Percutaneous Fixation For Pediatric Humeral Lateral Condyle Fractures.
Ahmed Shawkat Rizk M.D, Osama M. Essawy M.D

Orthopaedics and Traumatology Department, Faculty of Medicine, Benha University, Banha, Egypt.
Job: Assistant professor of orthopaedics and traumatology, faculty of medicine, Benha University.
Address: Shebeen el-kanater, Qaliobia
Tel:01221880770-0132721162
Email: drahmadshawkat@gmail.com

Abstract
Background: Traditionally, the initially non-displaced pediatric humeral lateral condyle fractures (PHLCFs) were treated conservatively while displaced or rotated fractures were treated by open reduction and internal fixation (ORIF). Late displacement and nonunion were reported in some conservatively treated cases meanwhile, epiphyseal necrosis with or without non-union and elbow deformity were reported in some cases treated by open reduction and internal fixation (ORIF). Few studies highlighted closed reduction and percutaneous fixation (CRPF) for displaced and/or rotated fractures. The aim of this study is to assess the outcome of closed reduction and percutaneous fixation for the treatment of pediatric humeral lateral condyle fractures.

Patients and Methods: A prospective study included 45 cases of pediatric humeral lateral condyle fractures (PHLCFs) that were pre-operatively classified according to Song et al classification; all cases were planned to have percutaneous fixation either in situ pinning if initially non-displaced or after closed reduction if displaced or rotated. If closed reduction failed, ORIF was done. The functional results were evaluated according to the modified Aggarwal et al. criteria.

Results: Closed reduction and percutaneous fixation (CRPF) was successful in 80.48% of cases with displaced and/or rotated fractures with satisfactory clinical and radiological results and no reported surgery-related complications in any case till the last follow-up with a mean follow-up duration 18.6 ± 3.04 months, ORIF was done in only 8 cases (representing 19.52% of the studied cases) after failed closed reduction. There was a statistically significant difference (p < 0.001) in the mean radiological union time and the mean time needed for restoration of the full functional capacity of the operated elbow between cases treated by CRPF and cases treated by ORIF.

Conclusions: Closed reduction and percutaneous fixation (CRPF) could be the treatment of choice for potentially unstable lateral humeral condyle fractures avoiding the complications of late displacement and elbow stiffness reported in some conservatively treated case. CRPF is an efficient and minimally invasive treatment option for some displaced and/or rotated fractures with very satisfactory clinical and radiological results. Open reduction and internal fixation (ORIF) could be restricted only for certain complex cases or after the failure of CRPF.

Keywords: Pediatric humeral lateral condyle fractures (PHLCFs), minimally invasive, closed reduction and percutaneous fixation, satisfactory clinical and radiological results.

Introduction:
Pediatric humeral lateral condyle fractures (PHLCFs) represent 15–17 % of elbow fractures and mostly occur in patients aged between 4 and 8 years (1). Theoretically, these fractures could occur by either a pull-off injury, in which avulsion of the lateral condyle occurs at the origin of the extensor/supinator musculature when a varus stress is applied to the extended elbow with the forearm supinated (the most common mechanism of injury) or a push-off injury, in which a fall onto the extended hand impacts the radial head against the lateral condyle, causing the fracture (2).

At the young age when these injuries typically occur, the distal humerus is primarily cartilaginous and so, interpretation of X-rays may be misleading because the visible fragment appears smaller than the actual size and displacement is greater than appreciated and usually associated with articular surface incongruity. Appropriate management requires clear understanding of the relevant
anatomy (the secondary ossification centers and blood supply), the different fracture patterns and possible complications (3). Fractures with minimal displacement must be carefully monitored when conservatively treated, as they have a high potential for displacement; once these displaced fractures consolidate in a malunited position, treatment is difficult and dangerous with many complications (3), meanwhile, excessive and vigorous soft tissue dissection during open reduction and internal fixation may lead to nonunion, avascular necrosis of the lateral condylar mass, premature physeal closure, cubitus valgus and elbow stiffness (4).

