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Saudi Orthopedic Association

Journal of Musculoskeletal Surgery and Research

Article in Press

Original Article

Innovative modifications in the K-wires: A boon for resource-constrained orthopedic hospitals

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Received: 11 October 2024
Accepted: 13 December 2024
Epub ahead of print: 03 February 2025
Published:

DOI
10.25259/JMSR_453_2024

Quick Response Code:

ABSTRACT

Objectives: Kirschner wires (K-wires) in orthopedic surgery have stood the test of time. They have several advantages and very few disadvantages. Being the most used and easily available implant, K-wires are very important in this specialty. Certain hand and wrist surgeries require specialized implants, which can be costly and not readily available in smaller hospitals and lesser developed nations. The authors want to discuss improvisation in the K-wire design in the form of (1) the introduction of crimping in the K-wire to cut them in flush with the cortex to avoid the infection associated with the unburied K-wire left outside the skin. (2) Incorporation of a hole in the above-mentioned crimped wire to make a modified suture anchor. (3) The threads at the tip and the shaft of the wire will make it useful in maintaining the released thumb web.

Methods: Our study included 11 cases of crimped K-wires, eight cases with a hole (like a suture anchor), and five cases of threaded K-wires. Patients were followed up with radiographs, and a functional assessment was performed using mini disabilities of the arm, shoulder, and hand scoring.

Results: All patients had good radiological and functional outcomes with no implant-related complications reported.

Conclusion: K-wire modifications can be a game changer in small centers in developing countries. Our described modifications can be easily replicated, improving patient care by significantly reducing the cost of the treatment without compromising the final outcome.

Keywords: Crimping, K-wire, Modification, Suture anchors, Thumb web contracture

INTRODUCTION

Martin Kirschner, a surgeon from Heidelberg currently in Germany (1879–1932), described the stainless steel (SS) wires for the first time in 1909 and used them in pairs, one above and the other below the fracture site, mainly to obtain distraction and avoid overlapping in the management of fractures.[1,2]

It is now commonly used in orthopedics, especially in hand and foot surgeries.[3] That can be used as an implant, which can be removed easily after it has served its purpose (while reducing a fracture intraoperatively or fixation, which needs the Kirschner wires [K-wires] to be there for a

How to cite this article: Kamath JB, Kamath RK, Mane PP, Jayasheelan N, Jain M. Innovative modifications in the K-wires: A boon for resource-constrained orthopedic hospitals. J Musculoskelet Surg Res. doi: 10.25259/JMSR_453_2024

few weeks) or stay permanently, such as in arthrodesis cases where the K-wires are left *in situ*. Ideally, it has a body and two tips. The tips can be trocar-tipped or bayonet-tipped. The trocar-tipped is ideally used in epi- or metaphyseal regions. The bayonet-tipped is used ideally in the diaphyseal regions, especially when used along with Illizarov's apparatus for obtaining the bony purchase. The body can be smooth or threaded, depending on the site and function it is used for. They can be either called Schanz or Denham pins.[2,4,5] K-wires normally come in 1 mm–2.5 mm; however, you can also get 0.6 and 0.8 mm if required. The commonly used in hand surgery are 1.0, 1.2, and 1.6 mm for phalangeal and metacarpal fixations. Sometimes, it is also available in fully threaded forms. It generally comes 6 or 12 inches long with one or both sides pointed.

It can be used as an implant, instrument, or part of an ex-fix [Joshi's external stabilization system (JESS), Suzuki frame, etc.]. Surgeons have used them as an implant alone or with other implants like SS wire. They can be used as single or multiple implants (parallel or criss-cross configuration). Some have used them as an instrument for decompressing acute osteomyelitis, as a drill bit (supposed to be more biological than the drill bit itself), or to make a cortical window.[2] They are supposed to be very low profile and easy to remove.

Some advantages of K-wires are that they are versatile, can be used as closed/open methods or isolated/combination methods, and are readily available and cheap. The ease of inserting a K-wire with minimal injury to soft tissue is what makes it one of the most widely used orthopedic implants.[2,6,7]

Although the K-wires are the workhorse in hand, foot, pediatric, and general orthopedics, they are not a panacea.[8] Some disadvantages of the K-wires are that they do not provide rigid fixation nor inter-fragmentary compression. Other possible complications are pin-track infection/loosening and impaling soft tissue (e.g., hand extensor tendons). If the K-wire has to be maintained for more than 3–4 weeks, it is recommended that it should be buried under the skin, which warrants one more surgery for the removal. The blunt K-wire tips protruding outside may be protected by the round K-wire balls (small, rounded JESS Clamp-like instruments) or protectors. This will prevent accidental migration and harm to other body parts like eyes. Infection associated with unburied K-wires is a menace that has brought in its own classification. Soft-tissue impaling comes in the way of early mobilization both mechanically and due to the pain.[3,9] Early K-wire removal due to pin-tract infection may result in non-union or decreased fracture or arthrodesis site stability, resulting in poor outcomes. Considering these issues with the K-wires, the authors describe the clinical use and the benefits of three K-wire modifications in hand practice.

