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Isolated Capitellum Humeri Fractures in Adults

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A B S T R A C T

From 2003 through 2009 we treated 35 patients who suffered from an isolated capitellum humerus fracture whom we treated with osteosynthesis. Patients who presented with concomitant fractures were not included. Thirty-four patients were categorized as Type I (Hahn-Steinthal) while one patient was Type IV (McKee). We describe the mechanism of injury and compared our results with works available in the literature. The average age of our patients was 38.6 years which was much younger than many articles about this type of injury found in the literature. The ratio of women to men in our study was 20:15. The surgical treatment was performed with various methods including: Kirschner wires, AO screws, Herbert screws and TwinFix screws. We discuss type of injury, days after injury operative treatment is performed, type of osteosynthesis used, the surgical approaches used for our treatment of capitellum humeri fractures, possible complications and our postoperative treatment. Results at the conclusion of treatment were excellent. Range of motion, shown in detail for each patient, was measured preoperatively, 1 month and 3 months postoperatively. We concluded that the major factors in successful treatment are how quickly the surgical treatment is performed after injury and early postoperative rehabilitation.

Key words: *capitellum humerus fracture, elbow injury, osteosynthesis, AO screws, Herbert screws, TwinFix screws*

Introduction

Capitellum humeri fractures were first described by Cooper[1] as an isolated injury in 1841. Hahn, in 1853, reported that this injury in a 63 year old woman had unsatisfactory results because of elbow flexion limitations[2]. Kocher provided the first clinical observation of this fracture in 1896[3–5]. Several articles about capitellum humerus fracture as well as its treatment were published in the following years. Works about capitellum humerus fracture were published by Steinthal in 1898[6], Lorenz in 1905[7] and Böhler[8] in 1956. Darrach[9,10] advised in 1916 that the fractured fragment should be excised. In 1933 Speed and Macy[11] reported good results after open reduction and internal fixation of the fragment with a wire nail. There was controversy about how to treat a capitellum humerus fracture, as some recommended excision of the fragment[12–14], while others advocated open reduction with or without internal fixation[15–17].

Today's classification of capitellum humeri fractures come from McKee's modification of the Bryan and Morrey classification[18,19]. Type I (Hahn-Steinthal) is a coronal shear fracture with one large capitellar fragment[2,6] (Figures 1 and 2). Type II are osteochondral lesions of the capitellum known by the eponym Kocher-Lorenz which merely involves a superficial osteochondral shell with little osseous bone, and is usually referred to as an 'uncapping' of the capitellum[4,7]. Type III fractures include all comminuted fractures of the capitellum[18]. Type IV fractures were added by McKee et al.[19] and are distal humeral articular surface fractures which extends medially in the coronal plane to include the lateral half of the trochlea. This can be recognized by the Double arc sign[19] on a plain radiograph.

Most authors suspected that the fracture was caused by a fall onto the out stretched hand with the elbow in extension or in slight flexion. The impact against the hand creates a force transmitted through the forearm to the radial head, which acts like a piston shearing off the capitellum[5,20]. Since the fracture is caused by the radial head striking the capitellum, associated fractures of the radial head would be expected to occur and in 1961 Palmer[21] reported a frequency of 31% of concomitant fractures of this type. Associated radial head fractures

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Fig. 1. A-P projection x-ray, Capitellum humerus fracture.

Fig. 2. L-L projection x-ray, Capitellum humerus fracture.

were classified according to Mason[22,23] as Type I (undisplaced), Type II (displaced simple) and Type III (comminuted). One investigation on concomitant fractures of the radial head and fractures of capitellum humeri showed 24% had associated fractures, 26% were Mason Type I and 74% Type II. There was no significant relationship found between a fracture of the radial head and pattern of capitellar fracture[23]. Today we know capitellar fractures can be sustained by direct injury in flexion and indirectly through an extended radius, as in falling on an outstretched hand[21,23]. Both mechanisms may produce a coronal shear fracture. Indirect trauma may be associated with a fracture of the radial head. It is likely that these fractures represent the extreme of a spectrum of injuries that include minor scuffing of the capitellum, often observed with radial head fractures[23,24]. Today it is suggested that all fractures confined to the distal humeral articular surface should be considered a subgroup of distal humeral fractures[25,26] and based on specialist imaging or operation, classified as such[25].