The aim of the current study is to assess the suitability and efficiency (clinically and radiologically) of closed reduction and percutaneous fixation (CRPF) as an option for treating either initially non-displaced, potentially unstable fractures or displaced and/or rotated pediatric humeral lateral condyle fractures as a midway alternative between the non-operative treatment and the classic open surgical intervention for such injuries.

Patients and Methods:

A prospective case series study was carried out in the Orthopedic department at Benha University Hospital and Health Insurance Hospital between March 2014 and December 2016 and included 45 cases of pediatric humeral lateral condyle fractures (PHLCFs). Cases with PLHCFs presenting within the first 2 weeks of injury whether initially displaced or potentially unstable were included in this study. Patients were clinically evaluated; for elbow swelling, neurovascular status and elbow stability in all directions. Clinical data eventually included the age of the patient, type of trauma, the injury/presentation interval and the initial management in lately presented cases.

Radiological assessment was done using 3 standard radiographic views (anteroposterior, lateral and internal oblique views). Fractures were classified preoperatively according to the degree of displacement and the fracture pattern using the Song et al classification (5).

They classified these fractures into five stages. Stage 1, the fracture is stable, displacement is $\leq 2$ mm, and the fracture line is limited to within the metaphysis. Stage 2, displacement is $\leq 2$ mm, the fracture line extends to the epiphyseal articular cartilage, and there is a lateral gap, the fracture stability is indefinable. Stage 3, the fracture is unstable, displacement is $\leq 2$ mm, and there is a gap that is as wide laterally as it is medial. Stage 4, the fracture is unstable and displacement is $>2$ mm. Stage 5, the fracture is unstable and displacement is $>2$ mm with rotation.

In addition to fracture displacement and fracture line extension, standard A.P views (Fig. 1) could tell about the relation of the fracture line to the capitellar epiphysis, the orientation of the displaced or rotated fragment either vertically or horizontally, the size of the metaphyseal fragment and finally, whether the elbow joint itself is subluxated / dislocated or not. We added an extra stage to Song et al. classification for describing cases of PHLCFs associated with elbow dislocation and was referred to as (stage 5+).

Internal oblique view x-rays (Fig. 2) can sharply determine the size of the metaphyseal fragment and tell whether a minimally displaced fracture is stable or potentially unstable depending on the extension of the fracture line to the joint surface. Cases with fractures that started laterally in the metaphysis and extends to reach the articular surface in both the A.P and internal oblique view x-rays - whether displaced or not - were considered potentially unstable and were considered as candidates for fixation and included in this study.

Lateral view x-rays were of little value in evaluation of such fractures at presentation but they were critically important (combined with the internal oblique view x- ray) for assessing the achieved reduction (Fig. 3-a) and evaluation of union progression during the follow-up and could tell about the proper time of wires removal after proper healing with complete disappearance of the fracture line (Fig. 3-b).
Figure 1: Standard A.P view of some of the studied cases with different fracture characteristics: (A) An incomplete fracture (not reaching the articular surface) with a lateral gap and ≤ 2 mm. (Song et al. stage - 1). (B) A complete fracture reaching the articular surface with a lateral gap and ≤ 2 mm displacement. (Song et al. stage - 2). (C) A complete fracture with a >2 mm displacement. (Song et al. stage - 4). (D) A complete fracture with a displaced and rotated fragment. (Song et al. stage - 5). (E) A complete fracture with a displaced and rotated fragment with elbow dislocation, (considered stage - 5+)

Figure 2: Internal oblique view x-ray of some of the studied cases with different fracture characteristics: (A) An incomplete fracture with the fracture line not reaching the articular surface. (B) A complete fracture with a non-displaced fragment with a large metaphyseal segment. (C) A complete fracture with a non-displaced fragment with a small metaphyseal segment. (D) A complete fracture with a displaced fragment with a small metaphyseal segment.

