Biomechanical Comparison of Fifth Carpometacarpal Fusion Methods: Kirschner Wires Versus Plate and Screws

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Background: Fractures and dislocations of the base of the fifth metacarpal can lead to arthritis of the fifth carpometacarpal (CMC) joint. For patients who are symptomatic and fail conservative management, arthrodesis of the fifth CMC joint can be offered. The fusion can be performed using Kirschner wires (K-wires), but can lead to complications such as pin tract infection and pin migration. A low-profile locking plate may represent an attractive alternative. The purpose of this study was to compare the biomechanical stability of these 2 fusion techniques.

Methods: Twelve fresh frozen cadaver hands were divided into 2 groups. The first group underwent fixation of the fifth CMC joint using 2 1.6 mm (0.062 inches) diameter K-wires in a cross-pin configuration. The second group underwent fixation using a 2.0 mm locking plate with 2 locking screws in the hamate and 3 nonlocking screws in the fifth metacarpal shaft. The specimens were then loaded in extension until failure.

Results: The stiffness was 15.0 ± 7.2 N/mm for the K-wire group and 14.7 ± 6.0 N/mm (mean $\pm$ SD) for the plate group ($P = 0.9366$). The peak loads were 62.5 ± 40.0 N and 64.6 ± 24.8 N for K-wire and plate groups, respectively ($P = 0.9181$). The energy to peak load was 294 ± 281 N mm for the K-wire group and 418 ± 190 N mm for the plate group ($P = 0.3904$).

Conclusions: Fifth CMC fusion using either K-wires or plate and screws showed no significant difference in stiffness, peak load, and energy to peak load. These results suggest the 2 methods provide similar biomechanical stability.

Key Words: fifth carpometacarpal joint—arthritis—arthrodesis—fusion.

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Intra-articular fractures of the base of the fifth metacarpal are relatively common. These injuries usually occur from a longitudinal force to the metacarpal head such as when a clenched fist hits an object.[1] As the intermetacarpal and carpometacarpal (CMC) ligaments firmly secure the radial base of the metacarpal, the force often causes an intra-articular fracture. With the extensor carpi ulnaris serving as the deforming force, a fracture dislocation similar to a mirror image of a Bennett fracture (reverse Bennett fracture) can result.[2]

Timely anatomic reduction and immobilization with or without fixation would be the ideal treatment for these fractures and fracture dislocations. However, the severity of the injury may be underappreciated on routine hand radiography, which can lead to a delay in treatment. A 30 or 45 degree pronation view can often reveal articular involvement and displacement that were underappreciated on standard hand films.[3,4] Even when they are recognized early, these fractures are often difficult to reduce and can lead to posttraumatic osteoarthritis with pain and decreased grip strength.[5]

Arthrodesis is an effective option for painful symptomatic arthritis of the fifth CMC joint. To our knowledge, the first description of fifth CMC fusion in the English literature was by Clendenin and colleagues in 1984. They described a technique in which a wedge of corticocancellous iliac bone graft is inserted into slots created in the fifth metacarpal and hamate. Because of significant donor site pain associated with iliac bone graft, Kirschner wires (K-wires) are more commonly used for fusion today. However, K-wires are associated with complications such as pin migration and pin tract infections. Furthermore, they require removal later, which can be an inconvenience for both the surgeon and the patient. A low-profile locking plate is potentially an attractive alternative that avoids such complications.

The purpose of this study was to compare biomechanical stability of these 2 fusion techniques: K-wires in a cross-pin configuration and a low-profile locking plate.

METHODS

Specimen Preparation

Twelve fresh frozen cadaver hands from 6 individuals were used for this study. Six hands were included in the K-wire group and the matching contralateral 6 hands were included in the plate group. In all specimens, the fifth metacarpal and the hamate were dissected. Cartilage from the fifth CMC joint was removed to expose cancellous bone. In the K-wire group, two 1.6 mm (0.062 inches) diameter K-wires were placed from the metacarpal into the hamate in a cross-pin configuration (Fig. 1). In the plate group, a 2.0-mm mini locking plate (Medartis, Basel, Switzerland) was applied on the dorsal surface of the fifth CMC joint and secured with 2 unicortical locking screws in the hamate and 3 bicortical nonlocking screws in the fifth metacarpal (Fig. 2).

Biomechanical Testing

Fifth metacarpals were potted with plaster of Paris in a polyvinyl chloride pipe. The potted fifth metarcarpals were secured and the hamate was loaded on the volar surface at 0.01 mm/s until failure in extension with an MTS machine (Eden Prairie, MN) (Fig. 3).

Statistics

SPSS 20 (IBM, Armonk, NY) was used for statistical analysis. The Student *t* test was used to compare the 2 groups. α was set at 0.05.

