures non-union is reported to be low even in partially devitalised fragments, however, it may occur in a setting of infection with higher rates noted in fracture patterns where posterior condylar comminution exists *(3)*. Overall, AVN rates range between 0% to 30% in fractures of the capitellum *(18,20)*.

There is a variety of fixation methods described utilising either a postero-lateral or antero-lateral based approach. Biomechanical studies have demonstrated that fixation of capitellum fractures with Acutrak® screws placed in a postero-anterior direction is superior to both an antero-posterior direction and the use of other fixation hardware such as a 4.0 mm cancellous lag and Herbert screw *(7,8)*.

In our series, 69% of patients were treated with an Acutrak® screw and 56% of them had an 'excellent' outcome on the MEPS. However, all but one patient was fixed with the screw placed in an antero-posterior direction and this was not specifically shown to be associated with an adverse outcome despite the above mentioned biomechanical findings.

Herbert and Fisher *(13)* initially designed their variable pitch cannulated screw to treat scaphoid fractures by allowing compression of two large fragments and burial beneath the articular cartilage. Subsequently, it was also shown to be useful for internal fixation of capitellum fractures too *(19,28)*. The major disadvantage of the Herbert™ screw is that its removal can be extremely difficult as care must be taken while burying the screw beneath the articular surface adequately. In our cohort a 'good' or better outcome was obtained in three out of four patients who had been fixed with such a device.

Other fixation methods such as Kirschner wires also exist. However, they are not ideal as they do not compress and may require removal afterwards, although they may be used as supplement to screw fixation *(19)*. Cancellous screws can also be used but they require insertion from the non-articular surface (posterior-to-anterior) because the screw heads cannot be countersunk *(19)*.

Although the approach is usually dictated by the fracture morphology while planning pre-operatively for such cases, most studies allude to a antero or postero-lateral based approach which generally has yielded good results *(2,31)*. The Dubberley classification is especially valuable in decision-making process regarding the surgical approach to be employed (6). Our results have also shown good results for those patients who had an antero-lateral based approach as demonstrated by Vaishya et al *(36)*.

The antero-lateral approach gives direct visualisation of the fracture fragment allowing anatomical reduction and a chance to inspect the joint completely, including the medial articular surface. As the blood supply to the capitellum originates posteriorly, there is little or no risk to its blood supply by this approach. Furthermore, both capitellum and trochlea portions can be fixed and screws in the latter can be placed slightly obliquely to obtain better purchase especially in a narrow distal humerus *(27)*.

As a near anatomical position is important for fracture healing and a good outcome, controlling rotation of the fragment is a necessary technical aspect of the surgical procedure. Ruchelsman et al recommend divergent screw placement to obtain better rotational control and to spread the screws wide enough, so that the chances of iatrogenic fracture of the capitellum are reduced *(31)*.

The postero-lateral capsular attachment is responsible for most of the distal humerus vascularity and can be compromised in an extended posterior approach which should be avoided while treating fractures of the capitellum and trochlea *(12,14,37)*.

Co-existing ligament injuries need assessing thoroughly and managing accordingly. There may be a case for routine imaging to include both a CT (computed tomography) scan and MRI (magnetic resonance imaging) scan irrespective of whether non-operative or an operative strategy is pursued. Further information is likely to a direct an appropriate form of management and can also assist in pre-operative planning. Examination under anaesthesia can also be employed as routinely done by Singh et al *(33)*, but the treating surgeon will need to be prepared to alter the management plan as necessary on table and the patient will need appropriate counselling about this prior to surgery. If the capitellum fracture is associated with a ligamentous injury then the involved ligaments should also be repaired to achieve elbow stability as done in one of our cases (concomitant MCL injury).

Puloski et al have shown that non-operative management by means of closed reduction and early mobilisation (within first 3 weeks) leads to good outcomes and can be undertaken in a safe and predictable manner *(26)*.

Trinh et al have demonstrated little difference in range of motion in those treated non-operatively or operatively and therefore advocated closed reduction as a form of definitive management before any surgical input *(35)*. Moreover, when fragment excision was compared with fixation, once again no difference in post-operative range of motion, presence of pain or joint instability could obviously be seen *(35)*. Anterior scarring may be observed in patients treated with an antero-lateral approach which can be avoided by not crossing the elbow flexion crease at 90° or by performing an anterior capsulotomy at the time of fixation as reported by Vaishya et al *(36)*.

In our series, nearly half of the patients achieved full flexion and a similar number had only a 10 degree extension lag. These outcomes are within a functional range of motion. Once the wounds have healed at around 2 weeks, with operative management early mobilisation is absolutely recommended to avoid stiffness.

In conclusion, these intra-articular fractures require appropriate reduction, preferably early as shown by Ashwood et al *(28)*, in order to regain a degree of normal elbow function. Current trends in the literature favour an open reduction and internal fixation for Type 1 and 3 injuries (Bryan and Morrey). Early mobilisation is the primary choice unless there is an associated injury and a single incision technique, either postero-lateral or antero-lateral with a screw placed either in an anterior-to-posterior or posterior-to-anterior direction is deemed acceptable. The type of fixation hardware in isolation is unlikely to specially affect outcomes in these patients.

Overall we believe that our study adds further to the literature on a subject which continues to be rare and confirms the effectiveness of treatment strategies as described by other authors regardless of hardware types.

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