*Acta Orthop. Belg.*, 2016, **82**, 889-895

*ORIGINAL STUDY*

# Long-term outcome in displaced lateral humeral condyle fractures following internal screw fixation in children

Giovanni FRONGIA, Csaba JANOSI, Arianeb MEHRABI, Jens-Peter SCHENK, Patrick GÜNTHER

*University Hospital of Heidelberg, Germany*

***Background*** **: The aim of this study was to investigate the long-term clinical outcome following open reduction and internal screw fixation of displaced lateral condyle fractures (LCFs) of the distal humerus and compare the outcome of primary and secondary LCFs.**
***Methods*** **: The clinical outcome in 31 children (mean age 5.8±2.4 years) operated for primary or secondary LCFs was retrospectively analyzed by standardized clinical examination and compared using the Mayo score, Morger score, and Patients Satisfaction score.**
***Results*** **: The scores did not differ significantly between the primary and secondary displacement groups (Mayo score: 99.3±3.3 vs. 100±0, p=0.852; Morger score: 3.8±0.5 vs. 3.9±0.3, p=0.852; Patients Satisfaction score: 3.7±0.6 vs. 3.9±0.3, p=0.546). Deficits in range of motion and joint axis deviation were minor (< 10°) and no elbow instabilities were observed.**
***Conclusions*** **: Surgical treatment of a secondary displaced LCF with open reduction and internal screw fixation leads to a favorable long-term outcome. The long-term outcome is similar between primary and secondary displaced LCFs.**

**Keywords** : lateral condyle fracture ; children ; displacement ; screw fixation ; follow-up ; outcome.

## INTRODUCTION

Lateral condyle fractures (LCF) of the distal humerus are the most common elbow fractures involving the growth plate and the second most common (5-20%) elbow fractures that occur during childhood *(6,14,15,18,26)*. LCF commonly occur between 2-14 years of age, with the highest incidence around the age of six years *(6,14)*. Complications include severe restrictions in motion and varus elbow-joint deformities due to radial overgrowth, as well as non-union and necrosis of the fragment *(12,36,29)*. Long-standing non-union of a LCF can cause tardy ulnar nerve palsy *(35)*.

■ Giovanni Frongia
■ Csaba Janosi
■ Patrick Günther
*Division of Pediatric Surgery, Department of General, Visceral and Transplantation Surgery, University Hospital of Heidelberg, Germany.*
■ Arianeb Mehrabi
*Department of General, Visceral and Transplantation Surgery, University Hospital of Heidelberg, Germany.*
■ Jens-Peter Schenk
*Division of Pediatric Radiology, Department of Diagnostic and Interventional Radiology, University Hospital of Heidelberg, Germany.*
Correspondence : Giovanni Frongia, Division of Pediatric Surgery, Department of General, Visceral and Transplantation Surgery, University Hospital of Heidelberg, Im Neuenheimer Feld 110, 69120 Heidelberg, Germany.
E-mail : gio@frongia.net


*No benefits or funds were received in support of this study.*
*The authors report no conflict of interests.*

LCFs can be treated using conservative and surgical approaches, depending on the grade of displacement. Fractures with a displacement of 2 mm or more are an indication for surgical treatment, while those with a displacement of less than 2 mm can be managed conservatively with cast immobilization *(7,24,32,33)*. There is a higher risk of secondary displacement (44% of cases) in conservatively treated LCFs *(34)*. LCFs with secondary displacements of 2 mm or more require surgical intervention. Options for surgical treatment include a reduction followed by fixation with K-wires *(7,33)*, one screw *(27,32,36,38)*, two screws *(18)*, or a combination of K-wires and screws *(4,15,31,37)*. The clinical outcomes following surgical treatment of primary and secondary LCFs have not been compared in detail. To the best of our knowledge, this is the first study to compare the long-term clinical outcome following primary and secondary displacement of LCFs treated by open reduction and internal screw fixation.