MATERIALS AND METHODS

This prospective study was conducted in a tertiary hospital catering to hand and microvascular injuries. The study period was between 2021 and 2024. Our study included 11 cases of crimped K-wire, eight cases of crimped K-wire with a hole, and five cases of threaded K-wires. All patients were clinically followed up regularly for six months. However, radiographs were followed up only till six months following the surgery. Functional range of movements and radiographs were assessed at the follow-up time, and mini-disabilities of the arm, shoulder, and hand scoring were done at the last follow-up.

Inclusion criteria

Our study included patients with small joint arthritis needing arthrodesis, fractures of the phalanx and metacarpal, soft-tissue injuries of the hand needing staged reconstruction, and capsular/ligamentous injury.

Exclusion criteria

Patients who lost to follow-up were excluded from the study.

Modification of crimped K-wires

In cases of arthrodesis or fractures where the rest of the hand has to be mobilized early, one can avoid leaving the tips of the K-wire outside or burying those K-wires for later removal. The surgeon can use a pre-crimped wire or crimping (on the table) of the K-wires. A 14-gauge hollow needle or a small sleeve will help cut the wire intraoperatively flush with the outer cortex [Figure 1]. This may be ideal in cases where uninterrupted early movements with a splinted arthrodesed joint or a fixed fracture are desired. The drawback is that the wires are difficult to remove even if one wants to remove the wires. However, if one needs to remove them due to infection, it will be relatively easy to remove. The pre-existent crimping makes the break in the K-wire easy and exact. For this reason, a K-wire made out of titanium is ideal, though it is much more difficult to crimp titanium metal both preoperatively and on the table [Figures 2-4].

Crimped K-wire with a hole (Buried headless K-wire) as a suture anchor

Reattachment of an avulsed ligament or a tendon, traumatic or surgical, has always been a problem in orthopedics and hand surgery. Sometimes, it is important to reattach the ligament, capsule, or tendon to restore form and function. We have introduced a hole in the K-wire about 2 mms proximal to the crimping toward the tip to use the same as a suture anchor. The hole is big enough to accept a 2-0–4-0 absorbable or non-absorbable suture material to be used as

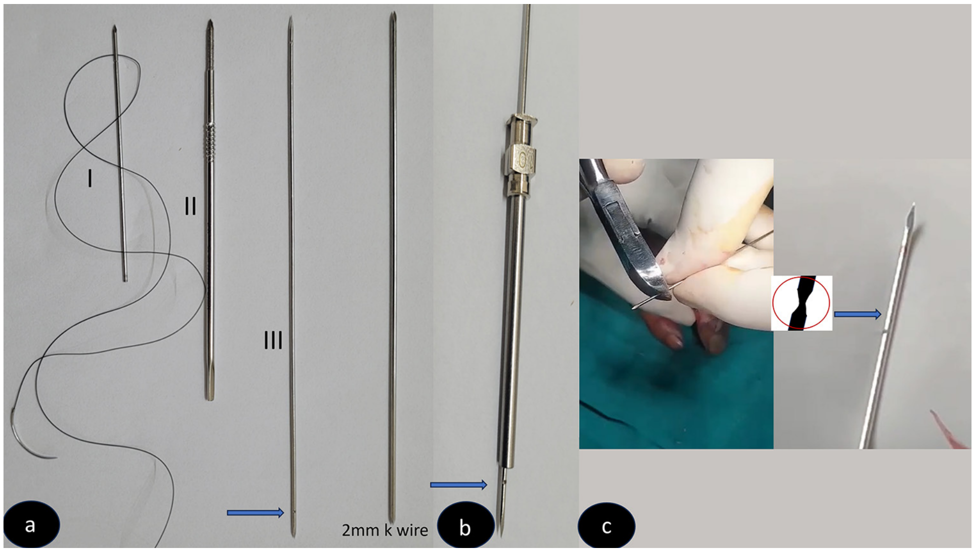

Figure 1: (a) Photo showing our three modifications of K-wire compared to a normal 2 mm K-wire (I – Crimped wire with a hole, II – Crimped wire with differential threads at proximal and distal level, and III – 1.2 mm crimped K-wire). (b) Cutting the crimped wire flush with the outer cortex with a hollow needle (anything more than 14-gauge). (c) On table crimping of the K-wire (Note: Crimping should not be more than 1/3rd of the diameter [blue arrow]. Zoomed image showing the crimping in a circle).

