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Treatment of pediatric displaced supracondylar humerus fractures by fixation with two cross K-wires following reduction achieved after cutting the triceps muscle in a reverse V-shape

Çocuklardaki deplase suprakondiler humerus kırıklarının tedavisinde triseps kasının ters V şeklinde kesilmesiyle sağlanan redüksiyon ve iki adet çapraz K-teli ile tespit

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Amaç: Çocuklarda deplase humerus suprakondiler kırıklarının cerrahi tedavi sonuçları değerlendirildi.

Çalışma planı: Çalışmaya 98 çocuk hasta (72 erkek, 26 kız; ort. yaş 7; dağılım 3 ay-14 yıl) alındı. Gartland sınıflamasına göre deplase suprakondiler humerus kırıklarının hepsi tip III kırıktı. On hastada (%10.2) fleksiyon tipi, 88 hastada (%89.8) ise ekstansiyon tipi yaralanma vardı. Beş hastada Gustilo-Anderson sınıflamasına göre tip 1 açık kırık vardı. Kırıkların hepsi posterior yaklaşımla tedavi edildi. Triseps kası ters V şeklinde kesilerek redüksiyon sağlandı ve epikondillerden çapraz gönderilen iki adet K-teli ile tespit yapıldı. Sonuçlar Flynn ve ark.nın ölçütlerine göre değerlendirildi. Son kontrolllerde, dirsek eklem hareket açıklıkları ve triseps kas kuvveti yanı sıra, çekilen grafilerde dirsek taşıma açısı, Baumann açısı, lateral humerokapitellar açı ölçüldü ve sağlam tarafla karşılaştırıldı. Ortalama takip süresi 42.6 ay (dağılım 7-80 ay) idi.

Sonuçlar: Flynn ve ark.nın ölçütlerine göre, 95 hastada (%96.9) kozmetik açıdan, 84 hastada (%85.7) ise fonksiyonel açıdan mükemmel ya da iyi sonuç elde edildi. Sağlam tarafla karşılaştırıldığında, ameliyat edilen tarafta ölçülen dirsek açıları, dirsek eklem hareket açıklığı ve triseps kas kuvveti anlamlı farklılık göstermedi (p>0.05). Ameliyata alınma süreleri kozmetik ve fonksiyonel sonuçlar açısından anlamlı farklılık yaratmadı (p>0.05). Hiçbir hastada işleme bağlı tel dibi enfeksiyonu, yetersiz kaynama görülmedi. Üç hastada (%3.1) kubitus varus deformitesi saptandı.

Çıkarımlar: Çocuklardaki deplase suprakondiler humerus kırıklarında, posterior girişim ile triseps kasının ters V şeklinde kesilmesiyle redüksiyon kolayca yapılabilmekte ve iki adet çapraz K-teli yeterli stabiliteyi sağlamaktadır. Tedavi sonucunda triseps kasında herhangi bir zayıflık meydana gelmemektedir.

Anahtar sözcükler: Kemik teli; çocuk; dirsek eklemi/yaralanma/cerrahi; kırık tespiti, internal/yöntem; humerus kırığı/cerrahi.

Objectives: We evaluated the results of surgical treatment for pediatric displaced supracondylar humerus fractures.

Methods: The study included 98 pediatric patients (72 boys, 26 girls; mean age 7 years; range 3 months to 14 years). According to the Gartland classification, all the displaced supracondylar humerus fractures were type III, being of flexion type in 10 patients (10.2%), and extension type in 88 patients (89.8%). Five were Gustilo-Anderson type 1 open fractures. All fractures were approached posteriorly. Reduction was achieved by cutting the triceps muscle in a reverse V-shape, followed by fixation using two cross K-wires from the epicondyles. The results were assessed according to the criteria of Flynn et al. At final follow-ups, elbow range of motion, the strength of the triceps muscle and, on radiographs, the carrying angle of the elbow, Baumann angle, and lateral humerocapitellar angle were measured. The mean follow-up was 42.6 months (range 7 to 80 months).