## METHODS

### Study design

Ethical approval was obtained from the Institutional Review Board. This study was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments. Informed consent was obtained from all study participants and their parents. LCF patients up to the age of 15 years who received an open reduction and internal screw fixation at our department between 2003 and 2013 were analyzed. Only LCF patients treated by open reduction and internal fixation with one screw without any additional K-wire were included. Exclusion criteria were fractures not treated exclusively by internal screw fixation (e.g. with an additional K-wire), a delayed intervention of more than 10 days after injury, and the presence of concomitant fractures or severe comorbidities. Demographic, preoperative, intraoperative, and postoperative data were obtained by retrospective review of the patient charts. The afflicted elbow was evaluated by a standardized clinical follow-up examination (range of movement, joint axis, and stability) in each patient as previously described *(39)*. In addition, the Mayo Elbow Performance score (max. score 100) *(2,3,11)* and the Morger score (max. score 4) *(21,25)* was calculated in each patient. Patient satisfaction with the postoperative result was also scored (1=very satisfied, 2=satisfied, 3=unsatisfied, 4=very unsatisfied). Patients with LCFs were subdivided into primary and secondary displacement groups and pre-determined variables were compared between both groups.

### Diagnostic and treatment approach

A LCF was diagnosed based on the anteroposterior and lateral radiographs at admission. The extent of fracture displacement was determined on

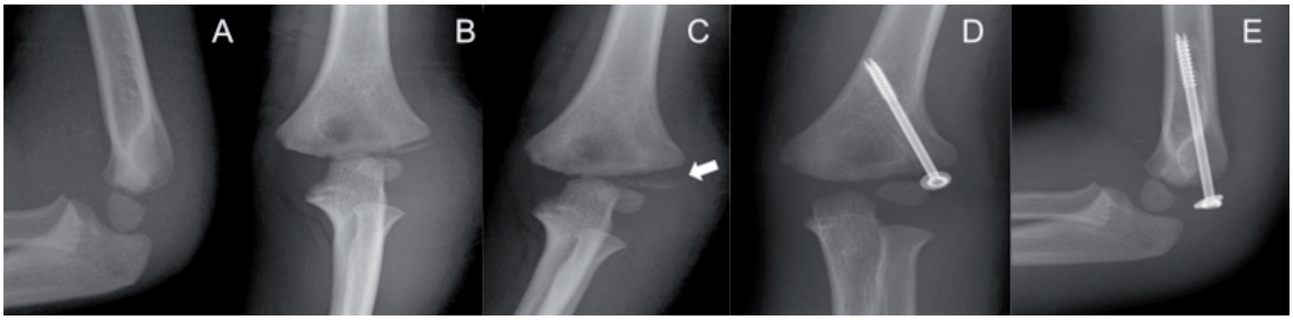


***Fig. 1.*** **—** Radiographs of a 4.5-year-old girl with a lateral condyle fracture of the left humerus. The initial fracture was displacement less than 2 mm (A, B). Follow-up x-ray 5 days after injury shows a secondary fracture displacement of approximately 4 mm (C, arrow). After open reduction and internal screw fixation with a plain washer, the postoperative radiographs show correct fracture repositioning at the articular surface (D, E).

plain radiographs until 2006 and subsequently on digital radiographs (Centricity PACS®, GE Medical Systems, Barrington, IL, USA). LCFs that were displaced less than 2 mm were treated conservatively by immobilization in a long-arm cast. Radiological controls using anteroposterior and lateral radiographs without a cast were conducted within 8 days of conservative management. Primary or secondary displacements measuring 2 mm or more were an indication for surgery (Figure 1). Open reductions were performed using a lateral approach. After clear exposition and exact reposition, the displaced LCF was provisionally fixed using a K-wire placed at an angle to the metaphyseal fragment. A 3.5-4 mm cannulated tension screw with self-taping threads and a plain washer was then screwed over the K-wire, which was then removed. Exact repositioning of the fracture at the articular surface was confirmed by fluoroscopy. The arm was immobilized in a long-arm cast for 2–3 weeks in all patients. Screws and washers were removed under general anesthesia after fracture consolidation was confirmed by radiography. Physiotherapy was indicated on an individual basis from 4 weeks after metal removal.

