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Original Article

What is the best fixation technique for the treatment of supracondylar humerus fractures in children?☆

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ABSTRACT

Objective: To define the best technique for the surgical treatment of supracondylar fracture of the humerus (SFH) in children, evaluating percutaneous pinning with side wires *vs.* cross-pinning.

Methods: Randomized controlled trials using the Medline, CAPES, and BIREME. The criteria for inclusion of articles criteria were: (1) randomized controlled trials (RCTs) comparing percutaneous wire fixation techniques, (2) SFH Gartland II B, III, and IV, and (3) children aged 1–14 years. The following were used as main variables: incidence of iatrogenic injury to the ulnar nerve and loss reduction.

Results: Eight studies were selected (521 patients) comparing surgical treatment with pinning in supracondylar fracture of the humerus in children Gartland II type B, III or IV. Iatrogenic injury to the ulnar nerve was greater with the cross-pinning technique, with RR 0.28 and $p = 0.03$, while the mini-open technique presented RR 0.14 and $p = 0.2$. A statistically significant greater loss of reduction in the lateral pinning was observed in FSU Gartland III and IV($p = 0.04$).

Conclusion: Based upon this meta-analysis of prospective randomized clinical trials, the following is recommended: (1) percutaneous pinning with lateral wires in supracondylar fractures of the humerus in children classified as Gartland II type B; (2) use of crossed wires for Gartland type III or IV, using the mini-open technique for the medial wire.

☆ Study conducted at Hospital Manoel Victorino and Hospital Regional de Santo Antonio de Jesus, Salvador, BA, Brazil.

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Qual a melhor técnica para fixação no tratamento de fratura supracondilar do úmero em crianças?

Palavras-chave:
Fraturas do úmero
Fixação interna de fraturas
Crianças
Fios ortopédicos

RESUMO

Objetivo: Definir a melhor técnica para o tratamento cirúrgico da fratura supracondilar do úmero (FSU) nas crianças e avaliar a pinagem percutânea com fios laterais *vs.* cruzados.
Métodos: Revisão de ensaios clínicos randomizados nas bases de dados Medline, Capes, Bireme. Os critérios de inclusão dos artigos foram: (1) Ensaios clínicos randomizados que comparam técnicas de fixação percutânea com fios, (2) FSU Gartland II tipo B, III e IV e (3) Crianças com um a 14 anos. Usamos como principais variáveis: incidência de lesão iatrogênica do nervo ulnar e perda da redução.
Resultados: Foram selecionados oito estudos (521 pacientes) que comparam tratamento cirúrgico com pinagem em fratura supracondilar do úmero em crianças classificadas como Gartland II tipo B, III ou IV. A lesão iatrogênica do nervo ulnar foi maior com a técnica de pinagem cruzada, apresentou RR 0,28 e $p = 0,03$, enquanto que na técnica de *mini-open* encontraram-se RR 0,14 e $p = 0,2$. Em casos de FSU Gartland III e IV, evidenciou-se maior perda da redução na pinagem lateral, com significância estatística ($p = 0,04$).
Conclusão: Embasado em nossa metanálise com ensaios clínicos randomizados prospectivos, recomendamos: (1) pinagem percutânea com fios laterais em fraturas supracondilar do úmero em crianças classificadas como Gartland II tipo B (2) Uso de fios cruzados para fraturas Gartland tipo III ou IV, com a técnica de *mini-open* para o fio medial.

Introduction

Supracondylar fracture of the humerus (SFH) is frequent in the immature skeleton.[1] There is predominance in the left side or the non-dominant side,[2] and fractures in elbow extension with posterior deviation represent 97% of cases.[2,3]

The most widely used classification is that described by Gartland,[4] which was proposed for fractures with elbow extension mechanism and based on deviations in the coronal plane in elbow radiographs. Type I: undisplaced or minimally displaced, with the anterior humeral line intact. Type II: small deviation, fragments in contact (intact posterior cortex), Type III: complete displacement of the fragments (posterior cortex injury). In 1996, Wilkins proposed the B-type subdivision for SFH in children with rotational deviation.[5–7] In 2006, Leitch et al.[8] added type IV, which describes multidirectional instability.