Results: According to the criteria of Flynn et al., 95 patients (96.9%) had perfect or good cosmetic results, 84 patients (85.7%) had perfect or good functional results. Elbow angles, elbow range of motion, and the strength of the triceps muscle were similar to those measured on the normal side (p>0.05). Time from injury to surgery did not have a significant influence on cosmetic and functional results (p>0.05). None of the patients exhibited procedure-related pin tract infection or insufficient bone union. Three patients (3.1%) developed cubitus varus deformity.

Conclusion: Reduction of pediatric displaced supracondylar humerus fractures may be achieved easily by the posterior approach, after cutting the triceps muscle in a reverse V-shape, and fixation with two cross-pinned K-wires provides adequate stability. This procedure does not result in weakness of the triceps muscle.

Key words: Bone wires; child; elbow joint/injuries/surgery; fracture fixation, internal/methods; humeral fractures/surgery.

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The most common fractures in children are supracondylar humerus fractures after distal radius fractures. They include 16.6% of all pediatric fractures,while they include 60% of elbow and its peripheric fractures. They're mostly seen under 7 years old. Generally extension type fractures seen after falling on open hand(95%-98%) ,while flexion type fractures percentage is 2-5% due to direct trauma.In non displaced fractures conservative treatment mostly prefered whereas surgical option takes over in displaced fractures. Anterior, posterior,lateral and medial surgical options can be prefered. At this point ,closed reduction and percutaneous pinning prefered as current treatment but open reduction and internal fixation takes over in case of open fractures,repetetive unsuccessful reductions,neurovascular damages,absence of the scope or inexperience of surgeons about percutaneous pinning.The basic aim in treatment is to gain full range of motion and to obtain normal elbow appearence in terms of cosmetic.

In this study,the results of displaced supracondylar humerus fractures evaluated who are operated in our clinic.

Materials and methodas

Bu çalışmada, 1997-2004 yılları arasında kliniğimiz In this retrospective study, 98 pediatric patients (72 boys,26 girls ; mean age 7 years; range 3 months-14 years) evaluated who are treated due to displaced supracondylar humerus fractures in our clinic.In fifty-eight patients left side affected,while right side affected in forty patients.In forty-four patients dominant side affected whereas non dominant side affected in 54 patients.

Fractures evaluated according to Gartland classification and only type III fractures were included to the study. Ten patients (10,2%) had flexion type fractures and 88 patients (89,8%) had extension type fractures. Five patients had type I open fracture according to the Gustillo-Anderson classification. Etiology of trauma was simple fall in 84 patients (85,7%),fall from high place in 10 patients (10,2%),traffic accident in four patients (4,1%).

In four patients,ipsilateral distal radius and ulna fracture seen addition to supracondylar humerus fractures.Ulnar nerve palsy seen in one patient.After the operation ,connective tissue disorder diagnosed to one patient who had problems such as scar healing and skin thickening and hardening as a result of evaluation with pediatric department.

When patients were brought to our emergency clinic,their fractures evaluated with anterior-posterior and lateral roentgenograms (Figure 1a).Then tried to obtain reductions with gentle manipulation.Herein the purpose was to relieve the elbow from displacement and extreme bad position until the operation time. Roentgenograms taken again after applying long arm splint in 90˚ flexion of elbow.After all these patients prepared to operation and operated as soon as possib-

