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ORIGINAL ARTICLE / ARAŞTIRMA YAZISI

Orthopaedics / Ortopedi

Do K-wire Configurations and Numbers Have Effects on Gartland Type 3 Pediatric Supracondylar Humeral Fractures?

Malik Çelik[1], **Alkan Bayrak**[1]

[1]Bakırkoy Dr Sadi Konuk Research and Training Hospital Orthopaedics and Traumatology Clinic, Istanbul, Turkey

Malik ÇELİK

Alkan BAYRAK

ABSTRACT

Aim: The purpose of this study was to compare pin configuration effects on early secondary displacement in the surgical treatment of pediatric supracondylar humeral fractures (SCHF).

Methods: The study consisted of 100 (68M, 32F) children who underwent surgery between 2010 and 2013 for Gartland Type 3 (SCHF). The patients were divided into five groups according to the top configurations. The average age at the time of injury was 7.34 (between 2 and 14 years). Bauman angle (BA), Humerocapital angle (HCA), Anterior humeral line (AHL), flexion range, extension range, and Carrying angle (CA) were compared at preoperative, postoperative 1st-day, postoperative last control, and non-operated side.

Results: There was no statistical difference between all five subgroups in terms of BA, AHL, HCA, and CA were the same on postoperative 1st-day and postoperative last control. Also, there was no statistically significant difference was observed between age, sex, and type of fracture. Five of the cases have pin site infection and in three patients occurred ulnar nerve injury due to initial trauma.

Conclusion: After a good and gentle reduction and early treatment of pediatric SCHF, all pin configurations maintain alignment. All pin configurations can be used for stabilization.

Keywords: Pediatric, Supracondylar Humerus Facture, Closed Fracture Reduction, Kirschner Wire

K-teli Konfigürasyonları ve Sayılarının Gartland Tip 3 Pediatrik Suprakondiler Humerus Kırıkları Üzerinde Etkisi Var Mı?

ÖZET

Amaç: Bu çalışmanın amacı, pediatrik suprakondiler humerus kırıklarının (SKHK) cerrahi tedavisinde, K-teli konfigürasyonunun redüksiyon kaybı üzerindeki etkilerini değerlendirmekti.

Yöntem: Çalışma, 2010-2013 yılları arasında Gartland Tip 3 (SCHF) için ameliyat edilen 100 (68/E, 32/K) çocuktan oluşturuldu. Hastalar K-teli konfigürasyonuna göre beş gruba ayrıldı (1 lateral-1 medial; 2 lateral- 1 medial; 2 medial- 1 lateral; 2 lateral; 3 lateral K teli). Yaralanma anındaki ortalama yaş 7.34 yıldır (2-14 yıl). Bauman açısı (BA), Humerokapital açı (HCA), Anterior humerus hattı (AHL), fleksiyon aralığı, ekstansiyon aralığı ve Taşıma açısı (CA) preoperatif, postoperatif 1.gün, postoperatif son kontrol ve opere olmayan taraf ölçülerek karşılaştırıldı. Ortalama takip süresi 24,96 ± 11,06 aydır (12-54 ay).

Bulgular: Postoperatif 1. gün ve postoperatif son kontrolde BA, AHL, HCA ve CA açısından beş alt grup arasında istatistiksel olarak fark yoktu. Ayrıca yaş, cinsiyet ve kırık tipi arasında istatistiksel olarak anlamlı bir fark gözlenmedi. Olguların beşinde pin dibi enfeksiyonu ve üç hastada ilk travmaya bağlı ulnar sinir yaralanması meydana geldi. İyatrojenik sinir yaralanması gözlenmedi.

Sonuç: Pediatrik SKHK' nın iyi ve nazik bir şekilde redüksüyonu sonrasında farklı pin konfigürasyonları arasında fark saptanmamıştır. Tespit için tüm pin konfigürasyonları kullanılabilir.