Surgical treatment is indicated in types IIB, III, and IV fractures. Closed reduction and pinning stabilization is the most commonly used technique.[9,10] Fixation can be performed with crossed pins[8] or lateral pins.[4] A mini-open technique is an option for medial passage.[11] The most common complication is cubitus varus (3–57% of cases),[11] and is mainly due to poor reduction or loss of reduction during treatment. The most frequent iatrogenic nerve injury is that of the ulnar nerve, with an incidence of 0–6%.[12]

This study aimed to define the best technique recommended by the contemporary literature for surgical treatment of supracondylar fracture of the humerus in children and to evaluate percutaneous pinning with lateral wires *vs.* crossed wires.

Materials and methods

A systematic review of randomized clinical trials was performed through literature search of PubMed, CAPES, and BIREME databases. The terms "supracondylar fractures," "percutaneous fixation," "k-wire," "children," "cross pinning," and "lateral pinning fixation" were used in different combinations. A direct search of studies listed in the references of the articles retrieved was also performed. There was no restriction regarding language of publication. Titles and abstracts of studies retrieved in the electronic search were evaluated, and full texts of selected articles were obtained.

Inclusion criteria were: (1) randomized controlled trials (RCTs) comparing percutaneous fixation techniques using wires, (2) SFH Gartland II types B, III, and IV, and (3) children aged 1–14 years. Exclusion criteria were: repeated study or surgical technique different from that advocated in this study. The two authors (GSQAP and CAAF) independently assessed the methodological quality of included studies using the Detsky Quality Index score (maximum of 21 points).[13]

Main variables considered were incidence of iatrogenic injury of the ulnar nerve and loss of reduction. Recommended secondary findings were radiographic results (Baumann angle, loading angle, humero-capitellar angle, Baumann angle variation, loss of loading angle). Loss of reduction was determined based on Baumann angle change according to the criteria reported by Skaggs et al.[14]: (1) no displacement (loss smaller than 6°), (2) moderate displacement (6°–12°), and (3) large displacement (larger than 12°).

Data were analyzed with Review Manager (Revman) 5.1. Heterogeneity of studies was assessed through a standard

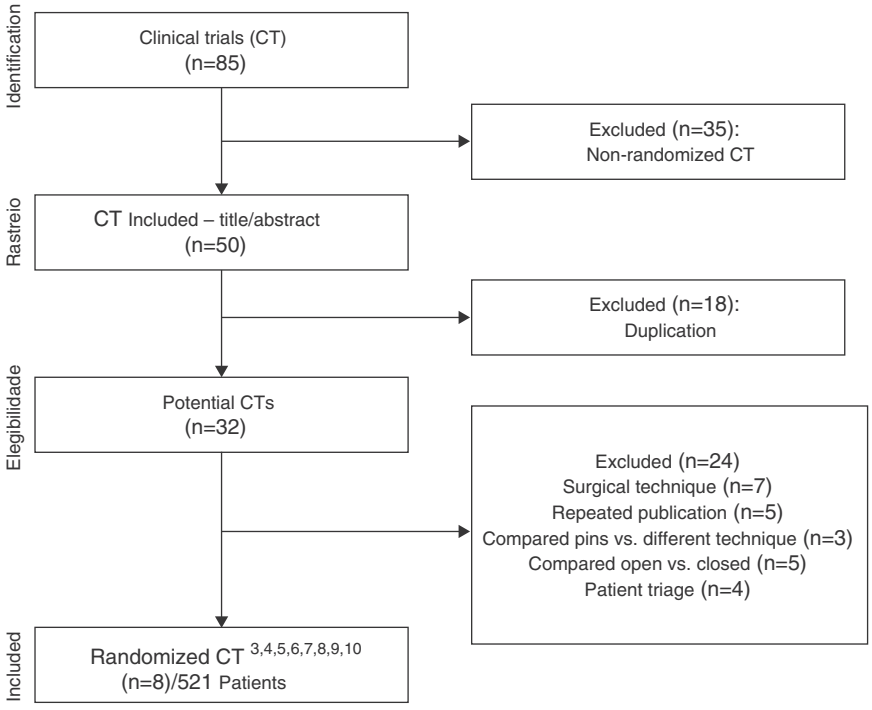

Fig. 1 – Study design.

chi-squared test (I^2), considered statistically significant with $p > 0.05$, and a I^2 greater than 50% were considered significant heterogeneity. For groups that presented heterogeneity, random effects were applied to selected data.