Figure 2: (a) Clinical picture showing untreated dislocation of distal interphalangeal joint of the right ring finger. (b) Anteroposterior and lateral radiographs confirming the distal interphalangeal joint dislocation. (c) Intraoperative pictures showing the cross-crimped wires cut flush to the outer cortex. (d) Intraoperative pictures showing no deformity (case done under wide awake hand surgery). (e) C-Arm pictures with a satisfactory position of K-wires. (f) Two-year follow-up radiographs showing good fusion of distal interphalangeal joint and no migration of the K-wires. (g) Clinical picture showing no deformity.

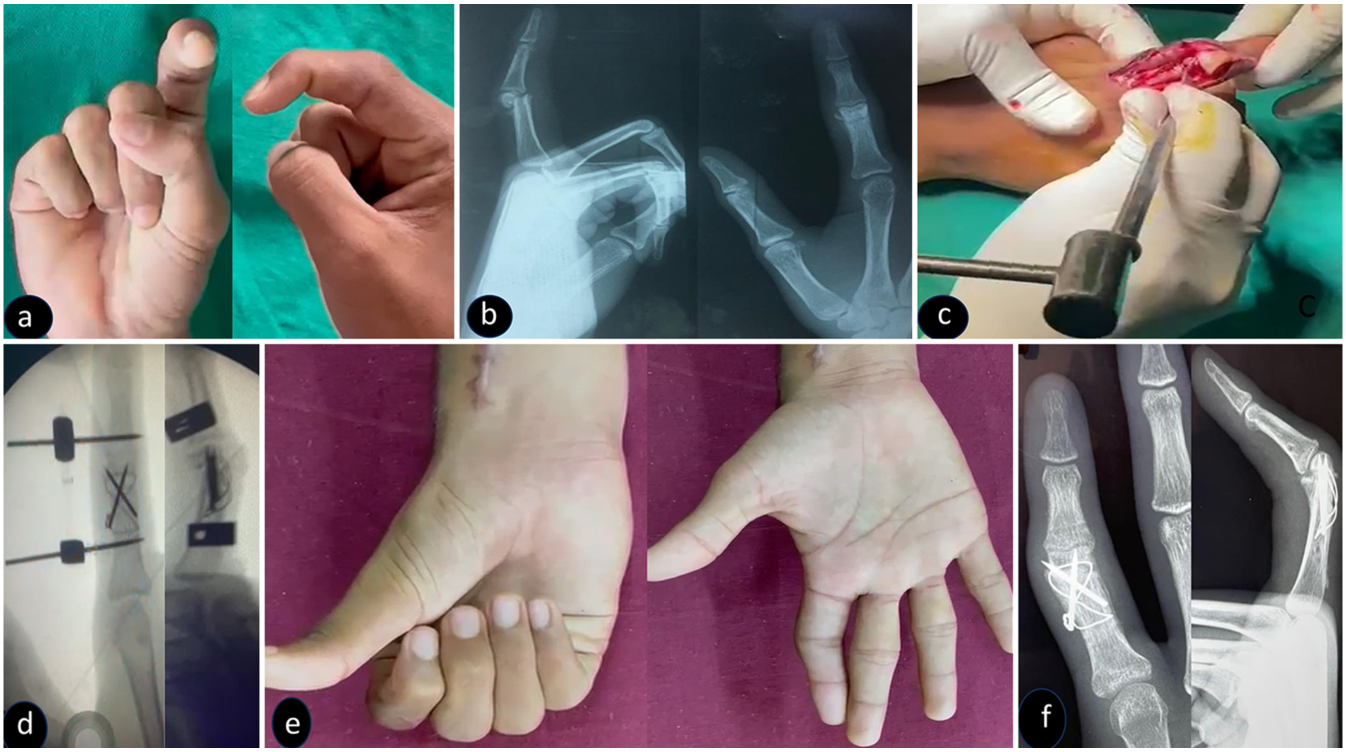

Figure 3: (a) Clinical picture showing deformity of proximal interphalangeal joint and a good range of movement at distal interphalangeal joint. (b) Radiograph showing malunited fracture of neck of proximal phalanx of the index finger. (c) Intraoperative picture showing osteotomy of the fracture site. (d) Intraoperative C-arm picture showing cross crimped K-wire with a figure of "8" stainless steel wire (28-gauge) to fix the osteotomy. (e) One-year follow-up picture showing a decent range of movement at the proximal interphalangeal joint. (f) One-year follow-up radiographs showing good union of fracture site with no migration of K-wires into the joint.

