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ORIGINAL STUDY

Does computerized tomography change the treatment decision in pediatric medial epicondyle fractures?

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The amount of displacement in medial epicondylar fracture is one of the most important criteria for treatment decision. The displacement of medial epicondyle fractures of the humerus may be underestimated by standard AP and lateral views of elbow. The aim of the current study is to show the clinical relavance of computerized tomography (CT) for medial epicondyle fractures.

A retrospective analysis on patients with medial epicondyle fracture was performed. Measurements were performed by 9 reviewer, there were 12 cases available for review with both radiographs and CT.

The difference between measurement of AP Xray versus frontal and axial CT scans was found to be statistically significant for 1st and 2nd assessments (p=0.001). The decision for operative treatment was higher after evaluation with CT for both first and second assessment and this was statistically significant (p=0,0001).

CT is found to be superior to determine the real amount of the fracture displacement and was relavant for treatment decision of pediatric medial epicondylar fractures. We also found a better interobserver agreement for axial CT scans relative to treatment decision.

Level of evidence : IV

Keywords : pediatric medial epicondyle fractures ; computerized tomography ; treatment decision

INTRODUCTİON

Fractures involving the medial epicondylar apophysis constitute approximately 14.1% of fractures involving the distal humerus and 11.5% of all fractures in the elbow region. In the large series of fractures of the medial epicondylar apophysis, most occurred between ages of 9 and 14, and the peak age incidence was reported as 11 to 12 years *(1)*.

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Treatment of pediatric medial epicondyle fractures is controversial *(16)*. Some authors reported good and satisfactory results with the nonsurgical method *(6)*, whereas anterior displacement of the fragment result in a dramatic loss of initial muscle strength and function *(5)* and the nonunion may cause valgus instability *(13)*. If the displaced fragment will reduce and union can be achieved, it prevents instability *(15)*.

Commonly cited indications for surgery include ulnar nerve dysfunction, entrapment of the fragment in the elbow joint, valgus instability of the elbow and high-demand upper extremity function *(13)*. Besides this, the amount of displacement in medial humeral epicondylar injuries is still an important indicator for surgical treatment. Up to date, there is no consensus on what specific magnitude of displacement should serve as the standard criteria for operative intervention. Displacement ranging between 2 to 20 mm was recommended for surgical treatment from various authors *(3,6,7,10,11,13,17,19,20)*.

The accurate measurement of the fracture displacement on the standard radiographs is controversial. In recently published reports, it has been shown that these measurements are inconsistent and inaccurate *(4,18)*. The use of computerized tomography (CT) to determine the amount of displacement provides more accurate results *(4)*.

In the current study, we aim to show the higher intra and interobserver reliability of the CT on standard AP radiographs for the surgical treatment of the medial epicondylar fracture in which radiographic measurement of displacement was used as surgical criteria.

MATERİALS AND METHODS

This retrospective study was approved by the local ethics committee. Between January 2012 to November 2014, 15 patients with medial epicondylar fracture were admitted to our emergency department. Inclusion criteria for the study were; Patient with isolated medial epicondylar fracture and patient who have both CT and AP and lateral radiographs. Patients with elbow dislocation and who had a lack of CT or radiographs were excluded from the study. From the aforementioned 15 patients with medial epicondylar fracture, 2 patients with elbow dislocation and 1 patient whose CT was absent, were excluded from the study. The study was performed with the remaining 12 patients. Demographic data of each patient was recorded.

Twelve children and adolescents met the inclusion criteria. There were nine males and three females with a mean age of 11.3 years (range, 8 to 14 years) at the time of injury (Table 1). All injuries were acute and resulted from a traumatic event.

