

K-wire Made Easy by Premarking Wire Trajectory on the Skin in Management of Finger Fractures

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Background: Hand injury in general and fractures in particular are among the most common complaints of hand trauma patients presenting to our emergency department. Depending on fracture types, geometry, locations, and stability, treatment options may vary from close reduction and splinting to close reduction and K-wire fixation, and finally, to open reduction and internal fixation. The aim of the study was to prove that premarking of K-wire trajectory helps reduce procedure and fluoroscopy time, as well as the number of wire-insertion attempts, and minimize bone and soft tissue injury in the management of phalangeal finger fractures.

Methods: This is a prospective descriptive study aimed to describe a surgical technique. Patients who underwent close reduction and K-wire fixation of phalangeal digital fractures were enrolled. A total of 20 cases were included.

Results: The total number of K-wires was 37, and the total number of successful attempts was 40; average fluoroscopy time was 22.75 seconds; and average total operative time was 14.25 minutes. Surgeries of all cases were supervised by a consultant physician, but some were performed by a junior resident in the team. The inaccuracy index was measured for the group.

Conclusions: Marking of the trajectory before placing K-wires for the management of digital fractures is not described in the literature. Our study describes an innovative operative technique that, when combined with the classic K-wire fixation technique, produces beneficial outcomes in the form of reduction in operative time and number of wire introduction attempts, with overall reduction in fluoroscopy time and soft tissue and bone damage (including false passages). (*Plast Reconstr Surg Glob Open* 2021;9:e3797; doi: 10.1097/GOX.0000000000003797; Published online 17 September 2021.)

INTRODUCTION

Trauma caused by hand fractures represents the most common hand complaint presented to our emergency department.¹ Overall, fractures of the diaphysis are the most common, and they have different locations of involvement: the head, neck, body, and basal area. In addition, there are different geometric patterns of fractures based on the relation of the fractured bony segments to

condylar transverse, oblique, and vertical intraarticular or extraarticular fractures.²

Depending on fracture types, pattern, locations, and stability, treatment plan options are formulated. The options include nonoperative close reduction and splinting versus operative intervention in the form of percutaneous K-wire fixation in an intramedullary or intraosseous fashion, or open reduction internal fixation with variable fixation methods, which include wire placement, cerclage wire, plates and screws, or lag screws fixation (a commonly practiced method).^{3,4}

Closed reduction and percutaneous K-wire fixation was described by Kirschner in 1927 as a semistable digital bone fixation method, which is alleged to be a simple, low-cost technique with minimal soft tissue damage and has the provision to remove the wires upon healing.⁴ Following specific corridors to avoid injury to tendons or ligaments results in superior functional outcomes and range of motion.⁵

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The general disadvantage of Kirschner wire placement technique is the challenge of correct wire placement while maintaining anatomical reduction, on top of significant soft tissue swelling, which makes accurate wire placement even more difficult and will require several drilling attempts, which will aggravate and worsen the edema. The risk of pin migration due to a lack of rigid compression at the fracture site increases the fluoroscopy time and prolongs surgery time \pm tourniquet time (if used). Immobilization during healing period is another major drawback.^{4,6}

In our study, we propose a technique that simplifies the K-wire insertion process by premarking the K-wire trajectory on the skin after anatomical reduction of the fracture components, with a permanent marker using X-ray imaging. Then the reduction is done, and a K-wire is inserted following the premarked trajectory on the skin after ensuring that the wire is in the bone component. The wire insertion is continued across the fracture line. The wire placement is confirmed with X-ray imaging to ensure accuracy, with the goal of reducing K-wire insertion attempts, fluoroscopy time, and procedure length.^{7,8}

Premarking of the trajectory before placing K-wires is a newly described surgical technique. The aim of the study was to present an innovative, easy surgical technique that can shorten operative time, reduce fluoroscopy time, and minimize the number of drilling attempts, thereby minimizing soft tissue and bone damage (including false passages).⁶

METHODS

This is a prospective descriptive study. Patients who underwent closed reduction and percutaneous K-wire fixation surgery for the management of digit phalangeal fractures were included. The study was conducted at the Prince Mohammed bin Abdulaziz Hospital and King Khalid University Hospital. An estimated 20 patients who had closed phalangeal fracture during January 2020 to March 2020 in any finger that required close reduction and K-wire fixation were enrolled in the study. Data collected included the number of K-wire attempts, the number of K-wires inserted, fluoroscopy time, and the length of the procedure. Inaccuracy index is the ratio between the number of attempts and the number of correctly placed K-wires. A ratio of 1 means the number of K-wires placed is equal to the number of attempts. A higher index (>1) indicates more attempts were made to correctly place the k-wires.⁹

Data were gathered from the hospital information system, and an operating room record special form was completed by the operating surgeons with the needed information, which included the data mentioned earlier, and the process was monitored by the principal investigator and supervised by the study supervisor. The procedures were performed by two surgeons who are qualified plastic and hand surgeons.

