Percutaneous Kirschner wire (K-wire) fixation for humerus shaft fractures in children: A treatment concept

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ABSTRACT

Background: Fractures of the humeral shaft are uncommon, representing less than 10 percent of all fractures in children. Humeral shaft fractures in children can be treated by immobilisation alone. A small number of fractures are unable to be reduced adequately or maintained in adequate alignment, and these should be treated surgically. In the present study, Kirschner wires (K-wire) were used to achieve a closed intramedullary fixation of humeral shaft fractures. The objective of this study was to evaluate the efficacy of intramedullary K-wires for the treatment of humeral shaft fracture in children. **Patients and Methods:** This prospective study was conducted in the Department of Orthopaedic surgery in M. M. Medical College from June 2005 to June 2010. Sixty-eight children with a mean age of 7.7 years (range, 2-14 years) were recruited from Emergency and out patient department having closed fracture of humerus shaft. All patients were operated under general anaesthesia. All patients were followed for 12 months. **Results:** Out of 68 patients, 64 patients underwent union in 42-70 days with a mean of 56 days. Complications found in four patients who had insignificant delayed union which were united next 3 weeks. Intramedullary K-wires were removed after an average of 5 months without any complications. The results were excellent in 94.11% and good in 5% children. **Conclusion:** This technique is simple, quick to perform, safe and reliable and avoids prolonged hospitalization with good results and is economical.

Key words: Children, humerus shaft fractures, percutaneous Kirschner wires

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INTRODUCTION

Fractures of the humeral shaft are uncommon, representing less than 10% of all fractures in children.[1] One of the most important features of humeral fractures in children is their ability to remodel and heal with minimal to no deformity despite displacement and angulation. The majority of these fractures can be treated by immobilisation alone. Surgical treatment of long bones fractures in children must first consider the fact that excellent results can be achieved with nonoperative care, with reported union rates of more then 90% and 100% full functional recovery.[2] Occasionally, reduction cannot be maintained due to excessive shortening, angulation or malrotation at the fracture site, making operative intervention necessary.[3] Over recent years the use of elastic stable intra-medullary nails has dramatically increased with the introduction of a variety of nails for paediatric fractures.[4] The Titanium Elastic Nail (TEN) for Elastic Stable Intra-medullary Nailing (ESIN) is intended for fixation of diaphyseal fractures of long bones where the medullary canal is narrow or flexibility of the implant is paramount. The biomechanical principle of the TEN is based on the symmetrical bracing action of two elastic nails inserted into the metaphysis, each of which bears against the inner bone at three points.[5,6] We present our experience with the use of percutaneous Kirschner (K)-wire fixation for humeral shaft fractures in children. The wires are cheaper than elastic nails. This method is, therefore, a valid alternative to the types of fixation for humeral shaft fractures used in developing countries.

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PATIENTS AND METHODS

This prospective study was carried out at the Orthopaedics department of M. M. Medical College from June 2005 to June 2010 following approval by the institutional medical ethics

committee. Consecutive children with fracture humerus admitted to our institute were included in present study if they met the following inclusion criteria:

1. Failed conservative treatment (fractures are unable to be reduced adequately or maintained in adequate alignment).
2. Polytrauma patients with multiple injuries.
3. Bileteral humeral fractures.
4. Segmental fractures.
5. Pathological fractures.
6. Nonunion or unacceptable malunion.
7. Associated injuries in the same extremities e.g., floating elbow.
8. Obesity.

Patients who sustained either open fracture or neurological injury, were excluded from the study.