Patients and Methods

We present 35 patients with isolated capitellar humeral fracture which were injured from 2003–2009. All patients were treated surgically with osteosynthesis of the humeral capitellar fracture. The average age of the patients at the time of injury was 38.6 years, the average age of the 15 male patients was 32.7 years and the average age of the 20 female patients was 43.1 years. In Table 1 is shown sex, age, number of days after injury the patient had surgery, and function of elbow (range of motion) before operation. The mechanism of injury in all patients was a fall onto the outstretched hand. Those involved in sports activities: 7 injured while inline skating, 4 injured while ice skating, 1 injured playing ice hockey and 1 injured playing soccer. In patients who fell from more than standing height: 3 cases fell from a bicycle, 1 fell from a 3 m high ladder, 1 fell from 1.5 m fence, 1 fell from a tree, 1 fell from a roof, 1 fell from construction staging and 2 fell down stairs. The remaining 12 patients fell from standing level, usually after tripping or slipping. All of the patients had preoperative radiology diagnostic: AP and LL and oblique x-rays, and in all patients CT (computerized tomography) was also made. CT allows for delineating the fracture pattern. CT scanning of the elbow is done at 1- to 2-mm intervals using axial or transverse cuts.

Surgical treatment

All patients were treated by open reduction and fixation of the fractured capitellum humeri. In 25 patients the operation was made with regional block anaesthesia, and in ten patients general endotracheal anaesthesia was used. The Kocher surgical approach was used in all cases but one. In the Kocher approach a 5 cm incision is made proximal to the lateral supracondylar ridge of the humerus and extended along this ridge, and continued to the radiocapitellar joint. The interval between the triceps muscle posteriorly, and the brachioradialis and extensor carpi radialis longus muscle anteriorly, is dissected to expose the lateral condyle and the capsule over the surface of the radial head. The interval between the extensor carpi ulnaris and the anconeus is dissected. The common extensor muscle origin is reflected anteriorly from the lateral condyle by subperioseal dissection. The posterior cortex of the lateral condyle should be cleared of soft tissue in preparation for the screw insertion. The joint capsule is incised longitudinally to expose the joint. Distally, it does not need to extend to the neck of the radius[27].

In one patient, whose fracture was treated 21 days after injury, a different approach was used due to the position of the capitellar fragment. This approach starts with a lateral incision in the region of the lateral epicondyle humerus, the anterior margins of the brachioradialis muscle and of the biceps medially are identified and dissection is continued between these two muscles and carried down to the humerus. The brachioradialis muscle is retracted outward and the biceps medially. The radial nerve is located at the bottom of the wound and is gently retracted. The retraction medially of the biceps muscle has brought into view the lateral portion of the brachialis muscle beneath it. The musculocutaneous nerve descends between these two muscles and then emerges laterally to the biceps tendon; it must not be injured. The lateral antibrachial cutaneous nerves supply the skin of the anterior and lateral surfaces of the forearm. The brachialis muscle is raised from the front of the lower end of the humerus and reflected toward the midline. The anterior lateral capsule of the elbow joint is now exposed in the wound, and an incision through it brings to view the lateral components of the elbow joint[28].

In both approaches, once the components of the elbow joint are exposed, the procedure is the same. If there are small bone fragments of the fractured capitellum or if there existed bountiful comminution of the same they are removed. However if there are larger pieces to work with osteosynthesis is performed, with full reposition of the fragments. The fracture site was cleaned from loose pieces of bone, blood clots and interposed tissue. The joint was inspected and the fractured capitellar humerus, which is usually displaced in anterosuperior position, was reduced back to anatomic position. This is helped by slight varus force and extension of the elbow. After reduction of the capitellum, flexing the elbow may help in maintaining reduction. Usually Kirschner wires were used for temporary reduction and then screws were placed. In ten cases Kirschner wires were the osteosynthesis method (7 females and 3 males), but most of these patients were operated in 2003 and 2004. After 2004 osteosynthesis was done with screws in 25 patients: Arbeitsgemeinschaft für Osteosynthesefragen (AO) screws were used in 13 patients (7 females and 6 males), 1 female patient had a combination of AO and Herbert screws, titanium Herbert screws (Figure 3) were used in 7 cases (3 females and 4 males) and titanium TwinFix screws were used in 4 cases (1 female and 2 males) (Figure 4). One patient who had osteosynthesis with Kirschner wires 6 days after injury was reoperated 10 days later because the previously reduced fragment had moved and re-osteosynthesis was made with TwinFix screws.