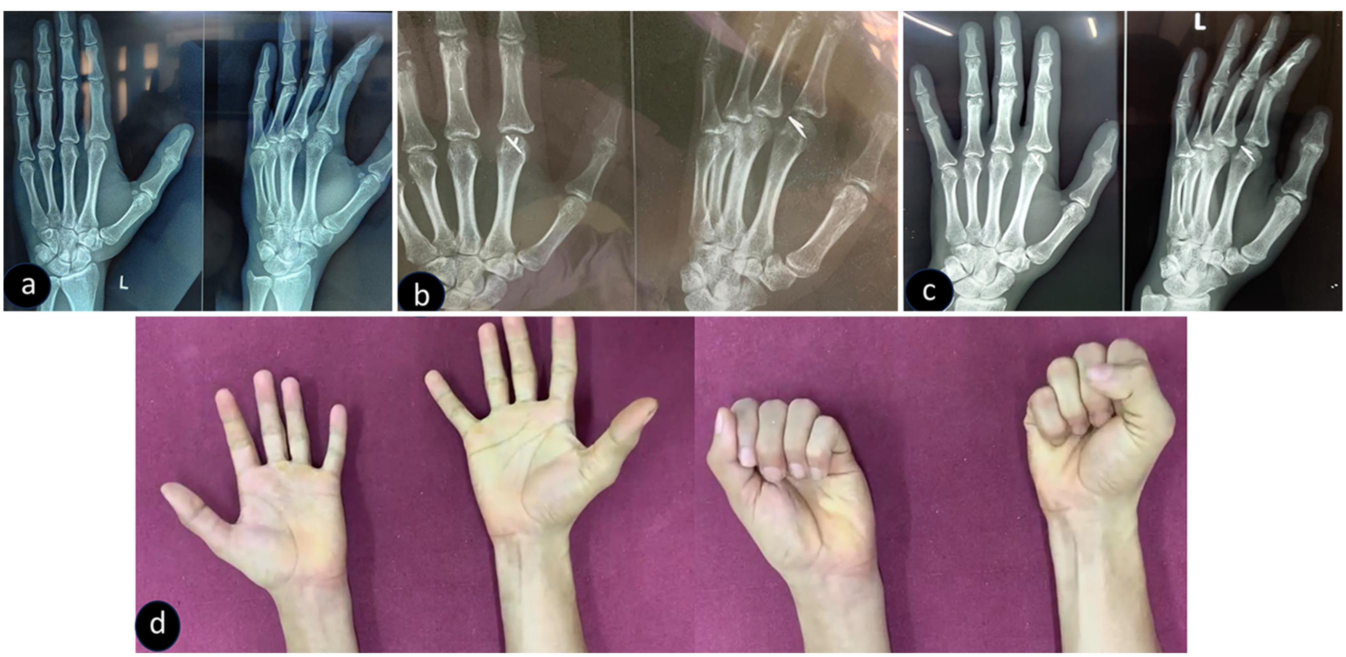

Figure 4: (a) Radiograph showing second metacarpal head fracture with a sliver of bone (associated with extensor tendon and capsule injury). (b) Immediate post-operative radiograph showing fracture of 2nd metacarpal head fixed with crimped wires. (c) One-year follow-up radiograph showing healed fracture with no wire penetration into the joint. (d) One-year follow-up clinical picture showing a good range of movement at the metacarpophalangeal joint.

