Technique Report

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Management of complex wrist fractures with volar and dorsal locked (double-locked) K-lock

Prieur du Plessis, MD[a,*], Marie-Cecile Fournier, PhD[b]

Abstract: This article is a technical note to outline a novel technique of fixation in complex, comminuted distal radius fractures using a double-locked K-wire construct using a new implant called K-lock. In these (AO) C-type fractures, with significant dorsal comminution, it is often difficult to attain stable and secure fixation of the dorsal rim fragments, especially the dorsal lunate fossa fragment. This often results in patients being treated by temporary spanning devices or asking to have a restricted use of the hand during a given period to avoid loss of position. If dorsal plating is necessary, because of the severity of the comminution, a double-locked K-wire (locked in both the dorsal and volar plates) offers a fixation option and may create a significantly stronger construct and allow confident early mobilization. The K-lock was recently launched by Newclip Technics as an adjunct to the Xpert Wrist 2.4 set as a fragment-specific fixation option. The wire has less chance of displacing or fracturing the fragment and has a smooth surface compared with a screw; this wire would be safer close to the joint in severe distal intra-articular comminution. Of the 9 cases performed so far (as is our usual practice), despite the complexity of the fractures, none were immobilized postoperatively and all started hand therapy in the first week. Most were driving by 2 weeks and returned to light work at 4 weeks and heavy work or sports at 6 to 8 weeks. This principle of fixation may also be extended to other fractures where dual plating is used.

Key Words: distal radius fracture, volar locking plate, dual approach, fracture specific

1. Introduction

There is still a wide variation in the treatment of wrist fractures. Most fractures, if requiring surgery, can be stabilized from the volar aspect with a volar locking plate. This would be the standard choice of most surgeons.[1] In severely comminuted fractures with dorsal fragments, especially in the intermediate column, a dual approach may be required with both volar and dorsal fixation.[2–4] These fracture patterns usually include a free dorsal lunate fossa fragment, and stabilizing this column is essential to the maintenance of radial length and congruency of the joint.[5] These fractures also often involve the sigmoid fossa of the distal radioulnar joint. Restoration of this joint relative to the ulna is important for functional recovery because it is essential for pronation and supination.[1,6] Currently, this is performed using locking plates. In these highly comminuted fracture patterns, when stabilization of the dorsal fragments cannot be achieved from the volar side or the fragments are too small and too distal to accept a screw, this technique may be very useful. This article illustrates a slight variation of the existing techniques by locking a fine wire with a specific "locknut" (the K-lock) into the volar and dorsal plates to produce a stable construct. Early mobilization is desirable in these cases, and with some fixation techniques, spanning external fixators or casts are used for a few weeks postoperatively to protect the construct and avoid position loss.[4,5,7] This new fixation may provide enough stability in these catastrophic fractures to avoid postoperative immobilization and allow confidence in the construct for early mobilization.

2. Typical clinical indications

The proposed technique focuses on severely comminuted fractures with very small fragments (specifically dorsally) for which volar plates seem insufficient.[8] We have found a bimodal distribution across age groups in these fractures such as younger patients with high-energy injuries and older patients with osteoporotic bone but similar fracture configurations. Representative examples are shown in Figure 1A and B, and a video is available in supplementary materials (http://links.lww.com/OTAI/A86). Only patients older than 20 years were eligible for the technique.

3. Surgical anatomy

The volar approach is standard. The pronator quadratus is dissected by sharp dissection, which allows for repair (if possible/surgeon preference) after fixation is completed.

Dorsally, the area mostly concerning in this technique is the dorsal ulnar column, which lies beneath the fourth extensor compartment. The dissection of this compartment is performed subperiosteally to allow a layer of tissue between the tendons and the plate construct when closure is performed.

4. Surgical technique

In 2020, the K-lock was made available as an adjunct to the set to enhance options for fragment-specific fixation, especially

P.d.P. is consulting for Newclip Technics. M.-C.F. is a paid employee of Newclip Technics.