Evaluation of radiographs and CT scans was performed by 9 senior orthopedic surgeons who are experienced in pediatric orthopedic trauma. A consensus meeting was done before the study began. Displacement greater than 5 mm was accepted as surgical criteria. Each reviewer performed their own evaluation and measurements independent and blinded from other participants. Participants were also blinded to the names and medical record numbers of the patients. Measurements were obtained for all patients including medial and anterior displacement of the fracture fragment on both radiographs and computed tomography scans on axial and frontal planes. Displacement was measured as the maximal distance between the fragment and the original (anatomical) location of the fragment *(18)*. Fracture displacement was measured two times per film to determine the mean measure by each independent reviewer on the radiographs. In the CT assessment, the direction of the displaced fragment with respect to its origin was defined by the 3-D CT reconstructions. The direct measurement of the displacement in millimeters was assessed with the use of two-dimensional reconstructions. With the use of a

Table I. — Patient demographics according to age and gender

Patient	1	2	3	4	5	6	7	8	9	10	11	12
Age/ gender	13/M	10/F	12/M	12/M	8/M	13/F	9/M	10/M	11/F	11/M	14/M	12/M

Fig. 1a. — Anteroposterior radiograph of a left elbow with a medial epicondyle fracture. A minimally displaced fracture line was seen

similar methodology that utilized the radiographs, two measurements were made per scans and the mean value was used for the analysis.

All measurements were obtained with use of the ruler tool provided on Novorad PACS (Novorad, American Fork, Utah). Digitally obtained images with standardized source distance of the intensifier allowed for accurate numbers to be obtained with use of this system.

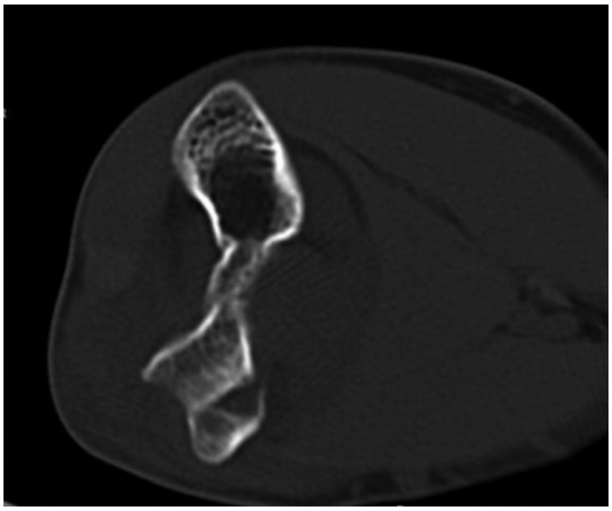

Fig. 1b. — A significant anterior displacement was seen on axial CT section of the same elbow

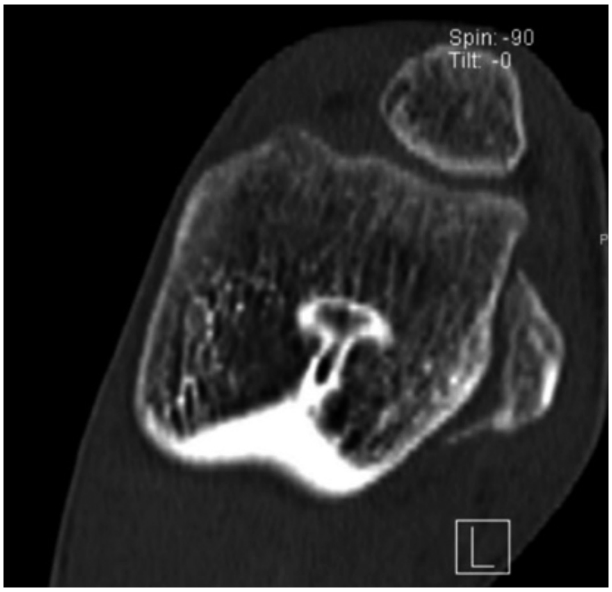

Fig. 1c. — Frontal CT view of the same elbow

Initial assessments were done on radiographs (Figure 1 a). The treatment decision asked for the fracture and the decision and measurements were recorded after measurements were done on radiographs. Then, assessment on CT scans was performed (Figure 1 b,c). The measurements of the CT scans on the axial and frontal planes were obtained and the treatment decision was recorded in the same manner. After initial assessments were completed, all measurements were repeated one month later again for intraobserver correlation. The treatment decision was asked again.