Anahtar Kelimeler: Pediatrik, Suprakondiler Humerus Kırığı, Kapalı Kırık Redüksiyonu, Kirschner Teli

Correspondence: Malik Çelik
Bakırkoy Dr Sadi Konuk Research and Training Hospital Orthopaedics and Traumatology Clinic, Istanbul, Turkey
Phone: +902124147174
E-mail: drmalikcelik@hotmail.com

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Pediatric supracondylar humerus fractures (SCHF), one of the most common fracture types in children, are mainly associated with extension type 2 and generally require surgical stabilization (1,2). Due to limited remodeling, anatomic reduction and alignment reconstruction are essential to restore normal elbow function and prevent future complications (3,4). Plaster immobilization, axial traction using tape or trans olecranon pin, external fixation, percutaneous pinning, and open reduction and pinning are the usual techniques applied for SCHF treatment (5,6). Closed reduction with pin stabilization which was first introduced by Swenson in 1948, is the most popular technique for displaced Garthland Type 2 and 3 SCHF (3,4,7). Displaced fractures can occur in early complications such as nerve (6-12%), vessel injury (3.7-7%), and compartment syndrome (8,9). Acceptable criteria of closed reduction are defined as restoration of the humeral capitellar angle greater than 90 on the AP view, intact medial and lateral columns on oblique views, and bisection of the anterior humeral line through the middle third of the capitellum on the lateral view. If close reduction can't acceptable open reduction with medial, lateral, posterior, anterior, posteromedial, and both medial and lateral approaches can be preferred (4,10).

Configurations of the K-Wires (KW) in the fixation of SCHF remain controversial. A medial KW is commonly preferred in the literature for strong stability, but unfortunately, it may increase the risk of iatrogenic nerve injury which was reported to be seen up to 15% (1,11,12). Lee et al. found that the crossed configuration provided better stability (13). Zionts et al. showed that optimal stability was provided by the crossed KW configuration in their experiments on adult human cadavers (14). Sankar et al. showed that there was no reduction loss in the cross KW configuration compared to the two lateral KW configurations, which is more commonly associated with the reduction loss (15). Also, one needs to keep in mind the other parameters that may affect the reduction loss in the short or long term such as a KW diameter, and multiple drilling which may result in osteonecrosis, instability, and pin loosening (11,16,17).

Pediatric SCHF preferred to be treated as soon as possible. This retrospective study aimed to evaluate KW number and configuration (crossed 1 lateral 1 medial, crossed 2 lateral 1 medial, crossed 1 lateral 2 medial, 2 lateral divergent, and 3 lateral divergent) effects on early stability. We hypothesize that more pins will provide more stability for pediatric SCHF.

Materials and Methods

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 fractures were retrospectively screened. Informed consent was obtained by all patients.

Patients with pathological fractures, conservative follow-up, less than the 1-year follow-up, and patients with incomplete postoperative follow-up were excluded from this study. The current study consisted of, one hundred patients (68 males and 32 females) who underwent surgery for Gartland type 3 supracondylar humerus fracture. 98% of the fractures are extension and 2% are flexion-type fractures. Of 73% of the patients' left humerus and 27% of the patient's right humerus were affected. 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. In the present study, the patients were divided into 5 groups according to their configurations of the K-wires in fixation; 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.

All patients were initially evaluated at the emergency room and peripheral neurovascular examination was reported. The SCHF was classified according to Gartland classification (3). A long arm plaster was used to immobilize the elbow in 1100-1200 of elbow flexion in a comfortable position. No closed reduction was attempted in the emergency department. The decision of the timing for the surgery was based on the patient's condition and operating room availability. Open fractures with associated vascular injury were immediately accepted to the operating room. In all the follow-up controls, the range of motion on the operated and non-operated sides was evaluated respectively and only the final control measurements were statistically analyzed and presented in this manuscript.

Table 1. The distribution of demographic characteristics, clinical and radiological outcomes of the patients

		n	%
Gender	Male	68	68
	Female	32	32
Group	2L+1M	51	51
	1M+1L	29	29
	2L	7	7
	3L	7	7
	2M+1L	6	6
Injured Side	Right	27	27
	Left	73	73
Trauma mechanism	Fall at home	53	53
	Fall at outdoor	47	47
Fracture type	Flexion	2	2
	Extansion	98	98
		Min / Max (Median)	Mean±SD
Age (years)		2-14 (7)	7,34±3,11
Time to operation (hours)		2-228 (16)	24,29±41,92
Hospitalization (days)		1-13 (2)	2,39±1,73
Operation time (minutes)		25-165 (50)	57,01±25,51
KW extraction time (days)		7-57 (30)	30,63±7,46
Follow-up duration (months)		12-54 (17,5)	24,96±11,06
		Min / Max (Median)	Mean±SD
Carrying angle (⁰)	Uninjured side	3,0 / 18,0 (10,0)	8,89±2,91
	Operated side*	3,0 / 20,0 (8,5)	9,06±3,45
Flexion angle (⁰)	Uninjured side	130,0 / 155,0 (140,0)	140,59±5,65
	Operated side*	110,0 / 150,0 (137,0)	136,34±7,88
Extension angle (⁰)	Uninjured side	170,0 / 195,0 (185,0)	183,75±4,64
	Operated side*	150,0 / 195,0 (180,5)	181,35±6,73