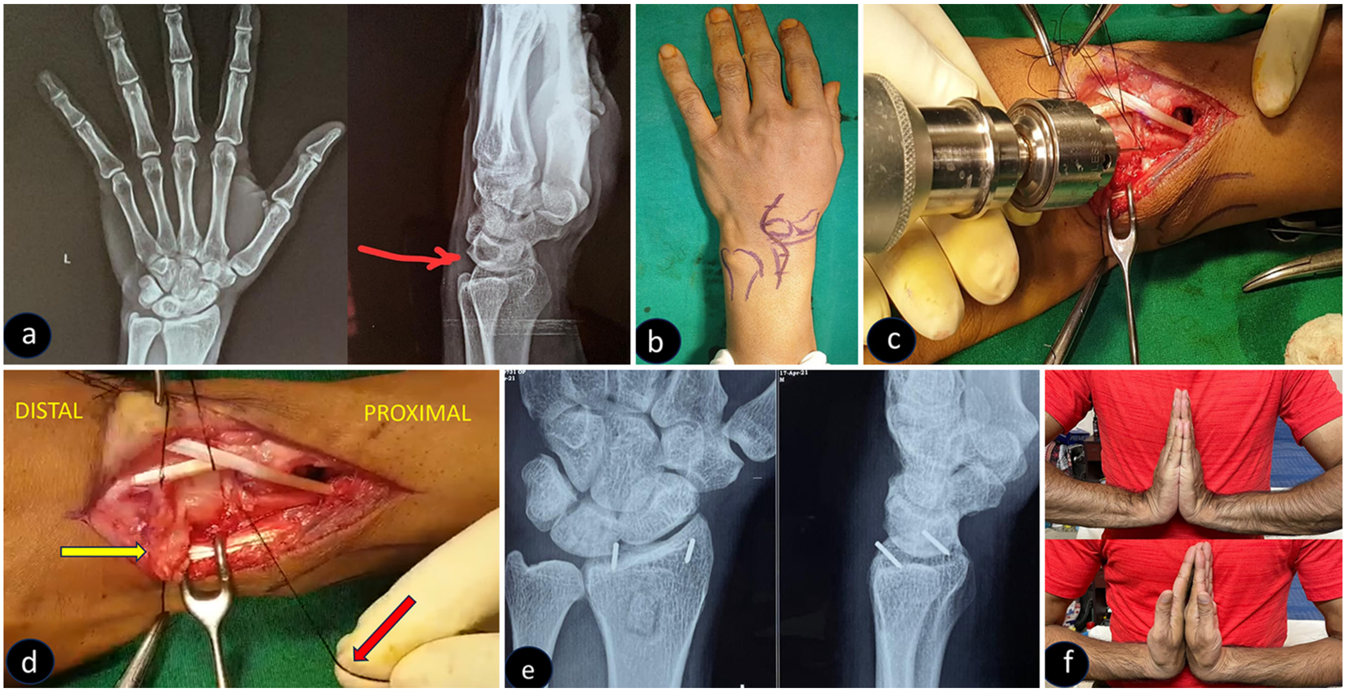

Figure 5: (a) Radiograph showing lytic lesion of lunate bone in anteroposterior and lateral views (red arrow). (b) Clinical picture showing the planned surgical incision. (c) Intraoperative picture showing the introduction of our suture anchor. (d) Intraoperative picture showing distal-based dorsal capsular reflection (Yellow pointer). Picture of an anchor being pulled by the surgeon (Red pointer). (e) Two-year follow-up radiograph showing healed lytic lesion of the lunate and healed bone graft donor site. (f) Two-year follow-up clinical picture showing a good range of movement at the wrist joint.

Table 1: The usage of crimped K-wires in various hand and wrist surgeries.

Case Number	Diagnosis	Procedure	Functional outcome using Quick DASH score	Radiographs	Complications
Case 1	Right ring finger DIP dislocation with arthritis	DIP joint arthrodesis	9.1/100	Complete Fusion achieved	None
Case 2	Index finger proximal phalanx head split fracture with non-union	ORIF with SS wire	11.4/100	Union achieved	Stiffness at PIP joint
Case 3	Right thumb Bennett's fracture	ORIF	18.2/100	Union achieved	None
Case 4	Left 2nd metacarpal head fracture	ORIF	15.9/100	Union achieved	None
Case 5	Right middle finger middle phalanx intra-articular fracture	ORIF	20.5/100	Union achieved	Stiffness at MCP joint
Case 6	Left little finger PIP joint arthritis	Arthrodesis	25/100	Complete fusion achieved	None
Case 7	Left 5th metacarpal head split fracture	ORIF	15.9/100	Union achieved	None
Case 8	Base of 5th metacarpal fracture	CRIF	9.1/100	Union achieved	None
Case 9	Ring finger PIP joint flexion deformity with arthritis	PIP joint arthrodesis	30.5/100	Complete fusion achieved	None
Case 10	5th metacarpal neck fracture	ORIF	11.4/100	Union achieved	None
Case 11	Right thumb Roland fracture	ORIF	18.2/100	Union achieved	None

ORIF: Open reduction internal fixation, CRIF: Closed reduction internal fixation, PIP: Proximal interphalangeal, MCP: Metacarpophalangeal, SS: Stainless steel, DIP: Distal interphalangeal, DASH: Disabilities of the arm, shoulder, and hand