Relative risks (RR) and risk differences were calculated for dichotomous outcomes. For continuous outcomes, mean differences and 95% confidence intervals (CI) were calculated.

Results

Initially, 85 clinical trials comparing percutaneous pinning in SFH in children were retrieved. Of these studies, 35 were excluded for not being randomized. Of the 50 RCTs, 42 were excluded for duplication and/or surgical technique used. Finally, this study included eight prospective RCTs, comprising 521 patients (Fig. 1). Regarding assessment of methodological quality, the Detsky Quality Index score ranged from 13 to 20 points (average of 15.7).[15–22]

Iatrogenic ulnar nerve injury in the treatment of SFH in children was more commonly observed in patients treated with cross-pinning when compared with lateral-only pinning (RR 0.28; 95% CI 0.09–0.87; $p = 0.03$). Heterogeneity was non-significant, with $I^2 = 0\%$. Among the eight RCTs included in the study, 12 patients (4.46%) presented iatrogenic injury of the ulnar nerve in the cross-pinning group, *vs.* only two patients in the other group (0.78%; Fig. 2).

When RCTs that used mini-open technique for cross-pinning were analyzed, no statistically significant differences were observed (RR 0.14; 95% CI 0.01–2.79; $p = 0.20$) regarding

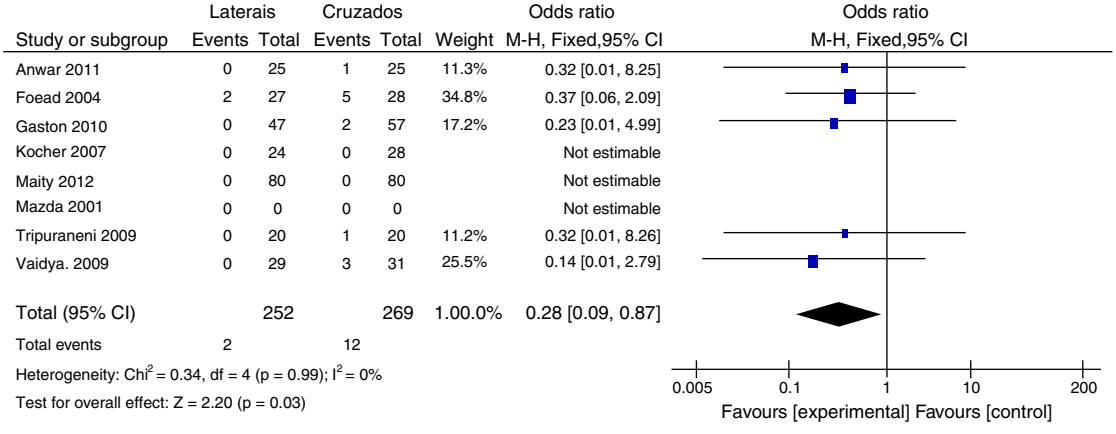

Fig. 2 – Comparative analysis to assess iatrogenic injury of the ulnar nerve in 521 patients who underwent percutaneous pinning with Kirschner wires for treatment of supracondylar fracture of the humerus in children.

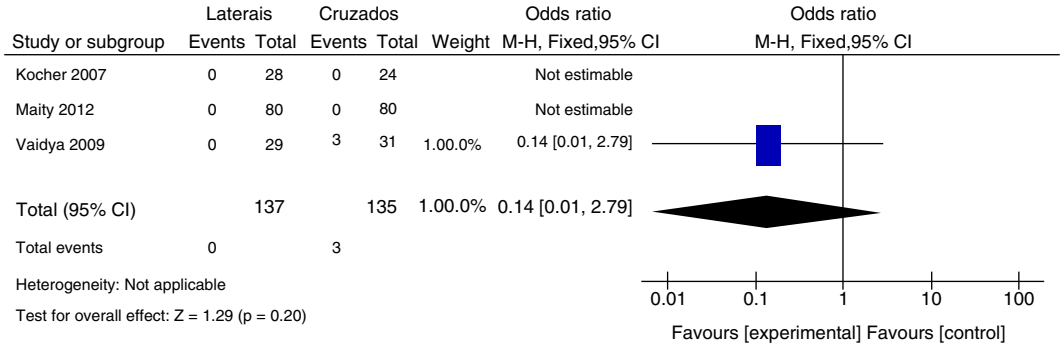

Fig. 3 – Comparative analysis to assess iatrogenic injury of the ulnar nerve in 272 patients who underwent percutaneous pinning with exclusively lateral or crossed Kirschner wires (with mini-open technique for medial access) for the treatment of supracondylar humeral fracture.