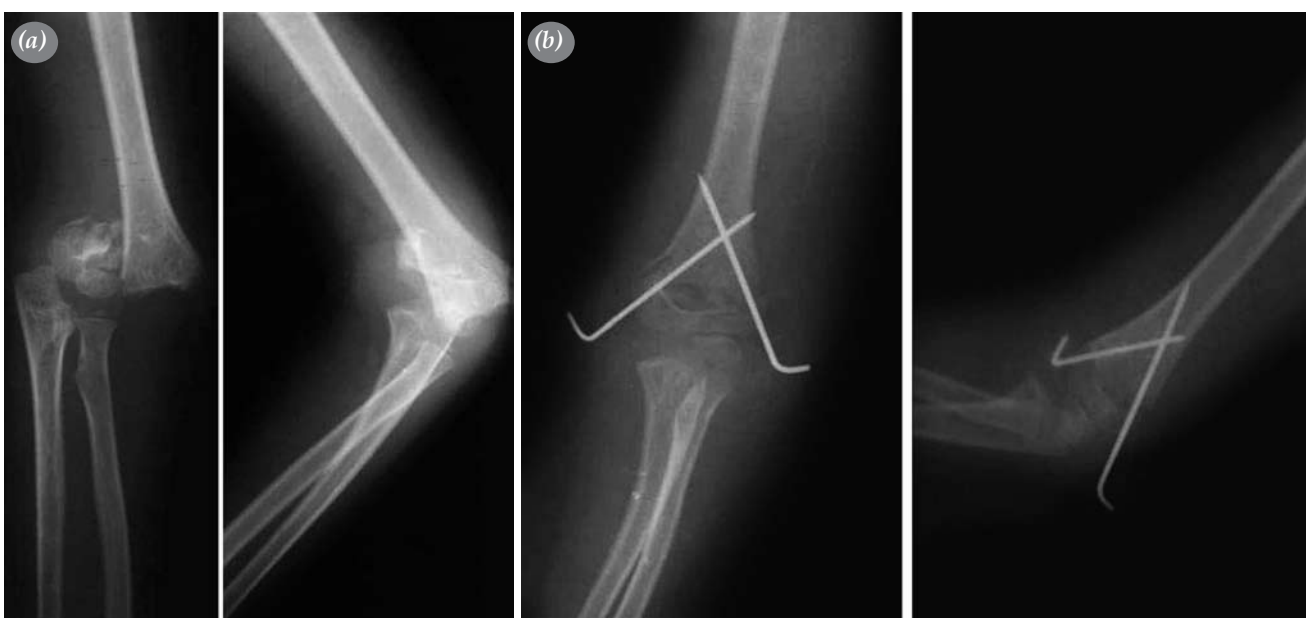

Figure 1. A 6 year old boy **(a)** preop and **(b)** early postop anterior-posterior roentgenograms.

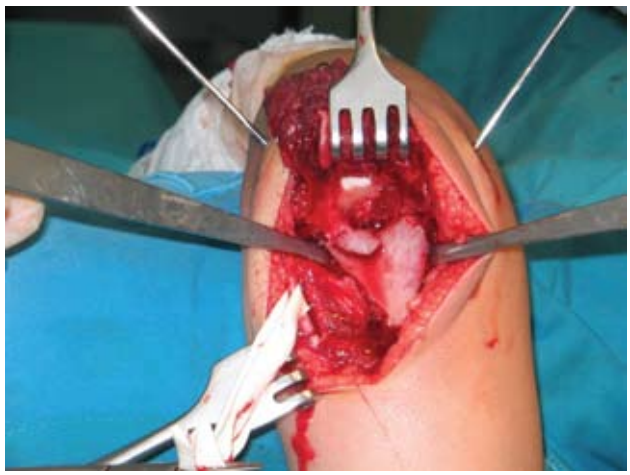

Figure2. Posterior approach performed and unlar nevre protected ant triceps mucsle cut in a V shape and overturned to anterior.Fixation obtained with two K-wires that sent through epicondyles. Commanding fracture is quite simple by this approach.

le. Thirty-nine patients(39,8%) operated in first eight hours,41 patients (41.8%) between 8-24 hours,18 patients (18,4%) operated after first 24 hours.

Tourniquet applied to upper extremities of fourteen patients.Posterior approach prefered in all patients. Ulnar nerve found and protected,then triceps muscle cut in a reverse V shape,and two K-wires sent from epicondyles in croosswise way,thus fixation established (Figure 2).By the way,stability control was made and the success of system was evaluated.After process finished,triceps muscle suturated and layers closed. Then roentgenograms taken after applying long arm splint in 90˚ flexion of elbow(Figure1b).At the end of the first month splint was terminated and motion was started.At the postop 6th week K-wires were taken out if the callus was enough.

