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Technical Note

Closed retrograde multiple intramedullary Kirschner wires fixation for humeral shaft fractures with the limb flexed over an articulated support

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ABSTRACT

Objective: To evaluate the results of multiple closed intramedullary Kirschner wiring via a supracondylar entry point for humeral shaft fractures.

Patients and methods: The charts of 37 patients with humeral shaft fractures treated with the Hackethal's technique between January 2007 and December 2011 were reviewed retrospectively. The operation was performed with the patient lying in supine ($n = 22$) or lateral ($n = 15$) position. The elbow was flexed over an articulated support with the arm kept in a vertical position. Thirty-three patients were available for final evaluation with a mean follow-up delay of 14 (range, 6–24) months. We were concerned about fracture union, range of motion of the shoulder and the elbow, and complications. Final evaluation used the criteria by Qidwai.

Results: Bone union rate was 94%. Restriction of ranges of motion of the shoulder more than 20° was noticed in two patients due to protruding wires. Three patients developed limitation of elbow extension owing to backing out of the wires. The overall results were excellent ($n = 26$; 79%), good ($n = 4$; 12%), and poor ($n = 3$; 9%).

Conclusion: Closed Hackethal's technique using K-wires gives satisfactory results in terms of bone union and elbow and shoulder function in selected humeral shaft fractures. The articulated support precludes the transolecranon traction.

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1. Introduction

Implants used for intramedullary stabilization of humeral shaft fractures range from both flexible nails and K-wires to the current trend of more rigid locking nails.¹ Small flexible diameter implants allow for alignment in the anteroposterior and lateral

planes and function as internal splints.^{1–3} Intramedullary devices such as Ender and Rush nails have fallen out of favor due to inability to obtain rotational or axial control.^{2,3} Related complications have been backed by earliest reports.^{4,5} To the contrary, Hackethal's technique (HT) of filling the intramedullary canal sequentially with flexible nails via a supracondylar entry point permits stabilization of humeri with

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Table 1 – Patients demographics and fracture characteristics.

Parameters	Number
Sex	
Male	30
Female	7
Mechanism	
Road Traffic accident	23
Fall	8
Assault	6
Location of fracture	
Proximal third	5
Transition proximal to middle third	7
Middle third	16
Transition middle to distal third	6
Distal third	3
Pattern of fracture	
A1	4
A2	6
A3	12
B1	3
B2	3
B3	2
C1	4
C2	1
C3	2
Closed fractures	32
Open fractures	
Type I	3
Type II	2

varying canal morphology.⁶ This procedure is a minimally invasive technique carrying the advantages of closed reduction of the fracture and limited surgical exposure that does not endanger the radial nerve.⁷ In a prospective study comparing the results achieved using compression plate and the HT to treat transverse fracture of the midshaft of the humerus, no differences have been found between the two methods.⁸ The HT performed with K-wires, instead of flexible nails is the mainstay in the surgical treatment of most displaced proximal and humeral shaft fractures in some trauma centers in Europe.^{9,10} The surgical technique can be performed using transolecranon traction.⁹ The purpose of this study was to evaluate our results employing K-wires to carry out the Hackethal's technique, the limb being flexed over an articulated support.

2. Patients and methods

Thirty-seven adult patients undergoing a multiply closed intramedullary K-wiring via a supracondylar entry portal for humeral shaft fractures at the orthopedic unit of a private hospital from January 2007 to December 2011 were identified and their charts reviewed retrospectively. The fractures were located from 5 cm distal to the surgical neck to 5 cm proximal to the olecranon fossa.¹¹ Impending and completed pathological fractures, fractures as the result of a gunshot injury, grade 3 Gustilo open fractures, and neglected fractures were excluded. Patients treated with other implants or intramedullary K-wires via open reduction of the fracture or an entry point other than the supracondylar site were not included in the series. The average age of patients was 34