Figure 3: Lateral view x-rays were useful in the assessment of reduction and evaluation of union progression (2 different cases). (A) A near anatomical reduction with proper engagement of the reduced lateral condylar mass. (B,C) Completely healed fracture with disappearance of the fracture line after anatomical reduction and K-wires fixation.

Operative technique:

All the studied cases were planned to have either, in situ pinning or closed reduction and percutaneous fixation with a minimum of 2 K-wires under C-arm guidance. Under general anesthesia and without tourniquet, in situ pinning was done for non-displaced, potentially unstable cases while reduction of the displaced fragments was tried by applying traction and varus stress with gentle pressure manipulating the displaced fragment from its posterior and lateral borders directing it anteromedially towards its bed with reduction to near anatomical position as much as possible. Reduction assessment using C-arm in 3 views (A.P - lateral and internal oblique view) then the reduced fragment was fixed.
percutaneously using at least 2 K-wires engaging the medial or the posterior cortex (Fig. 4).

Figure 4: Intra-operative C. arm images corresponding to the case presented in (Figure 1- C) showing fixation after achieving accepted reduction in all the 3 views with no articular step and a fracture gap less than 2 mm: (A) An A.P view X-ray showing near anatomical reduction with good distribution of the transfixing K. wires. (B) A lateral view X-ray showing near anatomical reduction with good engagement of the distal fragment. (C) An internal oblique view showing near anatomical reduction.

Displaced and rotated fragments were reduced with the same technique with the aid of another K-wire used as a joystick facilitating manipulation of the fractured fragment and once reduced to an accepted position, fixed to its bed as usual. If closed reduction failed to achieve an accepted position, open reduction and internal fixation was done.

Post-Operative protocol and follow-up:

Fixation was protected in above the elbow POP back splint for 2 to 3 weeks - depending on the patient's age, intraoperative stability and the early appearance of progressive healing without any eventual displacement that could be detected radiologically in the 2 weeks interval follow-up. Back splint were removed once dependable healing was detected; allowing early passive and active ROM then K-wires were safely removed once secure radiological union achieved and reported in Ap. and lateral views X-rays (Fig 5).

Patients were followed-up clinically and radiologically and the functional results were evaluated according to modified criteria of Aggarwal et al (6) as follows:

Excellent: Union in perfect alignment with a full range of motion at the elbow, without any change in carrying angle, without avascular necrosis/lateral prominence/premature fusion of physis. Radiograph shows a perfect reduction.

Good: Union with minimum displacement, limitation of terminal range of movements of not more than 15 degrees, no alteration in carrying angle, no premature fusion of the physis, no avascular necrosis, no local deformity, radiograph showing a step/gap of not more than 2 mm.

Fair: Union with minimum displacement, limitation of terminal range of movements of not more than 25 degrees, alteration in carrying angle of up to 10 degrees, premature fusion of the physis, no avascular necrosis, mild local deformity, radiograph showing a step/gap of 2-5 mm.

Poor: Non-union at the fracture site, gross limitation of elbow movements, alteration in carrying angle of more than 10 degrees, premature fusion of the physis, avascular necrosis of the fragment, visible deformity at local site, radiograph showing a step/gap of more than 5mm.

Figure 5: Five weeks post-operative X- rays corresponding to the case presented in (Figure 2- C) showing complete healing of the fracture.

Statistical analysis:

Statistical analysis was performed using SPSS ver. 19.0 (SPSS Inc., Chicago, IL, USA). Statistical analysis was done using a two-tailed Student t test and p < 0.05 was considered statistically significant.
Results:

A total number of 45 cases of pediatric humeral lateral condyle fractures (PHLCFs) in 45 patients (36 males and 9 female patients) were included in this study, the age of the patients ranged from 4.5 to 11 years with a mean age of 6.5 ± 1.5 years. The right side was affected in 28 cases while the left side was affected in the remaining 17 cases. The injury/surgery interval ranged from 1 to 12 days with a mean duration of 4.6 ± 3.7 days and cases were followed-up for 14 to 26 months post-operatively with a mean duration of 18.6 ± 3.04 months.

