

Finite Element Analysis of Fixation Strength in Kirschner Wire Fixation of Phalangeal Fractures - Additional Report on the Relationship Between Wire Intersection and Fracture Line

Yukinori Hayashi^{1,2}, Takashi Ajiki³, Hirokazu Inoue¹, Katsushi Takeshita¹
¹Department of Orthopaedic Surgery, Jichi Medical University, Tochigi, Japan,
²Department of Orthopaedic Surgery, Tochigi Prefectural Rehabilitation Center, Tochigi, Japan,
³Department of Orthopaedic Surgery, Ishibashi General Hospital, Tochigi, Japan
 Email of Presenting Author: r1442hy@jichi.ac.jp, aesculapius19xx@gmail.com

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INTRODUCTION: We previously analyzed and reported on the fixation strength of wire fixation for phalangeal fractures, using a 3D model of the proximal phalanx and varying the wire diameter and insertion angle. All previous models assumed that the fracture line and wire intersection matched. In this report, we investigate models where the intersection does not match.

METHODS: 3D models were constructed from the CT data of the 3rd proximal phalanx of 5 healthy men. A 1mm wide bone defect was created in the center of the diaphysis, leaving only the volar cortex as an incomplete fracture model. Two stainless steel cylinders imitating Kirschner wire, 1.5mm in diameter, were inserted at a 60° angle at the fracture site. The intersected wires were shifted 1mm proximally and distally, exploring 7 different variations up to ± 3 mm (Fig. 1). Using the finite element analysis software Mechanical Finder, we applied a vertical load to the bone head to evaluate fixation strength (Fig. 2).

RESULTS SECTION: In our analysis, the scenario with the highest level of fixation strength occurred when the intersection of the Kirschner wire and the fracture line was perfectly aligned. In this condition, the measured fixation strength reached up to 54 N. As we deviated from this central reference point of ± 0 mm, a consistent pattern of decreasing fixation strength was observed. Specifically, for every 1 mm of deviation in either the proximal or distal direction, there was approximately a 1.85% reduction in fixation strength (Fig. 3).

DISCUSSION: Previous studies showed that increasing the wire insertion angle and using a wire diameter of 1.5 mm or more increased fixation strength. Our current analysis revealed that the overlap of the fracture line and wire intersection led to the highest fixation strength, but slight deviations had minimal effect on strength. The analysis did not consider rotation, an essential factor in real clinical practice. Future studies will include an analysis considering rotation.

SIGNIFICANCE/CLINICAL RELEVANCE: This study informs the optimization of Kirschner wire fixation in phalangeal fractures, particularly regarding wire diameter and insertion angle.

Fig.1

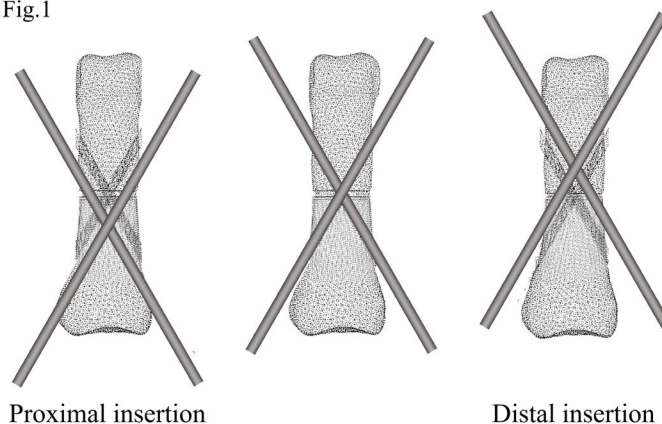


Fig.2

