Comparison of Crossed K-Wire and Mini-Hoffmann Fixation to Small pin, Non-Bridging External Fixation for Distal Metacarpal Fractures

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Background:

Metacarpal and phalangeal fractures are the most common fractures of the upper extremities; they account for about 10% of all orthopedic fractures. [1] In metacarpal and phalangeal fractures, a functional outcome is dependent on establishing early active motion. Early active motion requires sufficient stability at the fracture site.[2] Rigid internal and external fixation devices are used to treat unstable fractures that cannot be aligned with a simple cast. These fixation devices allow for immediate motion. Soft tissues around the fracture help to stabilize and add mechanical support to the fracture site.[3]

The purpose of this study was to compare the mechanical effectiveness of two conventional fixation systems, 2 crossed K wires (KW) and Mini Hoffmann external fixation (MH) to a prototype, non-bridging external fixation system (NBX) at controlling distal metaphyseal fractures of the metacarpal.

Methods:

Fifteen fresh adult human cadaveric complete rays, #2 – 5, with intact soft tissues had the flexor digitorum superficialis and flexor digitorum profundus tendons exposed to be held in a tendon clamp. The extensor tendons, collateral ligaments, dorsal skin and muscle all remained untouched. From the volar side, the metacarpal was exposed and a wedge of bone removed from the distal metaphysis to simulate an unstable fracture, see Fig. 1. The rays were divided randomly into three groups: group 1 was fixed with KW; group 2, with MH applying 2 parallel pins into the distal fragment (Fig. 1); group 3 with the NBX with 4, 1.5 mm pins in different planes of fixation in the distal fragment (Fig. 2), 5 rays per group.

The proximal fragment of the metacarpal was pinned with 2, 3 mm pins and held in a small Hoffmann II multi-pin clamp which was held in a vice so the metacarpal was positioned vertically with the phalange below, Fig.1 & 2. The tendon clamp was attached with a universal joint to the MTS ram, so the tendons were loaded in tension at a rate of 1 mm/sec. A PVC tube was placed on the volar side of the phalange to provide grip resistance under flexion loading. The loading cycle was recorded by video fluoroscopy and synchronized with the MTS load-deflection curve.

The collapse of the wedge gap in the distal metacarpal was identified in the video, and the same point in time identified on the load-deflection curve of the MTS reading. Thus the force to reach collapse of the wedge gap could be identified.