*M: medial entry, L: lateral entry, KW: K-wire * postop last control*

Surgical Technique

Under general anesthesia, a non-inflated high-arm tourniquet was placed on the arm in case when an open reduction and fixation was necessary. Intravenous cefazolin was administered to the patients based on their 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 the pronation process, we check fluoroscopy images on the coronal and sagittal planes. 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, 90–260) on the AP fluoroscopy view (Figure 3).

Under fluoroscopy guidance, the first KW was 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. To prevent iatrogenic ulnar nerve injury, medial mini-incision was used for the application of medial KW. Lateral KWs were preferred at divergent orientations. The surgeons who managed the operation used an adequate number of pins to fix the fracture with sufficient stability for all patients. After the reduction, the first KW was applied lateral side, the surgeons decided on the other KWs in the intraoperative period according to the flexion-extension fluoroscopy images. As indicated in figures 1-2 below, crossed 1L-1M KW and crossed 2L-1M KW were used in most of the patients. The pin number and orientation were entirely determined during surgery according to the configuration to achieve fixation stability. 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 were evaluated clinically and radiologically at 2nd-, 4th- and 6th weeks, 3rd- and 6th months, and annually in the postoperative period (Figure 1 and Figure 2). 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 the 4th and 6th week). The patients were asked to start passive range of motion exercises after the pin and plaster were removed.

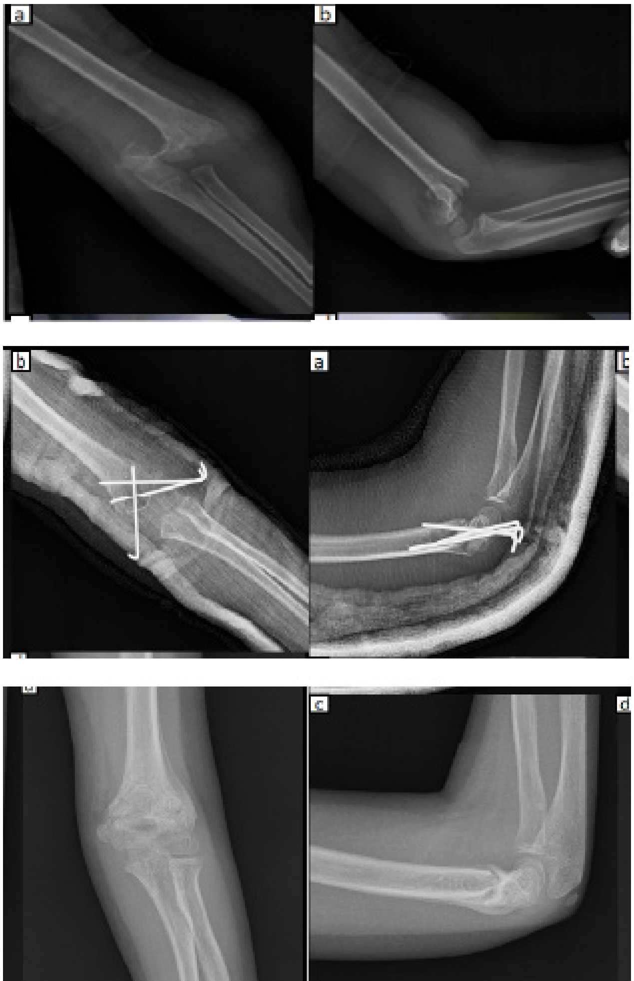

Fig. 1 6-year-old female patient diagnosed with Gartland Type 3 supracondylar humerus fracture (SCHF). A : Pre-operative anteroposterior (AP) and lateral (L) view. B: Early postoperative control X-rays AP and L view. C: Postoperative last control (13th month) X-rays AP view and L view.

