Double parabolic Kirschner-wires as dynamic distractor for treatment of unstable intraarticular phalangeal fractures of hand

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ABSTRACT

Background: Treatment of complex injuries of interphalangeal joints (IPJs) is difficult. The restoration of joint stability for early joint mobility till fracture union is the key for successful outcome. Although various treatment options like dynamic splinting, external fixator, closed reduction, transarticular Kirschner (K)-wire and ORIF, etc., are available in literature, a universally accepted ideal treatment for complex intraarticular fractures of IPJs is still evolving. Open reduction is difficult because fixation of volar fragment is often impractical and radical procedures like volar plate arthroplasty, arthrodesis or joint replacement, etc., may become mandatory for salvage. We describe percutaneous technique to treat unstable fractures and dorsal fracture–dislocations of the PIP joint and report short-term postoperative results.

Materials and Methods: Ten cases of unstable or potentially unstable intraarticular fractures including pilon fractures and fracture-dislocations of IP joints were treated percutaneously by double parabolic K-wire technique (DPK). The device was used as a dynamic distraction, using the principle of ligamentotaxis. The idea was to commence early postoperative continuous active and active-assisted joint motion exercises and to carry on the frame as a definitive treatment for achieving fracture union.

Results: In all patients of fracture-dislocation the reduction was satisfactory and early mobility was achieved. Although there is a tendency towards over-distraction, no loss of reduction occurred. Pin tract infection occurred in one with no delayed union or nonunion. The average total range of motion for each involved IP joint was 93.5 degree and the average total active range of motion was 90.8° each at the end of 4 months followup. Excellent to good results were restored in nearly all cases without further interventions.

Conclusion: DPK technique may be a cheap and valuable definitive treatment option in the management of unstable or potentially unstable intraarticular fractures of IPJs. The technique gave satisfactory radiological union and functional outcome in our small series. This technique may be worth considering in unstable or potentially unstable intraarticular fractures of IPJs with intact collateral ligaments and when other treatment options are impractical.

Key words: Double parabolic K-wires, dynamic distraction, fracture-dislocations, interphalangeal joints, intraarticular fractures

INTRODUCTION

Treatment of complex injuries of interphalangeal joints (IPJs) has significant failure rate especially after conservative treatment. Treatment is difficult and...
boutonniere, pseudoboutonniere, swan neck deformities, persistent subluxation, etc.) are well known complications after conservative treatment. It is known that adequate treatment of unstable injuries of phalangeal joints is difficult and these complex fractures have a significant failure rate. Return of good joint function requires anatomical reduction of the articular fragments and restoration of joint congruity and a stable functional arc of motion while the fixation device is providing stability for early mobilization. We have used dynamic distraction principle using ‘Double parabolic Kirschner (K)-wire technique’ (DPK) as a definitive mode of treatment in unstable or potentially unstable fractures or fracture-dislocations of IPJs (excluding the thumb) in our study.

**MATERIALS AND METHODS**

Cases of unstable fractures or fracture-dislocations in adults (not older than 5 days) including open fractures of IPJs were included in this prospective study. “Unstable fracture” was discretely defined as those where joint congruity has not been established following attempted closed reduction or where >40% volar joint surface is fractured. Any undisplaced intraarticular fracture with comminution to the metaphysis was considered ‘potentially unstable’. More than 20° angulation in AP stress radiograph (in extension) suggests complete tear of collateral ligament and such cases were excluded. Children and patients with diabetes, inflammatory arthritis and previous history of ipsilateral fractures of fingers were excluded.

The purpose of this study is to described a percutaneous technique to treat unstable fractures and dorsal fracture–dislocations of the PIP and DIP joint and to report short term postoperative results. Closed reduction is attempted manually under local anesthesia (digital block) to assess degree of instability and the approximate amount of distraction required by the device to achieve and maintain reduction and it was guided by the radiological fracture geometry. Accordingly, two long and pliable small diameter K-wires (Ranging from 1 to 2 mm) are selected on the basis of subjective assessment. An assistant holds the affected finger stably with adequate counter pressure during drilling. The K-wire is introduced through the phalanx (5-6 mm away from the joint level distally) in coronal plane in right angle to its long axis dorsal to the digital vessels while the MCPJ and IPJ were held in some flexion (20°-45°). Thereafter, a shorter second K-wire (with thicker caliber and less pliable than the previous wire) is placed 5-7-mm proximal to the involved joint parallel to the first K-wire. The overall axial and distal rotational alignment is noted. Both wires should be passed half of its length through the phalanges so that equal length is available on both radial and ulnar side of the phalanx.

The distal wire is bent to 90 degree dorsally on both radial and ulnar side so that enough interdigital clearance is available. Thereafter, the vertical parts of the wire are bent upon itself again to a parabolic shape on both ends and a pair of identical parabola is formed at both ends of the distal wire. The radius of curvature of either parabola increases from distal to proximal. Finally a hook is created in reverse direction with the help of a small plier in the free end of the parabola 3-4 mm distal to the proximal wire. This hook is now hinged to the proximal wire to construct a spring-like arrangement to gain the required distraction. The proximal wire should be cut short for interdigital clearance for ROM exercises. The proximal wire is then bent upon itself to make a small loop to hold the hook of the parabolas to avoid potential dislodgement during postoperative period.