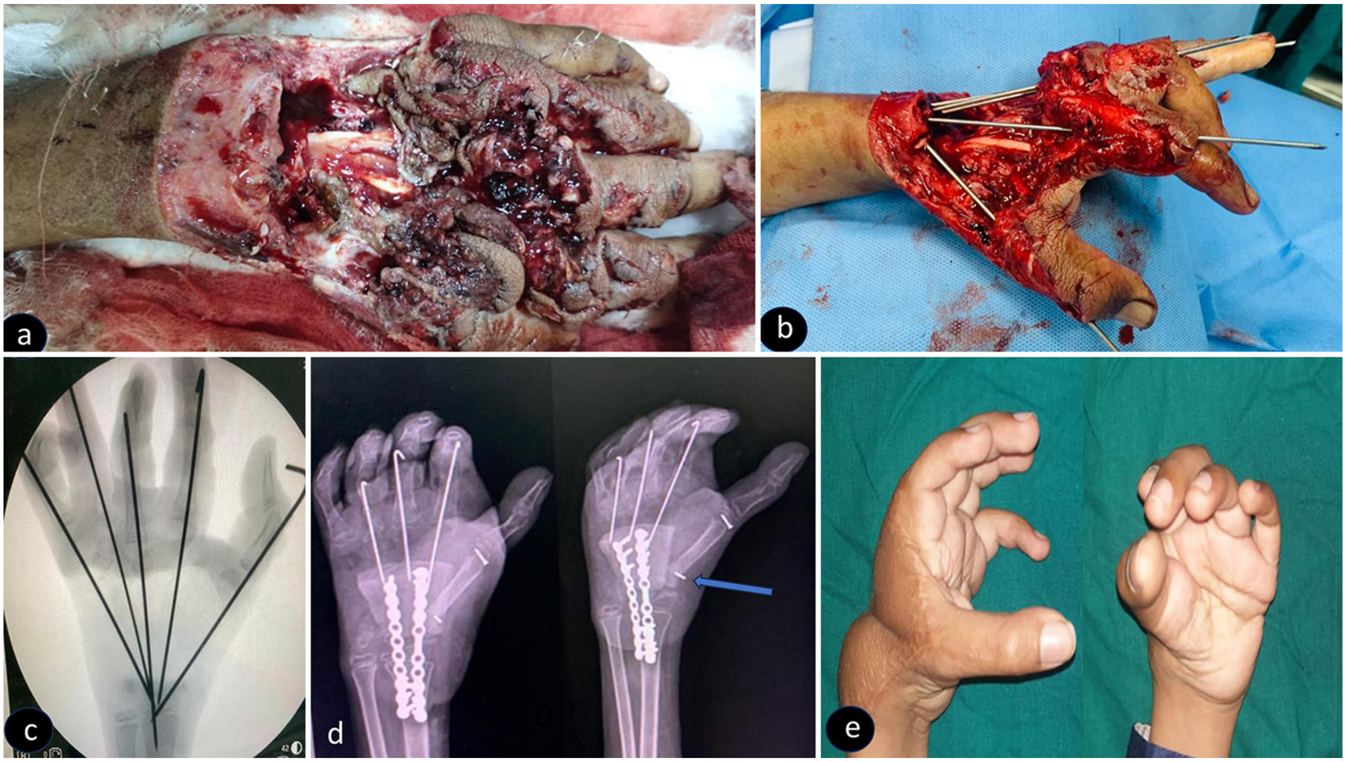

Figure 6: (a) Clinical picture of a young boy with a crush injury resulting in dorsal composite tissue loss over the left hand. (b) Intraoperative picture showing debridement and K-wire fixation to maintain the length of the metacarpal bone. (c) Radiograph showing reconstruction following groin flap, tricortical iliac crest graft, and reversed 4th metatarsal for the reconstruction of first metacarpal. (d) The abductor pollicis longus tendon was secured to the base of the newly constructed first metacarpal with our suture anchor (Blue pointer). (e) Clinical picture showing the follow-up at 1-1/2 years.

a suture anchor. One can pre-drill a hole with 1 or 1.2 mm ordinary (holeless) K-wire to use a 1.2- or 1.5-mm K-wire with a hole to be used as a suture anchor. The final insertion of the K-wire with a hole should be used either with a drill or a "T" handle with the chosen suture material already fed into the hole to be used as a suture material for soft-tissue repair. The "T" handle is better as it avoids the bunching of the suture material. In very osteoporotic bones, one may avoid any pre-drilling. We have used this modification effectively for reattaching the capsule [Figure 5] and a ligament [Figure 6].

The above two modifications are quite handy and useful, though the removal may be difficult. The authors have not had any difficulty so far, and especially in arthrodesis, the implant may not be removed, just like the cannulated headless screws. When used properly, we had no problem with the wire cutting. When 1.00- or 1.2-mm wires are used, breaking them is easier than bending them. We have also not experienced any accidental breaks in the wires, especially when the implants are used as suture anchors. Nearly, two years of follow-up has proved that these fears are only theoretical.