[a] Wairau Hospital, Blenheim, New Zealand, [b] Newclip Technics, Haute Goulaine, France

** Corresponding author. Address: Wairau Hospital, PO Box 1141, Blenheim 7201, New Zealand; e-mail address: prieurdup@icloud.com (P. du Plessis).*

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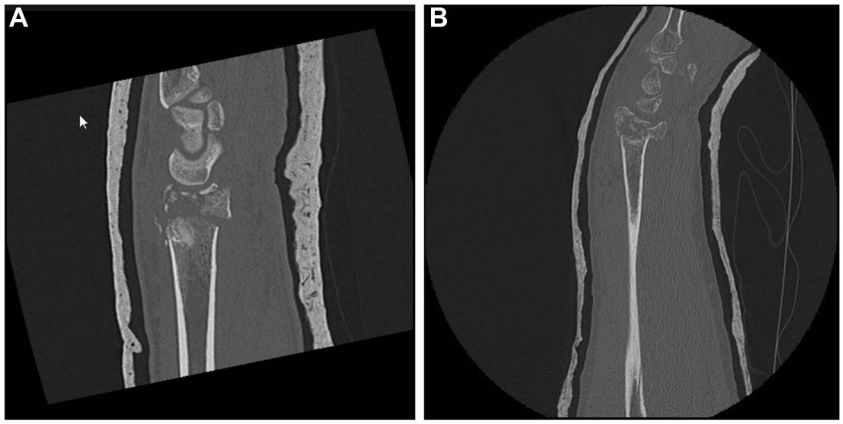

Figure 1. Sagittal CT scan showing dorsal comminution obtained from 2 patients.

for smaller fragments. The K-lock, allowing to lock a pin to the plate, has been used conventionally, as intended by the company, in several cases with good results (Figs. 2 and 3). A thought process then developed around the possible enhancement in construct strength by double locking the K-lock wire (volar and dorsal plates), for severely comminuted fractures for adequate reduction and rigid fixation.[2–4,9] All patients were operated on using the Newclip Xpert Wrist 2.4 set and K-lock (Fig. 4).

Most surgeons who deal with distal radial fractures prefer to fix from one side (mostly volar). However, there is a cohort of patients with significantly comminuted fractures where rigid fixation of the dorsal aspect of the distal radius is difficult to achieve with volar fixation only.[10] These difficulties are usually because of small, unstable dorsal joint fragments and fracture lines very close to or into the articular surface; locked screws placed from the volar aspect may not achieve sufficient purchase in these fragments.

All patients were examined with Computed Tomography (CT) scan as part of the preoperative planning stage and consented for the possibility of a dual-approach surgery. All patients also gave written informed consent to participate in the research, and the principles outlined in the Declaration of Helsinki have been followed. The study was deemed exempt from Institutional Review Board and Animal Use Committee Review because of the prospective and observational nature of the study.

Figure 2. Anteroposterior view of a conventionally used K-lock.

Figure 3. Lateral view of a conventionally used K-lock.

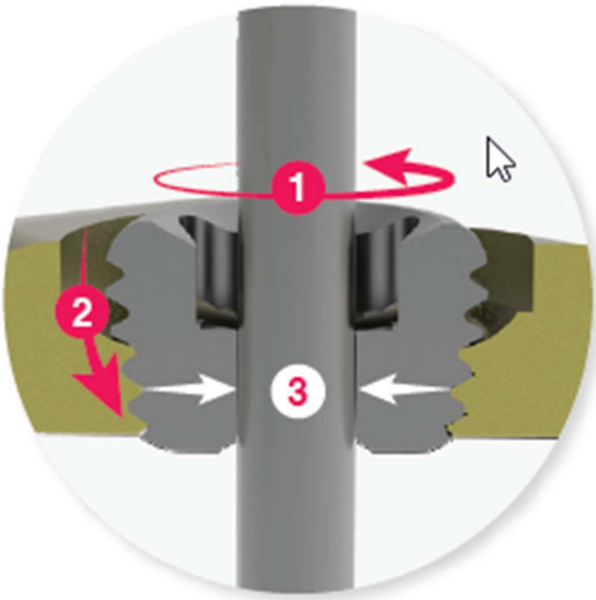

Figure 4. Presentation of the K-lock system.

5. Procedure

All patients were under general and/or regional anesthesia and used tourniquet. First, a flexor carpi radialis (FCR) approach is made to the distal radius. Using various techniques, as per usual procedure, the fractures are reduced and volar plates applied.

In all 9 patients, it was apparent that rigid fixation of the dorsal aspect of these fractures could not be achieved from volar fixation alone. This assessment is often made in the preoperative planning phase; however, sometimes the instability becomes more apparent intraoperatively.

The dorsal approach is made through the usual approach between the extensor pollicis longus tendon and the fourth compartment with subperiosteal dissection as far as possible to the desired position where stability is required. A hole is then selected distally on the volar plate, and the K-wire is drilled through the plate and dorsal fragment under vision and image-intensifier guidance. The wire is placed sufficiently proximal on the dorsal fragment to allow some room for the distal edge of the plate.