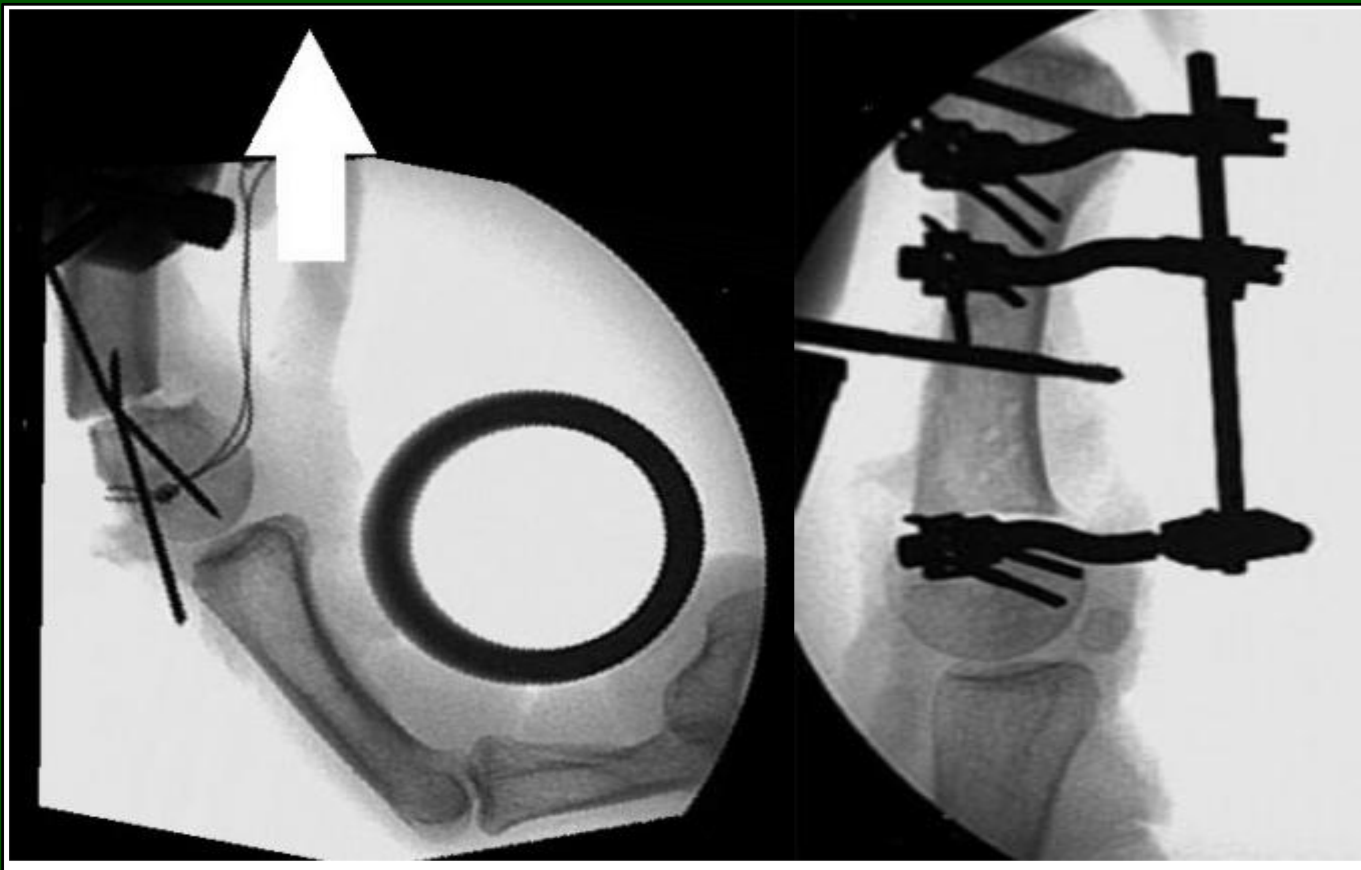

Figure 1 – K wire fixation after loading the flexor tendon group to the point of collapse of the fracture, left. Mini Hoffmann fixation before loading, right.