According to Song et al classification (5), 4 cases were stage -1 fractures, 6 cases were stage -2 fractures, 15 cases were stage -4 fractures, 17 cases were stage -5 fractures and the last 3 cases were displaced and rotated fractures associated with elbow dislocation and were considered stage -5+ fractures. According to Song et al (5), the reduction was considered accepted and closed pinning could be done when confirmed to be within 2 mm displacement or step-off especially on the internal oblique view while cases in which fragments could not be reduced to within 2 mm were treated by ORIF. In this study, in situ pinning was done in all the 4 cases with stage -1 fractures and closed reduction by direct thumb pressure and percutaneous fixation (CRPF) was done in the 6 cases with stage -2 fractures( representing 100% of such cases ). 14 of the 15 cases with stage -4 fractures (representing 93.33% of such cases) were successfully treated by CRPF while one case (representing 6.67% of such cases) needed ORIF. 11 of the 17 cases with stage -5 fractures (representing 64.70% of such cases) were successfully treated by CRPF while 6 cases (representing 35.30% of such cases) needed ORIF. CRPF was successful in 2 of the 3 cases with fracture dislocation (stage -5+ fractures) (representing 66.67% of such cases) while one case (representing 33.34% of such cases) needed ORIF (Fig 6).

In situ pinning -without reduction- was done in 4 cases. Closed reduction and percutaneous fixation (CRPF) was successful in 33 of the remaining 41 (representing 80.48% of cases with displaced and/or rotated fractures) with satisfactory radiological results and no late displacement or surgery related complications reported in any case till the last follow-up. Open reduction and internal fixation (ORIF) was done in only 8 cases (representing 19.52% of the studied cases) after failure to achieve an accepted reduction in a closed manner.

Beside the fracture stage (type), it was found that success of CRPF depends also on the injury/surgery interval and the size of the metaphyseal fragment. Much difficulty and high failure rate of closed reduction were encountered with fractures presented after 7 days of injury and with fractures with small metaphyseal fragments that made manipulation difficult and risky.

Regarding the quality of the achieved reduction, an anatomical reduction was achieved in all the 8 cases of ORIF after the failure of closed reduction (representing 100% of such cases). Of the 33 cases with successful closed reduction, accepted reduction (excellent and good) was achieved in 30 cases (representing 90.9% of such cases). 2 cases (representing 6.06% of such cases) had a fair reduction with a step of 2-5 mm and 1 case (representing 3.04% of such cases) had a poor reduction with a gap > 5 mm (Fig 7).
Union occurred in all cases except 1 case (representing 2.22% of all the included cases) that developed a stable fibrous non-union after premature removal of wires depending on a false radiological impression of a secure union in a case with lateral condyle fracture associated with elbow dislocation that was treated by CRPF (Fig. 8). The mean radiological union time - that was also the mean time for wires removal - in cases treated by CRPF was 28.4 ± 5.5 days (ranged between 21 and 35 days) while the mean radiological union time in cases treated by ORIF was 42.8 ± 5.7 days (ranged between 35 and 49 days) denoting a highly statistically significant difference (p < 0.001). The mean time needed for restoration of the functional range of motion of the operated elbow in the cases treated by CRPF was 9.2 ± 1.7 weeks (ranged from 7 and 12 weeks) while the mean time in the cases treated by ORIF was 13.4 ± 2.6 weeks (ranged between 10 and 16 weeks) denoting a highly statistically significant difference (p < 0.001) (Table 1).