Figure 5. Intraoperative X-ray with a couple of temporary fixation wires, the clamp in place, and the K-lock advanced through both dorsal and volar plates.

A dorsal plate is then placed, with a distal hole over the wire, and secured proximally with a cortical screw in the distal end of the sliding hole. Fine-tuning of the reduction is achieved using a combination of a distal radial reduction clamp on both plates and sliding the dorsal plate distally to increase palmar tilt by pushing the K-wire distally as a joystick. The ball-tipped clamp, ANC1105, Newclip Technics, similar to the one described by Lans et al,[11] also achieves compression over the coronal plane fracture. Depending on the fracture configuration, the volar side of the K-wire can be locked first to ensure a lever effect dorsally. Once reduction is achieved and compression is applied, the dorsal side of the K-lock is locked. The sequence of locking and adjusting can be varied depending on the fracture configuration. The wire is pliable, and a slight

TABLE 1

A subjective questionnaire was given to all patients to assess return to function

Participant	Sex	Age (y)	Light use of fingers and hand (days)	Driving (days or weeks)	Light work (weeks)	Return to heavy work or sports (weeks)
CA	M	26		Lost to follow-up		
FJ	F	71	1	3 weeks	3	4–5
MS	M	91		Deceased (18 months) but played violin from 2 weeks postoperatively		
DS	M	65	1	2 weeks	5	7
SH	F	35	7	4 weeks	6	8
ML	F	51	1	3–4 days	4	6
CG	F	73	1	6 days	2	12
CC	F	65	7	6 weeks	7	12
LF	F	67	5	3 days	6	6

Of note, all patients were encouraged to use their hands from immediately postoperatively. Driving is a good indication for us because it is a rural community and everyone is reliant on personal transport. The 2 patients who drove later only did so because they were advised by their primary health practitioners to wait. These times for return to function are not unusual for wrist fractures which have been stabilized. It is, however, noteworthy that all these patients had significantly comminuted unstable fractures, which usually take longer to return to function.

TABLE 2

Functional results for the 7 operated patients who performed their follow-up

Participant	Q dash score	Composite grip	Grip strength (kg)*	Flexion (°)*	Extension (°)*	Supination (°)*	Pronation (°)*	Push (kg)*	NPRS	GRC
FJ	9.09	Full	15/18	60/60	30/45	50/56	90/90	22/28	0	+5.0
DS	9.09	Full	45/48	55/80	50/50	80/90	45/45	22/25	1	+4.0
SH	0.0	Full	28/32	45/45	50/50	85/90	90/90	35/35	1	+4.5
ML	15.0	Full	29/35	50/60	45/50	85/90	90/90	30/35	1	+4.5
CG	4.55	Full	18/15	45/45	45/45	30/30	90/90	12/15	2	+5.0
CC	15.0	Full	25/30	45/50	45/50	80/80	90/90	25/35	0	+4.5
LF	4.54	90%	15/30	50/50	30/90	70/90	90/90	10/20	0	+4.0

With the help of the hand therapist, Quick Dash[8] (Quick Disability of the Arm, Shoulder, and Hand questionnaire) score functional measurements were performed. Points ranged from 0 to 100 (no disability−severe disability, respectively). A Numeric Pain Rated Scale (NPRS), ranged from 0 ("no pain") to 10 ("the worst pain imaginable"), and a Global Rate of Change (GRC) score (rating from −5 to 5 with 0 the reference value at surgery and 5 a normal feeling, corresponding to a total recovery) were also used.
* Expressed for the operative side over the nonoperative side.

bend is sometimes visible after locking. This can augment the contouring of small fragments of the joint itself. The locking holes are forgiving enough to not necessitate the exact position of the wire in the locking hole.

Various configurations of locking screws and more K-locks are then used to secure the remaining fragments as needed. The K-wires are cut flush and then impacted with the designated punch before locking. An artificial bone void filler (Bonalive putty) is used to fill the resultant dorsal void created by the reduction of the dorsal fragments. Soft-tissue closure is then performed and a bulky bandage applied. The final assembly is shown in Figure 5.

6. Postoperative management

In accordance with our usual practice (despite fracture complexity), no postoperative immobilization was used, with hand therapy commencing in the first week, allowing free use of the hand and wrist with loading only from week 6.