Before the study,standard protocol files prepared for all cases.In these files; elbow carrying angles,Baumann angles,lateral humerocapitellar angle measurements,neurologic examination signs,range of motion of elbow,and both triceps muscle strength for both elbow measured seperately.Range of motion and elbow carrying angle measured by goniometer.The findings evaluated according to criteria of Flynn et al.(Table 1).The mean following time was 42.6 months (range7-80 months)

Triceps muscle strength measured by an instrument that was designed by us.It was L-shaped and ,there was a handle on it with two reels.A polyester rope that

Table 1. Flynn et al. Measurements

	Cosmetic	Functional
	Difference in carrying angle (°)	Loss of range of motion (°)
Perfect	0-5	0-5
Good	6-10	6-10
Avarege	11-15	11-15
Poor	>15	>15

was passing the reel ,a wrist splint tahat restricted wrist motion, weight hanger and metal blocks were the other parts of mechanism.Weight hanger was hanged up 1 meter height from the floor with a rope to the reel that was at the tip of mechanism.The other terminal of rope bound to the wrist splint that was on patients forearm.The friction force of the reel and the gravity effect were negleted and the measurements made in terms of gram.Metal blocks were 250 gram,500 gram,1000 gram,2000 gram and the weight hanger was 250 gram(Figure3).

The handle with reel on it, was placed on the door. The patient was rest against the door and we wanted them to make full extension of arm.One assistant fixed the patients shoulder to prevent usage of shoulder muscles.We added metal blocks with different weigth until the forearm-plane contact ended.When the contact between them ended we measured the metal blocks weight.These procedures also performed to the non operated arm. The statistics of the study made with SPSS 11.5 program. In matched groups t- tests were used beside the frequency distribution analysis. The statistical significance was 0.005.

Results

At last controls the measurements of Baumann angle,lateral humerocapitellar angle,elbow carrying angles and triceps muscle strenth between both elbow, had no significant differencess (Table 2).

Patients also divided into two group according to the fracture side if it was dominant side or nondominant side.The aim in here was to evaluate the strength of triceps muscle if more weakening occurs when fracture was at the nondominant side in comparison to the dominant site.According to this,even though the fracture was on dominant side,there was no significant difference between postop muscle strength of arms($p>0,05$).If the operated side was

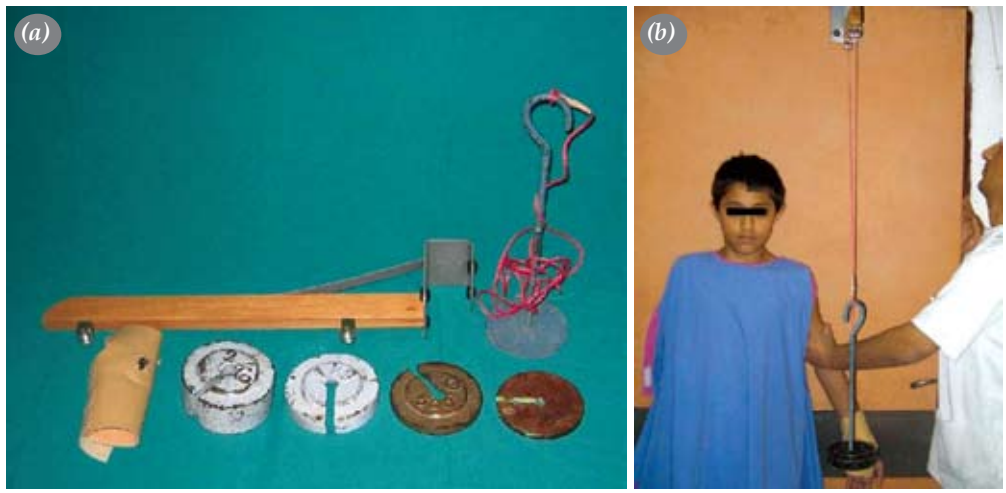

Figure 3. **(a)** The equ›ipment of reel system that designed by our clinic **(b)** and usage of it.