(range 16–79) years. Fracture pattern was described according to the AO Müller classification of fractures of long bone. The patient demographics and fracture characteristics are summarized in Table 1. In four patients radial nerve palsy was recorded at the time of admission. None of them had open fracture. Indications for surgery included polyfracture or polytrauma ($n = 26$), open fractures ($n = 5$), and inability to obtain or maintain an adequate closed reduction ($n = 6$). The average time between injury and surgery was 3 (range 1–10) days. A variety of surgeons with varying level of training have performed the procedure. The main steps of the standard technique described in several reports^{7,9,12} are outlined. The operation was performed under general anesthesia with the patient lying in supine ($n = 22$) or lateral position ($n = 15$). The elbow was flexed over a support with the arm kept in a vertical position (Fig. 1). The image intensifier was placed on the side opposite to the injured limb. The C arm was parallel to the floor with its concavity facing the patient (Fig. 2). It was rotated in the same plane to visualize the anteroposterior and lateral views of the arm. The support is articulated. Adjustment of its length by manipulations at the site of the articulation enables traction on the arm and achievement of the fracture reduction. This was checked by image intensifier. The limb was fixed firmly in this position by using an adhesive bandage between the forearm and an iron bar attached to the operating table. Open fracture if present was debrided first, irrigated, and closed on layers. A longitudinal posterior midline incision, about 5 cm in length was started close to the olecranon fossa and continued proximally. A long split incision in the triceps

Fig. 1 – Patient lying in lateral position with the elbow flexed over an articulated support.

Fig. 2 – The C arm was parallel to the floor with its concavity facing the patient.

was used to expose the posterior surface of the humerus. Care should be taken to avoid entering or traumatizing the elbow capsule. A window of 1.5×1 cm diameter was made in the posterior cortex using varying sizes of drill bits and rongeur at a point approximately 2.5 cm proximal to the olecranon fossa. Standard K-wire of 1.8–2.5 mm gently bent was used. In most cases the tip of the wire was made blunt before insertion. It was loaded on a T handle chuck and then inserted from the window into the medullary canal, crossing the fracture site, into the proximal fragment under image intensifier. The tip of the wire was driven up into the humeral head. Similarly other K-wires were inserted tightly within the medullary canal depending upon its size until interference fit was achieved. This was determined clinically by the inability to insert additional wires. Depending upon the size of the canal three to five K-wires were usually inserted. Care should be taken to keep the proximal tip of the wires divergent into the proximal metaphyseal part of the humerus. The fracture site was gently impacted in case of important comminution. The outer end of the wire was bent and cut. The wound was irrigated and closed in layers over a suction drain. Positioning and reduction of the fracture required approximately 20 min. The average duration of operation from skin incision to wound closure was 45 (range 30–60) min. Postoperatively a broad arm sling was applied to support the limb. Passive and active exercises were initiated as soon as the pain tolerance of the patient improved.

The mean hospital stay was 4 (2–7) days. After discharge from the hospital patients were seen every two weeks for a minimum of 8 weeks postoperatively and monthly thereafter. We were concerned about fracture union, range of motion of the shoulder and the elbow. Bone union was determined by the presence of bridging callus on both anteroposterior and lateral views and the absence of pain and bony tenderness. Delayed union was defined by a fracture which failed to show complete union at 16 weeks. Nonunion was defined as a fracture which did not show healing up to 24 weeks after operation.¹² At the final follow-up, the evaluation of ranges of motion of both shoulder and elbow and the overall assessment were performed using criteria by Qidwai¹² (Table 2).

Complications were also recorded. Four foreign workers came back home 21 days after wound healing. Thus 33 patients were available for final evaluation with a mean follow-up delay of 14 (range, 6–24) months.

3. Results

After the index operation, 29 fractures healed by an average delay of 9 weeks (range, 6–16 weeks) with full range of motion of the joints. Bone union was achieved in two patients between 16 and 24 weeks (Fig. 3A–D).

The overall results were excellent ($n = 26$; 79%), good ($n = 4$; 12%), and poor ($n = 3$; 9%) after the index operation. Restriction of ranges of motion of the shoulder more than 20° was noticed in two patients aged above 75 years with protruding wires in the shoulder. In one patient the tip of the wire was not made blunt. The wire was removed uneventfully in both cases. There were no complications stemming from operation such as nerve palsy or iatrogenic fracture of the supracondylar region. Three patients with comminuted fractures developed limitation of elbow extension between 10° and 20° due to backing out of the wires from the entry portal with pain. The wires were removed with relief of the pain and improvement of the elbow movements.

K-wires removal was performed electively in 17 other patients usually eight months after the index operation. Heterotopic ossifications around the entry portal with normal elbow range of motion were seen in three patients. Fracture nonunion was noticed in two patients. In the first patient with transverse fracture of the distal third union was obtained with plate fixation and bone graft. In the second patient, the fracture was comminuted and extended into the distal third of the humeral shaft. Reoperation was not performed. One patient with grade II open fracture developed superficial infection that responded well to dressings and antibiotics and later healed uneventfully. Three out of the four patients with nerve palsy had full spontaneous recovery within five months.

