INTRODUCTION:
Mechanical strain, which occurs during callus distraction, is known to stimulate osteogenesis. This method is used to close large bone defects as well as to achieve leg lengthening (Ilizarov). Our idea was to use the tissue strain induced bone formation to accelerate the bone healing process of normal fractures. To avoid a lengthening of the fractured bone the distraction was followed by a subsequent reduction and reconstitution of the original fracture gap. The hypothesis was that this temporary distraction enhances the fracture healing process.

METHODS:
Fourteen skeletally mature sheep underwent a middiaphyseal osteotomy of the right tibia, stabilized by external fixation with an interfragmentary gap of 3 mm. A custom-made external fixator (Figure 1) allowed either a temporary axial distraction (TD-group; n=6) or a constant fixation (C-group; n=8). Distraction began 7 days post-operatively at a rate of 0.5 mm, twice per day for 2 days and adjacent shortening of 1.0 mm, twice on the third day. The procedure was repeated 4 times. Fluorochrome labeling was performed at day 20 (calcein green) and day 27 (tetracycline). After 8 weeks the sheep were killed, and healing of the osteotomies was evaluated.

The amount of periosteal bone formation was determined by pQCT at the level of the osteotomy gap (Figure 2). A nondestructive three-point bending test was performed to measure the bending stiffness of the healed tibiae. Finally, undecalcified histology was performed, which allowed the quantitative determination of the new bone formation in the fracture gap and a time sequence analyses of the fluorescent labeled bone by a point counting method (Figure 2). Differences between control group and distraction group were tested using a Mann-Whitney-U test.

RESULTS:
Bending stiffness of tibiae after 8 weeks was 10.5 ± 6.7 Nm/mm in the TD group and was significantly (p<0.05) higher than in the C-group 8.1 ± 6.2 Nm/mm. Cross sectional area was significantly (p<0.05) higher in the TD-group (589 ± 66 mm²) than in the C-group (506 ± 78 mm²). In the fracture gap we found 26% bone in the TD-group and 12% bone in the C-group. After completing the distraction protocol there was a significantly higher bone formation rate in the TD-group than in the C-group, indicated by the fluorescent labeling at day 20. All results are normalized to the control group, which was representing 100% (Figure 3).

DISCUSSION:
Temporary axial strain in the osteotomy gap increased callus formation during secondary fracture repair in the gap and at periosteal and peripheral sites. Consequently mechanical stiffness increased. This study demonstrated the feasibility of fracture healing stimulation by the temporary application of mechanical strains. The distraction followed by subsequent compression can use the positive effect of strain induced bone regeneration without bone lengthening. The results suggest that in fractures with sufficient mechanical stability distraction across the fracture site could improve the healing process.

REFERENCES:

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