Should Kirschner Wires always be buried?

B. KIPPER, P. KIM, C. BRONFEN, N. DOLET, A. LAQUIÈVRE

Pediatric orthoepic surgery, Caen Normandie University Hospital

Osteosynthesis with Kirschner wires in pediatric orthopedics is the most frequently used technique. In fact, traversing the physis with a simple K-wire is only slightly damaging. There is no clear consensus on whether K-wires should be buried or left exposed. Nevertheless, it is commonly accepted amongst the pediatric orthopedic community that buried K-wires may be left in place longer and facilitate bony healing. Leaving them exposed would require an earlier removal and increase the risk of infection. Although these hypotheses may all seem evident, this chapter will attempt to verify these claims (1).

There are two types of synthesis using K-wires: bicortical K-wire osteosynthesis and elastic stable intramedullary nailing (ESIN). Bicortical osteosynthesis is most useful for the management of fractures of the metaphysis and epiphysis, especially fractures of the distal and proximal humerus, distal radius, medial malleolus, and hand and foot. Centromedullary nailing is useful for the management of diaphyseal fractures of long bones.

Even though, for certain types of fractures, such as at the level of the medial malleolus, the K-wires are systematically buried, in other anatomical regions it is debatable depending on the surgeon's preferences, especially at the level of the elbow.

According to Bashyal et al., K-wire fixation for supracondylar fracture treatment is more commonly left exposed, with deep and superficial infection rates of around 0.2% and 0.8%, respectively (2).

Many complications have been described with exposed K-wires (2). Infections, ranging from superficial infections to osteoarthritis, as well as subcutaneous inflammatory reactions, are the most frequent complications. Migration of exposed K-wires has also been described, such that the K-wires will escape into subcutaneous tissues which would require surgical removal.

Multiple studies have been published on displaced lateral condyle fractures. In fact, this fracture requires open reduction. The K-wires are often buried before wound closure. Soumen Das De et al. and Wai et al. (3-5) showed no significant differences in terms of infection rates between buried and exposed K-wires.

The literature review by Raghavan et al. (1), as well as the article by Launay et al. (6), showed that, apart from superficial infections (whether or not these would require per os antibiotics) and subcutaneous inflammatory reactions, leaving K-wires exposed was not more prone to complications.

Study	Study design	Population	Intervention/Comparator	Results	Complications
Chan et al., 2011	Retrospective Cohort	Children with lateral humeral condyle fracture $n = 75$, buried–42, unburied–33	Open reduction and fixation with K-wires Follow-up–8.4 months Unburied–4 weeks, wire removal + 2 weeks in backslab after wire removal Follow-up–5.6 months	No revision surgery. Buried wires-fixation with 2 wires, Divergence angle–11^0 Unburied wires – Fixed with 2 or 3 wires, Divergence angle–39^0 Cost savings per patient–$800–$1100	Buried-lateral condyle overgrowth in 4 patients Unburied wires Pin tract hypergranulation–2 ($p = 0.11$) Superficial pin tract infection–1 ($p = 0.26$) Lateral condyle overgrowth–7 ($p = 0.08$)
		Mean age–5.0 years, 47 boys, 28 girls	Buried–5 weeks of immobilisation	Wires left in situ Buried–11.6 weeks Unburied–4.4 weeks	
Ormsby et al., 2016	Retrospective cohort	Children with lateral humeral condyle fracture	Buried–2 percutaneous with arthrogram otherwise all open reduction and fixation Unburied–Open reduction Mean follow up–155 days	No incidence of non union. Strong association of skin erosion in buried group when treated early ($p = 0.07$)	3 needed revision surgery–1 buried, 2 unburied Buried group Skin erosion–14 Proven infection–9
		$n = 124$, buried–60, unburied 64	All buried wires removed in theatre under general anaesthetic	Buried wire removal mean–45 days (30–58) Unburied wire removal mean–29 days (11–43)	Unburied group Proven infection–8 Microbiologically proven infection Buried vs. Unburied statistically not significant ($p = 0.972$)
		Mean age–5.12 80 boys, 44 girls	Unburied wires removed in clinic	Cost saving per patient if unburied £1400	
Das De et al. 2012	Retrospective cohort	Lateral humeral condyle fractures	Open reduction and fixation Cast immobilisation Buried–6 weeks Unburied–5.5 weeks	Buried wire removal–6 weeks	Superficial infection Buried–6 Unburied–4, $p = 0.076$ Deep infection Buried–1, Unburied–0 Union time > 8 weeks–2 Others–4
		$n = 235$, buried–194, unburied–41	Buried wires removed under general anaesthesia	Unburied wire removal–4 weeks	Buried Pin migration–31 Pain from prominent pin–14 Superficial skin necrosis–2 Pin migration and revision–2 Union time > 8 weeks–4 Others–9
		Mean age buried-6.1, unburied 6.2 148 boys, 87 girls	Unburied wires removed in office without anaesthesia Median follow up Unburied–4 months, Buried–5 months	Average cost saving in unburied group per patient $3442	
Launay F et al., 2004	Retrospective cohort	Lateral humeral condyle fractures $n = 57$, Buried–25, unburied–32	Open reduction and fixation–52 Percutaneous fixation–5 Cast immobilisation–6.5 weeks	Average K-wire removal 5.9 weeks	Malunions-5 Lateral spur–42 Unburied complications Superficial infection–8 Deep infection–1 Lateral spur–27
		Mean age–6.2 years 38 boys, 19 girls	Buried wires removed under general anaesthesia Unburied wires removed in clinic with no anaesthesia		Buried complications Superficial infection–2 Lateral spur–15

