SCIENTIFIC ARTICLE

Headless Compression Screw Versus Kirschner Wire Fixation for Metacarpal Neck Fractures: A Biomechanical Study

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Purpose This study aimed to determine the biomechanical stability of headless compression screws in the fixation of metacarpal neck fractures and to compare them with another common, less invasive form of fixation, K-wires. The hypothesis was that headless compression screws would show higher stiffness and peak load to failure than K-wire fixation.

Methods Eight matched-paired hands (n = 31), using the ring and little finger metacarpals, had metacarpal fractures simulated at the physeal scar. Each group was stabilized with either a 3.5-mm headless compression screw or 2 0.045-in (1.1-mm) K-wires. Nineteen metacarpals were tested in 3-point bending and 12 in axial loading. Peak load to failure and stiffness were calculated from the load displacement curve. Bone mineral density was recorded for each specimen.

Results Bone mineral density was similar in the 2 groups tested for 3-point bending and axial loading. Stiffness was not significantly different in 3-point bending for headless compression screws and K-wires (means, 141.3 vs 194.5 N/mm) but it was significant in axial loading (means, 178.0 vs 111.6 N/mm). Peak load to failure was significantly higher in headless compression screws in 3-point bending (means, 401.2 vs 205.3 N) and axial loading (means, 467.5 vs 198.3 N).

Conclusions Compared with K-wires, headless compression screws for metacarpal neck fractures are biomechanically superior in load to failure, 3-point bending, and axial loading.

Clinical relevance Headless compression screws demonstrate excellent biomechanical stability in metacarpal neck fractures. In conjunction with promising clinical studies, these data suggest that headless compression screws may be an option for treating metacarpal neck fractures. *(J Hand Surg Am. 2017;■(■):1.e1-e6. Copyright © 2017 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words Metacarpal, neck, fracture, surgery, return to play.

Online Exclusive

METACARPAL FRACTURES ACCOUNT FOR 10% o 30% of all hand fractures.[1] They can affect the athletic or working-age population and can have considerable socioeconomic impact with prolonged immobilization.[2] Metacarpal neck fractures, particularly of the little finger, account for most of these injuries.[1,3,4] Although nonsurgical treatment can be successful, operative treatment is indicated when there is unacceptable rotation, shortening, or volar angulation. Some controversy exists as to

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the exact parameters that constitute acceptable alignment.[5]

There are numerous techniques reported in the literature for the fixation of metacarpal neck fractures. Closed reduction and K-wire fixation offer a relatively fast, minimally invasive option. Disadvantages of K-wire fixation, however, include the possibility of pin site infection, prominent hardware precluding early range of motion (ROM), and tethering of surrounding structures. On the other end of the spectrum, plate fixation provides strong fixation allowing early ROM and return to sports, but it comes at the expense of more extensive soft tissue disruption, risk of wound infection, possible hardware irritation, and tendon adherence.[6–9]

Headless compression screws have been accepted in the treatment of carpal fractures, most notably scaphoid fractures.[10–14] With support for an intra-articular starting point,[15] headless compression screw fixation for metacarpal neck and shaft fractures has been shown to be a reliable option for axially stable fractures.[16] The advantages of headless compression screws are relatively fast insertion and the minimally invasive insertion technique, decreasing risks associated with more extensive soft tissue dissection, stability allowing early ROM, and that it is an intramedullary implant, which eliminates the risk of hardware irritation. Although there is supporting clinical evidence, there have been no biomechanical data to compare headless screws with other forms of fixation for the stabilization of metacarpal neck fractures.

The purpose of this study was to perform a biomechanical comparison of 2 forms of metacarpal neck fixation, K-wire and headless compression screws. The hypothesis was that headless compression screws would show higher stiffness and peak load to failure than K-wire fixation.

MATERIALS AND METHODS

Specimen preparation and fixation

Eight matched-paired hands, an average age at death of 59 ± 6 years, and stored at −20°C, underwent dual-energy x-ray absorptiometry (DEXA) (Lunar DPI XQ Dexascan, Madison, WI). We measured a 1-cm^2 region within the metacarpal neck of each specimen. Specimens were randomized as a pair of hands into 1 of 2 groups: one treated with a K-wire fixation technique ($n = 15$) and the other with a headless compression screw technique ($n = 16$). After complete thawing at room temperature, the ring and little finger metacarpals were dissected free of all soft tissue. One little finger metacarpal was excluded owing to previous deformity. Fractures were created by locating the physeal scar under fluoroscopy and creating an osteotomy using a sagittal saw 1 mm thick.

For K-wire fixation, 2 0.045-in (1.1-mm) K-wires were introduced into the metacarpal head at the sulcus just radial and ulnar to the articular surface in a slightly dorsal position similar to that originally described by Lord.[17] Each wire was advanced in a retrograde fashion in the medullary canal until a firm end point was reached signifying the metacarpal base. This end point was confirmed with fluoroscopic imaging. We took care to advance the wires perpendicular to the osteotomy site and not to cross or intersect them at the fracture site. The remainder of the K-wire was cut, leaving approximately 15 mm protruding from the bone (Fig. 1).

For headless compression screw fixation, a 0.045-in guide wire with a trocar tip was inserted in a dorsal, central position in line with the metacarpal shaft. The distal segment (metacarpal head) was over-drilled using a 2.7-mm cannulated drill bit. A 3.5-mm, headless compression screw 32 mm long (Arthrex, Naples, FL) was then inserted over the guide wire to approximately 2 mm below the articular surface (Fig. 2).

Testing protocol

To test the most common deforming force of flexion-extension, we subjected 19 metacarpals (10 with headless compression screws and 9 with K-wires) to 3-point bending, apex dorsal, on a Materials Testing System servohydraulic test frame (MTS Systems Corp, Eden Prairie, MN), generating a load-displacement curve. Metacarpals were placed on a custom-made base consisting of 2 posts with a 35-mm gap in between. We carefully ensured that the fracture was placed the same way for each specimen with the dorsal surface down. The loading plunger was placed over the distal shaft of the metacarpal and an axial force was applied at 100 mm/min. Sampling was recorded at 100 Hz.

To test axial loading, which can be a common mode of failure, 12 metacarpals (6 with headless compression screws and 6 with K-wires) were potted in 1.5-in diameter polyvinyl chloride piping and plaster of Paris, leaving the equivalent of 15 mm of distal metacarpal exposed to be subjected to testing. Care was taken during potting to align the dorsal side of the metacarpal parallel to the polyvinyl chloride wall. Specimens were mounted onto the Materials Testing System frame using a custom-made clamp allowing alignment of the potted specimens to be