K-wire Fixation of Closed Hand Fractures Outside the Main Operating Room Does Not Increase Infections

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**Background:** Closed reduction and internal fixation (CRIF) of closed hand fractures in the main operating room (OR) is much more expensive than outside of the OR. However, there is a reluctance to fix fractures out of the OR due to the perceived increase in infections. Our goal was to prospectively analyze the infection rates of performing CRIF of closed metacarpal and phalangeal fractures in these two settings.

**Methods:** A multicenter prospective analysis of patients undergoing CRIF of metacarpal or phalangeal fractures inside or outside the OR was performed. Demographic data, injury characteristics, surgery information and postoperative infectious complications were recorded, including cellulitis, frank pus, and osteomyelitis.

**Results:** The study involved 1042 patients with a total of 2265 Kirschner-wires (K-wires). Infection rates were not statistically higher in the 719 patients who had CRIF outside of the OR (cellulitis 2.5%, frank pus 1.4%) compared with the 323 patients with CRIF in the OR group (cellulitis 3.4%, frank pus 2.5%). The OR group had a longer time to operation and a longer procedure time, but a shorter time with the K-wires in place.

**Conclusion:** K-wire fixation of closed hand fractures outside of the OR under field sterility is safe because it does not increase infectious complications compared to CRIF in the main OR under full sterility. (Plast Reconstr Surg Glob Open 2022;10:e4679; doi: 10.1097/GOX.0000000000004679; Published online 21 November 2022.)

**INTRODUCTION**

Fractures of the metacarpals and phalanges are very common, with an annual incidence of 18–77 per 100,000 people. The large number of injuries generate a need for an efficient management strategy. With increasing resource constraints and limited access to the main operating room (OR) environment in much of the world, managing hand fractures that have failed attempt at nonoperative management in the clinic or emergency room setting may provide more timely care and access for patients.

Although most hand fractures can be treated nonoperatively, Kirschner-wire (K-wire) fixation may be used reliably for the majority of metacarpal and phalangeal fractures that are closed, reducible and unstable. They act as a relatively inexpensive internal splint while the bone heals, but do not provide compression or rigid fixation. Closed reduction and internal fixation (CRIF) offers minimal soft-tissue damage; can be done under C-arm fluoroscopy; and the rates of union, active motion, pain, and complications are equal to open reduction internal fixation (ORIF) when done in the OR. They have been used for intraarticular fractures near the proximal and distal interphalangeal joints and metacarpal joints, transverse and short oblique fractures of the metacarpals and phalanges, dorsal blocking K-wire mallet fracture reduction, and application of dynamic distracting fixators, among others, with success. They are typically

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removed after 2 to 4 weeks once a fracture is clinically healed with no tenderness to deep palpation of the fracture site.

CRIF with K-wires of hand fractures in the ambulatory setting (ie, clinic or emergency department) with field sterility is much less costly and waste-producing than the main OR. ORs are associated with substantial cost because of the increased number of personnel involved and the amount of sterility materials consumed. Office- or clinic-based procedures have obvious benefits such as decreased procedure time, increased number of cases performed, convenience for the patient and physician, avoidance of a general anesthetic or regional block, and less waste going to landfills. However, there are currently no studies assessing difference in patient outcomes related to fixation of closed fixation of hand fractures in the OR versus outside of the OR.

One of the main barriers to performing CRIF in minor procedure rooms outside the main OR is the belief that postoperative infection rates are higher without the full sterility of the OR. The goal of this study was to determine if there is a difference in infection rates in patients who undergo CRIF of hand fractures in the OR versus the environment outside of the OR.

METHODS

This study was done with approval of each institution’s research ethics committee. This was a prospective, multicenter study comparing adult patients undergoing CRIF of acute metacarpal or phalangeal closed fractures in the OR versus out of the OR (ie, clinic, minor procedure room, or the emergency department). Patients were excluded if they had an open fracture with a laceration, needed open reduction internal fixation, had concomitant tendon or nerve injury, had soft-tissue loss necessitating flap or flap coverage, or had a pre-existing infection.

There were 19 centers that collected data in the study. Some centers performed CRIF exclusively in the OR, whereas others performed CRIF in the minor procedure room or OR setting, depending on the fracture pattern or availability of OR time. Patients were not randomized, and the place of operation and perioperative care was left up to each institution’s local practice pattern. We recorded infection data, demographics, handedness, smoking status, comorbidities, the center of operation, the type of anesthesia, type of sterility, number of pins, size of pins, and whether they were buried or nonburied. Patients were followed until the pins were removed. Pin site infection was deemed present if any of the following criteria were met: (1) surrounding cellulitis greater than 5 mm from the pin site; (2) pus was draining from the pin site; or (3) bacteriologic evidence of infection. Inflammation or redness less than 5 mm from the pin itself, or where the pin was buried, was not deemed an infection, but this reaction was recorded. There was no standardized pin site dressing applied as part of the study.

