Comparison between Fixation with Smooth Kirschner Wire and Cannulated Screws in Displaced Fractures of the Lateral Humeral Condyle in Children*

Comparação entre fixação de fio de Kirschner liso e de parafusos canulados em fraturas deslocadas do côndilo lateral do úmero em crianças

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Abstract

Objective To compare the use of cannulated screws and smooth Kirschner wires in terms of reducing the presence of exuberant callus and complications in pediatric displaced fractures of the lateral humeral condyle.

Methods An analytical cross-sectional study of consecutive cases was conducted from May to October 2021 with 30 children with displaced external humeral condyle fractures. The functional results regarding pain and range of motion were stratified using the Dhillon grading system.

Results A total of 19 patients underwent Kirschner wire fixation, and 11 underwent cannulated screw fixation. Closed fixation was performed in 14 cases (47%), and open fixation, in 16 (53%). Of the cases included, there was no loss to follow-up. Te sample was composed of 21 (70%) male patients, and the age ranged from 5 to 15 years, with a mean of 6.96 years. The most frequent cause of fracture was fall from height (50%), which was related to greater displacement on baseline radiographs. Complications that were not related to the reduction approach or the implant used were observed in 12 (40%) cases.

Keywords
- bone screws
- bone wires
- child
- elbow joint
- fractures, bone
- humeral fractures

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Conclusion The present study shows no benefits in relation to the use of smooth pins or cannulated screws to reduce the presence of exuberant callus in the consolidation of the fracture. We see that the complications that arise are related to the severity of the injury, and benefits cannot be identified in the choice of one implant over another. We could see that the Weiss classification helps to define the behavior in favor of open or closed reduction without interfering in kindness of the smooth pin or the cannulated screw for fracture fixation.

Resumo

Objetivo Comparar o uso de parafusos canulados e de fios de Kirschner lisos em termos da redução da presença de calo exuberante e de complicações em fraturas pediátricas deslocadas do côndilo lateral do úmero.

Métodos Um estudo analítico transversal de casos consecutivos foi realizado de maio a outubro de 2021 com 30 crianças com fraturas deslocadas de côndilo umeral externo. Os resultados funcionais para dor e amplitude de movimento foram estratificados utilizando o sistema de classificação Dhillon.

Resultados Ao todo, 19 pacientes foram submetidos à fixação de fio Kirschner, e 11 à fixação de parafusos canulados. A fixação realizada foi fechada em 14 casos (47%) e aberta em 16 (53%). Dos casos incluídos, não houve perda no acompanhamento. A amostra continha 21 (70%) pacientes do sexo masculino, e a idade variou de 5 a 15 anos, com média de 6,96 anos. A causa mais frequente de fratura foi queda de altura (50%), e esteve relacionada ao maior deslocamento nas radiografias da linha de base. Complicações que não estavam relacionadas à abordagem de redução ou ao implante utilizado foram observadas em 12 (40%) casos.

Conclusão Este estudo não mostra benefícios em relação ao uso de pinos lisos ou de parafusos canulados para reduzir a presença de calo exuberante na consolidação da fratura. Vemos que as complicações que surgem estão relacionadas à gravidade da lesão, e não é possível identificar benefícios na escolha de um implante ou outro. Pudemos ver que a classificação de Weiss ajuda a definir o comportamento em favor da redução aberta ou fechada sem dar preferência ao pino liso ou ao parafuso canulado para a fixação da fratura.

Palavras-chave
- parafusos ósseos
- fios ortopédicos
- criança
- articulação do cotovelo
- fraturas ósseas
- fraturas do úmero