4. Discussion

The main finding of the current report was the use of an articulated support to maintain the arm in vertical position.

Table 2 – Outcome assessment according to Qidwai.

Excellent	Full ROM of nearby joint or stiffness $\leq 10^\circ$ Normal function Presence of bridging callus at 16 weeks No postoperative infection
Good	Stiffness of nearby joint $\leq 20^\circ$ Satisfactory function Bridging callus between 16 and 24 weeks Postoperative superficial infection
Poor	Presence of one of the following: Stiffness $> 20^\circ$ Nonunion Irrecoverable radial nerve injury Postoperative deep infection
ROM: range of motion.

Fig. 3 – Radiographs of a polytraumatized patient with a C1 fracture of the midshaft of the humerus (A) preoperative X ray, (B): Postoperative X ray, (C), (D): AP and lateral views showing fracture union.

Retrograde intramedullary fixation of the humeral shaft fracture can be performed with the patient lying in prone,¹⁰ supine,^{5,13} or lateral⁷ position. Rodriguez Merchan¹³ used the supine position with a pad placed against the chest wall to allow traction. As for tibial fracture manual traction alone without traction table can be difficult and is a particular problem if assistance is limited.¹⁴ The transolecranon traction, the patient being in supine position is used by other authors.^{5,9,12} Postoperatively a case of ulnar palsy with spontaneous recovery was encountered in the series by Gayet et al⁹. Whether this complication was due to the transolecranon traction or not was unknown. Though transolecranon traction is seemingly simple it is our opinion that this requires some familiarity and surgical skill to be properly undertaken. The support employed enables traction on the arm without the use of transolecranon traction. The adjustment of the length of the support provides good consistency of traction and affords an acceptable reduction of the fracture which is maintained during the operation. The application of the traction does not require any special expertise and experience. Improvement of the reduction, if necessary was done via external manipulations of the fracture site without traction.

We postulate that this kind of installation is similar to that required for closed nailing of tibial or femoral shaft fracture. Outstanding results in the use of flexible nails to carry out the HT have been reported in literature.^{6,8,13}

Sound adherence to the surgical principles is the key to construct stability and fracture healing. Such principles include mainly the preservation of the fracture hematoma, the achievement of an interference fit while filling the diaphyseal medullary, the three points fixation of the implants, and their divergence into the humeral head.^{7,15}

Though the skin incision was 5 cm in length no fracture line was encountered in the operating site. Reduction of the fractures was performed using closed maneuvers.

The purpose of the current series was specifically to assess the effectiveness of K-wires. The bone union rate and excellent to good results achieved in the current study confirm previously reported results in the literature dealing with HT performed using K-wires.^{9,12} Gayet et al⁹ achieved a fracture healing rate of 95.7% and excellent to good results rate of 94.4%. In the series by Qidwai¹² the rates of bone union and excellent to good results were respectively 96.4% and 93%. K-wires are more flexible than the Hackethal nails. The original nail is 3 mm in diameter and difficult to insert in smaller patients.¹⁶ K-wires are cost effective, available, allow smoother introduction into the medullary canal, and easy to remove.¹⁷ Micromovements at the fracture site stimulate early bridging callus by converting shearing into compressive forces.^{12,17}

Studies by Gayet et al⁹ and Putz et al¹⁰ based on a large sample size with satisfactory anatomical and functional results could serve as baselines for potential preventable errors and complications such as protruding K-wires, heterotopic ossifications, and iatrogenic supracondylar site fracture. In the above mentioned studies^{9,10} protrusion of wire into the shoulder was noticed though the tips of the wires were made blunt.

The weaknesses of the current study are its retrospective design, the limited size of population, and the absence of comparison with traditional methods or control group. Operation was carried out by several surgeons with different surgical skills. This is a source of bias and could explain the complications observed. The strength of this report is that functional impairments due to surgical technical errors were in most cases eliminated after removal of the wires.

5. Conclusion

Using multiple K-wires via a supracondylar entry portal to stabilize humeral shaft fractures we achieved a bone union rate of 94% and excellent to good overall results in 91% of patients. Experience with our patients at a single center along with review of other reports lead us to concede that the Hackethal's technique for humeral shaft fractures in selected circumstances such as multiply injured patient is a valuable and feasible alternative to other treatment methods. By strictly adhering to the technical guidelines, a number of complications and errors like wire protrusion can be avoided. The major finding of this study was the use of an articulated support precluding the transolecranon traction.

Conflicts of interest

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

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