Table 1: Summary of articles on the management of lateral condyle fractures (1). Source: "Should Kirschner wires for fixation of lateral humeral condyle fractures in children be buried or left exposed? A systematic review" (with authorization by the editor. © 2019 Elsevier Masson SAS. All rights reserved for every country)

Sharma et al. (7) studied the complications associated with K-wires in pediatric traumatology (regardless of fracture type). They found, regardless of fracture type, a risk of complications of around 32%, with a high risk of infection if the K-wires are left exposed, if they are unicortical, and if the K-wires are left in place for longer than 4 weeks. In order to decrease the risks associated with treatment of lateral condyle fractures, Wai et al. (4) suggested removing exposed K-wires at 4 weeks and keeping a posterior splint for a supplemental 2 week after removal of the K-wires. However, early removal of the hardware, especially in these types of fracture, seems to increase the risk of non-union.

Concerning the upper limb, Lawrence et al. showed that the use of exposed K-wires at the level of the hand and the wrist is associate with an increased risk of infection. This is especially true in the treatment of fractures of the hand (8).

Leaving the K-wires exposed facilitates their removal in the clinic and does not require a second surgery under general anesthesia. Although this seems advantageous, the pain during the removal of the K-wires may be worrisome. Sorenson et al. (9) and Symons et al. (10) showed that this approach did not lead to extreme pain and was efficient. In their studies, there was no specific analgesic protocol.

Boon Leon Lim et al. (11) showed that paracetamol or NSAIDs, compared to placebo, did not decrease pain during K-wire removal. Nevertheless, the latter were efficient strategies of post-removal analgesia. The use of anxiolytics is not recommended in the literature. Templeteon et al. (12) showed that the per os use of Midazolam, administered before the removal of the K-wires in clinic, did not significantly decrease anxiety.

Many complications have been described with buried K-wires (13,15). The most frequent is K-wire protrusion after edema has diminished. Subcutaneous necrosis and discomfort from the implant have also been reported by patients. Furthermore, buried K-wires are at higher risk of migration.

From a cost-effectiveness point of view, leaving the K-wires exposed seems advantageous. In fact, the removal of hardware could be done in clinic, thus avoiding taking up hospital and operating room space, anesthesia consultations, etc. (4).

A team in Boston showed that, leaving the K-wires exposed would save the patient around 3,442$. They argued this to be financially advantageous despite a potential infection rate of around 40% (3,5).

Two articles in the literature have tackled the subject of centromedullary nails that are left exposed during the management of diaphyseal fractures of both bones of the forearm. In the study by Dinçer et al., the nails were not removed in clinic but in the operating room and were removed before 6 weeks (14). The authors did not find any significant differences in their case series in terms of infection rates or further fractures compared to those with ESIN that were buried and left in place between 6 and 12 months.

Kelly et al. successfully removed 36.2% of the K-wires in clinic without general anesthesia (15). Based on their experience, removal of the K-wire in clinic was undergone without complications. They did not report any major infection or further fractures. Nevertheless, these two studies are not powerful enough to warrant a change of surgical habits.

An alternative to these two techniques could be the use of absorbable pins. The first description of absorbable implants in animal models dates back to 1960 (16). Ever since, the advancement of bioabsorbable materials in their many forms (pins, screws, plates, anchors) has led to the development of new indications (17). In the literature, the use of this type of implant is particularly indicated in lateral condyle fractures and Salter IV fractures of the distal tibia (18).

Three different compositions of implants exist (17):

- Poly-Levo-lactic acid (PLLA) keeps its bony purchase for upwards of 12 months and is absorbed within 5 years (17,19).

- Polyglycolic acid is rapidly degraded within 3 months and loses its purchase within a month (20).
- Poly-p-dioxanone (PDS) loses its purchase in 2 months and is absorbed in 6 months (17).