Introduction

It is widely known that pediatric elbow fractures are a source of considerable anguish to the family and raise the concern of the treating orthopedist, since this injury is often resolved surgically, and this type of treatment is more a rule than an exception. Among elbow injuries, fractures of the external condyle are the second most frequent[1–4] (15% of the total), almost all of which have surgery as the treatment of choice. Its greater incidence is at 6 years of age, but it occurs in patients aged 2 to 14 years. The pattern of this fracture affects the lateral metaphysis and usually extends to the epiphysis, reaching the articular surface.[5,6] The peculiarity of these injuries of the external condyle lies in the complications observed if they receive delayed or insufficient management. Therefore, physicians should raise suspicion regarding this condition to prevent late diagnosis and inappropriate decisions in the management of the injury, whose complications include nonunion, malunion, cubital nerve injury, hypertrophic nonunion, avascular osteonecrosis, and residual angular deformities. Currently, there are many options to classify these injuries at the level of the external condyle. The most widely used is the Milch classification,[4,5,7] whose main weakness is not providing information that contributes to the decision-making or to the prognosis of the injuries, unlike the classification implemented by Weiss et al.,[2] who grouped injuries according to the integrity of the articular surface and the displacement of the distal fragment.

There is usually no doubt about taking the patient to surgery, but rather regarding the procedures to reduce and fix fractures with displacement greater than 2 mm. Open reduction and flat wire fixation are widely accepted and used by most surgeons who perform orthopedic surgeries in hospital emergency rooms. This is benefited by the fact that the Kirschner wire is the metallic implant most commonly available in surgical services. Some authors have described the use of cannulated screws to achieve better compression of the articular aspect of the fracture and to improve reduction strength. The present study aims to compare the use of cannulated screws and smooth Kirschner wires in terms of reducing the presence of exuberant callus

and complications in displaced pediatric fractures of the lateral humeral condyle.

Materials and Methods

An analytical cross-sectional study of consecutive cases treated in a hospital was conducted from May to October 2021. The inclusion criteria were patients of both sexes aged 5 to 14 years, with clinical and radiological diagnoses, with unilateral or bilateral involvement, and displacement greater than 2 mm on any radiographic view. The exclusion criteria were patients with pathologic injuries, those subjected to procedures performed by professionals not belonging to the research team, those operated on more than 10 days after the fracture event, those previously treated in another service, and those with incomplete medical records at the time of the study.

The present study was approved by the Hospital Teaching Department and by the Research Ethics Committee. A consent form signed by the parents or legal guardians was mandatory for the inclusion of the patients in the study. The treatment was selected by drawing lots, with the use of 40 envelopes, 20 containing the letter A (wire fixation) and the other 20, the letter B (cannulated screw fixation). The envelopes were selected in the preoperative holding area by the circulating nurse, who informed a member of the team of which implant should be used. After being selected, the envelope was separated from the initial group of envelopes.

All procedures were performed by the same team, using the following options of fixation: flat wires or a 4.0-mm cannulated screw system with partially threaded bolt. The decision to conduct open or closed reduction of the fracture was made according to the Weiss classification by assessing the admission radiograph. All patients subjected to fixation with flat wires were immobilized with long-arm splints for 6 weeks, and the wires were removed 4 weeks after surgery.

The patients subjected to fixation with cannulated screws were immobilized with a sling for 2 weeks and were allowed to move the elbow after the postoperative visit. The implant was removed in a surgical procedure at the 12th postoperative week.

In all cases, outpatient follow-up was performed at 7 days, 15 days, 28 days, ands 6 weeks. Follow-up was then performed at 3 months and 6 months, and annual follow-up is scheduled up to 3 years after the fracture.

The following variables were assessed: age, sex, affected side, trauma mechanism, type of displacement according to the Weiss classification, presence of bone exposure, type of reduction performed, fixation of the fracture, and presence and type of complications. The complications were rated as mild (superficial wound infections, clinical hypertrophic union, and elbow stiffness) and severe (avascular necrosis of the humeral condyles, malunion, nonunion, fishtail deformity, cubitus varus, and neurovascular injuries).

Lastly, the functional outcomes regarding pain and range of motion were stratified using the criteria proposed by Dhillon et al.,[5] who classify outcomes as excellent, good, fair, and poor according to the scores obtained in outpatient assessments at 6, 12, and 24 postoperative weeks. Loading angles were not evaluated in the follow-up images.

The results were obtained upon examination and by evaluating the baseline radiographs, assessing the descriptions of the surgical technique, and performing the outpatient follow-ups of each patient.