With field sterility, performed outside of the OR, there was surgical preparation with povidone-iodine or isopropyl alcohol-chlorohexidine gluconate and sterile draping of the areas that are involved in the surgery. Nonoperated parts were not draped (Fig. 1). There was no special ventilation. The floor was not washed in between cases. Sterile gloves and masks were used, but no surgical gowns or head covering. A basic instrument tray and K-wire equipment were used. A mini C-arm fluoroscopy machine was used to visualize the reduction and placement of the K-wires. Field sterility was performed in either the emergency department, clinic, or other minor procedure area, whereas standard full sterility was used in the OR.

STATISTICS

A power calculation was performed assuming equivalence in infection rate between the two groups. Assuming an infection rate of 0.05%–7% based on the literature, with a power of 0.90 and an alpha value of 0.05 with an equivalence limit of 4%, we needed 1040 patients. This was assumed for a 2:1 ratio of out of OR to inside OR. We chose to use 4% as an average incidence of infection for each group, in the middle of the standard range of infectious complications after K-wire fixation, and assumed that a doubling of this rate, or a 4% increase, would be a significant increase in infection. In other words, if there was truly no difference between in and out of the OR, then 1040 patients were required to be 90% sure that the limits of a two-sided 90% confidence interval would exclude a difference of more than 4% in the infection rate. We performed a two-sample unpaired Student t test for continuous variable and a chi-squared test for categorical variables. Statistical significance was set at a P value less than 0.05.

RESULTS

Our study included 1042 patients from 19 centers. (See table, Supplemental Digital Content 1, which displays the demographic information regarding the patient, injury, and surgery surrounding K-wire fixation of hand fractures in and outside of the OR. N = number, SD = standard deviation, http://links.lww.com/PRSGO/C285.) There were 2265 wires placed in total with an average 2.2 K-wires per patient. We found that infection rates were no different in the 719 patients who had CRIF outside of the
Table 1. Postoperative Infectious Complications between CRIF of Hand Fractures Performed in the OR versus out of the OR

| Postoperative Complications | Total, 1042 | OR, 323 (31.0%) | Out of OR, 719 (69.0%) | P       |
|-----------------------------|-------------|-----------------|------------------------|---------|
| Inflammation around pin < 5 mm | Yes: 93 (8.9%) | 283 no (87.6%), 40 yes (12.4%) | 666 no (92.6%), 53 yes (7.4%) | <0.05   |
|                            | No: 949 (91.1%) | 531 no (96.6%), 11 yes (3.4%) | 701 no (97.5%), 18 yes (2.5%) | 0.413   |
| Cellulitis > 5 mm around pin | Yes: 29 (2.8%) | 312 no (96.6%), 11 yes (3.4%) | 709 no (98.6%), 10 yes (1.4%) | 0.213   |
|                            | No: 1013 (97.2%) | 249 no (98.3%), 8 yes (2.5%) | 670 no (96.0%), 12 yes (1.6%) |         |
| Frank pus around wire       | Yes: 18 (1.7%) | 315 no (96.6%), 8 yes (2.5%) | 709 no (98.6%), 10 yes (1.4%) | 0.213   |
|                            | No: 1024 (98.3%) | 237 no (97.5%), 4 yes (2.5%) | 680 no (98.6%), 10 yes (1.4%) |         |
| Need for admission due to infection | Yes: 1 (0.1%) | None | 1 patient (0.1%) | 0.501   |
|                            | No: 1041 (99.9%) | 1 patient (0.1%) | 4 patients (0.5%) | 0.590   |
| IV antibiotics required     | Yes: 5 (0.5%) | 1 patient (0.3%) | 4 patients (0.5%) | 0.590   |
|                            | No: 1037 (99.5%) | 1 patient (0.3%) | 4 patients (0.5%) | 0.590   |

OR (cellulitis 2.5%, frank pus 1.4%) compared with the 323 patients with CRIF in the OR group (cellulitis 3.4%, frank pus 2.5%) (Table 1). There was no significant difference in OR versus outside of the OR with respect to the risk of frank pus at the pin site (P = 0.055) or postoperative cellulitis (P = 0.858).

We found that having the procedure performed in the OR increased the risk of inflammation less than 5 mm around the pin site compared to out of the OR. When comparing within groups, having pins placed in the emergency department has less risk of inflammation around the pin compared to in the OR. There was a higher incidence of postoperative inflammation in metacarpal versus phalangeal fractures. The use of postoperative antibiotics reduced the amount of inflammation surrounding the pin but had no effect on infectious complications such as cellulitis or pus. The use of preoperative antibiotics had no effect on any complications (Table 2).

