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Necessity of post-operative radiograph after percutaneous pinning of supracondylar humerus fracture

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Abstract

Introduction: Complications after closed reduction percutaneous pinning (CRPP) include loss of reduction, pin site infection and iatrogenic nerve injury. There is little evidence to support an ideal post-operative follow-up protocol, leading to variation based on surgeon's preference. This study aimed to determine the necessity of frequent radiographs after CRPP for supracondylar humerus fracture in children.

Method: This was a prospective study involving 34 patients, who underwent CRPP for displaced supracondylar humerus fracture. Patients were divided into two groups: Group A were followed-up at 4 weeks, while Group B were followed-up at one, two and four weeks. All radiographs were evaluated for Baumann's angle and anterior humeral line (AHL) relation with capitellum of humerus. There were 18 patients in group A and 16 patients in group B.

Result: Fourteen patients in Group A and 13 patients in Group B had less than six degree change in Baumann angle. There was no change in anterior humeral line relation with capitellum in either group.

Conclusion: This study found that loss of reduction after CRPP for supracondylar humerus fractures was similar in both groups. Therefore, post-operative radiographs after CRPP is not necessary.

Keywords: children; radiograph; supracondylar distal humerus fracture

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Introduction

Supracondylar fracture of humerus accounts for 85% of all elbow fractures in pediatric population.[1] Closed reduction and percutaneous pinning (CRPP) under C-arm guidance has been established as the standard treatment for displaced supracondylar humerus fractures in children.[2-4] Post-operative serial radiographs are used to identify changes in fracture alignment and pin position.[5-6] Complications that may occur include loss of reduction, pin migration, and iatrogenic nerve injury.[7-10] Radiographs help identify unstable fracture configuration that carry a significant risk of losing reduction before healing.[7] However, guidelines for post-operative follow-up are sparse.

Some studies advocate early radiographic evaluation, while others advocate radiograph only at the time of pin removal.[11-13] Although there are clinical practice guidelines that suggest treatment options for supracondylar humerus fracture including pinning techniques, and the number of pins to be used, there is limited evidence supporting a universally applicable post-operative follow-up protocol. The American Academy of Orthopaedic Surgeons clinical practice guide regarding supracondylar humerus fracture does not address the optimal timing of radiographic follow up.[4,14] The situation is similar in Nepal as well, as we have not found any study recommending the optimal time of obtaining post-operative radiograph during our literature search. Consequently, follow-up practices often depend on surgeon preference rather than clinical evidence, leading to considerable variations.[4]

This study aims to evaluate the necessity of frequent radiographs after CRPP and assess the incidence of loss of reduction in terms of changes in the Baumann angle and the relationship of the anterior humeral line with the capitellum.

Method

This was a prospective study conducted for one year duration, from 1st Nov, 2018 to 31st Oct, 2019. This study was carried out at Patan Hospital, a tertiary care center located in Lalitpur, Nepal. Ethical approval was obtained from the Institutional Review Committee of Patan Academy of Health Sciences (Ref. No: PSO1902051242). Total population sampling was done as this was a time bound study. Patients diagnosed as supracondylar humerus fracture and planned for CRPP were included in this study after obtaining written informed consent from participants' parents or guardians. Inclusion criteria included displaced supracondylar humerus fracture (Gartland type 2 and type 3). Old fractures (more than 2 weeks old), open fractures, patients lost to follow-up, presence of an associated vascular injury, re-trauma, and age more than 14 years were excluded.

Total population sampling was done and all patients meeting the inclusion criteria within one year were included in the study. Patients were randomly assigned to one of two groups, which was divided based on the day of the week, on which they presented to the hospital. The preoperative and intraoperative management for both groups were the same. Good reduction was indicated by an anterior humeral line that intersects the capitellum, a Baumann angle of more than 10°, and intact medial and lateral columns on oblique views. After meeting these criteria, CRPP was done under C-arm guidance and fixation was achieved with K-wires. All patients were placed in an above elbow posterior splint with the elbow in 60° of flexion. Patients received intravenous antibiotics and analgesics during their hospital stay.

Group A obtained post-operative radiograph immediately after the operation and at 4th week. Group B obtained post-operative radiograph immediately after operation and at 1st, 2nd and 4th week. Baumann angle in AP view and anterior humeral line's relation with capitellum in lateral view was measured on immediate post-operative radiograph and radiographs obtained at follow-up visits, and any differences observed were noted. We defined the Baumann angle as the angle formed between the physeal line of lateral condyle and a line perpendicular to the long axis of humerus and the angle between 9 and 26 degrees was considered as normal range.[9] Malalignment of over 10° in the coronal or sagittal plane, and failure of the anterior humeral line to intersect the capitellum was considered as unacceptable alignment.[1] Any change in Baumann angle by more than seven degrees was considered as loss of reduction.