Regarding data processing and analysis, data were introduced into a pre-codified electronic Microsoft Excel (Microsoft Corp., Redmond, WA, Untied States), version 2010, spreadsheet. The regression analysis was adjusted to age, sex, degree of displacement, and mechanism of trauma. Linear regression analysis was performed for the continuous variables of the radiographic assessments. Logistic regression analysis was performed for the discreet variables of the main complications.

Results

A total of 30 patients were included in the study, among the 1,332 pediatric patients who were admitted to the hospital emergency room over the 6-month study period. We did not include 11 cases of external condyle fractures diagnosed within the study period, And 4 cases were excluded because they did not meet the age criterion, and 7, because they presented with deviations below 2 mm and were treated conservatively. Among the cases included, there was no loss to follow-up. However, there was one case of interruption of the follow-up according to the study schedule (case 2), since the patient was absent after the first follow-up visit and resumed follow-up only at 5 months.

Regarding the demographic variables, 21 (70%) patients were male, and the age ranged from 5 to 15 years, with a mean of 6.96 years. The most affected side was the left one, accounting for 18 cases (60%). The causes of fracture included

Fig. 1 Weiss type-III fracture with the classic presentation.

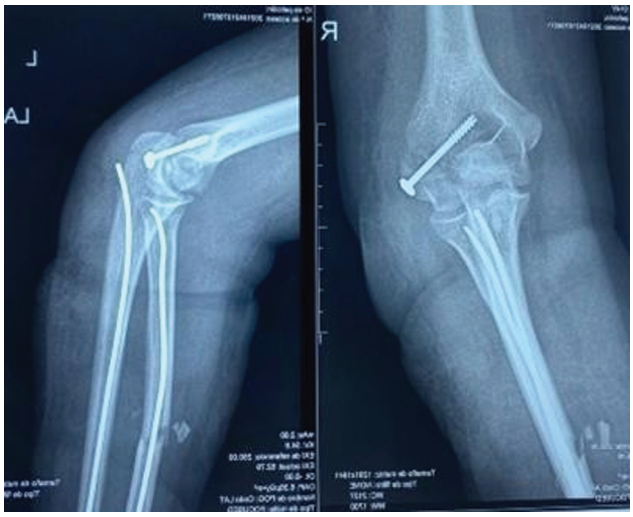

Fig. 2 High-impact trauma: neurapraxia.

fall from height, fall from own height, bicycle accident, direct trauma, and fall from motorcycle, the most frequent of which was fall from height (50%), an event that was related to greater displacement on baseline radiographs (►**Figs. 1** and **2**).

In total, 18 cases (60%) were classified as Weiss type-II fractures on admission, and 12, as type-III (40%).[2,3] The mean time from admission to the surgical procedure was of 3 days, with a maximum admission-to-surgery interval of 9 and 10 days in 2 cases, and immediate resolution was only achieved on the same day of the fracture event in 2 cases (►**Table 1**).

As for the reduction procedure, closed fixation was performed in 14 cases (47%), and open fixation, in 16 cases (53%). The decision was always made by the surgical team according to need during the preoperative assessment, in order to achieve anatomical reduction. No case underwent previous arthrogram (►**Table 1**). Overall, 19 cases (63%) underwent fixation with Kirschner wire, and 11 cases (47%), with cannulated screws (►**Table 2**). The relationship between open reduction and the implant used was not analyzed. The decision on which implant to use was always made in the operating room, based on previous operative planning.

The injury outcomes and range of motion were assessed postoperatively at 6 weeks and 12 weeks. According to the Dhillon grading system, 25 (83.3%) outcomes were graded as excellent and good, 4 were graded as fair, and 1 (3.3%) was graded as poor. Complications occurred in 12 cases (40%), including 5 cases of exuberant callus, 1 case of partial loss of fixation, and 1 case of reduced range of articular motion. Of the 6 patients presenting elbow stiffness, 3 (25%) are still undergoing follow-up and have been showing gradual improvement in range of motion. These patients underwent open reduction and cannulated screw fixation (n = 2) and Kirschner wire fixation (n = 1), because they presented with fragment rotation on the initial radiographs. Two patients presented traumatic radial nerve injury (►**Figs. 2** and **3**), and one patient had a postoperative radial nerve palsy due to protrusion of the cannulated screw (►**Fig. 3**). This last patient had a subsequent fracture malunion and is will undergo a new surgery.