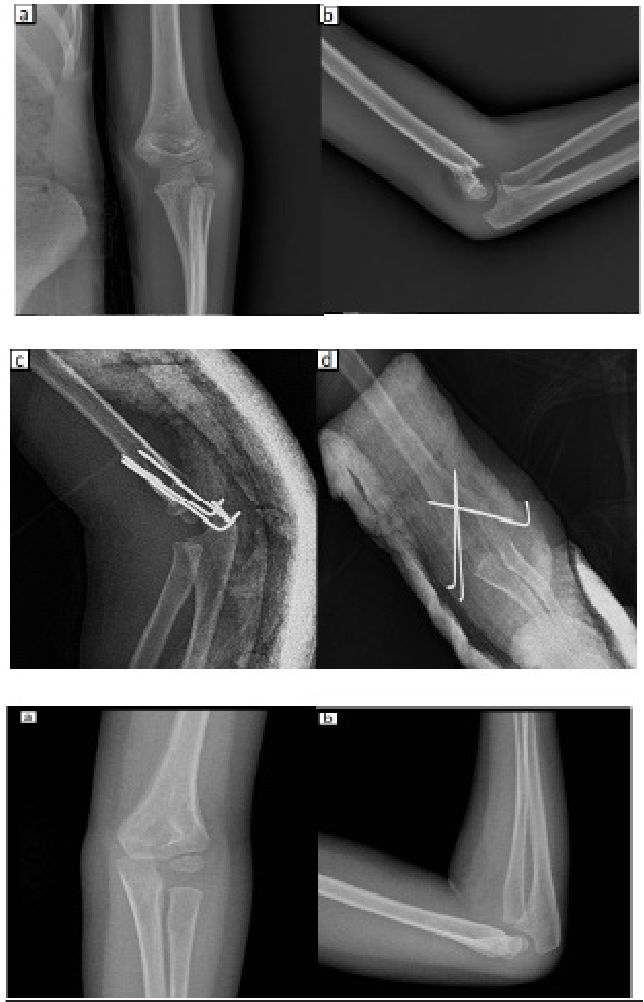

Fig. 2 5-year-old female patient diagnosed with Gartland Type 3 SCHF. A: Pre-operative AP view and L view. B: After closed reduction SCHF fixated by 2 Medial and 1 Lateral crossed KW, early postoperative control X-rays AP view and L view. C: Postoperative last control (15 months) X-rays AP view L view. The valgus deformity was observed during the follow-up period.

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, minimum, 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 were used for the evaluation of binary comparison. The Fisher-Freeman-Halton test was used for qualitative data comparison. P values were considered statistically significant when $p<0.01$ and $p<0.05$.

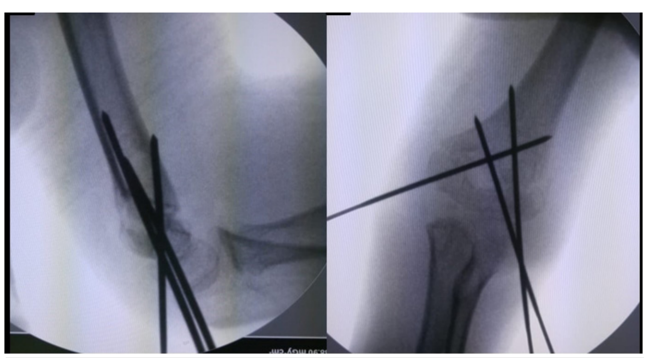

Fig. 3 6-year-old female patient diagnosed with Gartland Type 3 supracondylar humerus fracture (SCHF). After closed reduction, SCHF was fixated by 2 Lateral and 1 Medial crossed K-wire(KW) intraoperative fluoroscopy images AP and Lateral view.