Statistical analysis

The Number Cruncher Statistical System (NCSS) 2007 and the Power Analysis and Sample Size (PASS) 2008 Statistical Software (NCSS LLC, Kaysville, Utah, USA) programs were used for the statistical analysis. The intraclass correlation test was used to determine the level of correlation between the repeated measurements and Fleiss Kappa was used for the agreement of treatment decision for anteroposterior radiographs, frontal CT and axial CT of all reviewer. For each reviewer, ICC test was used to evaluate the agreement between first and second measurements and Cohen Kappa was used for an intraobserver variation of treatment decision. Variance analysis in repeated measurements was used for follow-up measurements of the data and Bonferroni-adjusted tests were used for pairwise comparisons. Interpretation of the values was carried out according to the guidelines proposed by Landis and Koch (12) (Table II). Statistical significance was defined as $p < 0.05$.

Table II. — Intraclass correlation coefficient interpretation values

Strength of Agreement	Agreement Value
Almost perfect (very good)	> 0.8
Strong (good)	0.7-0.8
Moderate	0.5-06
Fair	0.3-04
Poor	0-0.2

RESULTS

The difference between the measurement of AP X-Ray and frontal and axial CT was found statistically significant for both 1st and 2nd assessments ($p = 0.001$) (Table III, Table IV).

Treatment decision for operative treatment was found statistically higher after evaluation with CT for both first and second assessment ($p = 0{,}0001$) (Table V).

The interobserver agreement of measurements for AP X-Ray, CT frontal and CT axial was 0,700, 0,768 and 0,958 after first assessment and 0,800, 0,670 and 0,860 after second assessment, respectively. The interobserver agreement of treatment decision for X-Ray and CT was 0,296 and 0,470 after first assessment and 0,470 and 1,000 after second assessment, respectively (Table VI).

The intraclass correlation coefficient for the intraobserver agreement varied between 0.780 to 0.975 (good to very good) for the measurements on the anteroposterior radiographs, 0.797 to 0.996 (good to very good) for frontal CT and 0.593 to 0.994 (moderate to very good) for axial CT.

Table III. — 1st assessment findings for AP XRAY, Frontal CT and Axial CT

Doctor	AP XRAY (mm)	Treatment decision on XRAY		FRONTAL CT (mm)	AXIAL CT (mm)	Treatment decision on CT	
		OP	N/OP			OP	N/OP
	Av+SD(Median)	n (%)	n (%)	Av+SD(Median)	Av+SD(Median)	n (%)	n (%)
1	6.72±2.71 (6.68)	3 (25.0)	9 (75.0)	8.79±3.37 (8.66)	10.94±3.83 (12.20)	9 (75.0)	3 (25.0)
2	7.28±3.82 (6.94)	6 (50.0)	6 (50.0)	9.63±4.24 (9.57)	11.24±3.52 (10.47)	11 (91.7)	1 (8.3)
3	6.40±2.90 (5.60)	5 (41.7)	7 (58.3)	8.60±3.39 (8.11)	10.97±3.05 (11.45)	11 (91.7)	1 (8.3)
4	6.13±3.18 (4.60)	5 (41.7)	7 (58.3)	8.63±3.20 (9.17)	10.31±3.36 (10.22)	10 (83.3)	2 (16.7)
5	5.33±2.88 (4.71)	3 (25.0)	9 (75.0)	8.35±2.91 (8.29)	10.51±2.90 (11.35)	11 (91.7)	1 (8.3)
6	6.37±3.07 (6.86)	10(83.3)	2 (16.7)	7.42±3.45 (7.08)	10.67±3.45 (11.37)	10 (83.3)	2 (16.7)
7	5.61±2.87 (5.50)	4 (33.3)	8 (66.7)	8.00±2.54 (8.55)	8.56±3.17 (8.70)	9 (75.0)	3 (25.0)
8	7.32±3.03 (8.54)	11(91.7)	1 (8.3)	9.15±2.13 (8.49)	9.82±2.40 (9.88)	12 (100)	0 (0)
9	6.75±3.86 (6.25)	7 (58.3)	5 (41.7)	8.79±2.99 (8.40)	9.72±2.56 (11.00)	10 (83.3)	2 (16.7)