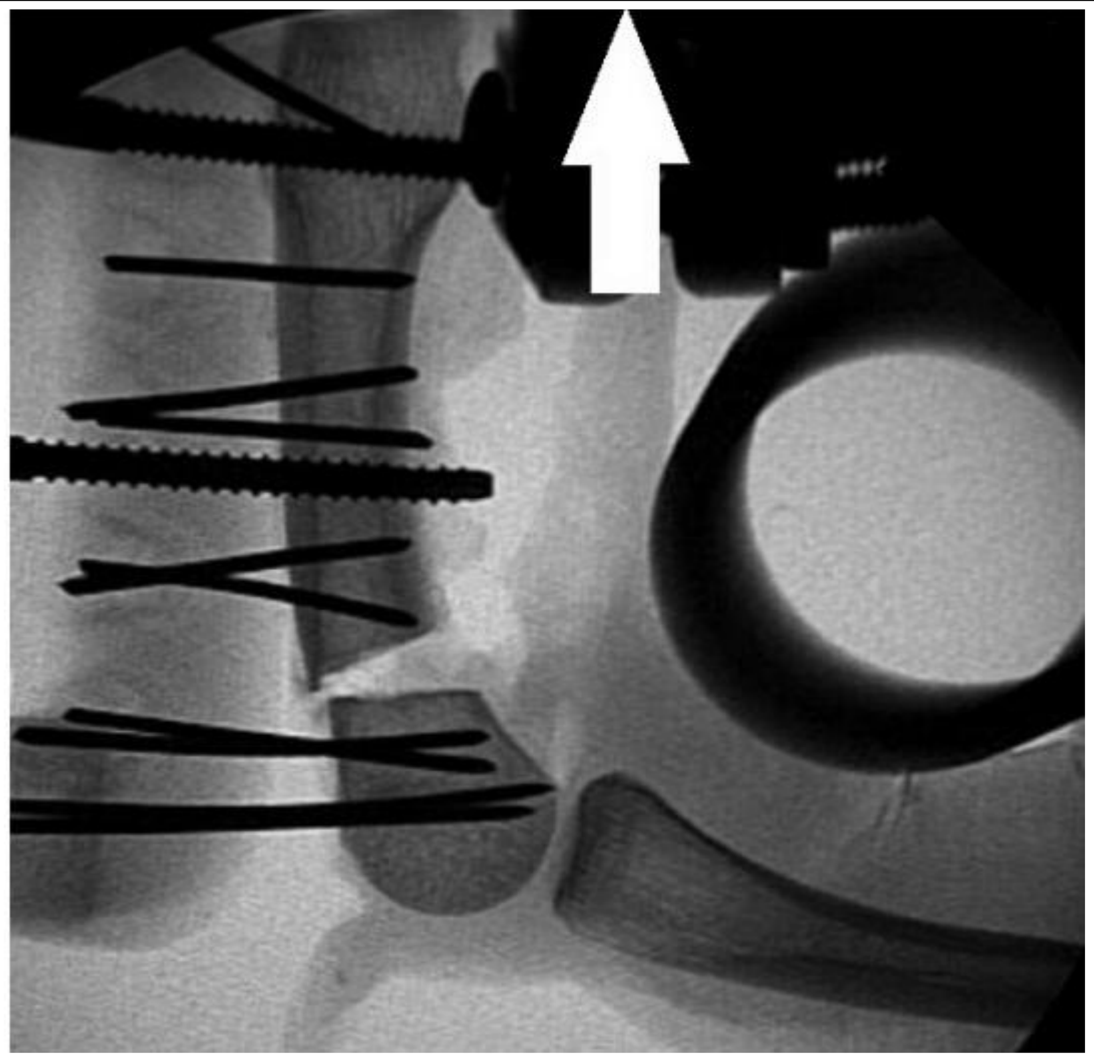

Fig. 2 – NBX fixator under load before fracture collapse.

Results: The load to cause collapse of the wedge gap in the distal metacarpal averaged 42.5 10.9 N for the KW group; 46.4 0.9 N, for the MH group; and, 94.1 53.6 N, for the NBX group. The difference between the NBX and both the KW and MH groups was significant, $P < 0.04$, by ANOVA for multiple comparisons. The KW and MH groups were not significantly different from each other.

With relaxation of flexor tendon load after collapse of the gap, the K wires remained bent and the gap partially closed. Most of the Mini Hoffman pins sprang back with no residual bend, but the distal bone fragment had slipped on the pins, so the fragments did not completely return to their anatomic position. The NBX pins remained fixed to the distal fragment, and the fragments returned close to their original position in 4 of 5 metacarpals tested.