Figure 7: Radiological results of some of the studied cases: (A) Excellent reduction, secure union with no late displacement in a case with a stage -2 fracture treated by CRPF. (B) Excellent reduction, secure union with no late displacement in a case with a stage -5 fracture treated by CRPF. (C) Fair reduction with an articular step of 2-5 mm in a case with a stage -4 fracture treated by CRPF. (D) Poor reduction with a fracture gap of about 5 mm in a case with a stage -4 treated by CRPF.
Figure 8: The final clinical (A) and radiological (B) result after CRPF of a case with stage -5+ fracture (fracture dislocation) corresponding to the case presented in (Figure 1- E) showing a near normal range of elbow motion (with only loss of the last 10 degrees of extension and small lateral prominence) in spite of a non-anatomically reduced fragment with a stable fibrous union.

**Table 1:** Mean time for radiological union and restoration of functional ROM

<table>
<thead>
<tr>
<th></th>
<th>Cases treated with PF (In situ pinning or CRPF)</th>
<th>Cases treated with ORIF</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cases</td>
<td>37</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Mean radiological union time (days)</td>
<td>28.4±5.5</td>
<td>42.8±5.7*</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Mean Time for restoration of functional ROM (weeks)</td>
<td>9.2±1.7</td>
<td>13.4±2.6*</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

*significant difference between cases treated with PF and ORIF (P<0.001)

In the 10 cases with stages 1 & 2 fractures that were previously considered by most surgeons candidates for conservative treatment in above the elbow back splints for 6 weeks, all cases achieved complete healing with no secondary displacement and fast restoration of the functional ROM of the injured joint by the 5th postoperative week. Early restoration of the functional ROM could be attributed to the early passive and active range of motion that was allowed as early as the 2nd or the 3rd postoperative weeks after removal of the protective splints with the wires in place.

In the last follow-up, 42 cases (representing 93.34% of the studied cases) were functionally excellent, 2 cases (representing 4.44% of the studied cases) were good and 1 case (representing 2.22% of the studied cases) was fair according to Aggarwal et al. modified criteria. In the 3 cases that were rated as good and fair according to Aggarwal et al. modified criteria, the radiological results were not typically reflected clinically. The affected elbow joints regained a very accepted functional range of motion with a painless stable joint even with the presence of non-anatomical reduction with articular step and/or a fracture gap with a stable fibrous nonunion (Fig 7 c-d & 8).

No cases developed superficial or deep wound infection after ORIF, pin track infection was reported in 3 cases and was controlled by a short course of oral broad-spectrum antibiotic and pin care using just alcohol while keeping active ROM. Till the last follow-up, no cases developed frank non-union with a gap, premature fusion of the epiphysis or avascular necrosis of the fragment or progressive deformity of the operated elbow.

**Discussion:**

Pediatric lateral condyle humeral fractures (PHLCFs) are basically an epiphyseal injury; hence, in the long run, it is inherently associated with a potential problem of growth arrest, premature physeal closure, a range of motion restriction and angular deformity of the elbow (7). These fractures - even when initially minimally displaced -
have a high risk for nonunion (Fig. 9) and/or secondary displacement due to its intra-articular location and subsequent pull from the common extensor muscles.

Figure 9: Although nearly non-displaced (A) and immobilized for 8 weeks, it went to non-union (B) that didn't heal over the next 1 year (C) although clinically asymptomatic apart from a loss of the last 5 to 10 degrees of extension and lateral prominence.

Classically, displaced (more than 2 mm) and/or rotated fractures had a clear and widely accepted decision for treatment in the form of open surgical treatment (ORIF); meanwhile, the controversy is marked when managing non-displaced or minimally displaced (<2 mm) fractures. Some surgeons advocate nonoperative treatment for minimally displaced (<2 mm) fractures (8,9,10), others recommend open surgical treatment for even minimally displaced fractures in which the fracture line is clear (11) others still advocate open reduction and fixation for all fractures given the propensity for minimally displaced fractures to become displaced when treated conservatively and to lead to complications when not recognized early (12).

According to the different authors (8-12), surgeons have three options for treating such cases. The first option is the open surgical treatment (ORIF) for all lateral condyle fractures once the fracture line is clear - even when non-displaced - given the propensity for non-displaced or minimally displaced fractures to become displaced when treated conservatively and to lead to complications when not recognized early. The second option is to treat minimally displaced (<2 mm) fractures conservatively with the reported possible risks of late displacement. The last option is to treat minimally displaced (<2 mm) fractures by closed reduction and internal fixation (CRPF).