Under general anaesthesia, the patient was placed supine with the arm placed on an arm rest. When retrograde insertion was utilised, a longitudinal incision is made laterally at the level of the lateral epicondyle 2-cm proximal to the growth plate. The cortex is opened with a 3.2- or 4.5-mm drill bit, depending on the size of the implant desired, and the drill is advanced under image intensification through the lateral column of the distal humerus into the medullary canal. The size of the implant is selected to be approximately 40% of the diameter of the canal, and two equally sized implants were used to prevent asymmetric force on opposite cortices. In general, implants were in the range of 2.5-3.5 mm. and the sharp tips were made blunt. The bent and blunt tip avoided perforation of the opposite cortex during introduction and helped in negotiating through the fracture site. The nail is driven to the fracture site, reduction is then obtained in a closed or open manner, and the implant is subsequently driven proximally to stabilize the fracture. A second small incision is then made over the medial epicondyle proximal to the growth plate. This is extended adequately to both visualize and protect the ulnar nerve or to allow blunt dissection down to the medial epicondyle with a haemostat to assure that the ulnar nerve is not within the operative field. The nails are driven proximally to within 1-2 cm of the proximal humeral physis, cut as close as possible to the insertion site, and impacted into place. Alternatively, both retrograde implants can be inserted through the lateral cortex to decrease risk of injury to the ulnar nerve. When antegrade insertion is indicated, a longitudinal incision is made over the proximal humerus at the level of the greater tuberosity, and dissection is taken down sharply to the humeral metaphysis distal to the physis. The rotator cuff is incised in line with the fibres. Image intensification is used to confirm the starting point. The cortex is entered using a 3.2- or 4.5-mm drill bit and the opening subsequently enlarged using a clamp. A single wire is inserted into the bone and passed into the distal fracture fragment as far as possible into the supracondylar area. The procedure is repeated to add a second implant. A small portion of the nail is left out of the cortex proximally to facilitate removal of implants. Wound is closed in layers. The postoperative regime consisted of application of a collar and cuff sling to the operated upper arm for two to three weeks. Patients were encouraged to start pendulum exercises of the shoulder as soon as comfortable. Radiographs were typically obtained 2 weeks postoperatively to check for loss of reduction, 6 and 12 weeks, postoperatively to evaluate healing, and as needed after 12 weeks. According to the criteria the results are graded as excellent when the fractures unites within 10 weeks without any complication, good when union occur within 16 weeks with treatable complications like superficial infection and poor when union occur before or after 16 weeks with one or more permanent complications like infection, implant failure, nonunion and limb shortening. Delayed union was recorded when the fracture united between 2 and 4 months while nonunion was noted when union had not occurred after 4-6 months of treatment. Follow-up was done for 12 months. Union was defined radiographically when bridging callus was visible on two standard views with partial obliteration of the fracture line, and clinically when bony tenderness were absent. Any difference in the limb length was measured. Thereafter, they were called after 10-12 weeks for implant removal. These patients were assessed clinically and radio logically for union at 12 months following surgery. Patients were assessed for delayed union (more than 8-16 weeks postoperative) and nonunion[7] (24 weeks following surgery). Statistical analysis was limited to calculation of percentage of patients who had unions, malunions, delayed unions or nonunions and excellent, good and poor outcomes.

RESULTS

There were 68 children in this study; 42 children were male and 26 children were females. The children were aged 2-14 years with a mean age of 7.7 years. There were 30 left-sided and 38 right-sided fractures. Forty-four children had met with a road traffic accident and 24 had a fall from a height. All were closed fractures. There were 47 transverse, 8 oblique, 5 spirals, 7 comminuted and 1 segmental fractures. Humeral fractures at middle one-third were 42 out of 68, fractures in 12 cases were at proximal one-third and fractures in 14 cases were at distal one-third [Tables 1 and 2] [Figure 1]. The patients were divided in four groups according to their age for simplicity. Age group between 2 and 4 years, in this group there were seven males and five females. Age group between 4 and 8 years, this group included eight females and 12 males. Age group between 8 and 12 years, this group consisted of seven female and 14 males. Age group between 12 and 14 years, this group consisted of six female and nine males. All patients were followed for 12 months. None was lost to follow-up. The clinical results of our study were rated based on the criteria of union, nonunion,[7] delayed union or malunion. The patients were followed according to their

clinical status. Sixty-four patients had union within 10 weeks. Union was achieved in four patients in 10-16 weeks. [Table 3]. None of the patients in our series developed migration or sinking of the intramedullary wires. Skin irritation by the protruding wire ends was encountered in 12 patients. This resolved in all cases on removal of hardware. In our study, there were four i.e., 5.88% delayed unions which were corrected within 3 weeks. K-wires were removed when visible callus formation were seen on X-ray after an average of 10-12 weeks. The results were excellent in 94.11% and good in 5.88% patients. [Table 4] [Figures 2 and 3].

DISCUSSION

Fractures of the humeral shaft are uncommon, representing less than 10 percent of all fractures in children.[1] One of the most important features of humeral fractures in children is their ability to remodel and heal with minimal to no deformity despite displacement and angulation. The majority of these fractures can be treated by immobilisation alone. A small number of fractures are unable to be reduced adequately or maintained in adequate alignment, and these should also be treated surgically. Ender nails and Rush pins are not sufficiently elastic for paediatric fractures.[8] Flexible intramedullary titanium nails (Nancy nails) devised by Ligier and Métaizeau *et al.*,[9-12] revolutionized the treatment of femoral shaft fractures in children. Based on the concept of flexible intramedullary nails, Al-Zaharani *et al.*,[13] Qidwai, and

Table 1: Age and sex variations in study group (*n*=68)

Age	Male	Female	Total
2-4	7	5	12
4-8	12	8	20
8-12	14	7	21
12-14	9	6	15
Total	42	26	68

Table 2: Site of humeral fracture (*n*=68)

Humeral site	No	Percentage
Proximal 1/3rd	12	7.64
Middle 1/3rd	42	61.76
Distal 1/3rd	14	20.58

Table 3: Percentage of cases who had unions, malunions, delayed unions or nonunions (*n*=68)

	Total cases	Percentage of cases
Union	64	94.11
Nonunion	0	0
Delayed union	4	5.88
Malunion	0	0

Table 4: Outcome of results of K-wires (*n*=68)

