Introduction: Fractures are often associated with soft tissue injuries, which significantly influence their treatment as exemplified by the common reference to their classifications. Furthermore, recent references to “biologic osteosynthesis” indicate the importance of perfusion at the fracture site and thus integrity of surrounding soft tissues and minimally invasive stabilisation techniques.1,2 In order to evaluate such factors, an appropriate experimental model was developed incorporating a standardized tibial shaft-fracture with a reamed non-comminuted soft tissue injury.

Methods: A pneumatically driven cylinder (Ø25mm ram, 6 m/s velocity) was used to produce a reproducible defined soft tissue injury. With an LVDT, the impact energy was monitored on a PC. Adjacent to the soft tissue injury, a mid-shaft fracture was then created with a sub-cutaneous 4-pt bending device in a minimal invasive manner. For induction of the fracture, a 1/3 osteotomy was created through two 2cm longitudinal skin incisions, which later served as approach for insertion of the fracture device. The fracture device was attached to the bone with two surface contact points and two mono-cortical Schanz-screws. A pretension of 49N was applied through the Schanz-screws and the fracture was then created by impact loading with a slap hammer.

Twelve sheep, equally divided in two groups, were bilaterally injured and treated. Prior to injury, the soft tissue thickness (STT) at the lateral compartment was measured using a cannula. Group I received a trauma with an impact depth of 1.4 x STT and was stabilized with an internal fixator (PC-Fix II, Synthes) in a minimally invasive fashion (MIS) in one leg and open ORIF in the other leg. Group II received a trauma with an impact depth of 1.6 x STT and was stabilized with similar MIS internal fixator in one leg and an unreamed intramedullary nail in the contralateral leg.

At the soft tissue injury site, intramuscular partial oxygen pressure (pO2) was measured with an indwelling catheter-probe using a polarographic method (LICOX). Lateral compartment pressure (CP) was monitored by a slit catheter-probe (Stryker-Osteon). Measurements were taken 0, 3, 9, 24 hrs after trauma and then daily for 1 week. Bilateral pO2 and CP measurements from tibiae of 12 uninjured sheep served as control measurements. Prior to euthanization at post-op day 7, intravital perfusion staining was performed followed by post-mortal vascular dye injection for histological evaluation. Comparisons of outcome measures between treatments within each group were done using a MANOVA. Comparisons of elevations with respect to the “uninjured” controls were done using an ANOVA with post-hoc Dunnett’s t-test. A repeated measurements general linear model regression analysis was performed to test for the differences between group I and II. For all analyses, significance level was p < 0.05. All procedures were carried out under supervision of the Animal Experimentation Commission of the Veterinary Office of Canton Graubunden.

Results: Of the 24 created fractures, 79% were simple transverse fractures (AO 42-A3), 17% simple oblique fractures (AO 42-A2) and 4% butterfly fractures (AO 42-B2). In all animals, a T-scheme GII soft tissue injury was produced. No animal showed evidence of compartment syndrome. No statistically significant differences were found between treatments within each group, and thus data were pooled for further analysis. The pO2 values in both groups were significantly elevated from control values for 2 days post-trauma (group I, p ≤ 0.02) and for 4 days post-trauma (group II, p < 0.04), peaking at 2.5x “uninjured” at 9 hrs post-trauma, Fig. 1. Although there was no significant difference between group I and II, the higher trauma was associated with a delayed return to control levels. The CP was significantly elevated from control values immediately post-trauma in both groups. Group I then returned quickly to control values. Whereas in group II, the CP values remained significantly elevated compared to group I (p = 0.02) and control (p < 0.005), Fig. 2. Preliminary histological evaluation showed decreased perfusion at the injured muscle. Quantitative histological analyses are currently pending.

Discussion: The presented trauma model allows the production of a standardized tibial mid-shaft fracture and a defined reproducible non-compartment-syndrome soft tissue injury. In both groups, significant elevations in intramuscular pO2 exhibited the presence of significant soft tissue damage. However, there was no significant difference in pO2 measurements between the two groups. The CP measurements on the other hand showed significantly increased pressures for the more severe trauma, implicating that pO2 may be a good measure of injury presence, but that CP measurements are more sensitive to the severity of trauma. Furthermore, the lack of differences in acute pO2 and CP measurements between approach and fixator types, supports the use of this model with a variety of surgical methods and implants. To our knowledge most animal models of fracture healing have no soft tissue injury. This is the first trauma model in large animals to achieve comparable clinical conditions. This model allows for investigation of healing of fractures with concomitant soft tissue injury and comparison of treatments thereof.

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