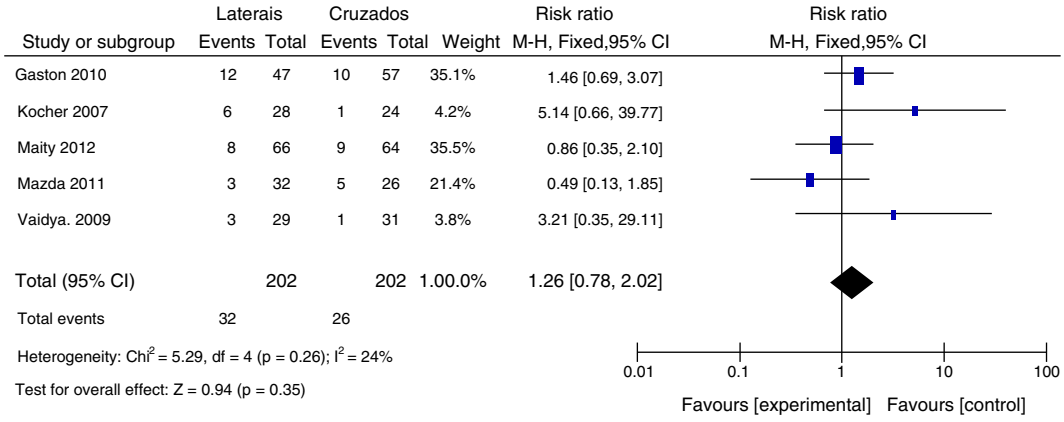

Fig. 4 – Comparative analysis to assess loss of reduction among 404 patients who underwent percutaneous pinning with exclusively lateral or crossed Kirschner wires for treating supracondylar humeral fracture in children.

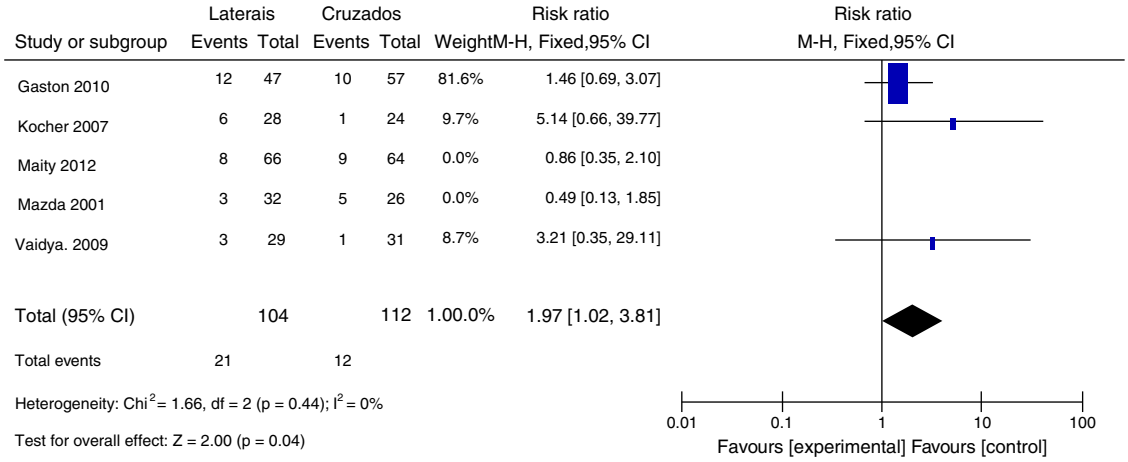

Fig. 5 – Comparative analysis to assess loss of reduction from 216 patients with SHF Gartland III or IV who underwent percutaneous pinning with exclusively lateral or crossed Kirschner wires.