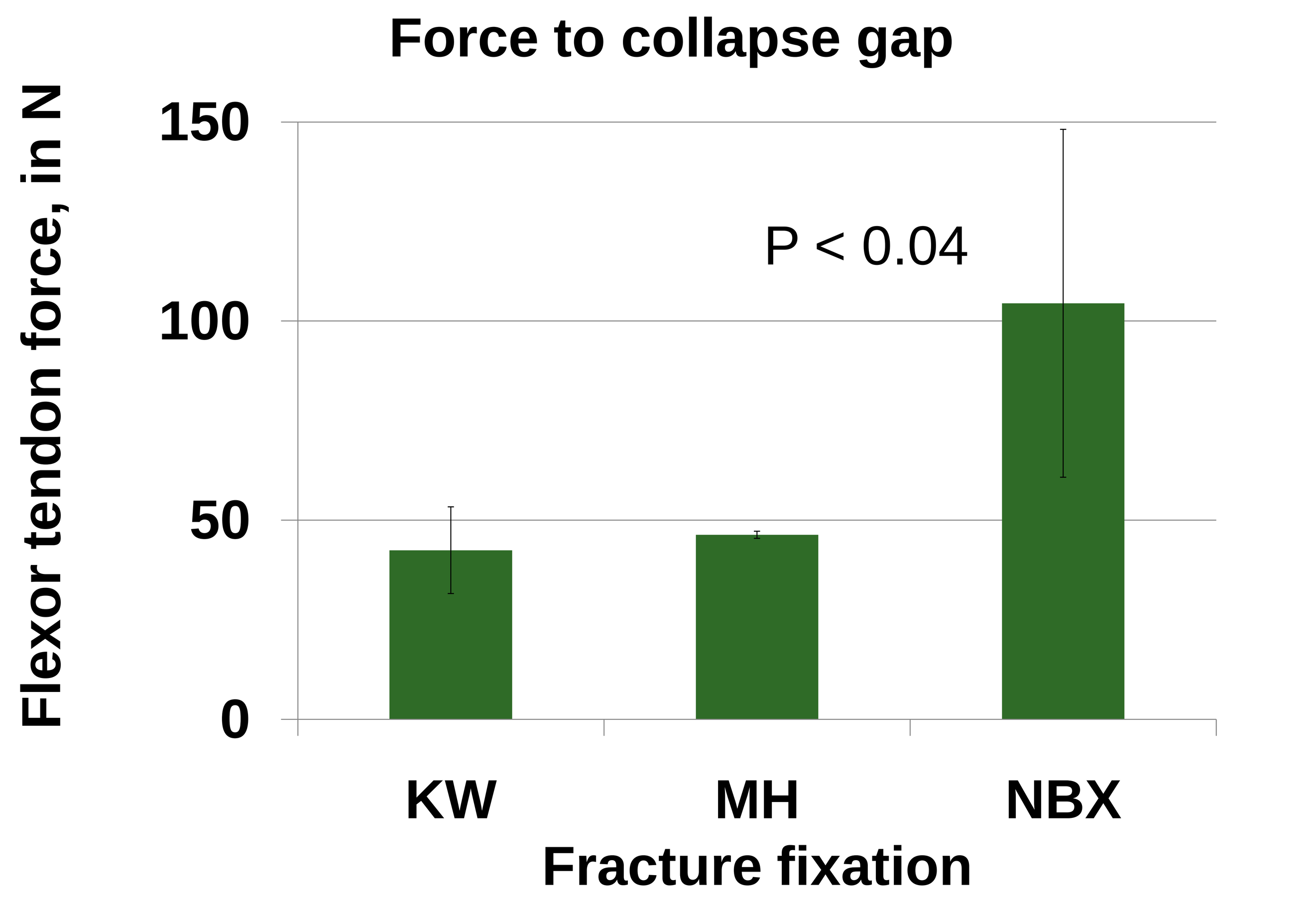

Figure 3 – there was a statistically significant increase in flexor tendon force required to collapse the gap in the NBX group compared to the KW and MH groups.

Significance:

Multiple pins of small diameter, in multiple planes of fixation can provide stability that is better than more conventional means of fixing metacarpal fractures near joints. In addition to better stability, there is an increased likelihood of multiple fragments staying in a correct anatomically reduced position.

References:

1) Stern, PJ, Green’s Operative Hand Surgery, 1999,
2) Firoozbakhsh, et al, J Hand Surg., 18A:1059, 1993m
3) Ouellette, EA, et al, CORR, 412:169, 2003

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