K-wire to maintain the space between the two metacarpals (for opening the thumb web contracture)

K-wires with threads in two or multiple areas along their length can maintain the space between the metacarpal bones before covering the raw area with a split skin graft or flap cover [Figure 7]. Trauma or burns may affect the thumb web, leading to contracture. The minimum inter-metacarpal angle between the 1st and the 2nd metacarpals should be 45–50°.[10] So once the thumb web is opened, the resultant raw area generally needs a flap cover. Maintaining the angle between the two metacarpals following the release is important, as it must be maintained by a wire with two different threads. The threads near the tip can purchase the second metacarpals, and the more proximal (to the drill) threads will take the purchase of the first metacarpal bone. The intervening non-threaded part of the K-wire can be as long as 15–20 mm, depending on the age and the release of the thumb web. The threaded portions can be 12–15 mm long, depending on the size of the metacarpals. At this juncture, the modified K-wire will be ideal and handy instead of passing the smooth K-wire across the 1st carpometacarpal (CMC) joint, causing stiffness and incomplete maintenance of the released thumb web. As the wires are threaded, the K-wires need to be removed with a drill once the flap settles and takes up well. Our experience suggests that a wire across the 1st CMC can reduce the movements, and it is better to have a wire with the threads between the 1st and the 2nd metacarpals, keeping the thumb web wide open for maintenance of the thumb web when a flap or split skin graft is used to cover the raw area.

RESULTS

All the patients included in our study were followed up for six months. Radiographical and functional assessment was assessed. Radiographs revealed satisfactory union in all the cases where crimped K-wire was used as a headless screw [Table 1]. All eight cases had good outcomes when a K-wire with a hole was used for capsular repair [Table 2]. All five with 1st web space contracture had good maintenance of 1st web space when a K-wire with thread was used to stretch the 1st web space [Table 3].

DISCUSSION

The authors have modified the existing K-wire to suit the need in orthopedics and hand surgeries and optimize the usefulness of the age-old and time-tested implant described in the literature. The standard headless screws, suture anchors are expensive and are not readily available in most of the underdeveloped countries. Our modifications have not been described in any English journals to the best of the author's knowledge, and the surgeons can use them as required to suit the purpose. These modifications can be easily replicated

Table 2: The usage of crimped K-wire with a hole (Buried headless K–wire) as a suture anchor in various hand and wrist surgeries.

Case number	Diagnosis	Procedure	Functional outcome using Quick DASH score	Radiographs	Complications
Case 1	Left wrist lunate lytic lesion	Curettage, bone grafting	6.8/100	Consolidated lesion	None
Case 2	Right wrist perilunate dislocation	Open reduction K-wire fixation with capsule repair	22.7/100	Satisfactory reduction	Stiffness of wrist joint
Case 3	Left 2nd MCP joint capsular bony avulsion	Capsular repair	15.9/100	Satisfactory union	None
Case 4	Left distal radius GCT	Excision, acrylic prosthesis and capsule repair	30.5/100	No recurrence	None
Case 5	Left scaphoid waist fracture non union	ORIF, bone grafting with capsular repair	34.1/100	Satisfactory union	Stiffness at wrist joint
Case 6	Right scaphoid intraosseous ganglion cyst	Curettage, bone grafting and capsular repair	27.3/100	Consolidated lesion	None
Case 7	Left volar rim distal radius fracture	ORIF with plate fixation and capsular repair	22.7/100	Satisfactory union	None
Case 8	3rd metacarpal head split fracture with capsular avulsion	ORIF with capsular repair	15.9/100	Satisfactory union	None

GCT: Giant cell tumor, MCP: Metacarpophalangeal, DASH: Disabilities of the arm, shoulder, and hand, ORIF: Open reduction internal fixation.

Table 3: The usage of threaded K-wire in various hand and wrist surgeries.

Case number	Diagnosis	Procedure	Functional outcome using Quick DASH score	Complications
Case 1	Left hand burns injury with 1st web space contracture	Contracture release, groin flap	38.6/100	None
Case 2	Left hand crush injury with multiple metacarpal fractures	Debridement, abdomen flap and K-wire	40.3/100	Stiffness of MCP joint
Case 3	Right hand firecracker burst injury	Debridement, abdomen flap and K-wire	40.9/100	Stiffness of MCP joint
Case 4	Left hand crush injury with 1st webspace contracture	Contracture release, groin flap	38.6/100	Stiffness of the interphalangeal joint of thumb
Case 5	Right hand post burns contracture	Contracture release, groin flap	47.7/100	None