### Data analysis

Frequency distributions were calculated for categorical variables. Categorical data (age, sex, fracture side) were compared using a Fisher exact test. Continuous variables were expressed as mean values ± standard deviation and were compared according to their normality distribution test. A Shapiro-Wilk`s test ($p>0.05$) and a visual inspection of their histograms, normal Q-Q plots and box plots showed that most demographics and treatment variables (exceptions see below) and also the Mayo-, Morger- and Patients Satisfaction scores were not approximately normally distributed within the study population. Therefore, these parameters were tested using the Mann-Whitney U-Test. The above mentioned normality test tools showed that the duration of surgery and the duration of immobilization and the duration of follow-up were approximately normally distributed, with a skewness of 0.154 (standard error 0.427) and kurtosis of -0.287 (standard error 0.833) for the duration of surgery and a skewness of 0.085 (standard error 0.427) and kurtosis of -0.865 (standard error 0.833) for the duration of immobilization and a skewness of 1.136 (standard error 0.724) and kurtosis of -0.576 (standard error 0.833) for the duration of follow-up. Therefore, these parameters were tested using an independent-sample T-test. Statistical analysis was performed using SPSS® Version 21 for Windows (SPSS® Corp., Chicago, IL, USA). A p-value $<0.05$ was considered statistically significant.

## RESULTS

During the observation period, 46 children with a LCF were operated, 40 (87.0%) of which met the inclusion criteria. Four patients (8.7%) were excluded because they were operated with a screw and an additional K-wire and two children (4.3%) were excluded because of a concomitant ipsilateral fracture of the elbow. Thirty-one (77.5%) patients met the inclusion criteria and participated in the study, while the remaining patients either denied participation (n=6) or could not be contacted (n=3). Twenty-one (67.7%) participants had a primary displacement and 10 (32.3%) had a secondary displacement. All patients were treated surgically by open reduction and internal fixation with one screw. Secondary displacements were diagnosed by radiograph on average 4.2±0.6 (3-5) days after the initial conservative treatment. The mean age of the participants was 5.8±2.4 years. Patient demographics and treatment course are shown in Table 1. Demographics, fracture side, duration of surgery, immobilization, and physiotherapy were all similar between the primary and secondary displacement groups. Only the time-point of surgery differed significantly between the two groups. Surgical treatment was performed on the day of presentation at our clinic at the earliest and 8 days after presentation at the latest. The collective mean follow-up period was 43.5±33.3 months (median 32, range 8–128). The mean follow-up period for the primary displacement group was 49.1±6.6 months (median 39, range 13-128) and the mean follow-up period for the secondary displacement group was 31.6±11.8 months (median 15, range 8-126) ($p=0.126$). During the follow-up examinations, we

Table I. — Demographics and treatment course

| | Collective group n=31 | Primary surgery n=21 | Secondary surgery n=10 | p-value* |
|---|---|---|---|---|
| Age (years) | 5.8±0.4 | 5.7±2.7 | 6.1 ± 1.6 | 0.646 |
| Sex (male) | 17 (54.8%) | 12 (57.1%) | 5 (50.0%) | 1.000 |
| Fracture side (left) | 18 (58.1%) | 13 (61.9%) | 5 (50.0%) | 0.701 |
| Time-point of surgery (days) | 2.6±0.5 | 1.3±1.6 | 5.3±2.1 | <0.001 |
| Duration of surgery (min) | 57.2±2.1 | 58.2±11.3 | 54.9±12.7 | 0.465 |
| Duration of immobilization (days) | 14.5±4.2 | 15.1±4.5 | 13.3±3.5 | 0.225 |
| Duration of physiotherapy (weeks) | 4.1±1.4 | 5.3±9.3 | 1.9±2.4 | 0.724 |
| Duration until metal removal (weeks) | 10.2±0.5 | 10.4±0.6 | 9.7±0.9 | 0.466 |

