An In Vitro Biomechanical Comparison of an Interlocking Nail System and Dynamic Compression Plate Fixation of Ostectomy Equine Third Metacarpi

David G. Wilson, DVM; Mandi J. Lopez, DVM, MS; Ray Vanderby, JR, PhD; Mark D. Markel, DVM, PhD

Interlocking nail fixation may offer some potential advantage over plate fixation for metacarpal fracture fixation; however, double plate fixation is biomechanically superior. Authors' addresses: Department of Large Animal Clinical Sciences, University of Saskatchewan, 52 Campus Drive, Saskatoon, SK, S7N 5B4 Canada (Wilson) and Comparative Orthopaedic Research Laboratory, School of Veterinary Medicine, 2015 Linden Drive W, Madison, WI 53706 (Lopez, Markel, Vanderby). © 2001 AAEP.

1. Introduction

Equine third metacarpal fractures challenge available treatment modalities due to the fact that they are frequently open and many are comminuted. The standard method of internal fixation is the use of two dynamic compression plates off set 90 degrees.1 Stabilization of minimally comminuted, closed third metacarpal fractures by traditional means has proven relatively satisfactory, but therapy for severely comminuted or open fractures is far less satisfying. Due to the tenuous soft tissue coverage of the third metacarpus, skin slough resulting in implant exposure is a serious and often disastrous complication. Interlocking nails have been used to repair human femoral, humeral, and tibial fractures and have been investigated for neonatal bovine femoral and equine humeral and tibial fractures.2–4 The purpose of this study was to compare the mechanical properties of an interlocking nail system with two dynamic compression plates to repair ostectomy equine third metacarpi. A surgical approach for placement of an interlocking nail into the medullary canal of the third metacarpus was also evaluated.5

2. Materials and Methods

Ten pairs of forelimbs intact from the mid-radius distally were collected from adult horses (3–20 years of age with estimated weights > 350 kg) that had been euthanatized for non-orthopedic reasons. The pairs were divided into two test groups (five pairs each), caudocranial four-point bending and torsion. Interlocking nails (6 hole, 13-mm diameter, 230-mm length) were placed in one randomly selected bone from each pair. Dynamic compression plates were placed dorsally (12 hole, 4.5 mm) and laterally (10 hole, 4.5 mm) on the contralateral bone from each pair. All bones had 1-cm mid-diaphyseal ostectomies.

NOTES
To compare the biomechanical properties of osteotomized equine third metacarpi repaired by the two techniques, 5 pairs were tested in caudocranial four-point bending to determine stiffness, yield, and failure properties. The remaining 5 pairs were tested in torsion to determine torsional stiffness and yield. Bending was performed using a load applied over a single-cycle ramp function at a constant displacement rate of 6 mm displacement/second to failure. For torsion, the longitudinal axis of the midshaft of the metacarpus was aligned along the axis of loading. Each specimen was loaded at a constant displacement rate of 0.17 radians/second until a rotation of 50 degrees was attained. Data was acquired at 0.1 second intervals throughout each test by analog/digital conversion and stored in a computer data file.

Mean values for each fixation method were compared using a paired t-test between each group. Significance was set at $p < .05$.

3. Results

The mean composite rigidity, yield load, and failure load of the interlocking nail/metacarpus composite and the plates/metacarpus composite in four point bending were 1589 N/mm and 1624 N/mm, 6894 N and 9990 N, and 12,846 N and 16,371 N, respectively. Statistical analysis showed no significant difference in the biomechanical values in bending between the two fixation methods ($p < .05$). Mean composite rigidity, gap stiffness, and yield load of the interlocking nail/metacarpus composite and the plates/metacarpus composite in torsion were 2.2 and 4.6 Nm/deg, 3.9 and 49.1 Nm/deg, and 94.8 and 131 Nm, respectively. There was a significantly higher yield load and composite rigidity of the plate/metacarpus composite, but no difference in gap stiffness between the two fixations.

4. Discussion

This study showed no significant differences in biomechanical properties between interlocking nail and double plating techniques for stabilization of osteotomized equine third metacarpi in caudocranial bending. Double plate fixation was superior in torsional yield and composite rigidity. Some of the advantages offered by the interlocking nail system over double plating include the fact that closed fractures could potentially be fixed closed reduction. Leg length can be maintained, intramedullary reaming provides cancellous bone graft to the fracture site, and any remaining periosteal vasculature should not be disturbed. In open fractures the interlocking nail would not be an issue in skin closure over the implant, and there is far less chance that the implant will be exposed if the skin sloughs over or around the original wound. Implant surface area is significantly less than that of two dynamic compression plates making bacterial adherence and establishment slightly less of a concern. However, our study indicates that double plate fixation of osteotomized equine metacarpi in vitro is biomechanically superior in torsion to interlocking nail fixation. Further studies comparing the fatigue characteristics as well as biomechanical behavior under compression and mediolateral bending will be helpful in comparing the two techniques.

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References