Results

The mean values for carrying angle (CA), mean flexion, and extension range on the operated side were; $9{,}06^0 \pm 3{,}45^0$, $136{,}34^0 \pm 7{,}88^0$, $181{,}35^0 \pm 6{,}73^0$, on the uninjured side were; $8{,}89^0 \pm 2{,}91^0$ $140{,}59^0 \pm 5{,}65^0$, $183{,}75^0 \pm 4{,}64^0$ respectively. No statistically significant difference was observed between subgroups in terms of age, sex, CA, and flexion-extension range in the comparison with the uninjured side ($p<0.05$. Baumann angle (BA) showed a statistical difference inside each group only on the first postoperative day ($p=0.015$). However, BA did not noticeably differ between different 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 ($p<0.05$). Significant differences were observed 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 2). Also, in posthoc binary analyses of BA, HCA, and AHL, statistical variations were found between preoperative values, postoperative values, and uninjured side ($p<0.05$ and $p=0.001$) (Table 3). Since, after reduction, the angular measurements changed, preoperative and postoperative measurements showed crucial differences. Within all groups, postoperative BA values show no statistical difference in postoperative 1st-day and last control. In addition, 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. In one case within the 2M+1L group, one pin had to be removed on the medial side on the 7th day due to a pin tract infection. All complications were resolved in the postoperative 8th weeks. Overall after the treatment process, all of the patients had successful healing, secondary displacement, and non-union were not reported.

Discussion

One of the most important findings of this study is that different KW configurations do not affect secondary displacement in the early postoperative period. Pediatric SCHF is the most common fracture that requires surgery in childhood. Although closed reduction and pin fixation are generally accepted techniques in the field, in some cases closed reduction may not be applied to some fracture types. In such cases, an attempt to manipulate the fracture makes the close reduction even more difficult. Consequently, when the manipulation fails, an open reduction must be used. However, this results in a trade-off between easy reduction, the direct appearance of the fracture site, early rehabilitation, and cosmetic dissatisfaction. Naturally, closed reduction and percutaneous pinning methods are generally desired treatment models for displaced SCHF (18,19). But it is controversial, how many K-wires are needed for stable fixation. The most common type is the percutaneous cross KW fixation (20). The goal of the present study was to evaluate the effect of KW number and configuration on early reduction loss. The number of KW and configurations were discussed in the literature (21,22). Especially lateral entered KW and cross-entered KW are compared. In the present study, 5 different pin configurations were compared. We would like to emphasize that this is the first study in the literature that compares 5 different ways.

Although previous studies agreed that crossed KW is the most stable pin configuration, iatrogenic ulnar nerve injury incidence is still highly observed in these groups (23,24). In some cases, medial mini-incision is used to prevent iatrogenic ulnar nerve injury (25). Inspired by the outcome of these studies, in this work, we used medial mini-incision with crossed KW for preventing iatrogenic ulnar nerve palsy. Since the medial KW entry may cause iatrogenic ulnar nerve palsy, lateral entry is accepted by many surgeons (19). However, even though laterally entered two pins showed statistically good results for preventing iatrogenic ulnar nerve injury, they caused a higher secondary loss of reduction. It is reported in the previous studies that laterally entered KW is less stable for rotational forces compared to crossed KW configuration and also causes early reduction loss (16,26,27). As commonly known, cast immobilization provides more stability, but it does not protect patients from rotational forces (28). Naturally, the dilemma between stability and iatrogenic nerve palsy requires new KW configurations. Therefore, some surgeons performed three lateral entered pins to prevent secondary reduction loss (24,29). Here, 5 different pin configuration subgroups were evaluated: 2L+1M, 1M+1L, 2L, 3L, and 2M+1L subgroups were compared for early reduction loss. All subgroups were equal, and there was no reduction loss between groups. Also, no statistical difference was found between all subgroups in terms of complications and secondary reduction loss in the present study. AHL, CA, flexion, and extension range were also compared in the current study. Many studies usually compare BA for remodeling which in some studies has variations (22,30). For early results, all radiological parameters were evaluated in the postoperative first day, postoperative last control, and non-operated side for reduction loss for limiting the variations. Although the number of patients in some subgroups is very low, all KW configurations provide enough stability and there was no statistical difference according to our findings.

