Introduction: It is widely accepted that the mechanical stability of osteosynthetic devices has an effect on the healing process and clinical outcome. Rigid fixation and immobilization of fracture fragments leads to direct cortical union; interfragmentary movement leads to callus formation. In complex fractures, complete fragment contact is rarely achievable and bone stability is re-established by callus formation. Clinically, use of an intramedullary nail is preferred to external fixators. However, unreamed nailing favors biology at the expense of mechanical stability.

The aim of this study was to determine to what degree fixation influences the initial situation at the fracture gap and the long term outcome. In particular, this study aims to quantify the influence of external fixation versus unreamed nailing on the initial mechanical stability and the long term biological outcome at the osteotomy site.

Material and Methods: Two groups each consisting of six female merino sheep (2 years, f), underwent a standardized midshaft osteotomy of the right tibia (gap = 3 mm). The osteotomy was stabilized with a monolateral external fixator in group I and an unreamed tibial nail in group II. The fixator was mounted medially and consisted of 6 Schanz' screws (Ø 5 mm, 3 inserted proximally, 3 inserted distally of the osteotomy) and 2 carbon fiber rods (Ø 10 mm). The fixator of group I was constructed to have an axial stiffness similar to that of the unreamed nail. A statically locked unreamed nail (UTN, Ø 9 mm) was shortened to 21 cm in order to fit to the length of a sheep tibia. To measure the fragment movements, both groups received additional screws proximal and distal to the osteotomy. Measurement of fragment movements were taken up to three times a week using an infrared camera system (PCReflex, Qualysis). Ground reactions were determined by means of a force platform (emed, novel). X-rays were taken once a week throughout the healing period of nine weeks.

The fractured tibiae were explanted and tested for torsional stability and until the fracture gap is filled with calcified bone. Stains of group II show a completely different situation: The callus tissue appears to be non-uniform with osseous areas surrounded predominantly by fibrous tissue. Periosteal osseous bridging can only be seen laterally, while bridging on the medial side was incomplete or non existent. Osseous filling of the intercortical gap did not occur. Bone area and area of mineralized bone were significantly lower in group II (p=0.002) as well as cortical and cortical bone area (p=0.002). Medial periosteal bone area (p=0.0026) and bone density (p=0.041) were significantly higher in group I, as well as callus bone area (p=0.026) and bone density (p=0.015) in the medial and lateral endosteal callus areas.

Conclusions: In both groups, the midshaft surgical trauma, the bone defect situation and the axial rigidity of the osteosynthetic devices were identical. Nevertheless, significant differences in the initial fragment movements, healing process and histological outcome were identified. It is well known that the success of treatment is due to the initial stability of the osteosynthesis. Due to the initially high relative movements of bone fragments, the callus formation was delayed in the unreamed nail group compared to the external fixation. In addition, unreamed nailing seems to impair the healing process with severe osteolysis in the diaphyseal cortical area. The less satisfying results of the unreamed nail may be attributed to the early weight bearing in sheep. As human patients avoid full weight bearing after surgery, the negative effects observed in this study for unreamed nailing may be reduced in a clinical situation.

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