Fig. 3. A-P projection x-ray, after osteosynthesis with 2 Herbert screws.

Fig. 4. L-L projection x-ray, after osteosynthesis with 2 TwinFix screws.

Range of motion measurements

All patients elbow range of motion was measured preoperatively, 1 month postoperatively and 3 months postoperatively. Normal full extension of the elbow is 0°. Normal flexion of the elbow is 140°. (For a maximum range of motion of 140°.) Normal rotation of the forearm pronation is 90° and supination is 90°, giving 0° the forearm neutral position with the thumb facing upwards (Table 1). (For a maximun range of motion of 180°).

Statistical analysis

The data (range of motion EXT-FLX and PRO-SUP) was analyzed using descriptive statisitcs and the Students t-test for comparison between pre operative range of motion, range of motion at 1 month, and range of motion at 3 months. Statistical significance was set at $p<0.05$. Data was analyzed using Statisica.

TABLE 1
PATIENT DATA

Sex	Age-in years	Operation on number days after injury	Preop ROM: EXT – FLX	Preop ROM: SUP – PRO	ROM Postop 1 month: EXT – FLX	ROM Postop 1 month: SUP – PRO	ROM Postop 3 months: EXT – FLX	ROM Postop 3 months: SUP – PRO
M	50	4	115	135	120	160	140	180
M	45	4	100	135	120	160	140	180
F	45	5	100	135	120	160	140	180
F	54	21	50	95	90	110	125	150
F	43	18	50	95	100	110	130	155
F	53	7	110	130	125	165	140	180
M	18	1	115	140	120	165	140	180
M	18	9	50	85	80	100	105	160
F	67	6	80	105	100	135	125	180
F	60	6	110	130	130	165	140	180
F	59	5	80	100	100	135	135	170
M	41	30	60	90	70	120	120	160
M	18	7	80	125	100	160	130	165
F	55	1	80	105	100	135	130	170
F	44	5	45	115	85	130	135	180
F	28	3	50	130	80	145	130	175
M	34	5	80	125	100	140	130	180
F	47	2	115	135	130	140	135	180
M	28	3	100	135	110	160	140	180
M	34	5	50	135	110	160	140	180
M	48	4	105	115	110	150	140	180
F	47	5	80	100	100	120	130	180
F	57	37	50	90	50	90	75	140
M	27	4	115	135	130	140	135	180
F	26	4	80	100	120	170	140	180
M	25	5	80	105	120	155	140	180
M	23	5	75	105	100	150	140	180
F	31	7	80	100	100	160	140	180
F	44	10	105	100	100	170	140	180
F	18	10	105	135	100	180	140	180
F	18	2	110	135	100	160	140	180
F	21	6 + 10	110	130	130	165	140	180
M	43	2	80	100	100	120	130	180
F	44	12	110	135	115	155	140	180
M	39	3	115	140	115	160	140	180

Preop – preoperative, Postop – postoperative, ROM – range of motion, Normal value for extension-flexion=0°–140°, EXT – extension, FLX – flexion, Normal value for supination – pronation=90°–0°–90° (total 180°), SUP – supination, PRO – pronation

Postoperative treatment

All cases of osteosynthesis with AO screws, Herbert screws or TwinFix screws started rehabilitation 24 hours after operation. Patients with Kirschner wire osteosynthesis started rehabilitation 7 days postoperatively. Cast immobilization was not used. Extraction of Kirschner wires was done 6 weeks after osteosynthesis, AO screws were removed 6 months postoperatively. Herbert screws and TwinFix screws were not removed.

Results

Clinical results of elbow motion after injury (before operation), 1 month after operation and 3 months after operation are measured as flexion, extension, supination and pronation (Table 1). The patient's medial and lateral elbow stability was tested after operation, and instability was not found in any of the 35 patients. Patients did not report they experienced pain during their normal range of motion while performing daily activities. Necrosis of