Table IV. — 2nd assessment findings for AP XRAY, Frontal CT and Axial CT

Doctor	AP XRAY (mm)	Treatment decision on XRAY		FRONTAL CT (mm)	AXIAL CT (mm)	Treatment decision on CT	
		OP	N/OP			OP	N/OP
	Av+SD(Median)	n (%)	n (%)	Av+SD(Median)	Av+SD(Median)	n (%)	n (%)
1	6.85±2.53 (6.75)	6 (50.0)	6 (50.0)	8.75±3.32 (8.75)	11.30±3.19 (11.85)	11 (91.7)	1 (8.3)
2	7.38±3.41 (7.45)	7 (58.3)	5 (41.7)	8.98±3.63 (8.70)	11.19±3.36 (10.65)	11 (91.7)	1 (8.3)
3	6.72±2.86 (6.00)	6 (50.0)	6 (50.0)	8.86±3.34 (8.35)	11.12±3.07 (11.65)	11 (91.7)	1 (8.3)
4	6.18±3.27 (4.70)	4 (33.3)	8 (66.7)	8.76±3.23 (9.00)	11.10±3.00 (11.80)	11 (91.7)	1 (8.3)
5	5.89±2.84 (4.80)	6 (50.0)	6 (50.0)	8.98±3.06 (8.65)	10.58±2.81 (11.65)	11 (91.7)	1 (8.3)
6	6.51±2.83 (6.50)	7 (58.3)	5 (41.7)	8.68±3.04 (8.65)	11.04±3.12 (11.55)	11 (91.7)	1 (8.3)
7	6.28±3.32 (5.85)	4 (33.3)	8 (66.7)	8.46±2.87 (8.05)	10.44±2.57 (11.10)	11 (91.7)	1 (8.3)
8	7.09±3.31 (8.30)	8 (66.7)	4 (33.3)	8.77±2.86 (8.10)	10.24±2.39 (10.63)	11 (91.7)	1 (8.3)
9	7.43±3.77 (7.80)	9 (75.0)	3 (25.0)	8.53±3.33 (8.35)	9.68±2.47 (10.05)	11 (91.7)	1 (8.3)

Table V. — Treatment Plan Based on Radiographic Evaluation

	XRAY		CT		
	N	%	N	%	P
1st assessment					
Nonoperative	54	50	15	13,9	0,0001
Operative	54	50	93	86,1	
2nd assessment					
Nonoperative	51	47,2	9	8,3	0,0001
Operative	57	52,8	99	91,7	
Total	108	100	108	100	

Table VI. — Interclass correlation coefficients

ICC		Interclass Correlation	
		%95 CI	
AP XRAY	1st assess.	0.700 (good)	0.509-0.877
	2nd assess.	0.800 (good)	0.645-0.923
CT FRONTAL	1st assess.	0.768 (good)	0.598-0.909
	2nd assess.	0.670 (good)	0.471-0.862
CT AXIAL	1st assess.	0.958 (very good)	0.913-0.985
	2nd assess.	0.860 (very good)	0.736-0.949
		Fleiss kappa	%95 CI
Treatment XRAY	1st assess.	0.296 (fair)	0.202-0.390
	2nd assess.	0.470 (moderate)	0.376-0.565
Treatment CT	1st assess.	0.625 (good)	0.530-0.719
	2nd assess.	1.000 (very good)	0.905-1.094

The intraclass correlation coefficient for the intraobserver agreement varied between 0.426 to 0.833 (moderate to very good) for treatment decision regarding radiographs, 0.429 to 1.000 (moderate to very good) regarding to CT.