* Between primary and secondary displacement group

observed a 10° deficit in elbow extension compared with the contralateral side in four patients from the primary displacement group, but not in the secondary displacement group (p=0.277). Three children in the primary displacement group and one child in the secondary displacement group had a 10° deficit in elbow flexion compared with the contralateral side (p=1.000). Additionally, a 10° varus deviation of the joint axis compared with the contralateral side was present in one child with a primary displacement, while no varus defects were observed in the secondary displacement group (p=1.000). The affected elbow joint was deemed clinically stable in all patients at the clinical examination and anamnestically based on daily routine. The clinical and Patients Satisfaction scores calculated at follow-up are presented in Table II. Clinical and Patients Satisfaction scores were consistently high (Mayo score 99.5±2.7; Morger score 3.8±0.5; Satisfaction score 3.8±0.5) and similar between the primary displacement and secondary displacement groups (Table 2). Three children in the secondary displacement group had a follow-up period of less than 12 months (two children 8 months, one child 9 months). None of these three children showed any deficits in range of motion and joint axis deviation at the follow-up examination and all had the highest possible Mayo, Morger, and Patients Satisfaction scores.

## DISCUSSION

The aims of the study were to investigate the long-term clinical outcome of LCFs after surgical treatment with open reduction and internal screw fixation and to compare the outcomes of primary and secondary displacements. Surgical treatment of primary and secondary displacements by open reduction and internal fixation with one screw had a favorable long-term outcome, determined by high clinical and Patients Satisfaction scores. The outcome was independent of the time-point of fragment displacement and surgery. Because the results from the primary and secondary displacement groups did not differ significantly, an initial conservative approach is feasible. If the LCF presents with a borderline displacement, and surgical intervention can be performed in the case of a secondary displacement. In the present patient series, there were some cases of initial borderline displacement without secondary displacement. In these cases, we ruled out further dislocation and need for surgical intervention by x-rays. Our findings indicate that surgical intervention within 8 days of presentation is adequate for an optimal postoperative outcome. Delayed surgical intervention, especially later than 3 weeks after injury, has been associated with poor outcome and might increase the risk of avascular necrosis of the fragment due to impaired blood supply *(14)*. However, successful reunion of a displaced LCF with a good clinical range of movement was reported in 87% of patients presenting more than 4 weeks after injury *(26)*. In other studies, late surgical intervention has been suggested as a reason for non-union of LCFs, even in the absence of other symptoms *(8,28)*. Treatment performed 5-10 months *(28)* or even 5-120 months *(8)* after injury successfully remodeled the elbow joint, improved the range of motion over time in skeletally immature patients, and prevented the progression of cubitus valgus deformities and subsequent dysfunction of the ulnar nerve. Children with symptomatic non-union and mal-union may also benefit from late surgical treatment, even up to 14 years after injury *(23)*. However, optimal initial treatment should be the main goal. Our findings suggest that this can be achieved by surgical intervention within 8 days of trauma.

Open reduction is the favored treatment for a displaced LCF *(37)*. Closed reduction and fixation can also be used with an additional open reduction and internal fixation if fracture displacement exceeds 2 mm *(31)*. Selected cases of LCF have also used closed reduction and screw fixation with an intact cartilage hinge and congruent joint surface *(27)*. Compared with K-wires, screw fixation can compress and stabilize the fracture, reducing the consolidation time and postoperative elbow deformities associated with fracture instability *(12,29,36)*. LCFs can be fixed with K-wires *(18)* to prevent pseudoarthrosis *(37)*, but this treatment has been associated with postoperative varus deformities *(30,37)*, so is not widely used *(5,20,10,22)*. Improved elbow function and faster recovery were reported in children following screw fixation of LCFs. Wound infections only occurred in patients treated with percutaneous K-wires *(18)*. However, screw removal requires an additional operation, while percutaneous K-wires can easily be removed without surgery *(18)*. Bio-absorbable pins or screws have been used as a reasonable alternative to metal counterparts for LCF treatment, with similar clinical and radiological outcomes *(3)*. However, the long-term outcome of using bio-absorbable screws has not been determined yet. Placement of an additional axial K-wire in the trochlea increases stability, especially in the central part of the LCF *(13,37)*. This approach minimalizes the rotational instability associated with screw fixation, but this may not be important because we observed favorable long-term results after screw fixation without an additional K-wire placement in both primary and secondary displaced LCFs.