capitellum humeri was not identified in any patients on radiologic examination. Signs of loose intra-articular bodies or secondary osteoarthritis were not observed and none of the patients had osteitis or wound infection following surgical treatment. After 3 months 19 of 35 patients (54.3%) had ideal normal extension-flexion (0°–140°). Extension greater than 5° is not considered satisfactory, at 10° extension contraction is present and range of motion is unsatisfactory. We tolerated extension to 5° as satisfactory. We also tolerated a flexion of 130° as satisfactory. Therefore at 3 months postoperatively, 27 of 35 patients (77%) had satisfactory range of motion results in extension-flexion measurements (mean=133°, standard deviation 12.6°). At the same time, 3 months postoperatively, 26 of 35 patients (74.3%) had ideal supination-pronation (90°–90°) of the forearm. Excellent range of motion is considered with 85° and we tolerated 80° as a satisfactory result. At 3 months postoperatively, 32 of 35 patients (91%) had satisfactory clinical results in supination-pronation measurements (mean=175°, standard deviation 10.1°). The increase in range of motion, in degrees, FLX-EXT was statisitacally significant ($p<0.0000001$) for all three pairs tested with the t-test (Figure 5). The increase in range of motion, in degrees, SUP-PRO was statisitacally significant ($p<0.0000001$) for all three pairs tested with the t-test (Figure 6).

Discussion

Fractures of the capitellum humeri are rare with an annual incidence of 1.5 *per* 100,000 in a population over 13 years of age[23]. In the literature, the higher prevalence of this injury is found in women, especially over 60 years of age, and it has been suggested this is related to the greater carrying angle of the female elbow and postmenopausal osteoporosis[23,29]. Our patient population was

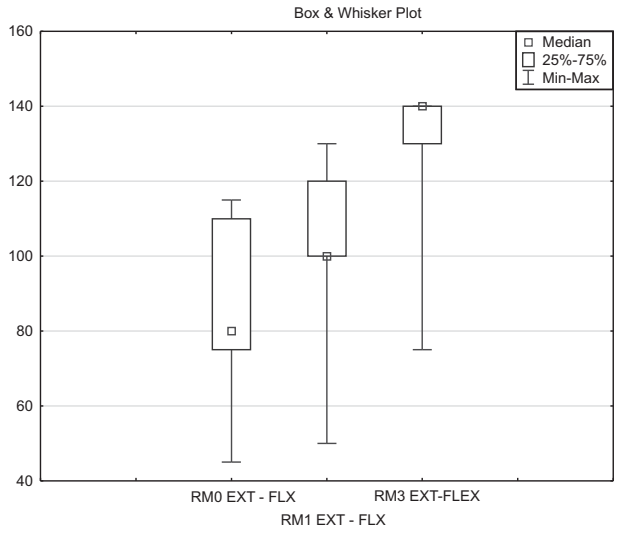

Fig. 5. Box and Whiskers plot of Extension-Flexion range of motion RM0:preoperative, RM1: 1 month post operative, RM3:3 months postoperative. Differences between all three groups are statistically significant. (p<0.0000001).

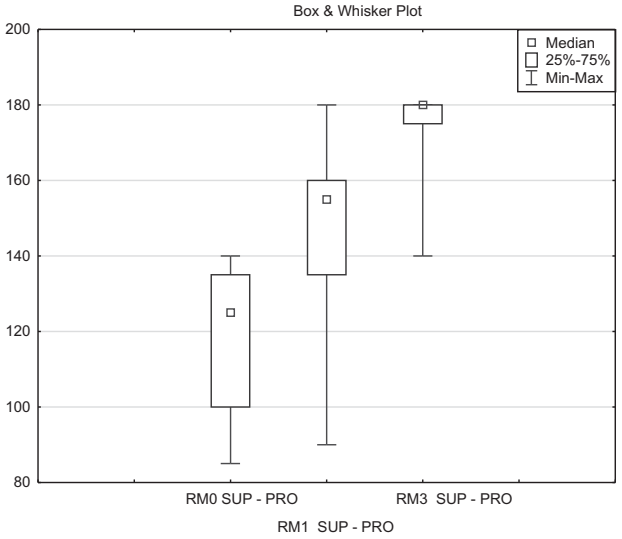

Fig. 6. Box and Whiskers plot of Supination-Pronation range of motion RM0:preoperative, RM1: 1 month post operative, RM3:3 months postoperative. Differences between all three groups are statistically significant. (p<0.0000001).

generally younger, our average was 38.6 years; we had only two patients who had 60 or more years of age. It may be that the older populations had additional fractures more than an isolated capitellum humerus fracture, in which case osteoporosis may play a greater part. In the literature it can be found that women suffer from capitellum humerus fractures 4 times more often than men[30], again our patient results are different, with 20 women and 15 men.