Outcomes	No	Percentage
Excellent	64	94.11
Good	4	5.88
Poor	0	0

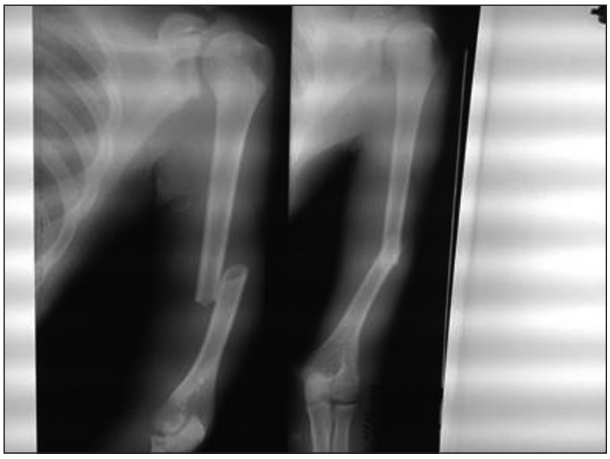

Figure 1: Pre-operative radiograph of fracture shaft of humerus

Figure 2: Post-op radiograph of fracture shaft of humerus

Figure 3: Follow-up radiograph of 6 months of fracture shaft of humerus

Khattak,[8] recently advocated the use of intramedullary K-wire fixation for femoral fractures in children with encouraging results. Huber *et al*.,[14] advocated flexible titanium nailing for the treatment of all diaphyseal fractures in children. Khan *et al*.,[15] recently advocated the use of intramedullary K-wire fixation for humeral shaft fractures in children with encouraging results. The principle of osteosynthesis with intramedullary K-wires is a biomechanical idea that aims at early bridging callus formation leading to rapid restoration of bony continuity.[14] Just like the Nancy nails, the flexible K-wires allow controlled oscillating micromovements that permit changing compression on different parts of the fracture line, leading to early external callus formation. Each K-wire provides three points of fixation: One at the entry point, a second at the apex of the curve of the K-wire and a third at the tip, which is embedded in the cancellous bone of the proximal metaphysis. Stability is provided not only by the intramedullary K-wires but also by the bone itself and surrounding soft tissues.[9-12] The bone provides axial stability and each wire provides three point fixations. The bent tips provide rotational stability. The surrounding muscles also provide stability by acting as guide ropes. Increasing the number of K-wires enhances the stability of fixation.[8-12] Kiely *et al*.,[16] tested the mechanical properties of different combinations of flexible nails in a model of a paediatric femoral fracture. They found no difference in the mechanical properties of paired straight, S-shaped and C-shaped nails. Griffet's[17] study involved 86 children (average age 11.8 years). As early as day 30, all patients had normal knee mobility and symmetrical foot progress angle. At 2-year follow-up, frontal angulation and leg length discrepancy had decreased and affected 2% of patients. Four patients (5%) suffered from superficial infections. There were no cases of osteomyelitis or refracture. Swamy[18] stated that 14 children-11 boys and three girls (aged 5-12) were treated with stainless steel K-wires as an intramedullary device in the treatment of paediatric femoral shaft fractures. Intramedullary 'K'-wire fixation has a place in the management of paediatric diaphyseal femoral fractures, because it is technically simple, quick to perform, safe and reliable and avoids prolonged hospitalization. However, meticulous attention to surgical technique is of paramount importance. It is although less rigid than the titanium elastic nails but in the absence of the latter, it affords a cheap and easily available method of osteosynthesis. In most of our cases, we used K-wires from both medial and lateral cortices. In five cases with a distal humeral shaft fracture, antegrade K-wiring was done from the greater tuberosity region. Reduction was easier by rotating the wire tip in the smaller distal fragment with the added advantage that the entry point was far away from the fracture site.[8] In our series, three patients out of 68 complained postoperative elbow pain, which was spontaneously resolved in 2 weeks. None of the patients in our series developed migration or sinking of the intramedullary wires. In 12 cases, we encountered skin irritation by protruding wire ends at the entry point. Cutting the wires close to the bone and hairpin bend of the wire ends minimised this problem. There were four cases of delayed unions, which were corrected within 3 weeks. Percutaneous K-wire fixation for humeral shaft fractures in children has distinct advantages over other conservative and over operative techniques. The low cost and universal availability of K-wires (as compared to titanium nails) and the short hospital stay make this treatment cost-effective and particularly suitable for developing and underdeveloped countries. This is a simple technique and sophisticated instrumentation is not required. This is a minimally invasive technique with small stab incisions at the entry point. The amount of blood loss is small as compared to plating.[8] Cosmetic damage is minimal (as compared to other open techniques like plating). It affords advantages of easy nursing care, early mobilisation and avoidance of psychological problems due to prolonged immobilization.[9-12] Percutaneous K-wire fixation is a biological method of fixation, which provides a combination of elastic stability and mobility. Closed methods leave the fracture haematoma intact, leading to the formation of early bridging callus.

CONCLUSIONS

Close intramedullary fixation using K-wires can achieve good outcome. The wires are cheaper than elastic nails and plates, require minimal expertise to insert, and can be removed under local anaesthesia as an out-patient procedure. This method is therefore a valid alternative to the types of fixation for humeral shaft fractures used in developing countries.

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