TECHNIQUE

After standard sterility and positioning measures, close reduction of the digital fracture in the involved finger is

performed, and the finger is maintained in the same anatomical position intended for K-wires placement (Fig. 1). With hands usually held in the pronated position, a K-wire is placed over the finger's skin surface (Fig. 2), and an X-ray image is taken to confirm the trajectory (Fig. 3). Once the alignment is achieved, marking is done along the K-wire line using a permanent marker to guide the direction of drilling. The number of wires needed usually is two, and occasionally only one is needed (Fig. 4). As shown in Figure 5, a photograph is taken after the two K-wires are inserted (correct placement from the first attempt). The final results are shown in Figure 6.

RESULTS

Table 1 shows all the data for the 20 patients included in the study. There were 21 phalangeal fractures (one patient had two fractures in two different fingers). Ring finger was the most commonly involved finger in 10 patients followed by the little finger in five. The fluoroscopy time ranged from 15 to 30 seconds (average 22.75 seconds). The operative time range from 10 to 20 minutes (average 14.25 minutes). (See figure 1, Supplemental Digital Content 1, which displays the procedure time and fluoroscopy time. <http://links.lww.com/PRSGO/B773>.)

One case had four K-wires inserted, 14 had two K-wires, and five had one K-wire. In total, 17 fractures



Fig. 1. Positioning of the injured hand on an arm board, usually with the dorsal surface facing the cephalad to facilitate dorsal approach.



Fig. 2. Placing the K-wire over the fracture site before insertion to check the accuracy of the trajectory.



Fig. 4. Final view of the hand with a criss-cross marking of the planned trajectory before insertion.



Fig. 3. Intraoperative XR confirming the correct trajectory after fracture reduction.



Fig. 5. Intraoperative XR after insertion of the K-wire, with the aid of the preinsertion marking technique.



Fig. 6. Intraoperative XR after insertion of the K wire, with the aid of the preinsertion marking technique.

had the same number of attempts to the same number of K-wires inserted, two had three attempts, and the last case had five attempts for two phalangeal fractures that required four K-wires for fixation. That makes the inaccuracy index equal to one in 17 cases, and greater than 1 (1.2, 1.5, and 1.5) in three cases only. (See figure 2, Supplemental Digital Content 1, which displays the number of wires, the number of attempts, and accuracy index. <http://links.lww.com/PRSGO/B773>.)

Twelve cases were handled by the consultant in charge, whereas eight cases were treated by a surgical assistant or resident in training and supervised by the consultant. (See figure 3, Supplemental Digital Content 1, which displays the level of surgeon who performed the procedure. <http://links.lww.com/PRSGO/B773>.)

DISCUSSION

Operative techniques for hand fracture surgical fixation continue to evolve over the years, with open reduction internal fixation offering better functional outcomes. Still, close reduction with K-wire fixation is an operative technique widely used by many hand surgeons. Following the available soft tissue anatomical corridors between tendons and ligaments during K-wire insertion is a crucial maneuver to decrease and avoid possible damage to ligaments and tendons.^{4,5} It is worth mentioning that soft tissue handling and improved accuracy of fixation are among the fundamental goals of this study. As hand fractures continue to be the most common hand injuries, presenting refinement of the K-wire fixation technique is highly beneficial.¹⁻³ Management of digital fractures in the hand varies depending on the preference of the treating surgeon and the complex geometry of the fracture. However, fracture fixation with K-wires is considered a widely practiced technique with considerable risk of complications ranging from misplacement, worsening of comminution, soft tissue injuries, and the need for frequent X-ray shots with their consequent radiation exposure risk. K-wire placement requires three-dimensional imagination and hand-brain coordination even in expert hands, in order to reduce the incidence of soft tissue trauma and the risk of neurovascular bundle injury and the development of false passages in the bony component. We describe a simple strategy to accomplish that aim by premarking the planned trajectory path of the placed K-wire over the skin surface of the fractured bone before insertion under X-ray imaging, which results in an improved accuracy of wire placement, and reduces the soft

Table 1. Patient Data for 20 Patients

Patients	Finger Site	Phalanx Site	No. Fractures	No. Attempts	No. K-wires	Inaccuracy Index	Length of Operation (min)	Fluroscopy Time (s)
1	Thumb	Proximal	1	2	2	1	13	22
2	Index	Middle	1	2	2	1	15	20
3	Middle	Distal	1	1	1	1	5	15
4	Middle	Proximal	1	3	2	1.5	16	25
5	Middle	Middle	1	2	2	1	13	16
6	Ring	Distal	1	1	1	1	6	15
7	Ring	Distal	1	1	1	1	7	16
8	Ring	Middle and proximal (2 fractures)	2	5	4	1.2	20	30
9	Ring	Middle	1	2	2	1	16	26
10	Ring	Middle	1	2	2	1	15	23
11	Ring	Proximal	1	2	2	1	18	21
12	Ring	Proximal	1	3	2	1.5	14	26
13	Ring	Proximal	1	2	2	1	15	16
14	Ring	Proximal	1	2	2	1	13	18
15	Ring	Proximal	1	2	2	1	14	20
16	Little	Distal	1	1	1	1	8	15
17	Little	Distal	1	1	1	1	7	15
18	Little	Middle	1	2	2	1	17	23
19	Little	Middle	1	2	2	1	16	27
20	Little	Proximal	1	2	2	1	14	28
Total				40	37			