7. Pearls, pitfalls, and complications

Although a new technique, the below mentioned point has been found to be useful:

The dorsal side of the double-locked K-wire is cut and impacted first where possible. This ensures less protrusion of the remnant of the wire dorsally.

8. Case illustration

Nine patients were operated on since early 2021. All patients have achieved bone union approximately 6 weeks after surgery, and no radiological loss of position was found (Table 1). Up to now, none of these patients has required metalware removal. It is important to note that these patients were operated on over a period of 18 months and at the time of functional review, for this article, the patients were at varying stages of recovery. The patients reported a recovery to a near-normal or normal functional state where the most telling parameter is probably the Global Rate of Change (GRC)[12] (Table 2). GRC values were positive (corresponding to

Figure 6. Anteroposterior view of the final construct with fluoroscopy.

Figure 7. Lateral view of the final construct with fluoroscopy.

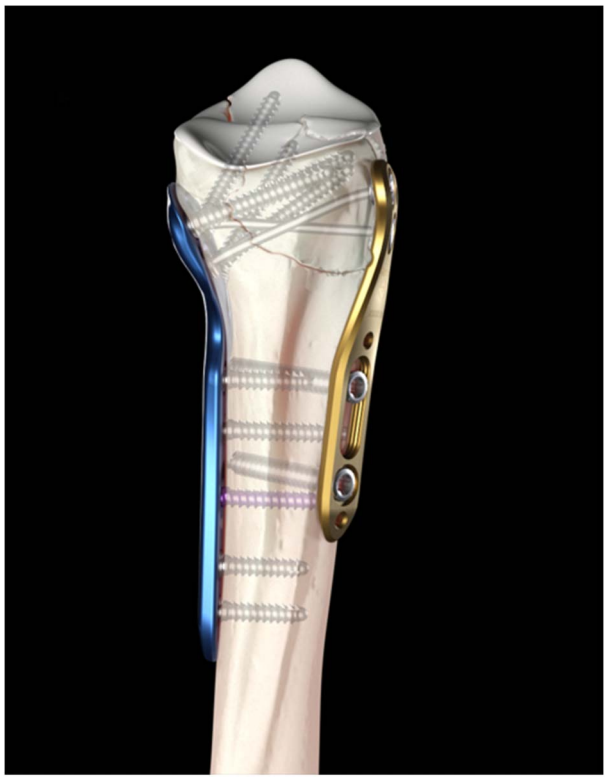

Figure 8. 3D illustration of the final construct (global view).

an improvement) for all patients and very close to the optimal value of 5 (2 patients ranked at 4, 3 at 4.5, and 2 at 5). The pronation obtained after surgery was the same as the contralateral arm for all patients.

Figures 6 and 7 present radiographs illustrating the final constructs while Figures 8 and 9 are 3D illustration of the assembly.

9. Discussion

The principle of the K-lock is the ability to implant an angular stable locked pin into a small fragment which is at risk of either displacing or fracturing with screw insertion (diameter of a K-wire is twice as thin as a screw: 1.2 mm and 2.4 mm, respectively).[13,14]

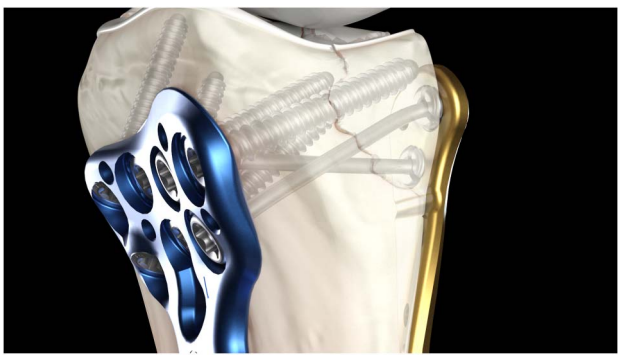

Figure 9. 3D illustration of the final construct (focus on the fracture at the distal radius).

However, if double plating is inherently necessary for reduction and fixation, using a double-locked wire creates significantly enhanced stability of the reduced joint and strengthens the whole construct as the plates are then joined together through the K-lock wires. In these catastrophic fractures, this technique provides a fixation option not previously available, which creates a stable construct, which in turn allows confidence in the pursuit of early mobilization and therapy.[15] Connecting the 2 plates with the K-wire has both a load-bearing and load-sharing effect, by transferring the forces to both cortices with slight flexibility in the wire, allowing the normal concavity of the joint to carry the load during early mobilization.[16] This is why we suggest to place the double-locked wire in the area of most instability.