nondominant,the mean weakening was 5.5%,whereas 9,2% at the dominant side. According to Flynn et al. criteria the cosmetic results were perfect or good in 96,9% of patients, while the functional results were perfect or good in 85.7% (Table 3,Figure 4). In case of the time that passed untill operation , there was no significant difference in cosmetic and functional results of patients who are operated in first eight hours,between8-24 hours and after first 24 hours (p>0,05).

We didn't see any complications such as myositis ossificans, early or late vascular problems, nonunion, compartment syndrome in our cases.Only one patient who had structural skin problems, early debridated due to wound area infection.Third surgical aproach made to that patient to release posterior tissues because of developed joint contractures.The assesment result of that patient was bad. Intraop unlar nerve was seen as injured in that patient who had also unlar nerve palsy before operation.But his paralysis and neurologic profile recovered at 6th week control after postop.

There was no complication seen due to open fractures of type I that are classified according to Gustillo-Anderson. Except the patient with connective tissue disorder,there wasn't seen any superficial or deep pin infections. Cubitus varus deformity seen in three patients (3,1%).But among them one patient also had cubitus varus in the other elbow so it was thought as anatomic variation and he was negleted from the study.

Conclusion

There are many treatment methods in supracondylar humerus fractures weather conservative or surgical.These methods vary according to fracture type and displacement grade,edema in soft tissues and condition of neurovascular structures.There is consensus in treatment of type I and type II fractures,but there is no common treatment method for type III fractures.Basic aim in supracondylar humerus fractures is to gain full range of motion of elbow and to obtain a normal appearence of elbow in case of cosmetic.

In literature,it's known that there are many papers about closed reduction and percutaneous pinning.Closed reduction and percutaneous pinning techniuqe have advantages like not opening of fracture area, less infection risk,shorter operation time,but also have disad-

Table 2. Comparison of angles and muscle strength of both elbow

	Non fracture side	Fracture side	
	Ort.±SS	Ort.±SS	*p*
Baumann angle (°)	75.4±7.0	75.6±7.3	>0.05
Carrying angle (°)	8.1±4.2	7.5±6.1	>0.05
Lateral humerocapital angle (°)	40.2±4.6	39.8±5.2	>0.05
Triceps muscle strength(Newton)	62 433.0±32 444.2	61 452.0±32 444.2	>0.05

Table 3. Results of treatment according to Flynn measurements

	Functional						Cosmetic					
	Extension type		Fleksiyon tipi type		*Sum*		Extension type		Flexion type		*Sum*	
	No	%	No	%	No	%	No	%	No	%	No	%
Perfect	66	75.0	6	60.0	72	73.5	71	80.7	8	80.0	79	80.6
Good	11	12.5	1	10.0	12	12.2	15	17.1	1	10.0	16	16.3
Avarege	2	2.3	2	20.0	4	4.1	2	2.3	1	10.0	3	3.1
Poor	9	10.2	1	10.0	10	10.2	–		–		–	
Sum	88		10		98		88		10		98	

vantages such as experience necessity,radiation exposure of patient and doctor due to scope,iatrogenic nerve injuries and not evaluating fracture reduction directly. Lee and Kim advised closed reduction and percutaneous pinning in their recently published paper,but also mentioned about the diffuculty of reduction and added that a "lever method" can be performed with using a thick pin to reduce the fracture more easier. Although current treatment choice is closed reduction and percutaneous pinning in displaced pediatric supracondylar humerus fractures,open reduction and internal fixation takes over in case of open fractures,unsuccessfull reduction trials,neurovascular damages,absence of scope,inexperience of surgeons about percutan pinning.

Figure 4. Clinical appearance 43 months after operation.

