FRACTURE HEALING IN A SHEEP MODEL OF OSTEOPOROSIS

Materials and Methods
In this study 13 sheep were included and divided into two groups. Group 1 contained of 6 osteoporotic animals (8 years old). Group 2 had 7 healthy animals (5 years old). The duration of the experiment was 12 months.

In group 1 osteoporosis was induced during 7 months by means of ovariectomy, calcium and vitamin D restricted diet and steroid medication according to the induction regime of a previous study [1].

The bone mineral density decreased at the distal radius 21.9 ± 1.8% and at the distal tibia 19 ± 2.9% in cancellous bone and 2 ± 1.6% in cortical bone. After a period of 3 months without steroids a mid-tibial transverse osteotomy of the right tibia was performed and stabilised with a custom made external fixator (4 Schanz-screws) with a removable middle section. The osteotomy gap was 3 mm.

With a custom made measurement device the bending stiffness was determined before osteotomy and at weekly intervals from load/displacement curves. A load of 16 N was applied. Measurements of the bone mineral density (BMD) at the osteotomy gap at the right tibia were performed post operatively, at 4 and 8 weeks using peripheral quantitative computed tomography (pQCT, Densiscan 1000) to determine callus area and density (g/cm³). The slice thickness was 1.5 mm with an increment of 1.5 mm obtaining 10 consecutive slices. A matrix of 512 x 512 pixels was used. BMD from cortical and cancellous bone was determined in the same manner at the distal left tibia at the same intervals.

Weekly radiographs from the osteotomy site were taken in the a.p. direction to demonstrate callus formation and bone healing with clinically relevant measures. After 8 weeks the sheep were sacrificed and the stiffness of both tibiae was determined in a non destructive torsional test. The test was repeated 5 times and mean values were calculated. The maximum torsional angle was 7°.

Statistics: 2-sample t-Test, Wilcoxon Test, 1-sample t-Test, repeated measures analysis

Results:
The osteotomised tibiae from the control group reached the initial in vivo stiffness (100 ± 3%) 42 days post operatively. At the same time the osteoporotic animals reached 63 ± 4% of the initial stiffness. At 56 days after osteotomy the in vivo stiffness in the osteoporotic group was still below initial stiffness (94 ± 5%). In the osteoporotic animals the 50% bending stiffness was delayed 15 days.

BMD of cancellous bone at the tibia increased 1.5% in the control group over 4 weeks and 3.6% in the osteoporotic group. Cortical bone density increased 0.6% in the control group and 1.9% in the osteoporotic group.

The weekly radiographs from the osteotomy site showed less callus density and formation in the osteoporotic animals. QCT data showed at the osteotomy gap 35% lower callus density in the osteoporotic group after 4 weeks and 26% lower density after 8 weeks. Callus area at the osteotomy site was 33% smaller in the osteoporotic group after 4 weeks and 12% smaller after 8 weeks.

Comparing the intact and the osteotomised tibia after 8 weeks in torsional stiffness there was a reduction of 3% in the osteotomised side in the non osteoporotic group. In the osteoporotic animals there was a difference of 33% between intact and osteotomised tibia. We found a difference of 52% in torsional stiffness of osteotomised tibiae from the two groups.

Conclusion:
Fracture healing of a standardised mid-tibial transverse osteotomy in osteoporotic sheep seems to be retarded compared to non osteoporotic animals. In the osteoporotic group the increase of the in vivo stiffness, callus formation and callus density and torsional stiffness were found to be smaller. Histomorphometrical analysis will show more details.

With the custom made device measurement was sensitive enough to detect differences in bending stiffness. During the experiment no steroid effect on bone formation was seen as BMD increased in osteoporotic and non osteoporotic sheep due to seasonal influence.

Reference: