Title Page

How many K wires do we need in the surgical treatment of pediathric type III supracondylar humeral fracture?

The study entitled '**How many K wires do we need in the surgical treatment of pediathric type III supracondylar humeral fracture?** was performed in Bakırköy Dr. Sadi Konuk Training and Research Hospital, Department of Orthopedics and Traumatology, Istanbul, Turkey.

The manuscript submitted does not contain information about medical device(s)/drug(s).

No funds were received in support of this work.

No relevant financial activities outside the submitted work.

IRB Approval ID:2014/18/05 IRB Approval Date: 29.12.2014

Study Protocol

After the approval of the local ethics committee (Approval ID: 2014/18/05), medical records of patients who underwent surgery between 2010 and 2013 for Gartland type 3 fracture were retrospectively screened. Patients with pathological fractures, conservative follow-up, less than the 1-year follow-up, and patients with incomplete postoperative follow-up were excluded from the study. In the present study, the patients were divided into 5 groups according to the configurations of the K-wires in fixation as Group 1 (crossed 1 lateral 1 medial), Group 2 (crossed 2 lateral 1 medial), Group 3 (crossed 1 lateral 2 medial), Group 4 (2 lateral divergent), and Group 5 (3 lateral divergent). Closed reduction and percutaneous pinning were initially preferred in all patients. One hundred patients (68 males and 32 females) who underwent surgery for Gartland type 3 supracondylar humerus fractures were included in the study. 98% of the fractures are extension and 2% are flexion type fractures. The left humerus was affected by 73% and the right humerus in 27%. While 53% of the fractures occurred with a simple fall at home, 47% were outside. The distribution of demographic features and injury characteristics of the patients were presented in Table 1.

All patients evaluated at the emergency room and peripheral neurovascular examination were reported. The SCHF classified according to Gartland classification [5]. A long arm plaster used to immobilize the elbow in 110^0-120^0 of elbow flexion in a comfortable position. No closed reduction was attempted in the emergency department. The timing of the surgeries was determined by the patients' condition and operating room availability. Open fractures with associated vascular injury were taken to the operating room emergently on presentation. Range of motion on the operated and non-operated side was evaluated at all controls and at final control measurements were statistically analyzed.

Surgical technique

Under general anesthesia, a high-arm tourniquet was placed on the arm, but not inflated and prepared for open reduction and fixation if needs. Intravenous cefazolin used for appropriate for patients' weight. The upper limb was prepared and dressed. Closed reduction was applied via manual traction. Then varus-valgus position checked by the surgeon by palpating the epicondyles and discussed with the preoperative images. While gradually flexing the elbow in extension type fractures (hyperextension can be used in some flexion type fractures), the surgeon pressed the olecranon to push the distal fragment in the sagittal plane to anteriorly for reduction. In pronation, we check fluoroscopy images on the coronal and sagittal plane (Figure 1). The reduction was considered acceptable when the anterior humeral line (AHL) bisected the middle third of the capitellum as observed on the lateral view and the humeral capitellar angle (HCA) was normal (range, 9^0–26^0) on the AP fluoroscopy view [5,6].

Under fluoroscopy guidance, the first KW applied on the lateral epicondyle to the medially. For cross-wiring medial epicondyle was centered and KW applied medial to lateral. KWs were used for the fixation in different configurations such as 2 medial+1 lateral, 2 lateral+1 medial, 2 lateral, 3 lateral, or 1 medial+1 lateral. Mini-incision at medially to prevent iatrogenic ulnar nerve injury was used for the application of medial KW. Lateral KWs were preferred at divergent orientation. The surgeons who managed the operation used an adequate number of pins to fix the fracture with sufficient stability for all patients. Surgeons decided on the number and configuration of pins used in the intraoperative period. After the fractures are reduced, the first k-wire is applied laterally. They decided on the other KW in the intraoperative period according to the flexion-extension fluoroscopy images after the first KW. Most of the patients used cross KW 1L-1M and cross KW 2L-1M (Figure 1, Figure 2, and Figure 3). The pin number and orientation were determined entirely according to the configuration to achieve fixation stability during surgery. In the fractures where the arm is

edematous and the medial epicondyle cannot be palpated, the use of a lateral pin is preferred to avoid the risk of ulnar nerve injury. The pin diameter was determined according to the age of the patient and the cortical thickness of the humerus seen on the lateral radiograph. All patients evaluated clinically and radiologically at 2nth-, 4th- and 6th weeks, 3rd- and 6th months, and annually in the postoperative period (Figure 2 and Figure 4). The elbow was immobilized with a long arm plaster for 4 to 6 weeks. Plaster and pins were removed in the outpatient clinic after callus formation seemed (between 4th and 6th week). The passive range of motion exercises was started after the pin and plaster removed.

Statistical results

Statistical analysis was performed with NCSS (Number Cruncher Statistical System) 2007 (Kaysville, Utah, USA). Many Whitney U test was used for descriptive statistical methods evaluation (average, standard deviation, median, frequency, ratio, minımum, maximum) and not normally distributed data comparison. Kruskal Wallis test was used for not normally distributed three and upper groups quantitative data comparison. Mann Whitney U test was used for the definition of the different groups. Friedman test was used for the comparison of intragroup not normally distributed parameters and the Wilcoxon Signed Ranks test and Marginal Homogeneity test was used for evaluation of binary comparison. Fisher-Freeman-Halton test was used for qualitative data comparison. P values were considered statistically significant when $p<0.01$ and $p<0.05$.

Results

The mean CA was $9,06^0 \pm 3,45^0$ on the operated side and $8,89^0 \pm 2,91^0$ on the uninjured side. The mean flexion range was $136,34^0 \pm 7,88^0$ on the operated side and $140,59^0 \pm 5,65^0$ on the uninjured side. The mean extension range was $181,35^0 \pm 6,73^0$ on the operated side and $183,75^0 \pm 4,64^0$ on the uninjured side. No statistically significant difference was found between subgroups in terms of age, sex, carrying angle (CA), flexion-extension range in the comparison with the uninjured side ($p<0.05$) (Table 2). Baumann angle (BA) showed a statistically significant difference between the groups only on the first postoperative day ($p=0.015$). However, BA did not differ significantly between the groups on the preoperative, postoperative final control, and uninjured side ($p<0.05$). Also, HCA and AHL did not differ significantly between the groups on the preoperative, the first postoperative day, postoperative final control, and uninjured side ($p<0.05$). A significant difference was found between preoperative measurements and postoperative first day, postoperative final control, and uninjured side measurements in the 2L + 1M group for BA ($p=0.004$), and in the 2L, 1L+1M,

and 2L + 1M groups for HCA ($p=0.001$, $p=0.001$, and $p=0.034$; respectively) (Table 3). In posthoc binary analyzes of BA, HCA, and AHL, there were significant differences between preoperative values, postoperative values, and uninjured side ($p<0.05$ and $p=0.001$) (Table 4). Preoperative and postoperative measurements showed a significant differences, because after reduction the angular measurements changes significantly. Postoperative BA values show no statistical difference in postoperative 1st-day control and last control. All of the patients had successful healing and there was no non-union. In complete primary reduction and secondary displacement was not reported in any patients. The mean HCA averaged 8,9±2,9 (range 3 to 18) on the uninjured side and 9,06±3,45 (range 3 to 20) on the injured side ($p<0.05$). Injury-related complications were seen in three patients, including ulnar nerve damage. Pin tract infection occurred in five patients. One patient in the 2M+1L group, one pin has removed in the medial side on the 7th day due to pin tract infection. All complications resolved in postoperative 8 weeks.