Introduction: Tunnel placement is one of the key issues for the success of anterior cruciate ligament (ACL) reconstruction. Concern about anterior impingement of the graft in the femoral notch has led to a more posterior tibial tunnel placement resembling the tibial postero-lateral (PL) bundle insertion site. In one cadaveric study, when the trans-tibial technique is used to drill the femoral tunnel, the femoral tunnels tend to be placed high in the notch, far from the center of the anatomical insertion site. However, other cadaveric studies have shown that a more anatomical tunnel placement has biomechanical advantages. The aim of this study was to evaluate the effect of tunnel placement on bone-tendon healing in ACL reconstruction by analyzing the biomechanical properties.

Materials and Methods: Twenty-one, three year old, female Nubian goats were used in this study. The goats were divided into three groups of seven. Goats in each group underwent ACL reconstruction on their right knee with three different tunnel placements. In the first group (Figure 1A), the ACL reconstruction was performed by placing the graft from the anteromedial (AM) bundle tibial insertion site to the AM bundle femoral insertion site (AM-AM group). In the second group (Figure 1B), the reconstruction was performed with the graft placed from the PL bundle tibial insertion site to the femoral AM bundle insertion site (PL-AM group). In the third group (Figure 1C), the graft was placed from the PL insertion site in the tibia to a high femoral position in the femoral notch (PL-H AM group).

Twelve weeks after surgery, all goats were sacrificed and the left knee was used as a control. To evaluate the biomechanical properties, anterior tibial translation (ATT) and in situ forces were measured in different knee flexion angles (30, 60, and 90 degrees) using a robotic/UFS testing system (Stäubli RX-90). Afterwards, cross section area, and ultimate failure load were measured using laser 3D digitizer (Konica Minolta VIVID 910 3D digitizer, Konica Minolta Sensing Inc., Japan) and a material testing machine (Adelaide Testing Machines, Model TTS-25 Series, Toronto, Canada). The ultimate stress was calculated by dividing the failure load by cross section area.

Surgical Technique: Each goat underwent ACL reconstruction with a single strand Achilles tendon split graft. The tunnels were drilled differently in each group as described above. After passing the graft, the femoral fixation was performed with sutures tied over a titanium button and the tibial fixation performed by tetherying the sutures to a screw post applying manual tension with the knee at 30 degree of flexion. Statistical analysis was performed with ANOVA. Statistical significance was defined as P < .05.

Results: Anterior tibial translation: The average ATT of the AM-AM group at 60 degrees (4.72±0.56 mm) was significantly less than the averages of both PL-AM and PL-H AM group at 60 degrees (6.76±1.29 and 7.40±1.68 mm). The control group also displayed significantly higher force when compared with all three reconstructed groups (Fig 2C).

The average ultimate stress of control group (48.50±10.69 N/mm²) was also significantly higher when compared with all three reconstructed groups (Fig 2C).

Discussion: The graft placement for ACL reconstruction has been broadly studied. In fact, it is known that tunnel misplacement is one of the main causes of graft failure in ACL surgery. The goal of a correct graft / tunnel placement is to achieve a physiological loading of the graft in order to avoid overstretching, promote bone graft healing, and provide the biomechanical conditions necessary to better restore knee kinematics. Our results showed that a lesser ATT and greater in situ force were present when the graft was placed from the AM bundle tibial insertion site to the AM bundle femoral insertion site (anatomical graft placement). This suggests that an anatomical load could play a role in the healing process. Also, a graft placed in an anatomical placement, having the proper load, may lead to knee stabilization and more closely restore normal knee kinematics.

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