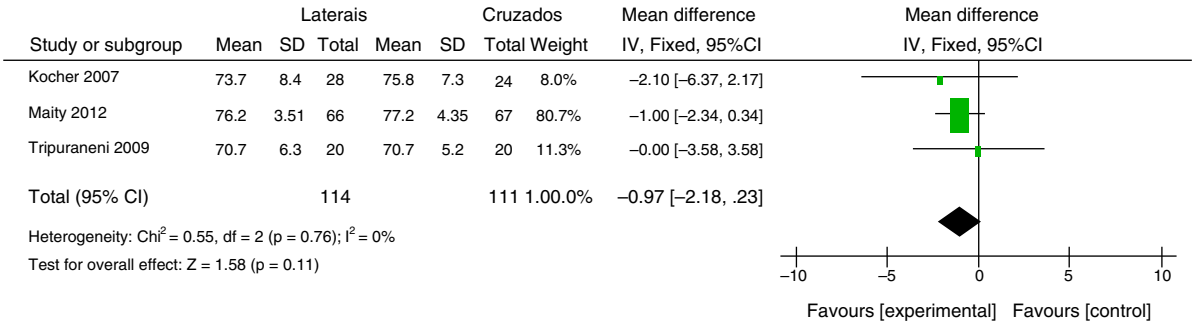

Fig. 6 – Baumann angle.

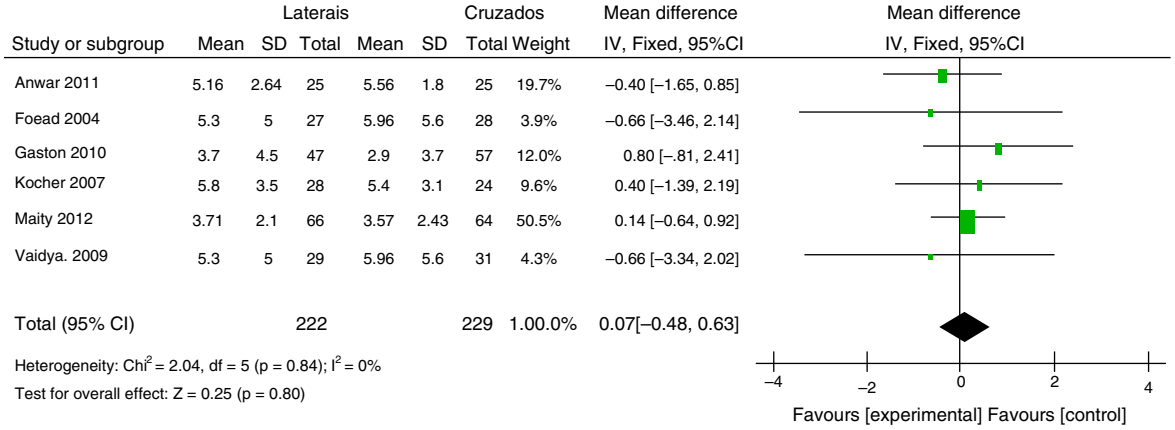

Fig. 7 – Variation of Baumann angle.

ulnar nerve injury when compared with lateral pinning (Fig. 3).

Patients submitted to lateral percutaneous pinning presented greater loss of reduction (32 cases; 15.84%) when compared with those who underwent cross-pinning (26 cases; 12.87%); the difference was not statistically significant ($p = 0.35$; Fig. 4).

When analyzing patients with SFH Gartland III and IV, a statistically significant ($p = 0.04$) greater loss of reduction was observed in patients submitted to lateral pinning (21 cases – 20.19%). Loss of reduction was observed in 12 patients (10.71%) in the cross-pinning group (Fig. 5).

No statistically significant difference was observed between the two techniques regarding the Baumann angle, Baumann angle variation, loading angle, loading angle variation, humero-capitellar angle, and humero-capitellar angle variation (Figs. 6–9).

Discussion

Iatrogenic injury of the ulnar nerve is an important factor to be analyzed when treating SFH using percutaneous pinning with Kirschner wires in children. The incidence of ulnar nerve injury observed in the present study (4.46%) is in agreement with the results previously found in the literature.[15–22] Babal et al.[23] concluded that medial pinning is the leading cause of iatrogenic ulnar nerve injury. Brauer et al.[24] demonstrated that use of medial pin increased the incidence of neurologic injury by 1.84 times.