Shikinami et al. showed that the absorption time of these materials also depends on their intraosseos localization (e.g., a metaphyseal pin is more rapidly absorbed) (21). Bicortical contact allows a slower absorption of the implant.

The use of these implants seems advantageous on numerous fronts, such as the avoidance of a second surgery for hardware removal, especially when said removal could be difficult (pelvis, hand, etc…) (17). Furthermore, lower infection rates have been described with lower complication rates secondary to protruding buried or exposed pins (22). In addition, there is less fear of implant migration since there is osseointegration (22). Finally, these materials are MRI-compatible (18).

Multiple disadvantages have been described in the literature (19). These pins have a lower resistance compared to regular Kirschner wires. Some patients present with soft tissue reactions weeks after the implantation of hardware. This is translated clinically by pain and sterile discharge with mononuclear cells on cytology containing materials coming from the implant. In most cases, these reactions spontaneously resolve without any impact on bony healing (20,22,23).

Moreover, these pins are radio transparent. It is thereby more difficult to locate them intra-operatively using fluoroscopy (20).

Svensson et al. reported two cases of osteolysis and non-union of the radial head after the use of absorbable screws (24). Hope et al. described avascular necrosis (AVN) of the medial condyle (20). Nevertheless, it is difficult to assess whether this AVN is due to a deleterious dissection or to the type of hardware used for fixation. Studies on bio-absorbable materials are scarce in the pediatric population. A few articles based on animal models have shown little impact on the physis and that it is possible to use these materials even after traversing the physis (25).

There is no clear consensus on the advantages or disadvantages of burying the pins. However, leaving the pins exposed does not seem to lead to higher complication rates and is financially sensible. A possible alternative to these two methods, but this day rarely used, would be to use absorbable pins.

When and how to remove the K-wires?

The period of immobilization and removal of the K-wires is variable according to the anatomical region of the fracture. This period varies according to the type of fracture, the acuteness of the fracture, and the surgeon’s preferences.

Below is a non-exhaustive list of the primary durations of consolidation before removal of the K-wires:

- Supracondylar: 4-6 weeks
- Lateral condyle: 6 weeks
- Medial epicondyle: 4-6 weeks
- Olecranon: 6 weeks
- Pelvis: 6 weeks
- Distal and proximal extremities of the tibia: 6 weeks
- Medial malleolus: 6 weeks
- Hand: 4 weeks for the metacarpals and phalanges (same for foot fractures)
- Calcaneus: 6 weeks
- ESIN in the diaphysis of the bones of the forearm, femur, or tibia: 6 months to 1 year

When the K-wires are to be removed in the operating room, radiographs may be ordered preoperatively to assess bone consolidation and verify that their localization is still intact, or alternatively by making use of intra-operative fluoroscopy. Four-step antisepsis as well as aseptic scrubbing by the surgeon are necessary for strict antisepsis. Draping may be undertaken by simple cloth, perforated, or extremity drapes. No antibiotic prophylaxis is required intra-operatively.

The use of a tourniquet seems indicated, depending on the anatomical region. For fractures having required deep dissection, and if the K-wires are easily accessible, it is recommended to make use of the previous incision. If the K-wires were placed percutaneously and then buried, then a stab incision should be made overlying the palpated pin. In order to gain access to the K-wire, dissection of subcutaneous tissues may be required with a Halstead-Mosquito clamp. The K-wires are then removed with a dedicated wire holder. Finally, for wound closure, the subcutaneous tissues should be closed if judged necessary. For the skin, fast absorbable, non-absorbable, or running sutures may be used depending on the previous wound's scar.

If there is hypergranulation tissue overlying the pins, an elliptical excision of the poor-quality tissue is recommended with tensionless closure of the skin with non-absorbable sutures.

If the hardware is being removed in clinic, the patient should be well prepared. Prescribing painkillers prior to presenting to clinic is also recommended.

The removal of the hardware in itself is simple and may be done with an equimolar mixture of oxygen and nitrous oxide (EMONO). If the pins are exposed, they are simply removed with a wire holder. The orifice of the pins may bleed slightly, in which case pressure should be applied with a sterile gauze for a few seconds until the bleeding stops. Sutures are almost never required during these procedure.

References:

1. Raghavan R, Jones A, Dwyer AJ. Should Kirschner wires for fixation of lateral humeral condyle fractures in children be buried or left exposed? A systematic review. Orthop Traumatol Surg Res [Internet]. 2019;105(4):739–45. Available from: https://doi. org/10.1016/j.otsr.2019.03.007

2. Bashyal RK, Chu JY, Schoenecker PL, Dobbs MB, Luhmann SJ, Gordon JE. Complications After Pinning of Supracondylar Distal Humerus Fractures. 2009;29(7):704–8.