RESULTS

The stiffness was 15.0 ± 7.2 N/mm for the K-wire group and 14.7 ± 6.0 N/mm (mean $\pm$ SD) for the plate group ($P = 0.9366$,

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The authors declare that they have nothing to disclose.

For reprint requests, or additional information and guidance on the techniques described in the article, please contact Ryu Yoshida, MD, at ryoshida@alum.mit.edu or by mail at Department of Orthopaedic Surgery, UCONN HEALTH, 263 Farmington Avenue, MARB 4th Floor, Farmington, CT 06030-4037. You may inquire whether the author(s) will agree to phone conferences and/or visits regarding these techniques.

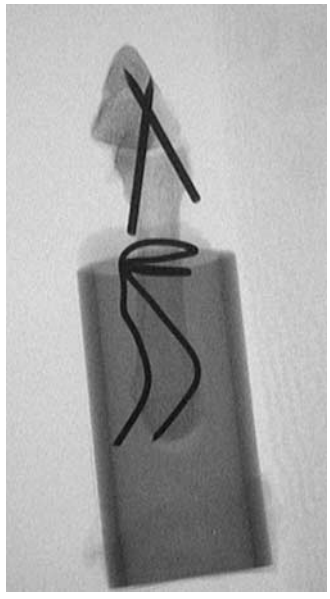

FIGURE 1. Arthrodesis of the fifth carpometacarpal joint with 2 Kirschner wires in cross-pin configuration. full color online

Fig. 4). The peak loads were 62.5 ± 40.0 and 64.6 ± 24.8 N for K-wire and plate groups, respectively ($P = 0.9181$, Fig. 5). The energy to peak load was 294 ± 281 N mm for the K-wire group and 418 ± 190 N mm for the plate group ($P = 0.3904$, Fig. 6). All specimens in the plate group failed by bending of the plate. All specimens in the K-wire group failed by bending of K-wires.

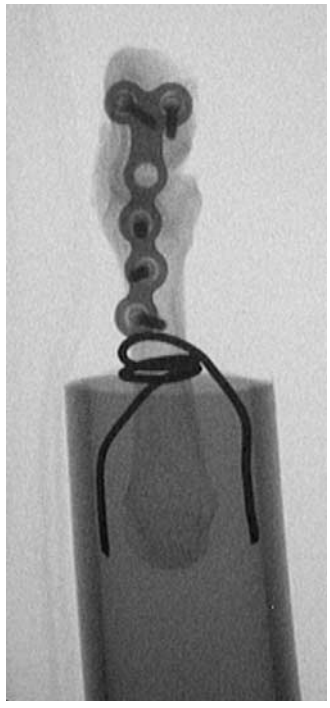

FIGURE 2. Arthrodesis of the fifth carpometacarpal joint with a dorsal locking plate. Three cortical screws were placed in the metacarpal and 2 locking screws were placed in the hamate. full color online

FIGURE 3. Biomechanical testing set up on the MTS machine. The metacarpal potted in a polyvinyl chloride pipe is stabilized while the hamate is loaded in extension. full color online

DISCUSSION

Stability is essential for a successful fusion of a joint. K-wires are widely used in arthrodeses in hand surgery. The purpose of this study was to determine if low-profile plates provide similar biomechanical stability as K-wires when applied to the fifth CMC arthrodesis.

Low-profile plates with locking holes present an attractive alternative to K-wires as they avoid possible complications such as pin migration, pin site infection, and necessity for pin removal. Furthermore, because plates do not need to be routinely removed, they may also offer the theoretical advantage of continued stabilization the fifth CMC fusion site. This longer period of stabilization may be an advantage particularly in patients with risk factors for slower bone union, such as smoking or diabetes mellitus.

The surgical technique involves preparation of the joint, which is similar to arthrodesis with K-wires. A key difference is that the dorsal longitudinal incision is extended 2 to 3 cm distally beyond the fifth CMC proper. This allows visualization of the fifth metacarpal shaft for plate application. Using a chisel,

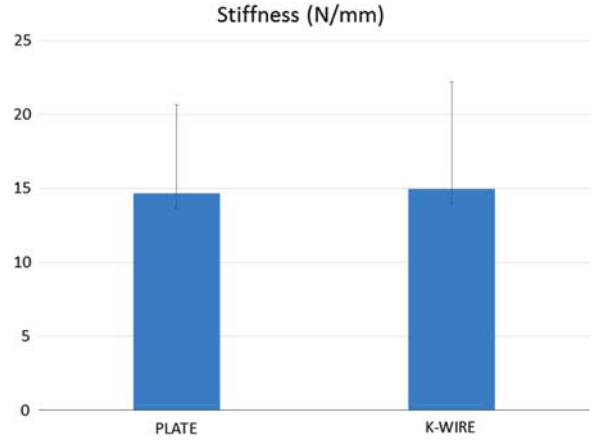

FIGURE 4. Comparison of stiffness of the K-wire group and plate group showed no significant difference ($P = 0.9366$). K-wire indicates Kirschner wires. full color online