DISCUSSION

The most important finding of the present study is that, CT is more reliable and accurate than standard radiographs in determining real fracture displacement and for the treatment decision of the medial epicondyle fractures in pediatric patient group, in which radiographic measurement of displacement was used as surgical criteria. Similar results were gained in studies which evaluated the effect of CT on the treatment decision on foot injuries *(2,14)*. The interobserver agreement was found much better for the treatment decision regarding to CT in our study.

Displacement still remains an important factor to consider when making a treatment decision for medial epicondyle fractures, even though the presence of factors such as incarcerated fragment in the joint, ulnar nerve dysfunction and joint instability may affect the treatment decision. Controversies usually exist on the extent of displacement. The range was reported to be between 2-20 mm from various authors *(3,6,7,10,11,13,17,19,20)*. It is essential to obtain an appropriate image for a reliable evaluation. We used CT to measure the extent of displacement to overcome this problem. It was shown that CT provides more accurate results for the displacement of medial epicondyle fractures *(4)*. In the present study, it was gained higher intraobserver and interobserver reliability with CT respect to the standard radiographs. The results of our study support Gottschalk et al., who advocate that CT can accurately determine the amount of displacement in all planes *(9)*.

Imaging studies tried to reduce the underestimation of the amount of fracture displacement. In two current studies, addition of two different positions of the elbow (internal rotation and axial view) was recommended for evaluation of true displacement of the medial epicondylar fracture *(8,21)*. Gottschalk recommended the use of 45 degrees internal oblique views addition to AP and lateral views of the elbow for the assessment of humeral medial epicondyle fractures. He reported that, it has good intraobserver and interobserver reliability to more accurately estimate the true displacement of these fractures and can augment the treating surgeon's ability to determine true displacement *(8)*. Whereas Souder advocates that even an additional internal rotation view to standard AP and Lateral radiographs underestimates the actual displacement of medial epicondyle humerus fractures. Therefore, he described a new axial projection of elbow and reported that this newly described axial projection demonstrated more accurately and reliably the true displacement while reducing the need for advanced imaging such as CT *(21)*. However, we think that it might be difficult to gain a standard 45 degrees internal oblique view and axial projection of the elbow in clinical practice. It is obvious that CT provides better visualization of bone structures. A three-dimensional CT scan is very helpful to understand the fracture pattern. A current study by Edmonds prove that minimally or nondisplaced fractures on radiographs actually can have about 1 cm of anterior displacement when CT was used to approximate the displacement amount *(4)*.

A significant intraobserver and interobserver variability might be seen even accurate imaging is obtained. Pappas suggest a standard set of measurement guidelines, which include the use of the anteroposterior radiograph when possible and consistently measuring at the point of maximal displacement *(18)*. Measurements in our study were made as Pappas description for both for radiographs and CT. The interobserver agreement was found very good on axial CT, whereas AP radiographs and frontal CT had a lower agreement.

There are some limitations of our study. In this study there was lack of power analysis and it was designed retrospectively. It is well known that prospective randomized studies have the greatest strength. The sample size is limited. The treatment decision was based on radiological assessment, where other criteria have an impact on treatment decision such as the presence of an incarcerated fragment in the joint, ulnar nerve dysfunction and joint instability. Also, there is a general concern for exposure to radiation for children and cost of CT. The strengths of the present study include the participation of 9 different reviewers who were experienced in pediatric orthopedic trauma. Each reviewer made his own measurements with use of the electronic ruler tool available on the PACS system and all reviewers were blinded to the patients names and medical record numbers.

In conclusion, the present study showed that CT scan is superior to the XRAY in describing the amount of real displacement in medial epicondyle fractures. Inter- and intraobserver agreement was found much higher for measurement of the fracture displacement with CT. There is also much higher surgical treatment decision according to CT scan results. There is need for prospective randomized clinical trials for a better understanding of the effect of fracture displacement on clinical outcome.

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