3. De S Das, Bae DS, Waters PM. Displaced Humeral Lateral Condyle Fractures in Children : Should We Bury the Pins ? 2012;32(6):573–8.

4. Wai L, Chan M, Ming H. Exposed versus buried wires for fixation of lateral humeral condyle fractures in children : a comparison of safety and efficacy. 2011;329–33.

5. Ormsby NM, Walton RDM, Robinson S, Brookes- fazakerly S, Chang FY, Mcgonagle L, et al. Buried versus unburied Kirschner wires in the management of paediatric lateral condyle elbow fractures : a comparative study from a tertiary centre. 2016;69–73.

6. Launay F, Leet AI, Jouve J, Sponseller PD. Lateral Humeral Condyle Fractures in Children. 2004;24(4):385–91.

7. Sharma H, Taylor GR, Clarke NMP. A review of K-wire related complications in the emergency management of paediatric upper extremity trauma. 2007;252–8.

8. Hsu LP, Schwartz EG, Kalainov DM, Chen F, Makowiec RL. Complications of K-Wire Fixation in Procedures Involving the Hand and Wrist. YJHSU [Internet]. 2011;36(4):610–6. Available from: http://dx.doi. org/10.1016/j.jhsa.2011.01.023

9. Sorenson SM, Hennrikus W. Pain During Office Removal of K-Wires From the Elbow in Children. 2015;35(4):341–4.

10. Sean Symons 1 , Ram Persad MP. The removal of percutaneous Kirschner wires used in the stabilisation of fractures in children. Acta Orthop Belg.

11. Trial ARC. Percutaneous Pin Removal in the Outpatient Clinic — Do Children Require Analgesia ? 2014;597–602.

12. Templeton P, Orth F, Burton D, Tr F, Cullen E, Lewis H, et al. Oral Midazolam for Removal of Kirschner Wires in the Children ’ s Orthopaedic Outpatient Department : A Randomized Controlled Trial. 2010;30(2):130–4.

13. Mcgonagle L, Elamin S, Wright DM. Buried or unburied K-wires for lateral condyle elbow fractures. 2012;(August 2011):513–6.

14. Dinçer R, Köse A, Topal M, Öztürk İA, Engin MÇ. Surgical treatment of pediatric forearm fractures with intramedullary nails : is it a disadvantage to leave the tip exposed ? 2019;1–6.

15. Kelly BA, Miller P, Shore BJ, Waters PM, Bae DS. Exposed Versus Buried Intramedullary Implants for Pediatric Forearm Fractures : A Comparison of Complications. 2014;34(8):749–55.

16. Surgery O, Health T. Bioabsorbable Implants : Review of Clinical Experience in Orthopedic Surgery. 2006;32(1):171–7.

17. Bassuener SR, Mullis BH, Harrison RK, Sanders R. Use of Bioabsorbable Pins in Surgical Fixation of Comminuted Periarticular Fractures. 2012;26(10):607– 10.

18. D. Rovinsky, R. C. Durkin NYO. The use of bioabsorbables in the treatment of children's fractures. Tech Orthop. 1998;13(2):130–8.

19. Takada N, Otsuka T, Suzuki H, Yamada K. Pediatric Displaced Fractures of the Lateral Condyle of the Humerus Treated Using High Strength , Bioactive, Bioresorbable F-u-HA / PLLA Pins : A Case Report

of 8 Patients With At Least 3 Years of Follow-Up. 2013;27(5):281–4.

20. Hope PG, Williamson DM, Coates CJ, Cole WG, Clinical I. BIODEGRADABLE ELBOW FRACTURES PIN FIXATION IN OF. 1991;73(6):6–9.

21. Shikinami Y, Matsusue Y, Nakamura T. The complete process of bioresorption and bone replacement using devices made of forged composites of raw hydroxyapatite particles / poly L - lactide (F-u-HA / PLLA). 2005;26:5542–51.

22. Nomikos GN, Papagelopoulos PJ, Soucacos PN. Early Experience with Biodegradable Implants in Pediatric Patients. 2009;1591–8.

23. O Böstman 1 , E A Mäkelä, J Södergård, E Hirvensalo, P Törmälä PR. Absorbable polyglycolide pins in internal fixation of fractures in children. J Pediatr Orthop. 13(2):242-.

24. PJ1 S, PM J, G H. Internal fixation with biodegradable rods in pediatric fractures: one-year follow-up of fifty patients. J Pediatr Orthop. 14(2):220-.

25. E A Mäkelä, S Vainionpää, K Vihtonen, M Mero, J Laiho, P Törmälä PR. The effect of a penetrating biodegradable implant on the epiphyseal plate: an experimental study on growing rabbits with special regard to polyglactin 910. J Pediatr Orthop. 7(4):415-2.