Discussion

Surgical procedures in cases of pediatric displaced fractures of the external condyle have already been described in many articles (►**Fig. 4**). However, there is controversy regarding the requirement of always indicating open reduction and performing absolute stability fixation or flat wire osteodesis. In order to achieve the optimal fixation of this type of fracture, Ganeshalingam et al.[8] assessed 336 children from 2005 and 2014 but did not find significant differences in the use of both implants, with the final decision relying on the surgeon, according to their training in the method with which they feel more comfortable. We selected the type of reduction by assessing baseline radiographs in order to restore the articular line under an image intensifier.[9–11] In four cases, closed reduction was not possible, although they were classified as Weiss type-II. Of these cases, two underwent surgery up to 24 hours after arriving at the hospital; thus, the short time until surgery did not prevent the performance of open surgery.

Regarding the best selection method for a more effective comparison of the implants used, we believe that conducting a draw before the surgical procedure helped reduce bias, but we should adjust the approach in terms of fragment deviation or rotation, with injuries classified as Weiss type-III evolving differently from those classified as type-II, since there is a trend to perform a closed reduction when the fragment is not rotated in its baseline presentation.

The time from admission to surgery is believed to be acceptable, since our hospital is still requiring a negative coronavirus disease 2019 (COVID-19) test for anesthetic clearance. Elbow protection with long-arm casting was maintained up to week 6 in all patients subjected to wire fixation, and those who underwent screw fixation were allowed to move their elbow since week 2, which is similar to the approach indicated by Li and Xu[12] in 2012. No differences were observed regarding the range of motion at postoperative week 12. According to the medical team's decision, rehabilitation assisted by occupational physical therapy is not indicated.

A review conducted by Tan et al.[13] using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement reported that complication rates are high in this type of injury, sometimes leading to permanent changes in elbow functionality. Therefore, close follow-up is imperative, with no optimal indication of preferred fixation implant.

In line with the literature,[10,11,14] our rate of complications was of 40%, with only 2 cases consisting of severe or permanent complications. The complications found in the present study were those expected for this type of fracture, as they could not be related to the implant selected but rather to baseline fragment rotation and to the open approach, which is required in Weiss type-III fractures.

Table 1 Demographic variables, type of trauma, fracture classification, time until surgery

Case	Gender	Age (years)	Side	Mechanism of trauma	Weiss classification	Time until surgery
1	Male	7	Right	Fall from height	III	4
2	Male	14	Left	Fall from motorcycle	II	10
3	Female	5	Right	Fall from own height	II	1
4	Male	5	Right	Fall from height	III	1
5	Male	5	Left	Fall from bicycle	II	5
6	Male	5	Right	Fall from bicycle	III	4
7	Female	5	Left	Fall from own height	II	6
8	Male	9	Left	Fall from height	II	0
9	Male	7	Left	Fall from own height	II	5
10	Male	5	Left	Direct trauma	II	1
11	Female	7	Left	Fall from own height	II	1
12	Male	8	Left	Fall from own height	II	1
13	Female	5	Right	Fall from height	III	4
14	Female	6	Left	Fall from own height	II	1
15	Male	5	Left	Fall from height	III	2
16	Male	9	Right	Direct trauma	III	2
17	Male	11	Left	Fall from height	II	4
18	Male	5	Right	Fall from own height	II	0
19	Male	5	Left	Fall from height	III	1
20	Male	7	Right	Fall from own height	II	4
21	Female	6	Left	Fall from height	III	3
22	Male	5	Left	Fall from height	II	2
23	Male	8	Left	Fall from own height	II	2
24	Female	5	Right	Fall from height	III	2
25	Female	5	Right	Fall from height	III	1
26	Male	10	Right	Fall from height	II	5
27	Male	15	Right	Fall from motorcycle	II	1
28	Male	6	Left	Fall from height	II	9
29	Male	7	Left	Fall from height	III	3
30	Female	7	Left	Fall from height	III	3

Regardless of the choice for closed reduction or fixation with compression screws, patients may present with exuberant scar in the fracture healing process. None of the cases developed changes in elbow functionality related to hypertrophic nonunion.