Fine tuning of distraction is done by changing the radius of curvature of each parabola with pliers at the end of the
procedure depending on findings of intraoperative check X-ray. An increase in radius can correspondingly increase the distraction force and vice versa when the hinge is working satisfactorily. Residual radio-ulnar deviation (if any) can be corrected by mirroring both these parabolas. Neurological and vascular status of the operated digit is checked, pin tracts dressings are done and limb is elevated for the first 3-5 days to reduce postoperative digital edema. Active finger flexion and extension is encouraged from the first day and active assisted exercises from second or third postoperative day. NSAIDs (alone or in combinations with tramadol) were given according to severity of pain. After 4-6 weeks the frame is removed under local anesthesia. Active physical therapy was continued. Outcome measures assessed were [Table 1] active and total range of motions, residual deformities, etc. We couldn’t use any international hand functional scoring system in our study because some of our patients were not literate enough to answer standard international questionnaire based scoring. Therefore the authors designed a practical and physician based outcome assessment system shown in table. The presence of a residual flexion deformity >20° and rotational malalignment over five degree, were considered poor outcome even if other parameters were excellent. Results were assessed at the end of 4 months (after the fracture) or after 2 months of frame removal whichever was earlier.

RESULTS

The age group of the patients was from 21- 52 years. Half of the cases were on the nondominant hand. There were two cases of grade I open injury. Majority of the cases were involving the ring finger (n=7), followed by the index finger (n=2). Most cases (n=6) were dorsal fracture dislocation with an appreciable volar fragment. The mechanisms of injury were fall, sports injury and industrial injury. In all patients the fracture-dislocation was reduced satisfactorily with DPK technique as confirmed in postoperative radiograph [Figure 4a-b]. Early postoperative mobility was achieved in all ten patients. A tendency towards over distraction was noted. There was no loss of reduction after achieving fracture reduction, and there was no pin tract infection except in one. Apparently there was no difference in the final clinical outcome between the open (n=2) versus closed injuries (n=8) or between pure fractures (n=4) versus fracture dislocations (n=6). Gross malunion, delayed union or nonunion did not occur in any case. At a minimum followup of 4 months (range, 4–12 months the mean range of motion was from 4° of extension to 93° of flexion at the PIP joint. Radiographic analysis revealed union in all cases). There were no subluxation or dislocation events or any major complications. Assessment reported in this study is at 4 months for all cases. The average total range of motion for each involved IP joint was 93 degree and the average total active range of motion was 91 degree each at the end of 4 months followup. No restriction of motion was noted in any MCP joints. At the end of 4 months after the fracture fixation or 2 months after frame removal the results were excellent in two, good in six, fair in two and poor in none [Table 2].

DISCUSSION

Most fractures of the phalanges or metacarpals are amenable to closed treatment, with favorable outcomes. However, unicondylar and bicondylar fractures, fracture-dislocations, and fracture-related instability of the proximal interphalangeal joint are difficult to treat. Stability of the joint depends on the articular contour, collateral ligaments and volar plate in fingers. Collateral ligaments should be intact for our method to work since it is based on ligamentotaxis. Any attempt to regain good joint function necessitates anatomical reduction of the articular fragments and restoration of joint congruity and a stable functional arc of motion while the fixation device is providing stability for early mobilization. DPK has the potential to fulfill these requirements. The term parabolic is used here to describe the shape of the frame correctly. Basically something that is bowl-shaped (as an antenna or microphone reflector) may be called a parabola. Geometrically, parabolic curve means a plane curve generated by a point moving so that
its distance from a fixed point is equal to its distance from a fixed line: the intersection of a right circular cone with a plane parallel to an element of the cone.8

In phalangeal fractures malunion, instability, stiffness with gross reduction in range of motion and typical deformities mentioned earlier are well known problems after conservative treatment.5 Therefore, we adopted aggressive but minimally invasive technique. Special types of dynamic splinting and dynamic external fixators, which are not readily available are the other treatment options for dorsal fracture dislocations of the proximal interphalangeal (PIP) joint. ORIF is described for a single large volar/fracture fragment where it is held reduced and fixed with one or two K-wires or mini screw (1.5 or 1.3 mm) put in interfragmentary fashion.7 But fixation of the volar fragment with ORIF may be impractical at times, due to difficult fracture geometry. Moreover the feasibility of fixation can be assessed objectively only when the joint is surgically explored.

DPK works on the principles of ligamentotaxis without exploring the fracture site. The joint mobilization is impossible where articular fragments are comminuted and fixed with K-wire. The fragment may be debrided and volar plate arthroplasty may be done.5 The basis of this salvage procedure is to restore mobility with immediate provision for a smooth fibro-cartilaginous surface. Other salvage procedures like arthrodesis or IPJ replacement arthroplasty, etc., may sometimes be necessary.6 Our method could avoid these radical procedures. Hand fractures can be complicated by deformity from no treatment, stiffness from overtreatment, and both deformity and stiffness from poor treatment.10 It is interesting to note that the major residual disability in fracture dislocation of the IPJs is not instability, but pain and stiffness.11 Some authors have used the Disabilities of the Arm, Shoulder, and Hand (DASH) and visual analog pain scale questionnaires for outcome assessment at the end of their study for such fractures,12 but we have not used such scoring system in our study. Theoretically it is possible that in severe pin tract infection nonresponsive to dressing and antibiotics removal of the frame before fracture union may be required; leading to poor outcome since other methods (e.g. open reduction) may be contraindicated. The limitation of the study is small number of cases and a shorter followup. The outcome is likely to improve further with a longer followup. The present report also lack comparison with other methods reported.

## Conclusions

DPK wire technique is a simple, cheap definitive treatment option in the management of unstable or potentially unstable intraarticular fractures of IPJs in carefully selected cases. Satisfactory reduction of the fractures/dislocations may be achieved in most cases without further intervention. The technique gave satisfactory radiological union, pain free finger and satisfactory functional outcome in our small series. The technique may be worth considering in unstable intraarticular fractures of IPJs with intact collateral ligaments especially when other treatment options are impractical.

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