Angular stability of locking screws in intramedullary nails does not improve their mechanical performance

INTRODUCTION

The preferred treatment of distal tibia fractures so far depends on the preference of the operating surgeon and the exact fracture location. Retaining mechanical stability by osteosynthesis becomes increasingly difficult with distal extension of the fracture. While intramedullary nailing is the preferred choice for shaft fractures, locked plating becomes more and more common with increasing distal extension of the fracture. However, recently the option of angular stable locking screws was introduced for intramedullary nails (1). This angular stable locking technology has revolutionized plate osteosynthesis. Increased mechanical performance of intramedullary nails due to angular stability of locking screws could potentially improve fixation for certain types of fractures. In the case of distal tibia fractures such screws would expand the indication for intramedullary nailing for more distally located fractures.

The aim of this study was to compare the stiffness of the implant-bone-construct and the interfragmentary movement in the treatment of distal tibia shaft fractures using reamed nailing and unreamed nailing, with and without angle stable interlocking. We hypothesized that additional angular stability in the locking screws of intramedullary nails would improve their mechanical performance.

MATERIAL AND METHODS

Twenty four artificial saw bones (4th generation medium left Tibia, Sawbone, Sweden) were osteotomized to simulate a distal tibia fracture at one-fifth of the tibia length (AO classification: 43-A3). The osteotomized sawbones were stabilized with T2 tibia Nails (Stryker) using the following techniques:

- UNREAMED NAIL (ø 8mm) with standard locking,
- UNREAMED LOCKED NAIL (ø 8mm) with angular stable locking
- REAMED NAIL (ø 10 mm) with standard locking
- REAMED LOCKED NAIL (ø 10 mm) with angular stable locking

For comparison of the different intramedullary nailing techniques with plating, one group obtained fixation with an angular stable - LOCKED PLATE (LCP, Synthes).

The constructs were embedded distally and proximally with polymethylmethacrylate (PMMA) to fit the attachments of the materials testing machine (Figure 1, Instron 9974, High Wycombe, UK). Distal fixation was performed with a cardanic hinge and proximal fixation with another hinge for axial loading and a linear bearing for torsional loading. Loading was performed in off-axis compression and torsion with a physiological gait loading protocol that includes weight bearing and muscle forces (2). Maximum axial forces of 350N and torsional loads of 10Nm were applied sequentially in 3 test cycles of each of the constructs. Deformation of the constructs and movement of the osteotomy gap was measured with an optical tracking system (Pontos, GOM, Germany).

The results were tested for statistical significance by ANOVA with a Bonferroni post hoc test (SPSS 17.0, Chicago IL).

RESULTS

Angular stability of the locking screw did neither improve stiffness in axial direction (p>0.7) nor in torsion (Figure 2, p>0.8) compared to conventional locking. However, reaming the intramedullary canal and using a thicker nail significantly increased torsional stiffness by 43% (Figure 2, p<0.01) and axial stiffness by 21% (p<0.01).

Displacement of the osteotomy gap resulted primary from bending of the bone implant construct. Due to their intramedullary location the nail constructs prevented bending much more effectively than the locked plate construct (Figure 3). The resulting gap displacements were up to 5 times higher for the plate compared to the nail (Figure 3, p<0.01). Also the thicker nail prevented gap displacement much more effectively than the thin nails. The angular stability of the locking screws had no influence on the resulting gap displacement (Figure 3, p>0.5).

DISCUSSION

The addition of angular stability to distal locking screws in intramedullary nails does not provide any benefits in terms of mechanical stability in distal tibia fractures. Conventional locking screws, inserted in free hand technique are rarely placed in a perfectly rectangular direction. By free hand locking multiple screws will get jammed between nail and bone and will therefore provide already angular stability for the construct.

SIGNIFICANCE

The findings of this study demonstrate that specially designed angular locking mechanisms can not improve mechanical performance and are thus unlikely to affect clinical performance of intramedullary nailing for distal tibia fractures.

ACKNOWLEDGEMENTS

Stryker Osteosynthesis provided financial support for this study.