Data entry and processing were done using EPI Info version 7. Mean and standard deviations were calculated for continuous variables.

Result

Out of 34 students, there were 28(82.35%) male and 6(17.65%) female. The mean age of Group A was 6.91±2.59 years where as 7.75±2.35 years in Group B, Table 1.

In group A, four patients had the same Baumann angle in the immediate post-operative radiograph and fourth week radiograph, remaining 14 patients had some change in their Baumann angle. The mean immediate postoperative Baumann angle was 15.77±3.90 degrees. The fourth week post-operative Baumann angle was 17.611±3.758 degrees. The mean difference of Baumann angle was 1.83±2.007 degrees.

Table 1. Demographic characteristics of patients included in the study (n_1=18, n_2=16)

Variables	Group A n_1(%)	Group B n_2(%)
Gender		
Male	15(83.33)	13(81.25)
Female	13(81.25)	3(18.75)
Mean Age	6.91±2.59	7.75±2.35

n_1: Group A; n_2: Group B

In group B, three patients had the same Baumann angle at immediate postoperative, 1st, 2nd and 4th post-operative weeks radiographs. Remaining 13 patients had some change, but the changes were less than 6 degrees. The mean immediate Baumann angle was 15.18±4.67 degrees. The mean Baumann angle in 4th post-operative week was 17.06±4.35 degrees. The mean difference of Baumann angle was 1.875±1.408 degrees. The greatest difference between immediate post-operative and final radiographs was in both groups was less than six degrees which can be considered not relevant because of the effect that elbow rotation can have on Baumann angle. In both groups, there was no change in anterior humeral line's relation with capitellum among immediate and follow-up post-operative radiographs.

Two (12.50%) patients in group B had immediate post-operative measurement outside acceptable criteria. In 1(6.25%) patient, the initial Baumann angle was 7°, but the anterior humeral line was crossing the capitellum, so no intervention was done. Baumann angle during 1st, 2nd, and 4th weeks follow-up was 10°. In the other patient, both the Baumann angle and anterior humeral line were unacceptable, so had to undergo revision CRPP after the immediate post-operative radiograph.

In Group A, eleven patients had anterior humeral lines crossing the capitellum through the middle 3rd, and one patient had crossing through the posterior 3rd of the capitellum. In Group B, ten patients had anterior humeral lines crossing the capitellum through the anterior 3rd, five patients had crossing through the middle 3rd, and one patient had crossing through the posterior 3rd of the capitellum. In both groups, there was no change in the relation of the anterior humeral line with the capitellum over the period of four weeks

Discussion

In our study, 27 patients showed some change in the Baumann angle. The mean change in Baumann's angle in the two groups over the period of four weeks was similar. In both groups, there was no change in the relation of the anterior humeral line with the capitellum over the period of four weeks.

Radiologically significant loss of reduction was observed in one patient, evident on the immediate post-operative radiograph. There was medial translation of the distal fragment, which was not corrected, and the K-wires had only engaged the proximal fragment. The primary purpose of post-operative radiographs is to detect such malalignment early, and identify unstable fracture pin configurations that may result in significant loss in reduction before healing, thereby allowing for timely intervention if necessary.[7] A study from The Children's Hospital of Philadelphia, United States of America (USA) reported that loss of fixation following pin placement typically results due to failure to engage both fragments by two or more pins with pins missing the distal fragment, failure to achieve bicortical fixation with two pins or more, or inadequate pin spread to control rotational forces at the fracture site. They concluded that these failures are due to technical errors at the time of initial pin placement.[10]

A study conducted at DuPont Hospital for Children at Wilmington, USA observed that most instances of pin back out or fracture translation occurred in high grade fractures.[5] If the stability of the pin construct is confirmed at surgery, mild alignment changes and pin migration observed in post-operative radiographs after pinning have little effect on long term sequel or clinical management. They found that there is no significant risk of complications, provided that adequate intraoperative stability is achieved.[5]

In our study, one patient in Group B had to undergo revision CRPP after immediate postoperative radiograph revealed unacceptable radiological parameters. Our findings are consistent with other literature. Another study from Harvard Medical School, USA found no increase in complications with late follow-up and they concluded that early radiographs did not provide any added benefit to the surgeon, clinic and patient. When a stable, anatomic or near anatomic reduction and fixation is achieved, clinical and radiographic follow up can be safely deferred until pin removal.[7] Another study conducted across Orthopedic Institute for Children/UCLA, Duke University Medical Center and Texas Scottish Hospital for Children reported no difference in the number of unscheduled clinic or ER visits between patients who were seen early and those with delayed first visits. The early follow-up cohort did not demonstrate a lower incidence of postoperative complications. At the final follow-up, all patients, regardless of follow-up timing, achieved radiographic union without clinical deformity. They concluded that obtaining radiographs at an early follow-up visit in the asymptomatic patient does not alter management or clinical outcome. They recommended that each practitioner must weigh the theoretical benefits of an early clinical visit with the cost to the family and healthcare system.[15]