Some studies have shown an immobilization period of at least 4 weeks *(12,37)*. However, we observed no complications after 2-3 weeks immobilization and this is in agreement with other published reports *(22)*.

In the present study, a secondary displacement was treated by open reduction and internal screw fixation in one third of participants. A high percentage of secondary interventions after initial conservative treatment have been reported by others *(9,12,22,34,37)*. This highlights the importance of close radiological monitoring following primary conservative treatment. The risk of a secondary displacement cannot be estimated from the width of the initial fracture gap, therefore radiological follow-up following conservative treatment is mandatory *(22)*. In this study, we report that anteroposterior and lateral radiographs are suitable for detecting secondary displacements, in agreement with previous findings *(37)*. Inaccurate primary diagnosis and management disrupts the postoperative outcome *(10)*. However, interpreting LCFs correctly from radiographs can be difficult and necessitates routine *(19)*. Fracture displacement can be underestimated on radiographs *(17)*. In uncertain situations, MRI can be a helpful tool for evaluating the degree of displacement *(16)*, but is not routinely necessary *(37)*. We detected all secondary displacements within 5 days, therefore the optimal time-point for follow-up radiography in two planes is 5 days after the

Table II. — Clinical and patient satisfaction scores at follow-up

| | Collective group n=31 | Primary surgery n=21 | Secondary surgery n=10 | p-value* |
|---|---|---|---|---|
| **Follow-up** (months) | 43.5±6.0 | 49.1±6.6 | 31.6±11.8 | 0.217 |
| **Mayo Elbow score** (max. 100) | 99.5±0.5 | 99.3±3.3 | 100±0 | 0.852 |
| **Morger score** (max. 4) | 3.8±0.1 | 3.8±0.5 | 3.9±0.3 | 0.852 |
| **Patients satisfaction score** (max. 4) | 3.8±0.1 | 3.7±0.6 | 3.9±0.3 | 0.546 |

* Between primary and secondary displacement group

initial conservative treatment *(22,37)*. Follow-up radiography earlier than 3 days after injury may be too early to detect a secondary displacement and radiographs taken after the first week may not reveal significant alterations in the fracture gap *(22)*.

There are a number of limitations to the present study. First, various biases, such as undetectable confounding factors, can affect the data quality due to the retrospective nature of the study. Second, the number of participants was limited, which restricted the detection of significant differences between groups. However, we adhered to strict inclusion criteria and did not include patients with initial conservative treatments at our department who may have been further treated elsewhere. Third, technical factors, such as incorrect x-ray projection, misinterpretation of radiographs, and underestimation of fracture displacement on the radiographs may have led to a false diagnose *(19)*. However, all radiographic findings were reviewed short-term in our pediatric radiology department, therefore these potential biases are unlikely. Fourth, surgical techniques were not compared in this study because we only included one method. These limitations should be addressed in further prospective comparative studies with larger patient numbers.

## CONCLUSIONS

We report a favorable clinical outcome following the treatment of displaced LCFs with open reduction and internal screw fixation. Particular attention should be paid to recognizing secondary displacement of the LCF. We showed that the optimal timepoint to monitor displacement by control radiographs is 5 days after the trauma. Open reduction and internal screw fixation of a correctly diagnosed secondary displacement provides a favorable long-term outcome that is similar to the clinical outcome of primary displaced LCFs.