When comparing the two study groups in terms of surgical approach and functionality using the Chi-squared test, we found that these variables influenced in only 34% of the results, with no significant values supporting the use of one fixation implant over another.

The time elapsed from admission to the surgical procedure was statistically significance (Student *t* test), thus favoring the short time until surgery.

The hypothesis that absolute stability would reduce the onset of exuberant scars or the complication rates has not been confirmed,[8,14,15] since there was no significant evidence to support it. We observed that each implant led to different paths during the follow-up, but these paths come together in the medium term, and there is no difference in favor or against any of the implants. We believe that open reduction is demanding and requires proper training for a successful outcome.

The present study has limitations, including the small sample size, no clear algorithm to indicate fixation with smooth wires or cannulated screws, and its retrospective nature. The reduced number of patients was probably related

Table 2 Cases managed with internal fixation with Kirschner wire or cannulated screws

Case	Weiss classification	Treatment	Reduction	Complications	Dhillon system
1	III	Kirschner wire	Open	Exuberant callus	Excellent
2	II	Cannulated screw	Open	Nervous injury	Fair
3	II	Ki rschnerwire	Closed	–	Excellent
4	III	Kirschner wire	Open	–	Excellent
5	II	Cannulated screw	Closed	Exuberant callus	Excellent
6	III	Kirschner wire	Open	Exuberant callus	Excellent
7	II	Cannulated screw	Closed	–	Excellent
8	II	Kirschner wire	Closed	Reduced mobility	Good
9	II	Cannulated screw	Closed	–	Excellent
10	II	Kirschner wire	Open	Exuberant callus	Excellent
11	II	Kirschner wire	Closed	–	Excellent
12	II	Kirschner wire	Closed	–	Excellent
13	III	Cannulated screw	Open	Exuberant callus	Excellent
14	II	Kirschner wire	Open	–	Excellent
15	III	Cannulated screw	Open	Nonunion	Poor
16	III	Kirschner wire	Open	–	Good
17	II	Cannulated screw	Closed	–	Excellent
18	II	Kirschner wire	Closed	–	Excellent
19	III	Kirschner wire	Open	Elbow stiffness	Fair
20	II	Kirschner wire	Closed	–	Excellent
21	III	Cannulated screw	Open	Elbow stiffness	Fair
22	II	Kirschner wire	Closed	Partial loss of fixation	Excellent
23	II	Kirschner wire	Closed	–	Excellent
24	III	Cannulated screw	Open	Elbow stiffness	Fair
25	III	Kirschnerwire	Open	–	Excellent
26	II	Cannulated screw	Closed	–	Excellent
27	II	Cannulated screw	Closed	–	Excellent
28	II	Kirschner wire	Open	–	Excellent
29	III	Kirschner wire	Open	–	Excellent
30	III	Kirschner wire	Open	–	Excellent

to the absence of statistically significant results. This does not seem a particular problem of the present study. Due to the infrequency of lateral condyle injuries, we could not find large case series in the literature. Therefore, future multicenter studies can be conducted to obtain a larger sample size and to achieve more representative values. The indication of smooth wires or screws is another problem, and, in our hospital, surgeons are allowed to choose their preferred fixation method. Although this can be interpreted as a major problem, the lack of clear definition on the best internal fixation for this specific traumatic injury creates a huge difficulty to propose an algorithm that must be followed. Moreover, the lack of clear indications on how to fix the injury precludes the indication of guidelines for the postoperative period. Finally, the retrospective nature of the present study can be one of the reasons we did not find statistical differences between the implants used for internal fixation.