Another study conducted across Mayo Clinic, Rochester and University of Kentucky, Lexington observed that no patients returned to operating room based on radiographs taken after the seven-to-ten-day initial visit.[16] Although the re-operation risk was low, any cases requiring revision surgery were detected during the initial post-operative or immediate post-operative radiographs. Radiographs obtained at the 3-4 weeks did not result in any return to operating room, but did prompt some physician to extend the period of casting. They concluded that radiographs obtained ten days following CRPP did not alter clinical decision making. Hence, radiographs should be obtained within 7 to 10 days of CRPP and need not be repeated unless the clinical situation warrants it, such as severe fracture pattern, continued pain or clinical deformity.[16] One study from Memorial Care and Miller Children's and Women's Hospital, USA recommended that if intra-operative fixation is stable, patient should be immobilized and followed-up at 3 to 4 weeks for a radiograph and removal of pins. Whereas, if stability of construct is questionable, the patient should be followed up at 7 to 10 days with-operative scheduled radiograph post.[17] Another study done in Children's Hospital of Orange County, USA reported that obtaining post-operative radiographs before pin removal, although routinely performed, is not necessary as it did not alter the management.[18]

In our study change of Baumann angle by more than 7° was considered as loss of reduction which was similar to the criteria chosen by a previous study from Los Angeles Orthopaedic Medical Center, USA.[19] Another study from Rady Children's Hospital, USA defined loss of reduction as change of Baumann angle of more than 10°.[1] This cutoff was selected because it represents a true radiographic change, not only a projection difference in radiograph or measuring error. They also advised all patients to wear a sling in addition to a cast and avoid at risk activities until there is radiographic evidence of healing.[1] Another study from Children's Hospital, Los Angeles chose a difference of 12° between the perioperative and final Baumann angle to represent a meaningful change. According to them, this arbitrary limit allowed for minor variations in arm positioning during radiographic evaluation as well as measurement variability.[12] One study from USA studied the effect of humeral rotation in Baumann angle, when humerus was placed at 30° of flexion to cassette compared to humerus parallel to x-ray cassette. It was observed that, for every 10° rotation, Baumann angle varied by 6°.[20]

We defined the Baumann angle as the angle formed between the physeal line of lateral condyle and a line perpendicular to the long axis of humerus. Angle between 9° and 26° was considered as normal range, which is similar to that reported by other studies.[12,19] A study from USA demonstrated that Baumann angle to be a highly reliable measurement with excellent inter-observer (r=0.78) and intra-observer reliability (r=0.80).[19] Despite varying level of expertise, both intra-observer and inter-observer measurements were within 7°, suggesting that a variation of up to 7° should be considered to be within normal error of measurement. They also observed Baumann angle to be an ideal outcome measurement tool as it is simple, repeatable and can be applied universally by individuals with different levels of expertise.[19] This is different to the Baumann angle described by other studies where the Baumann angle is described as the angle between a line bisecting the long axis of humeral diaphysis and a line drawn along the bony landmarks of the humeral metaphysis at the lateral growth plate.[6,20]

There are a few limitations of this study. Firstly, the study period was time limited to one year, hence, and we did not evaluate the long-term outcome of patients. In addition, the size of K-wire and the fixation technique are important determinant of fracture stability after CRPP; these factors were not evaluated in this study.[1,8,9] In addition, this was a time bound study and sample size calculation was not done. Hence, we were not able to perform statistical analysis to compare the change in Baumann's angle between the two groups. We also did not calculate the actual economic benefit to the patient. Patients in group B had an average of two additional radiographs taken compared to group A. This difference in radiation exposure could not be quantified but reduced radiation exposure was considered advantageous. We suggest future studies should quantify the economic benefit to the patient as well as the reduction in radiation exposure when post-operative visits and radiographs are reduced.

Conclusion

This study found that loss of reduction after CRPP for supracondylar humerus fractures, as indicated by change in Baumann's angle and the relation of the anterior humeral line with the capitellum was similar in patients who underwent frequent radiographs and in patients for whom radiograph was obtained only at the time of pin removal. Therefore, we found no added benefit of frequent radiographs in post-operative management of supracondylar humerus fracture after CRPP.

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Conflict of Interest
None

Author's Contribution
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