The most frequent type of fracture is Type I (Hahn-Steinthal) and makes up 47% of all fractures of the capitellum humerus, the majority of these injuries are sustained by a fall from standing height[23]. In our study, all but one patient were categorized as Type I. Type II (Kocher-Lorenz) and Type III (comminuted) fractures of the capitellum humeri are found in considerably less numbers. Type II and Type III were not included in our study, not because of its rarity but because these types are usually treated with bone extraction due to the small lesion of the capitellum or comminution which cannot be solved with osteosynthesis treatment. Type IV (McKee) makes up 36% of capitellum humerus fractures in women, while found in 54% of cases in men[23]. In our study from 35 cases, we had only one Type IV fracture which was isolated and the patient was a 55 year old woman. Because Type IV fractures generally do not appear as an isolated injury, the patients with concomitant fractures have not been included in this study.

Capitellum humeri fractures associated with radial head fracture occurs in 24% of cases[23]. We only presented isolated fractures capitellum humeri, however other than radial head fractures, which are frequently associated with capitellum humeri fractures, fractures such as humeral medial and lateral epicondyle, trans and intercondylar humeral fractures, distal metaphyseal humeral

fracture, fracture of the olecranon process of the ulna and fracture of the coronoid process of the ulna may be associated with capitellum humeri fractures. In men, reported in the literature, capitellum humeri fractures are frequently caused by high-energy trauma, especially motor vehicle accidents; only 50% of men sustain injury as a fall from standing height, compared to women with 91%[23]. In our study, there were not any patients with capitellum humeri fracture from a motor vehicle accident. However, injury in men was mostly caused by high energy trauma, described in Patients and Methods. In our study we have large number sport injuries, 7 inline skating, 4 ice skating, 1 ice hockey, soccer 1, bicycling 3, all of which involved speed increasing the energy inducing trauma.

Surgical treatment of capitellum humeri fractures is absolutely indicated because the fragment may block flexion in all four types of capitellum humeral fractures. Perfect reduction by closed manipulation is impossible[12,20,31–34]. Open reduction with or without internal fixation, also is technically difficult[5,12], while a perfect reduction is mandatory[12]. We describe the surgical approach to the capitellum humeri towards which, from our experience, repositioning the fracture is made most possible, as is preparation of where the bone needs to be repositioned with the divided fragment. In 34 patients the Kocher approach was used with very satisfactory results and osteosynthesis of the fracture. In only one case we chose to use a different surgical approach, described in Patients and Methods, because the fracture was 3 weeks old and soft tissue interposition was present between the fractured bone surfaces. AO screws were used in this case because we did not have Herbert or TwinFix screws available. In the described approach used with this patient the possibility of damaging the radial nerve was a concern although it is easily identified in the projection and gently moving it allows for the repositioning and osteosynthesis to be performed. We made reposition of fractured bone, osteosynthesis and screw placement from anterior to posterior, but in all other patients for whom osteosynthesis screws were used the screws were placed posterior to anterior (Figure 4). Posterior to anterior placement is recommended in the use of Herbert and TwinFix screws which are headless and provide better fixation in osteoporotic bone or when the fragment of bone is smaller. We did not have any radial nerve injury in our study. Kirschner wires were used in all fractures for temporary reduction of the fracture, and we used guide wires for insertion of cannulated screws such as Herbert and TwinFix. In the beginning of our study we performed treatment with Kirschner wires only and later with AO screws; we had good results with all methods. Only in one patient, a 21 year old woman, after osteosynthesis with Kirschner wires the fracture fragment moved and we repeated the operation and osteosynthesis was preformed with two TwinFix screws.

The surgical treatment of capitellum humeri fractures have always been made through a simple incision[12]. The skin incision is minimal, not larger than 5–8 cm, depending upon the constitution and weight of the patient. We believe that osteosynthesis of the capitellum is indicated in every instance except when the fracture fragment is so small that there is no way for a screw to be placed, or if there is total comminution of the fracture fragments. Still Watson-Jones observed in 1976[5,35] that 'just excision of the fragments leaves a raw bone surface which increases the risk of developing capsular adhesions and restricted mobility'. Instability of the elbow has not been reported after isolated fractures of the capitellum humeri[1] and avascular necrosis is very rare[5,12,30,36–38]. In results of our study we did not have these complications.