## REFERENCES

1. **Agarwal A, Qureshi NA, Gupta N, Verma I, Pandey DK.** Management of neglected lateral condyle fractures of humerus in children : A retrospective study. *Indian J Orthop*. 2012;46(6):698-704.
2. **An KN, Chao EY.** In: Morrey BF, editor. The elbow and its disorders. 2nd ed. Philadelphia: W. B. Saunders. In 1252. p. 85-97.
3. **Andrey V, Tercier S, Vauclair F, Bregou-Bourgeois A, Lutz N, Zambelli PY.** Lateral condyle fracture of the humerus in children treated with bioabsorbable materials. *Scientific World Journal*. 2013 ; 2013 : 869418.
4. **Ayubi N, Mayr JM, Sesia S, Kubiak R.** Treatment of lateral humeral condyle fractures in children. *Oper Orthop Traumatol*. 2010 ; 22(1) : 81-91.
5. **Badelon O, Bensahel H, Mazda K, Vie P.** Lateral humeral condylar fractures in children: a report of 47 cases. *J Pediatr Orthop*. 1988 ; 8(1) : 31-4.
6. **Bast SC, Hoffer MM, Aval S.** Nonoperative treatment for minimally and nondisplaced lateral humeral condyle fractures in children. *J Pediatr Orthop*. 1998 ; 18(4) : 448-50.
7. **Chou PH, Feng CK, Chiu FY, Chen TH.** Isometric measurement of wrist-extensor power following surgical treatment of displaced lateral condylar fracture of the humerus in children. *Int Orthop*. 2008 ;32(5) : 679-84.
8. **Eamsobhana P, Kaewpornsawan K.** Should we repair nonunion of the lateral humeral condyle in children? *Int Orthop*. 2015 ; 39(8) : 1579-85.
9. **Finnbogason T, Karlsson G, Lindberg L, Mortensson W.** Nondisplaced and minimally displaced fractures of the lateral humeral condyle in children : a prospective radiographic investigation of fracture stability. *J Pediatr Orthop*. 1995 ; 15(4) : 422-5.
10. **Flynn JC.** Nonunion of slightly displaced fractures of the lateral humeral condyle in children: an update. *J Pediatr Orthop*. 1989 ; 9(6) : 691-6.
11. **Frongia G, Günther P, Romero P, Kessler M, Holland-Cunz S.** Elbow dislocation in childhood. Long-term observational study. *Unfallchirurg*. 2012 ; 115(2) : 125-33.
12. **Hasler CC, von Laer L.** Prevention of growth disturbances after fractures of the lateral humeral condyle in children. *J Pediatr Orthop B*. 2001 ; 10(2) : 123-30.
13. **Hasler C, von Laer L.** Screw osteosynthesis in dislocated fractures of the radial condyle of the humerus in the growth period. A prospective long-term study. *Unfallchirurg*. 1998 ; 101(4) : 280-6.
14. **Jakob R, Fowles J V, Rang M, Kassab MT.** Observations concerning fractures of the lateral humeral condyle in children. *J Bone Jt Surg Br*. 1975 ; 57(4) : 430-6.
15. **Leonidou A, Chettiar K, Graham S, Akhbari P, Antonis K, Tsiridis E, et al.** Open reduction internal fixation of lateral humeral condyle fractures in children. A series of 105 fractures from a single institution. *Strateg Trauma Limb Reconstr.* 2014 ; 9(2) : 73-8.
16. **Kamegaya M, Shinohara Y, Kurokawa M, Ogata S.** Assessment of stability in children's minimally displaced lateral humeral condyle fracture by magnetic resonance imaging. *J Pediatr Orthop*. 1999 ; 19(5) : 570-2.
17. **Knutsen A, Avoian T, Borkowski SL, Ebramzadeh E, Zionts LE, Sangiorgio SN.** Accuracy of radiographs in

assessment of displacement in lateral humeral condyle fractures. *J Child Orthop*. 2014 ; 8(1) : 83-9.

**18. Li WC, Xu RJ.** Comparison of Kirschner wires and AO cannulated screw internal fixation for displaced lateral humeral condyle fracture in children. *Int Orthop*. 2012 ; 36(6) : 1261-6.

**19. Marcheix PS, Vacquerie V, Longis B, Peyrou P, Fourcade L, Moulies D.** Distal humerus lateral condyle fracture in children: when is the conservative treatment a valid option? *Orthop Traumatol Surg Res*. 2011 ; 97(3) : 304-7.