Table 2. Comparison of Bauman's angle, humerocapital angle and anterior humeral line between groups

		Groups					
		2L+1M (n=51)	1M+1L (n=29)	2L (n=7)	3L (n=7)	2M+1L (n=6)	
Bauman angle		Mean±SD Min-Max (Median)	Mean±SD Min-Max (Median)	Mean±SD Min-Max (Median)	Mean±SD Min-Max (Median)	Mean±SD Min-Max (Median)	ᵃp
Preoperative		11,68±14,86	17,18±17,11	11,02±10,95	13,91±23,40	9,34±23,75	0.608
		-10/41,59 (14)	-12,3/ 54 (17,1)	-10/21,76 (11)	-10/46 (24)	-10/52 (4,1)	
Postoperative 1st day		20,81±7,24	19,82±5,19	18,06±4,79	10,33±12,76	7,81±14,71	0.055
		9,5/38 (20)	10/30,9 (19,7)	11,5/27,3 (17)	-18,2/18 (13,7)	-12/21,3 (14,8)	
Postoperative last control		20,17±6,59	19,76±4,85	16,70±5,05	19,34±5,89	20,35±5,55	0.534
		8/37 (19)	11,6/29,2 (19)	11/27 (16)	11,7/ 30,5 (19)	12,2/ 27 (21,6)	
Uninjured side		21,21±10,75	19,40±8,49	16,71±6,05	23,75±5,99	19,72±2,36	0.286
		-10/43 (18,2)	-10/39 (18,2)	10,7/28 (14,1)	16 / 31,70 (22)	16,3/ 22,2 (20)	
Alteration (postop 1st day – postop last control)		-0,16±4,78	0,05±3,81	1,35±2,37	-9,0±17,83	-12,53±18,42	0.074
		-12,45/20 (0,5)	-8,16/9,7 (-0,3)	-2/5,21 (0,5)	-11,45 (-3,3)	-19,10 (-3,3)	
ᶜp		**0,004****	**0,001****	**0,016***	**0,019***	**0,012***	
Humerocapital angle		Ort±SD Min-Max (Median)	Ort±SD Min-Max (Median)	Ort±SD Min-Max (Median)	Ort±SD Min-Max (Median)	Ort±SD Min-Max (Median)	ᵃp
Preoperative		-4,79±28,23	0,77±30,29	0,38±38,38	5,71±29,54	7,84±24,15	0715
		-50 / 56 (-10)	-47,4/85 (-10)	-50/51,6 (-10)	-28/48 (-10)	-12,7/54 (3,3)	
Postoperative 1st day		40,35±8,44	41,02±5,71	44,89±3,60	45,51±7,90	41,08±5,54	0.188
		23,75/58 (40)	33/54,2 (40,8)	39,76/49 (45)	34/55 (47)	34/50,4 (39,6)	
Postoperative last control		42,40±7,62	43,02±4,74	44,78±6,13	48,86±7,70	41,62±6,21	0.160
		26,2/60 (40,8)	35/56 (42,6)	34,6/52 (45,4)	36,4/ 57,2 (53)	35,3/51,4 (40)	
Uninjured side		44,65±7,70	43,78±6,62	47,68±6,63	49,34±8,05	40,83±5,24	0.144
		29,8/60 (42,6)	33/59,3 (42,9)	35,40/56 (49)	34,9/59 (48,5)	37,3/ 51 (39,3)	
ᶜp		**0,001****	**0,001****	**0,034***	**0,016 ***	**0,012 ***	
Anterior humeral line		n (%)	n (%)	n (%)	n (%)	n (%)	ᵇp
Preop	1/3 Anterior	10 (19,6)	5 (17,2)	2 (28,6)	1 (14,3)	0 (0)	0.179
	1/3 Medial	3 (5,9)	0 (0)	1 (14,3)	2 (28,6)	0 (0)	
	1/3 Posterior	38 (74,5)	24 (82,8)	4 (57,1)	4 (57,1)	6 (100)	
Postop 1st day	1/3 Anterior	11 (21,6)	4 (13,8)	2 (28,6)	2 (28,6)	0 (0)	0.633
	1/3 Medial	29 (56,9)	14 (48,3)	3 (42,9)	4 (57,1)	3 (50,0)	
	1/3 Posterior	11 (21,6)	11 (37,9)	2 (28,6)	1 (14,3)	3 (50,0)	
Postop last control	1/3 Anterior	3 (5,9)	0 (0)	0 (0)	1 (14,3)	0 (0)	0.505
	1/3 Medial	39 (76,5)	22 (75,9)	5 (71,4)	6 (85,7)	4 (66,7)	
	1/3 Posterior	9 (17,6)	7 (24,1)	2 (28,6)	0 (0)	2 (33,3)	
Uninjured side	1/3 Anterior	0 (0)	1 (3,4)	0 (0)	0 (0)	0 (0)	0.823
	1/3 Medial	33 (64,7)	19 (65,5)	5 (71,4)	4 (57,1)	5 (83,3)	
	1/3 Posterior	18 (35,3)	9 (31,0)	2 (28,6)	3 (42,9)	1 (16,7)	