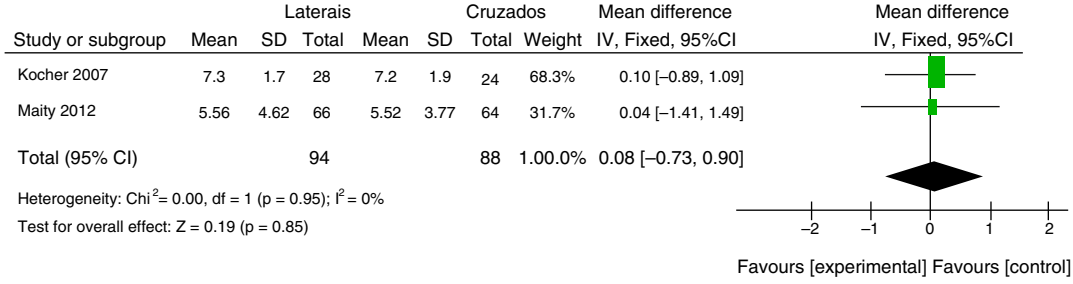

Fig. 8 – Loading angle.

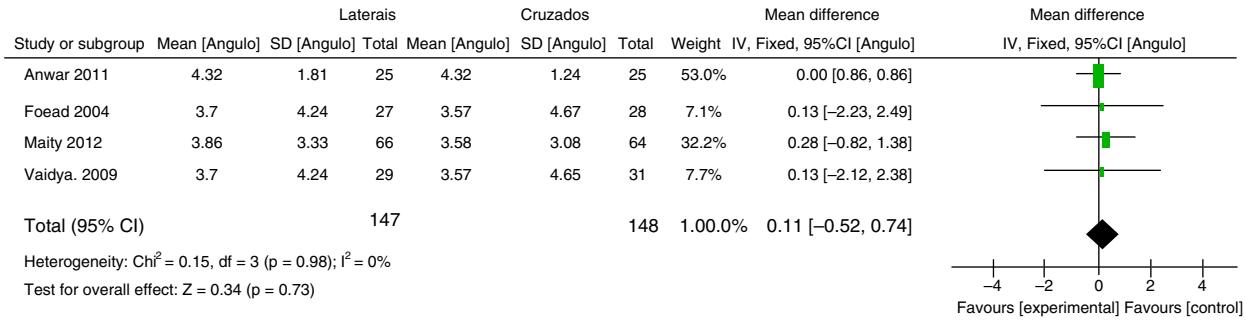

Fig. 9 – Variation of loading angle.

In this meta-analysis, a statistically significant difference was observed in the incidence of iatrogenic injury of the ulnar nerve when comparing techniques of lateral pins *vs.* crossed pins ($p = 0.03$), which confirmed the relationship of iatrogenic injury of the ulnar nerve with the passage of a medial pin. Neural recovery usually occurs after 2–2.5 months of observation, but it can take up to 6 months.[11] In the studies included in this review, all patients recovered from the neurological deficit during follow-up.

Previous studies have shown that mini-open technique for medial pin presents a low incidence of ulnar nerve injury.[11] In this study, no statistically significant difference was observed in the analysis of ulnar nerve injury when using medial pin with mini-open technique.

Regarding loss of reduction, the literature still presents inconsistent results.[18,23,24] In a retrospective study of 345 children with SFH, Skaggs et al.[25] observed no difference in relationship to maintenance of fracture reduction when comparing both surgical techniques. In a clinical and biomechanical study, Omid et al.[26] found similar stability using divergent, spaced lateral wires when compared with cross-pinning. In a systematic review, Brauer et al.[24] observed residual deformity (secondary to loss of reduction) in 3.4% of patients treated with cross-pinning and in 5.9% of patients treated only with lateral pin, a statistically significant result. They concluded that cross-pinning provides greater stability in the wire configuration (they should cross above fracture) and that the probability of deformity or loss of reduction was 58% lower when compared with lateral pinning.

The present meta-analysis did not find a statistical significant difference for loss of reduction when evaluating the totality of patients involved in the studies included. When groups with fractures type III or IV of Gartland were assessed, incidence of loss of reduction was approximately 10% higher in the group with lateral wires, a statistically significant difference ($p = 0.04$).

Conclusion

Based on this meta-analysis with prospective randomized clinical trials, the authors recommend: (1) percutaneous pinning with lateral wires for SFH in children with Gartland II type B fractures; (2) crossed wires in Gartland type III or IV fractures, with a mini-open technique for the medial wire.

Conflicts of interest

The authors declare no conflicts of interest.

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