**20. Mintzer CM, Waters PM, Brown DJ, Kasser JR.** Percutaneous pinning in the treatment of displaced lateral condyle fractures. *J Pediatr Orthop*. 1994 ; 14(4) : 462-5.

**21. Morger R.** Fractures and luxations of the elbow in childhood. *Bibl Paediatr.* 1965 ; 83 : 1-107.

**22. Pirker ME, Weinberg AM, Höllwarth ME, Haberlik A.** Subsequent displacement of initially nondisplaced and minimally displaced fractures of the lateral humeral condyle in children. *J Trauma*. 2005 ; 58(6) : 1202-7.

**23. Roye DP, Bini SA, Infosino A.** Late surgical treatment of lateral condylar fractures in children. *J Pediatr Orthop*. 1991 ; 11(2) : 195-9.

**24. Saraf SK, Khare GN.** Late presentation of fractures of the lateral condyle of the humerus in children. *Indian J Orthop*. 2011 ; 45(1) : 39-44.

**25. Schück R, Bartsch M, Link W.** Surgical treatment of distal humerus fractures in children. *Z Kinderchir.* 1989 ; 44(5) : 283-5.

**26. Sharma H, Sibinski M, Sherlock DA.** Outcome of lateral humeral condylar mass fractures in children associated with elbow dislocation or olecranon fracture. *Int Orthop*. 2009 ; 33(2) : 509-14.

**27. Shirley E, Anderson M, Neal K, Mazur J.** Screw Fixation of Lateral Condyle Fractures: Results of Treatment. *J Pediatr Orthop*. 2014.

**28. Shimada K, Masada K, Tada K, Yamamoto T.** Osteosynthesis for the treatment of non-union of the lateral humeral condyle in children. *J Bone Jt Surg Am*. 1997 ; 79(2) : 234-40.

**29. Skak S V, Olsen SD, Smaabrekke A.** Deformity after fracture of the lateral humeral condyle in children. *J Pediatr Orthop B*. 2001 ; 10(2) : 142-52.

**30. So YC, Fang D, Leong JC, Bong SC.** Varus deformity following lateral humeral condylar fractures in children. *J Pediatr Orthop*. 1985 ; 5(5) : 569-72.

**31. Song KS, Kang CH, Min BW, Bae KC, Cho CH, Lee JH.** Closed reduction and internal fixation of displaced unstable lateral condylar fractures of the humerus in children. *J Bone Jt Surg Am*. 2008 ; 90(12) : 2673-81.

**32. Sulaiman AR, Munajat I, Mohd EF.** A modified surgical technique for neglected fracture of lateral humeral condyle in children. *J Pediatr Orthop B*. 2011 ; 20(6) : 366-71.

**33. Thomas DP, Howard AW, Cole WG, Hedden DM.** Three weeks of Kirschner wire fixation for displaced lateral condylar fractures of the humerus in children. *J Pediatr Orthop*. 2001 ; 21(5) : 565-9.

**34. Thonell S, Mortensson W, Thomasson B.** Prediction of the stability of minimally displaced fractures of the lateral humeral condyle. *Acta Radiol*. 1988 ; 29(3) : 367-70.

**35. Toh S, Tsubo K, Nishikawa S, Inoue S, Nakamura R, Harata S**. Long-standing nonunion of fractures of the lateral humeral condyle. *J Bone Jt Surg Am*. 2002 ; 84-A(4) : 593-8.

**36. von Laer L.** Die Fraktur des Condylus Radialis Humeri im Wachstumsalter. *Arch Orthop Traumat Surg*. 1981 ; 98 : 275-83.

**37. von Laer LR.** [Fracture of the radial condyle of the humerus in the growth period]. *Unfallchirurg*. 1998 ; 101(4) : 271-9.

**38. von Laer L.** Verschraubung der Fraktur des Condylus radialis humeri beim Kind. *Oper Orthop Traumat*. 1989 ; 3 : 163-9.

**39. Wessel LM, Günter SM, Jablonski M, Sinnig M, Weinberg AM.** [Predicting growth patterns after supracondylar fracture of the humerus in childhood]. *Orthopade*. 2003 ; 32(9) : 824-32.