Those in the OR were more likely to have preoperative antibiotics, whereas those out of the OR were more likely to have postoperative antibiotics. In subgroup analysis, those in the emergency department were more likely to get postoperative antibiotics than the other sites of operation, including the OR, as well as more likely to get preoperative antibiotics than if the procedure was done in the clinic or minor procedure area. Of those patients who received postoperative antibiotics, 71.8% (286 patients) had coverage for 7 days. Those in the OR had their K-wires removed earlier than those out of the OR. (See table, Supplemental Digital Content 1, http://links.lww.com/PRSGO/C285.)

There were more 0.035-inch and 0.062-inch wires and less 0.045-inch K-wires used in OR than out of the OR (P < 0.05). When comparing the K-wire sizes, there was a higher incidence of frank pus with 0.045-inch K-wires and less with 0.035-inch K-wires (P = 0.026). There were 21 patients in whom 0.028-inch wires were used (2.0%), 350 with 0.035-inch (33.7%), 614 with 0.045-inch (59.0%), five with 0.054-inch (0.5%), 17 with 0.062-inch (1.6%), and 33 patients in whom a combination of sizes were used (3.2%). There was an equal number of K-wires per patient, but more were buried in the OR group. (See table, Supplemental Digital Content 1, http://links.lww.com/PRSGO/C285.) Having the K-wires buried or nonburied did not increase the risk of postoperative inflammation, cellulitis, or pus (Table 2).

When comparing those patients with their surgery performed in the OR versus out of the OR, there were more female and older patients. (See table, Supplemental Digital Content 1, http://links.lww.com/PRSGO/C285.) There was a longer time to surgery and longer surgery time when performed in the OR. (See table, Supplemental Digital Content 1, http://links.lww.com/PRSGO/C285.) Those cases performed in the OR were more likely to have a regional or general anesthetic with a tourniquet, whereas those out of the OR were more likely to have local anesthetic with epinephrine and no tourniquet. (See table, Supplemental Digital Content 1, http://links.lww.com/PRSGO/C285.)

Table 2. Risk Factors for Postoperative Infectious Complications after Closed Reduction K-wire Fixation of Hand Fractures

| Risk Factor               | Postoperative Inflammation | Postoperative Cellulitis | Frank Pus |
|---------------------------|---------------------------|--------------------------|-----------|
| Wire size                 | 0.201                     | 0.312                    | 0.026*    |
| Buried vs nonburied       | 0.707                     | 0.712                    | 0.490     |
| Phalax vs metacarpal      | 0.006*                    | 0.815                    | 0.401     |
| Finger (thumb, index, long, ring, or little) | 0.940                     | 0.465                    | 0.470     |
| Crush                     | 0.518                     | 0.285                    | 0.087     |
| Preoperative antibiotics  | 0.210                     | 0.900                    | 0.278     |
| Postoperative antibiotics | 0.005*                    | 0.262                    | 0.303     |
| OR vs out of OR (out of OR not split into subgroups) | 0.009*                    | 0.413                    | 0.213     |
| Place of operation (subgroups included for out of OR) | 0.006*                    | 0.856                    | 0.055     |
| Smoking                   | 0.057                     | 0.067                    | 0.245     |
| Tourniquet                | 0.013*                    | 0.693                    | 0.029*    |

*p<0.05

DISCUSSION

With increasing resource constraints, performing CRIF of hand fractures outside of the OR can increase efficiency, reduce costs and perioperative processing, and improve patient convenience.16 However, given the concern for postoperative infection rates outside of the OR, our goal was to determine if there was a difference in CRIF of hand fractures inside versus outside of the OR. This prospective comparative study of 1042 patients and 2265 K-wires demonstrated that patients who underwent K-wire fixation of metacarpal or phalangeal fractures with field sterility outside of the OR did not have a higher infection rate (cellulitis greater than 5 mm, frank pus) than those who had surgery in the OR.
We found that there was an increase in pin site inflammation less than 5 mm when CRIF was performed in the OR versus outside of the OR. The emergency department environment had significantly less risk of pin site inflammation on subgroup analysis compared to the main OR. This may be related to the time to surgery, as when stratified based on time to operation, the emergency department was 3.59 days compared to 8.98 days for the OR (P < 0.05). The average time to operation for the clinic and minor procedures area was 7.25 and 5.43 days, respectively. The reduction in pin site inflammation with those performed in the emergency department may also be related to the increased pre- and postoperative antibiotic use in this group. We did find a reduction in overall postoperative inflammation with the use of postoperative antibiotics but there was no reduction in frank infection complications.