tissue injury, as well as operative and fluoroscopy time, even if handled by junior-level surgeons because they are following a premarked trajectory. This is in agreement with the statement by Malik et al in a review article: procedure and radiation exposure time increase when a junior surgeon is performing the surgical fixation when compared with a senior surgeon, due to lower technical skills, less operative experience, and being worried of peer pressure and embarrassment,¹⁰ with average radiation exposure of 5–80 mrem, and average fluoroscopy time of 6–170 seconds. This is a descriptive study involving an innovative simple trick that is mainly intended to elaborate a new technique that could help in improving the accuracy of K-wire placements and thus, reduce the incidence of soft tissue damage, operative and fluoroscopy duration, and number of K-wire insertion attempts in the management of hand fractures even by junior surgeons or trainees.^{10,11}

CONCLUSIONS

Marking the trajectory before placing K-wires in the management of digital fractures is not described in the literature. This article describes a new technique that, when used as an adjunct to the classical approach of K-wire fixation, offers beneficial outcomes in managing digital fractures by minimizing wire insertion attempts and soft tissue injury.

RECOMMENDATIONS

1. This article aims to describe the feasibility of a simple trick in a common surgical procedure, practiced in almost all surgical centers that deal with hand fractures, and not to compare it with other surgical techniques.
2. Further studies with a larger sample size of value are needed to confirm our results.
3. Future studies comparing our method of K-wire fixation with the standard K-wire fixation method in regard to the factors assessed in our study will be of great value.
4. Elaborating the advantages of our technique over the blind placement technique in terms of accuracy, soft tissue injuries, and radiation exposure, in a large-scale blinded study is recommended.

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REFERENCES

1. Scott H. Kozin, MD, Joseph J, et al. Operative treatment of metacarpal and phalangeal shaft fractures. *J Am Acad Orthop Surg.* 2000;8:111–121.
2. Lögters TT, Lee HH, Gehrmann S, et al. Proximal phalanx fracture management. *Hand (N Y).* 2018;13:376–383.
3. El-Saeed M, Sallam A, Radwan M, et al. Kirschner wires versus titanium plates and screws in management of unstable phalangeal fractures: a randomized, controlled clinical trial. *J Hand Surg Am.* 2019;44:1091.e1–1091.e9.
4. Adams JE, Miller T, Rizzo M. The biomechanics of fixation techniques for hand fractures advances in pediatrics. Available at <https://www.ncbi.nlm.nih.gov/pubmed/24209948>. Published November 2013. Accessed August 11, 2018.
5. Rex C, Vignesh R, Javed M, et al. Safe corridors for K-wiring in phalangeal fractures. *Indian J Orthop.* 2015;49:388–392.
6. Lundin M, Woo E, Hardaway J. The cost of quality: open reduction and internal fixation techniques versus percutaneous K-wire fixation in the management of extra-articular hand fractures. Available at <http://www.alliedacademies.org/articles/the-cost-of-quality-open-reduction-and-internal-fixation-techniques-versus-percutaneous-kwire-fixation-in-the-management-of-extra.html>. Accessed August 11, 2018.
7. Singer G, Denver C. Radiation exposure to the hands from mini C-Arm fluoroscopy. *J Hand Surg Am* 2005;30A:795–797.
8. Bahari S, Morris S, Broe D, et al. Radiation exposure of the hands and thyroid gland during percutaneous wiring of wrist and hand procedures. *Acta Orthop Belg.* 2006;72:194–198.
9. Leaman C, Kotwal R, Williams P, et al. A simple tip to improve the inaccuracy of crossed K-wire placement in the management of displaced paediatric supracondylar fractures of the humerus. Available at <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3954292/>. Published November 2012. Accessed August 11, 2018.
10. Malik AT, Rai HH, Lakdawala RH, et al. Does surgeon experience influence the amount of radiation exposure during orthopedic procedures? A systematic review. *Orthop Rev (Pavia).* 2019;11:7667.
11. Kocaoğlu H, Kalem M, Kavak M, et al. Comparison of operating time, fluoroscopy exposure time, and functional and radiological results of two surgical methods for distal forearm fractures of both-bones in pediatric patients: is it necessary to fix both bones? *Acta Orthop Traumatol Turc.* 2020;54:155–160.