*ᵃKruskal Wallis Test, ᵇFisher Freeman Halton Test, ᶜFriedman Test, *p<0,05*

Table 3. Post-hoc analysis and comparison of Bauman's angle, humerocapital angle and anterior humeral line between preop, postop 1st day, postop last control and uninjured side

	Groups				
	2L+1M (n=51)	1M+1L (n=29)	2L (n=7)	3L (n=7)	2M+1L (n=6)
Bauman angle	[d]p	[d]p	[d]p	[d]p	[d]p
Preop – postop 1st day	0.001**	0.011*	0.023*	0.028*	0.001**
Preop - postop last control	0.001**	0.011*	0.026*	0.018*	0.001**
Preop – uninjured side	0.001**	0.011*	0.026*	0.021*	0.001**
Postop 1st day - postop last control	0.827	0.955	0.116	0.091	0.116
Postop1st day - uninjured side	0.337	0.936	0.612	0.735	0.075
Postop last conrol - uninjured side	0.198	0.882	0.735	0.612	0.463
Humerocapital angle	[d]p	[d]p	[d]p	[d]p	[d]p
Preop – postop 1st day	0.001**	0.001**	0.028*	0.028*	0.026*
Preop - postop last control	0.001**	0.001**	0.018*	0.028*	0.016*
Preop – uninjured side	0.001**	0.001**	0.028*	0.028*	0.026*
Postop 1st day - postop last control	0.213	0.234	1.000	0.398	0.458
Postop1st day - uninjured side	0.251	0.086	0.553	0.310	0.753
Postop last conrol - uninjured side	0.178	0.210	0.398	0.612	0.753
Anterior humeral line	[e]p	[e]p	[e]p	[e]p	[e]p
Preop – postop 1st day	0.001**	0.019*	0.023*	0.016*	0.013*
Preop - postop last control	0.001**	0.019*	0.031*	0.018*	0.015*
Preop – uninjured side	0.001**	0.019*	0.023*	0.016*	0.013*
Postop 1st day - postop last control	0.083	1.000	0.157	1.000	0.317
Postop1st day - uninjured side	0.110	0.525	0.664	1.000	0.317
Postop last conrol - uninjured side	0.089	0.763	1.000	1.000	0.317

*[d]Wilcoxon Signed Ranks Test, [e]Marginal Homogeneity Test, **p<0.01, *p<0.05*

As recommended acute treatment of SCHF prevents complications such as compartment syndrome, infection, nerve injuries, etc. In the current study, all patients without any comorbidities were treated in 6-8 hours. In some patients with acute upper respiratory tract infection or brain injury, surgery could be performed when anesthesia was available.

Common nerve injury in postoperative period rates have been reported as 2%-5% in closed reduction and 3%-13% in open reduction (29). Ulnar nerve injury was seen in three patients due to primary injury. Whereas pin site infection occurs in rates of 2.4-6.4%, deep infection and osteomyelitis are rarely observed (29). Pin site infection occurred in five patients. In one case we removed one medial KW on the first week in the 2M+1L group. The other KWs maintained the alignment. Other complications such as compartment syndrome, deep infection, and secondary displacement were not observed in our study. We found that all five subgroups have enough stability and avoid reduction losses, one should note that there were small populations in subgroups, no randomization, and the follow-up periods were relatively short which all might be argued as the weakness of this study.

Our study has several limitations that need to be underlined. A small number of patients, the single-center design, and the retrospective nature of this study should be acknowledged.

Conclusion

Different KW configurations do not affect on secondary displacement in the early postoperative period. Surgeons could prefer fewer K-wires such as 2 cross KW or 2 lateral KW for SCHF fixation. Also, all KW configurations maintained the correct alignment after an anatomic reduction in both open and closed reduction. Early treatment, slight traction, and adequate operation technique provide good functional and radiological outcomes independent from the KW configuration.

Ethical Consideration

The study was approved by Bakirkoy Dr.Sadi Konuk Research and Training Hospital, Clinical Research Ethics Committee, Approval ID: 2014/268 (29.12.2014).

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