This controversy aroused important questions like: What are the parameters determining the stability of such fractures? Which fractures are actually stable and could be safely treated conservatively and which fractures are potentially unstable and need fixation? Why treating potentially unstable, non-displaced fractures by open surgical treatment if it is possible to fix these fractures safely and efficiently in a closed manner (percutaneously) by either in situ pinning or by closed reduction and percutaneous fixation? Is it always necessary to do an open reduction and internal fixation for all early presented displaced and/or rotated pediatric humeral lateral condyle fractures?

Rotated fractures, displaced fractures, complete non-displaced fractures extending from the metaphysis laterally and reaching the articular surface, incomplete fractures with a lateral fracture line that opens producing a lateral gap with varus stress applied to the extended elbow (Fig. 10) and concealed injuries characterized by massive lateral swelling and crepitus on palpation are potentially unstable fractures and represent clear indications for fixation; either percutaneously or after open reduction.

Figure 10: Concealed fracture of the lateral condyle that became obvious when the elbow was examined under varus stress indicating that the fracture was inherently and potentially unstable with possible late displacement if not properly managed.

Traditionally, displaced and/or rotated fractures were treated by open reduction and internal fixation (ORIF) using K-wires of suitable number and diameter according to the age of the patient and the size of the fractured
fragment. Meanwhile, few studies presented percutaneous fixation of such fractures for selected cases. Foster et al. (10) used closed reduction and internal fixation (CRIF) for non-displaced or minimally displaced fractures as an alternative treatment for both conservative treatment and open surgical treatment. Mintzer et al. (9) tried CRIF in fractures with 2 to 4 mm of displacement and used arthrography to document the adequacy of reduction and congruency of the joint. Thomas et al. (13) described percutaneous pin fixation with two divergent pins placed percutaneously after a closed reduction for minimally displaced fractures in order to maintain the alignment. They (9,10,13) didn't recommend CRIF for rotated fractures. Newly published studies strongly challenged the necessity for the open reduction of a displaced fracture, advocating good results following closed reduction and internal fixation (CRIF) of completely displaced and/or rotated fragments (5,14,15). Advocates of closed reduction hypothesize that ORIF might be unnecessary in many cases and that it might even lead to avascular necrosis as a result of extensive soft tissue dissection (5,14,15).

Song et al. (5) presented closed reduction and internal fixation (CRIF) for pediatric lateral condyle fractures and reported a success of 73% with no cases of non-union or mal-union. They suggested that CRIF often represents an effective treatment for displaced lateral condyle fractures. Song et al (5) had only 6 cases with rotated fractures and reported 50% success rate for doing CRIF. In a subsequent study by Song et al (15) that included 24 cases with rotated fractures, they reported successful CRIF in 18 cases representing 75% of the studied cases. The progressively increased success rate between the 2 studies by Song et al (5,15) was explained as reported by them by a progressive learning curve and experience accumulation.

In this study, closed reduction and percutaneous fixation (CRPF) was successful in 80.48% of cases with displaced and/or rotated fractures with satisfactory clinical and radiological results and no reported surgery related complications till the last follow-up. This study included 17 cases with rotated fractures in which closed reduction and percutaneous fixation was successful in 11 of these 17 cases representing 64.7% of such cases.