MCP: Metacarpophalangeal, DASH: Disabilities of the arm, shoulder, and hand

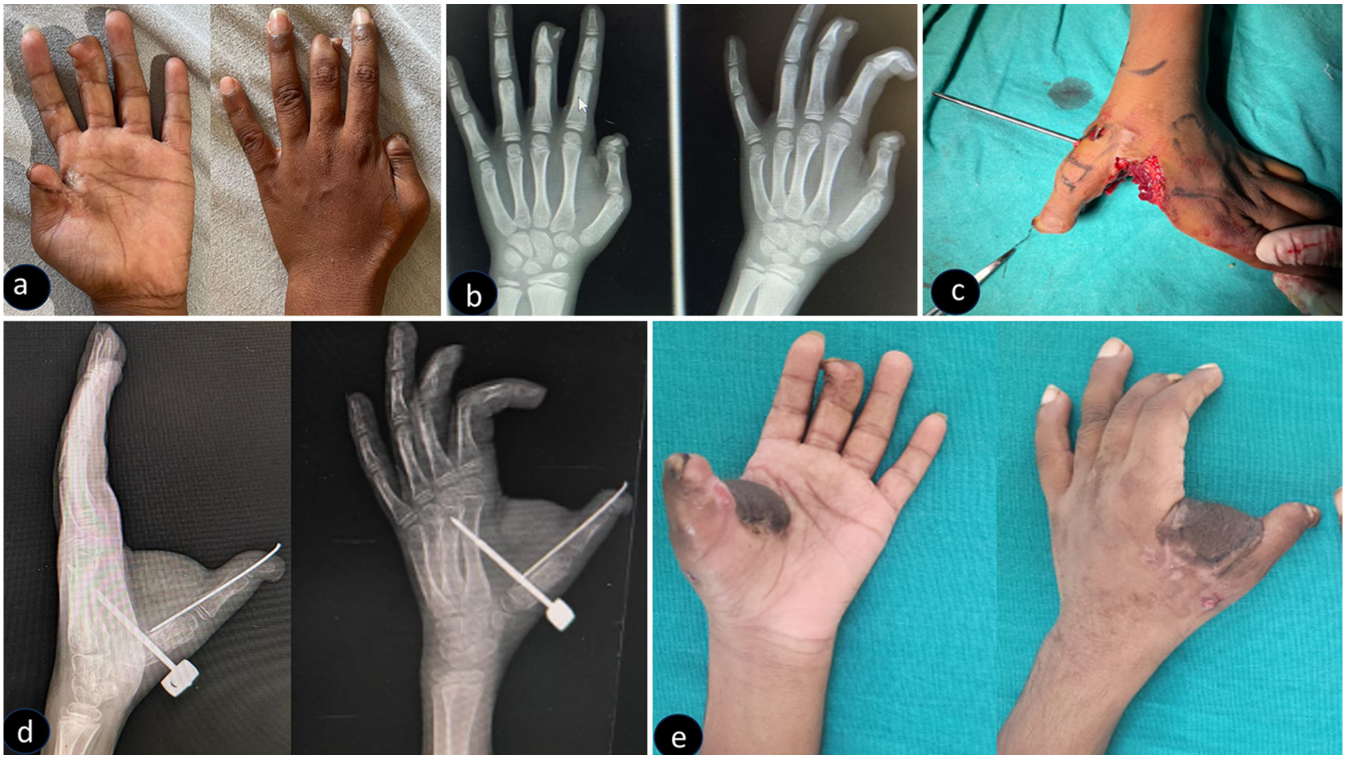

Figure 7: (a) Clinical picture showing left first webspace post burns contracture. (b) Radiographs showing decreased intermetacarpal angle between 1st and 2nd metacarpals. (c) The contracture was released and maintained with our modified K-wire with two threaded portions, and groin flap coverage was done. (d) Radiograph showing maintained intermetacarpal angle between first and second metacarpals. (e) Clinical picture at a six-month follow-up with maintained 1st webspace.

in any center that manages orthopedics and trauma cases. Moreover, unlike the costly implant, these modifications do not add to the expenses of the patients. They also provide functional results similar to those of a standard implant.

The smaller sample size, the short duration of follow-up, and the lack of biomechanical assessment or comparison with standard instruments are the major limitations of our paper. The authors would want to do a comparative study between the standard implants and their modifications in the near future.

CONCLUSION

Modification of K-wires can be used in managing certain procedures in resource-limited centers and developing countries. Our described modifications can be easily replicated, which can benefit patients by significantly reducing the cost of the treatment without jeopardizing the functional outcomes.

RECOMMENDATIONS

The authors strongly recommend these changes, which can be easily followed in smaller centers that do not have the standard inventory.

AUTHORS' CONTRIBUTIONS

BJK, KRK, PPM, and MJ: Conceived and designed the study, conducted research, provided research materials, and collected and organized data. MJ, NJ, and PPM: Analyzed and interpreted data. BJK, KRK, MJ, and PPM: Wrote the initial and final draft of the article and provided logistic support. All authors have critically reviewed and approved the final draft and are responsible for the manuscript's content and similarity index.

ETHICAL APPROVAL

Ethical approval is taken from the Institutional Ethical Committee of Kasturba Medical College, Mangalore (IEC KMC MLR 08/2021/519), dated August 22, 2021.

DECLARATION OF PATIENT CONSENT

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patients have given their consent for their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published, and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY FOR MANUSCRIPT PREPARATION

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

CONFLICTS OF INTEREST

There are no conflicting relationships or activities.

FINANCIAL SUPPORT AND SPONSORSHIP

This study did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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