This certainty has provided the confidence in the construct to allow early mobilization and a significantly early return to function despite very severely comminuted fracture configurations.

With careful preoperative planning for the position of the double-locked K-lock(s), it actually makes the procedure relatively easy.

Dorsally subperiosteal dissection is routinely performed so as to minimize potential surgical damage to the tendons.

Essentially, this is a construct combining some of the features of angular stable locked screws with fine-wire–type fixation. This allows the implant (wire) to be very close to the joint in distally comminuted fractures. With the technique of using a clamp to compress across the 2 plates, compression is then maintained over coronal fracture lines by locking both sides of the wire. This leads to a stable construct even in these complex comminuted distal radius fractures, which then allows early mobilization and return to function. There was no loss of position on follow-up X-rays, and all fractures healed.

In the continuity of this work, we wish to conduct a biomechanical study. We will continue to follow these patients through their progress, as well as the new cases, to increase the number of cases benefiting from this technique.

This technique as a principle of fixation (a K-wire locked in opposing plates across an intra-articular fracture) could also be expanded to use in other fractures where dual plating is used such as tibial plateau and tibial pilon/plafond fractures and possibly supracondylar humerus fractures.

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References

1. Qazi S, Graham D, Regal S, et al. Distal radioulnar joint instability and associated injuries: a literature review. *J Hand Microsurg*. 2021;13: 123–131.
2. Medlock G, Smith M, Johnstone AJ. Combined volar and dorsal approach for fixation of comminuted intra-articular distal radial fractures. *J Wrist Surg*. 2018;7:219–226.
3. Hadzhinikolova M, Zderic I, Ciric D, et al. Volar versus combined dorsal and volar plate fixation of complex intraarticular distal radius fractures with small dorsoulnar fragment - a biomechanical study. *BMC Musculoskelet Disord*. 2022;23:35.
4. Ring D, Prommersberger K, Jupiter JB. Combined dorsal and volar plate fixation of complex fractures of the distal part of the radius. *J Bone Joint Surg Am*. 2004;86:1646–1652.
5. Sakamoto S, Doi K, Hattori Y, et al. Comminuted dorsal ulnar fragment in distal radius fractures treated using the integrated compression screw with a mini-plate. *J Hand Surg*. 2022;47:394.e1–394.e6.

6. Geissler WB, Fernandez DL, Lamey DM. Distal radioulnar joint injuries associated with fractures of the distal radius. *Clin Orthop*. 1996: 135–146.
7. Alluri RK, Hill JR, Ghiassi A. Distal radius fractures: approaches, indications, and techniques. *J Hand Surg*. 2016;41:845–854.
8. Beck JD, Harness NG, Spencer HT. Volar plate fixation failure for volar shearing distal radius fractures with small lunate facet fragments. *J Hand Surg*. 2014;39:670–678.
9. Sagerfors M, Bjorling P, Niklasson J, et al. Combined volar T-plate and dorsal pi-plate for distal radius fractures: a consecutive series of 80 AO type C2 and C3 cases. *J Wrist Surg*. 2019;8:180–185.
10. Ghafoor H, Haefeli M, Steiger R, et al. Dorsal Plate osteosynthesis in simple and complex fractures of the distal radius: a radiological analysis of 166 cases. *J Wrist Surg*. 2021;11:134–144.
11. Lans J, Alvarez J, Kachooei AR, et al. Dorsal lunate facet fracture reduction using a bone reduction forceps. *J Wrist Surg*. 2019;8:118–123.
12. Kamper S. Global rating of Change scales. *Aust J Physiother*. 2009;55:289.
13. Schumer ED, Leslie BM. Fragment-specific fixation of distal radius fractures using the trimed device. *Tech Hand Up Extrem Surg*. 2005;9:74–83.
14. Seré I, Ortiz E, Deimundo M, et al. Fracturas marginales volares de radio distal: fijación con clavijas adicionales a la placa volar. *Rev Asoc Argent Ortop Traumatol*. 2020;85:197–203.
15. Moore AM, Dennison DG. Distal radius fractures and the volar lunate facet fragment: Kirschner wire fixation in addition to volar-locked plating. *Hand (N Y)*. 2014;9:230–236.
16. Bain G, MacLean S, McNaughton T, et al. Microstructure of the distal radius and its relevance to distal radius fractures. *J Wrist Surg*. 2017;06: 307–315.