Compared to the 2 studies by Song et al (5&15), the overall superior results (80.48% in this study compared to 73% by Song et al) could be explained by the fact that 6 minimally displaced cases that were potentially unstable were included in this study whereas Song et al (5) managed cases like these, conservatively. On the other hand, our results in treating cases with rotated fractures by CRPF were inferior when compared to the results presented by Song et al (15) when treating such cases (64.70% in this study compared to 75% by Song et al). Compared again to the 2 studies by Song et al (5&15), this study included 3 cases with lateral condyle fractures associated with elbow dislocation representing a more severe entity of such injuries. The direction of dislocation was posteromedial with the fractured lateral condyle still aligned with the radial head in both cases as described by Eksioglu et al. (16). Closed reduction was successful in 2 of the 3 cases representing 66.66% of the studied cases. Dislocation of the elbow associated with lateral condylar fractures of the humerus is a rare injury in children with only a few cases reported in the literature. Although the addition of an elbow joint dislocation would seem to indicate a more severe injury and perhaps a worse outcome, this was not noticed in our study in the 2 cases treated by closed reduction and percutaneous fixation or the case treated by ORIF.

Compared to what was reported by Junichi et al. (17), 2 to 3 weeks of immobilization was too short period as they recommended 6 weeks of immobilization, but results regarding immobilization period, union time and time of wires removal were comparable to other studies, Thomas et al (14) recommended 21 days K-wire fixation for displaced lateral condylar fractures of humerus in children. Nasab and Sabahi (18) found that callus formation was enough to safely remove the k-wires by 30 days after surgery in most of their cases with no subsequent displacement. Boz et al (19) reported excellent results in 78% and good
results in 21.7% of their patients with displaced lateral condylar fracture of the elbow treated by open reduction with 28 days pin fixation. Gooi et al (20) found that after open reduction and internal fixation with 2 K-wires for lateral condyle fractures, the union was seen in 28 days in most of their patients. Cases that were classically treated by ORIF with soft tissue dissection that usually needed longer rehabilitation period for restoration of full ROM of the operated elbow - if fully restored - could be treated with such minimally invasive procedure with no soft tissue violation and marvelous preservation of the precious blood supply to such susceptible growing fragment. Also, cases that were traditionally treated conservatively by immobilization for 6 weeks with a possible risk of secondary displacement could be treated with CRPF with no risk of secondary displacement and were immobilized for only 2 to 3 weeks then started active ROM. Definitely; shorter immobilization period means a faster restoration of the elbow ROM and muscle power.

In light of the results of this study and the previous work done by Foster et al. (10), Mintzer et al. (9) and Song et al (5&15), answers to the previously asked questions could be presented. Fractures of the lateral condyle are not the same, fracture line extension and its relation to the capitellar epiphysis, the size of the metaphyseal fragment, the direction of displacement and orientation of the displaced or rotated fragment either vertically or horizontally and the presence or absence of associated elbow dislocation are different variables producing different types or categories of such injuries. It is not always necessary to do an open reduction and internal fixation for all early presented pediatric humeral lateral condyle fractures. Closed reduction and percutaneous fixation could replace - with superior clinical results - ORIF in most of the cases especially non-displaced, potentially unstable fractures that were treated traditionally by ORIF.

The relatively small number of cases in this study with a relatively short-term follow-up period, the absence of a control group for each fracture stage, the absence of accurate correlation between the injury/surgery interval and the success or failure of closed reduction and reduction assessment using only image intensifier that could be less accurate in such age group compared to other modalities as arthrography or MRI represent the limitations of this study; however, these limitations do not undermine the results achieved by this study.

**Conclusions:**
Closed reduction and percutaneous fixation (CRPF) could be the treatment of choice for potentially unstable fractures avoiding the complications of late displacement reported in some conservatively treated case. CRPF is an efficient and minimally invasive treatment option for some displaced and/or rotated fractures with very satisfactory clinical and radiological results. Open reduction and internal fixation (ORIF) could be restricted only for certain complex cases or after the failure of CRPF.

**Conflict of interest:**
All authors have no conflict of interest to disclose and didn’t receive any fund or research grants.

**Ethical approval:** The study was approved by ethical committee of Benha University and were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

**Informed consent:** All patient’s parents signed an informed consent after clear explanation of the surgical procedure.

**Level of evidence:** Level IV.

**References:**


4- Fontanneta P, Mackenzie DA, Rosman M. Missed maluniting and malunited fractures of