Pin-tract infections occur in approximately 0.05%−7% of cases and can be secondary to bacteria entering the wound surrounding the K-wire after insertion. Infections can lead to loss of fixation, malunion, non-union, or osteomyelitis. Risk factors include diabetes, obesity, smoking, and perioperative antibiotic use. Pin-tract infection must be differentiated from pin-tract irritation to reduce unnecessary antibiotic use.

Wound infection has been described as present if two of the three following criteria are met: (1) there is surrounding cellulitis of the area; (2) pus is draining from the wound; and (3) bacteriologic evidence of infection. These are the criteria we used for our study. Pin-tract reaction, however, will present as increased warmth, changes in normal skin color, serous or bloody discharge at the site, and typically will resolve in 72 hours after pin removal. Of note, the majority of literature surrounding pin-tract infections are in relation to pins used for external fixators for long bone fixation, which are left in for a prolonged period of time with a subsequent infection rate up to 100%, as opposed to K-wire fixation for hand fractures, which are removed after 2−4 weeks.

van Leeuwen et al retrospectively looked at 1213 patients who underwent CRIF of hand and wrist fractures with nonburied pins. They had a 7% infection rate, 0.4% need for open debridement, 0.2% osteomyelitis, and 0.5% rate of admission for intravenous antibiotics. Those not admitted to hospital were treated with oral antibiotics or pin removal successfully. They did not find any significant risk factors for developing infectious complications. Ridley et al looked at 695 adult patients with hand and wrist fractures who underwent CRIF with either buried or nonburied K-wires. They found that exposed wires, particularly those placed in metacarpal fractures, led more commonly to hand infections than buried wires. However, other groups have found no increased risk of exposed versus buried K-wires for postoperative infectious risk. This is similar to our study, where we had no increased risk of infectious complications or inflammation with nonburied versus buried wires. However, 0.045-inch K-wires had a higher risk of frank pus than other sizes. We also found that metacarpal fractures increased inflammation around the pin site, but not frank infection complications. Our rates of infection were smaller than others, with 2.8% overall cellulitis greater than 5 mm, 1.7% frank pus at the pin site, and 0.1% osteomyelitis or need for admission.

Complications of Kwire insertion range from 15% to 42%. Sharma et al looked at 105 pediatric upper extremity fractures treated with K-wires and subsequent complications. Their complications included pin-tract infection (5%), overgranulation (12%), hypersensitive scar (1%), neurapraxia or axonotmesis (4%), osteomyelitis (1%), tendonitis (2%), and migration of the K-wire (4%). Field sterility has been shown to have a low incidence of postoperative wound infection. LeBlanc et al looked prospectively at 1504 carpal tunnel releases in a multicenter trial and found a superficial and deep infection rate of 0.4% and 0%, respectively. Hashemi et al looked at wound infections after 1035 day-case procedures under field sterility and found a postoperative infection rate of 1.1%. Field sterility was comprised chlorhexidine preparation along with cloth drapes and the absence of face masks or surgical gowns. The 11 infections were found after carpal tunnel release, trigger release and excision of Dupuytren contracture. They did not include CRIF of hand fractures. Starker and Eaton looked at the placement of K-wires in the emergency department in 75 patients and found a 0.0% incidence of pin-tract infection, osteomyelitis, or joint infection. The only complications were an excoriated pin site, granulating pin tract and a need for revision in the OR. They did not compare these complications to those in the OR and patients with open fractures were admitted to the hospital to receive 2 to 3 days of intravenous antibiotics, which is no longer standard practice. Also, Dua et al retrospectively looked at CRIF of 222 pediatric hand fractures in the OR using a field sterility technique versus full preparation and draping. There was no difference in complications between the groups.

One of the limitations of this article is the heterogeneity surrounding preoperative and postoperative antibiotic use and pin site care. We did not stipulate postoperative dressings, antibiotics, or therapy protocol as part of this study. There were also differences in the OR versus out of OR groups in antibiotic use, duration of K-wire placement, K-wire sizes, K-wire burial rates, and patient age and sex. Given the heterogeneity of place of operation of some centers in this study, with some performing CRIF exclusively in the OR or clinic setting, we were unable to randomize the patients. To clarify this point, irrespective of fracture pattern, patients at these centers who perform CRIF exclusively outside of the OR were treated outside of the OR for closed injuries of the metacarpal and phalanges. However, in those centers where procedures are performed both inside and outside the OR, there may have been selection bias as to those done in the OR. A prospective randomized trial could help to confirm these findings. We feel, however, given the large sample size and multiple providers involved, our study reflects a true representation of current practice trends and risks involved in performing CRIF of hand fractures in the OR versus the minor procedure room.
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