The success of this treatment and the good results of the operation are in early mobilization. All our patients started rehabilitation of the elbow very early following surgery and the end result in all of them was excellent. Poor results are found in those patients who had preoperative contracture of the elbow and were not operated soon after injury, in these cases the capitellum humerus fracture was not recognized immediately, or the patient did not consent to surgery. Rehabilitation started 24 hours post operatively if AO, Herbert or TwinFix screws were used for osteosynthesis. Rehabilitation was started 7th postoperative day for patients who had Kirschner wire osteosynthesis. Of the 8 patients who had less than satisfactory results 4 patients had delayed treatment prior to osteosynthesis of a minimum of 18 days to a maximum of 37 days. The remaining 4 patients had unsatisfactory measurements only in extension after three months. They were sent on additional rehabilitation. After 6 months two patients returned for control with ideal function. The other two patients did not return for control and we assume they have satisfactory function since they did not seek further treatment. Headless screws which were used in this study are usually placed posterior to anterior, however if the broken part of the capiellum was smaller we used headless screws from anterior to posterior. Compared with published studies some authors[5,39,40,41] have found good results with headless screws placed in the anterior to posterior direction. Likewise, in recent literature, Mahiroguliari et al.[42] recommmends fixation in a posterior to anterior direction with at least two headless screws. We did not find a difference in results or the late function of the elbow in relation to the direction the headless screw was introduced. Ring et al.[25] concluded that treatment of the articluate part of the distal humerus can have satisfactory elbow function when operative reduction and fixation with buried implants are used. Dubberley et al.[43] also reported patients with isolated capitellar fractures treated with open reduction and internal fixation having better functional results than more complex fractures although they had favorable patient outcomes overall. It is the authors opinion that stable fixation is to be sought to allow for early motion which increases the patient's functional recovery.

Osteosynthesis has been used in the treatment of broken capitellum humeri fractures for at least 40 years; methods have included Kirschner wires, staples, bone pegs, AO small fragment screws, Herbert titanium screws and TwinFix titanium screws[1,17,30,41,44–46]. Herbert and

TwinFix screws are the most advanced compared to the various other types of osteosynthetic devices because they are placed within the bone without any outside prominence and they need not be removed[30]. In our patients we did same. Modern fixation methods provide instant fracture stability without compromising articular integrity, which are prerequisites for achieving good functional results[30,47]. Minimal invasive surgery for capitellum humerus fractures is possible, especially when different cannulated screws or biodegradable screws are used. However, even though we support minimal invasive surgery methods wherever they may be anatomically used, in this region we do not prefer it because of the possibility of damaging the radial nerve and because of the very difficult close anatomical fragment repositioning of the fractured capitellum.

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IZOLIRANI PRIJELOMI CAPITULUMA HUMERUSA KOD ODRASLIH

SAŽETAK

U razdoblju između 2003 i 2009 g. operacijski smo liječili metodom osteosinteze 35 bolesnika s izoliranim prijelomom capituluma humerusa. Trideset i četiri bolesnika su pripadali tipu I prijeloma (Hahn-Steinthal) dok je samo jedan bolesnik klasificiran kao tip IV (McKee). U radu smo opisali mehanizam ozljede i usporedili naše rezultate s dostupnim rezultatima u svjetskoj literaturi. Srednja starosna dob naših bolesnika iznosila je 38,6 godina i znatno je mlađa nego starosna dob u brojnim objavljenim radovima za izolirane prijelome capituluma humerusa. Omjer broja ozlijeđenih žena u usporedbi s muškarcima u našem istraživanju bio je 20:15. Kirurško liječenje koje smo primjenili sastojalo se od

više različitih metoda: upotreba Kirschnerovih žica, AO vijaka, Hebertovih vijaka i TwinFix vijaka. Prikazali smo za svakog bolesnika način ozljeđivanja, vrijeme operacijskog liječenja nakon ozljede, vrstu osteosinteze i kirurški pristup koji smo koristili, te moguće komplikacije kao i poslijeoperacijsko liječenje. Rezultati koje smo dobili su bili izvrsni. U radu je prikazana pokretljivost u zglobu lakta za svakog bolesnika, prije operacije, te mjesec dana, kao i 3 mjeseca nakon operacijskog zahvata. Zaključili smo da je osnovni čimbenik uspjeha liječenja koliko je brzo nakon ozljede izvršena kvalitetna osteosinteza te rana poslijeoperacijska rehabilitacija.