Anabolic Steroids Reduce Muscle Degeneration Caused by Rotator Cuff Tendon Release in Sheep

Christian Gerber¹, Dominik C. Meyer, MD¹, Martin Flück¹, Brigitte von Rechenberg², Mario Benn², Karl Wieser, MD¹.
¹Balgrist University Hospital, Zurich, Switzerland, ²Equine Department, Vetsuisse Faculty, University of Zurich, Zurich, Switzerland.


Introduction: Strategies to prevent or at least reduce fatty infiltration and atrophy of the muscle after a rotator cuff tendon rupture, which are widely recognized as the major structural limitation for successful operative repair, are of tremendous interest. It was the purpose of this study to test the hypothesis that anabolic steroids are able to avoid and / or reverse muscle degeneration caused by musculotendinous retraction in an experimental rotator cuff model in sheep.

Methods: The infraspinatus (ISP) tendon was released in 18 alpine sheep. After 16 weeks of musculotendinous retraction, repair of the musculotendinous unit was performed. Sheep were sacrificed 6 weeks after repair. 6 sheep served as controls, 6 were treated with weekly intramuscular injection of 3 mL nandrolone decanoate (50 mg/mL) starting after ISP repair (group N6W) and 6 with nandrolone starting immediately after tendon release (group N22W).

Muscle biopsies were taken before tendon release, after 16 and 22 weeks. MRI and CT imaging was performed immediately after ISP release, after 6 weeks, prior to ISP repair and prior to sacrifice for investigation of musculotendinous retraction (CT), density of the muscle tissue (CT), volume (MRI T2) and fat fraction of both ISP muscles (MRI DIXON).

Results: There were no significant differences regarding the right ISP muscle volume between the control group and group N22W at any time-point. However, the increase of ISP volume after repair in the N6W group was significant compared to the volume decrease in the control group (p=0.02) and the N22W group (p=0.01). In the control group the right ISP muscle volume (MRI) decreased to 80 ±8 % after 6 weeks, remained stable at 78 ±11 % after 16 weeks and decreased further to 69 ±9 % after 22 weeks. Group N6W and group N22W changed to 74 ±11 % / 72 ±9 % after 6 weeks, to 76 ±13 % / 73 ±6 % after 16 weeks and 78 ±14 % / 67 ±5 % after 22 weeks. There was no significant difference in the left ISP muscle between the three groups at any time-point (p=0.395). The amount of fatty infiltration was significantly lower if nandrolone treatment started immediately after tendon release. Compared to the control group, which showed a continuous increase of fatty infiltration from 63 ±7 HU and 12 ±4 % at the time-point of tendon release to 54 ±4 HU and 17 ±4 % after 6 weeks; 26 ±11 HU and 50 ±9 % after 16 weeks and 11 ±13 HU and 60 ±8 % after 22 weeks, animals of the N22W group showed significantly less fatty infiltration after 16 weeks (54 ±7 HU and 16 ±5 %; p<0.001) and 22 weeks (49 ±17 HU and 22 ±7 %; p<0.001) respectively. However, the lower amount of fatty infiltration in animals of the N6W group after 22 weeks (18 ±13 HU; p=0.41 and 56 ± 12 %; p=0.55) was not significantly different compared to the control group. Neither the amount of chip retraction (CT) after 16 weeks, nor the achieved lengthening
of the musculotendinous unit after repair showed significant differences between the 3 groups (p=0.288).

The CT and MRI findings were qualitatively confirmed by the current preliminary histological results. There was a strong increase in adipocyte numbers after 16 weeks of retraction and especially 6 weeks after the repair in the samples without nandrolone treatment and a variably increased muscle fiber cross-sectional area after tenotomy. In contrast, fatty infiltration after 16 and 22 weeks was markedly reduced with a variable increase in muscle fiber cross section in the animals treated with nandrolone immediately after tendon release.

**Discussion:**

**Significance:** Anabolic steroids have the potential to prevent the onset of fatty muscle infiltration if application starts immediately after tendon release and seem to induce muscle hypertrophy if the application is started after repair.
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