Open reduction recommended firstly by Mc Lenan. According to Miles et al. closed reduction gently tried,if reduction couldn't be obtained then open reduction can be prefered.Open reductions recommended in situations such as vascular problems accompanied by fractures,developed neurovascular damages after tried closed reduction,the fractures that need irrigation and debridement. Luria et al. performed angiography to 24 pediatric displaced supracondylar humerus fractures with nonpalpabl radial arter pulse and showed that in 58% of them after immediate and gentle closed reduction radial arter pulse became palpabl again.And they recommended open reduction for pulseless patients.

Ek_io_lu et al. compared two group patients.They performed open reduction and internal fixation by posterior approach to 43 patients and they performed closed reduction and percutaneous pinning to 21 patients. But they didn't find any significant difference between 2 group.

It's thought that weakening of muscle strength and joint motion loss is the disadvantage of posterior approach due to cutting triceps muscle. But Sibly et al. showed that there would be no loss of joint motion range when compared this technique with closed reduction and percutaneous pinning. Kasser et al. showed that this technique cause 6% of loss of triceps strength but also added that this technique can be used in complex distal humerus fractures.In our study if operated side is nondominant,mean muscle strength loss was 5,5%,but if dominant , mean loss wass 9,3%. In compatible with other studies,more weakening of operated dominant side

shows that dominant side triceps muscle much more affected from cutting.In our study when we look their longtime clinical and examination results,our technique does not create additional morbidity,and we think that our technique is reliable and effective from the point of surgeon and patient

There are also anterior,lateral and medial approaches besides posterior approach in supracondylar humerus fractures.Eren et al. after observing 40 cases ,they recommend medial approach due to occuring of less scatris and low risk of damaging ulnar nerve. They also showed that there was no difference between medial and lateral approaches in case of function. Ay et al. evaluated 61 patients who treated with anterior approach,and pointed out that this approach caused less scatris and neurovascular structures assesed beter.Furthermore anterior approach ddidn't not need any muscle cut. Gennan et al.evaluated 30 cases who were performed anterior and posterior approaches and clarified that this approach caused joint motion loss in high ratio so it must not thought firstly.But in our study ,results are satisfactory(Table 3).

In literature wire configurations for pediatric supracondylar humerus fractures discussed considerably.2 crosswise K-wires sent through epicondyles or 3 wires configuration or 2 parallel K-wires sent through one epicondyle are the configurations.Topping et al.showed that paralel 2 K-wires that are sent through one epicondyle provide enough fixation and thus ulnar nerve palsy prevented. Zenious et el. especially made attribution to that study and added that for displaced and rotational fractures,this method was not enough and extra one K wire from medial must be sent to form 3 wires configuration to increase stability. Kocher et al. compared 2 parallel wires from lateral and 2 crosswise way wires fixation methods and didn't find any significance that affect results or predominance between them .Eralp et al. specified that three wires configuration increases the stability significantly when compared to crosswise K-wire configuration.In our study,2 crosswise K-wires configuration which was used by us found as easy applicable and the results were satisfactory.

Importance of surgery time exhibited in current studies.Leet et al. evaluated 158 cases.This retrospective study compared immediate treated group with delayed treated group results.They found that the time that passed until operation was unrelated with the results and it ddidn't not increase the failure rate.Another similar study by Mehlman et al.showed also that there was no favourable or unfavourable effect of surgery time on morbidity.In our study we couldn't show any relation between the time that passed until operation and operation success.

As a result ,instead of operating a displaced supracondylar humerus fractures with no neurovascular pathology in restricted emergency operating room conditions without any planning, we should operate these in suitable electif conditions.This is our opinion.But of course the time that passes until operation should be kept as short as possible.Besides that cutting triceps in a reverse V shape by posterior approach results in good exposure to fracture and thus internal fixation can be done easily.This condition does not decrease severely the strength of triceps muscle.On the basis of our experience about intraop stability control,we recommend sending 2 crosswise K-wires through epicondyles for internal fixation becouse it provides enough stability.

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