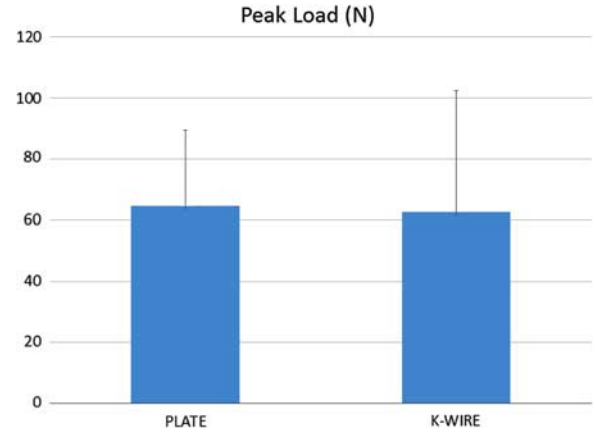

FIGURE 5. Comparison of peak loads of the K-wire group and plate group showed no significant difference ($P = 0.9181$). K-wire indicates Kirschner wires. full color online

curette, or a small burr, the articular surfaces of the fifth CMC joint are decorticated while protecting the insertion of the extensor carpi ulnaris tendon. Once the 2 surfaces are denuded of cartilage and are congruent, a plate is applied. If desired, autologous cancellous bone graft can be harvested from the Lister tubercle and applied to the fusion site.

Some surgeons favor other procedures that preserve motion at the fifth CMC joint, including resection arthroplasty, which can be performed alone[6] or supplemented with tendon interposition,[7] suspensionplasty,[8] silastic prosthesis,[9,10] or fusion of the fifth metacarpal to the fourth metacarpal.[11] However, Clendenin et al[2] report no clinically apparent loss of motion after fifth CMC fusion, and our experience has been similar. Patients have full motion at the metacarpophalangeal and wrist joints, and triquetrum-hamate articulation also allows motion at the midcarpal joint.[12] Furthermore, Clendenin et al[2] report that patients also regained grip strength to 93% of the contralateral, uninjured hand. Thus, fifth CMC fusion remains an effective treatment, especially for patients with more severe arthritis or for heavy laborers who need to preserve grip strength.

The results of the current biomechanical study show that arthrodeses with K-wires versus a small dorsal plate have similar stability. However, the study has several limitations.

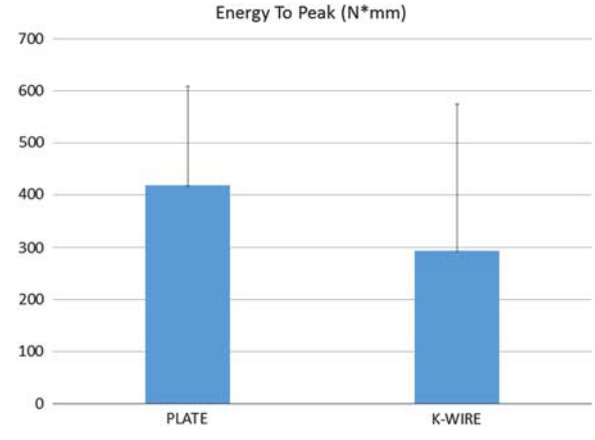

FIGURE 6. Comparison of energies to peak load of the K-wire group and plate group showed no significant difference ($P = 0.3904$). K-wire indicates Kirschner wires. full color online

First, it is a cadaveric study, which does not account for biological responses and healing that occur after surgery. Second, the stability of the construct was tested only in a single mode of failure. We elected to test failure in extension because the fifth CMC joint extends in power grip. Furthermore, plates would have been at significant advantage over K-wires if failure to flexion had been tested; flexion force on a dorsally applied plate would have generated a stabilizing, compressive force at the fusion site. The loading parameter (0.01 mm/s) was chosen based on a previous study by Capo et al[13] comparing various fixation methods for proximal interphalangeal joint arthrodesis.

CONCLUSIONS

Fifth CMC fusion using either K-wires or a plate and screws showed no significant difference in stiffness, peak load, and energy to peak load. These data suggest that a low-profile dorsal plate provides stability similar to K-wires for arthrodesis of fifth CMC. Further research is warranted to determine which technique is associated with superior clinical outcomes.

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