One of the strengths of the present study is that all patients were operated on by the same surgical team, at the same hospital. Although there is no defined algorithm for the management of lateral condyle fractures in our nstitution, all orthopedic surgeons are always discussing the case both in the preoperative and postoperative periods, so tips and tricks, and pitfalls and drawbacks of all procedures are discussed as learning for subsequent cases. Another advantage of the present study is that it provides more information for the demography and management of lateral condyle fractures. As almost all studies present small case series, the present study will certainly

Fig. 3 Severe complication: nounion.

contribute to future reviews and encourage surgeons interested in children's elbow injuries to carry out multicenter studies.

Conclusion

The present study shows no benefits in relation to the use of smooth pins or cannulated screws to reduce the presence of exuberant callus in the consolidation of the fracture. We see that the complications that arise are related to the severity of the injury, and benefits cannot be identified in the choice of one implant or another. We could see that the Weiss classification helps to define the behavior in favor of open or closed reduction without interfering in kindness of the smooth pin or the cannulated screw for fracture fixation.

Author´s Contributions

All authors have read and approved the final version of the article. ADNV: conception and design, analysis and interpretation, data collection, writing the article, ANF: critical revision of the article, final approval of the article, statistical analysis, overall responsibility.

Conflict of Interests

The authors have no conflict of interests to declare.

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Fig. 4 Open reduction with the Kocher approach.

References

1 Jakob R, Fowles JV, Rang M, Kassab MT. Observations concerning fractures of the lateral humeral condyle in children. J Bone Joint Surg Br 1975;57(04):430–436
2 Weiss JM, Graves S, Yang S, Mendelsohn E, Kay RM, Skaggs DL. A new classification system predictive of complications in surgically treated pediatric humeral lateral condyle fractures. J Pediatr Orthop 2009;29(06):602–605
3 Milch H. Fractures and fracture dislocations of the humeral condyles. J Trauma 1964;4:592–607
4 Ersan O, Gonen E, Arik A, Dasar U, Ates Y. Treatment of supracondylar fractures of the humerus in children through an anterior approach is a safe and effective method. Int Orthop 2009;33(05): 1371–1375
5 Dhillon KS, Sengupta S, Singh BJ. Delayed management of fracture of the lateral humeral condyle in children. Acta Orthop Scand 1988;59(04):419–424
6 Toh S, Tsubo K, Nishikawa S, Inoue S, Nakamura R, Harata S. Long-standing nonunion of fractures of the lateral humeral condyle. J Bone Joint Surg Am 2002;84(04):593–598
7 Haynes RJ, Sullivan E. The Pediatric Orthopaedic Society of North America pediatric orthopaedic functional health questionnaire: an analysis of normals. J Pediatr Orthop 2001;21(05): 619–621
8 Ganeshalingam R, Donnan A, Evans O, Hoq M, Camp M, Donnan L. Lateral condylar fractures of the humerus in children: does the type of fixation matter? Bone Joint J 2018;100-B(03): 387–395
9 Schlitz RS, Schwertz JM, Eberhardt AW, Gilbert SR. Biomechanical Analysis of Screws Versus K-Wires for Lateral Humeral Condyle Fractures. J Pediatr Orthop 2015;35(08): e93–e97
10 Bloom T, Chen LY, Sabharwal S. Biomechanical analysis of lateral humeral condyle fracture pinning. J Pediatr Orthop 2011;31(02): 130–137
11 Launay F, Leet AI, Jacopin S, Jouve JL, Bollini G, Sponseller PD. Lateral humeral condyle fractures in children: a comparison of two approaches to treatment. J Pediatr Orthop 2004;24(04): 385–391
12 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(06): 1261–1266

13 Tan SHS, Dartnell J, Lim AKS, Hui JH. Paediatric lateral condyle fractures: a systematic review. Arch Orthop Trauma Surg 2018; 138(06):809–817
14 Hasler CC, von Laer L. Prevention of growth disturbances after fractures of the lateral humeral condyle in children. J Pediatr Orthop B 2001;10(02):123–130
15 Stein BE, Ramji AF, Hassanzadeh H, Wohlgemut JM, Ain MC, Sponseller PD. Cannulated Lag Screw Fixation of Displaced Lateral Humeral Condyle Fractures Is Associated With Lower Rates of Open Reduction and Infection Than Pin Fixation. J Pediatr Orthop 2017;37(01):7–13