Comparison Of Tibial Plateau Slope In Ovine, Canine And Human Knees

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Disclosures: 

Introduction: Large animal models are often necessary to comply with regulatory preclinical research requirements and the principles of translational medicine in the development of orthopedic treatments for the human knee. Ovine and canine models are frequently used in investigations of anterior cruciate ligament (ACL), collateral ligament, meniscal, and cartilage injury and knee joint arthroplasty. Ideal animal models approximate human body weight, joint size, knee biomechanics and anatomy. Various aspects of the ovine and canine knee anatomy have been compared to that of the human. The posterio-distal inclination of the tibial plateau, often referred to as “tibial plateau slope” (TPS), has been measured radiographically in the human and canine knee, but not in the ovine. The purpose of this study was to measure TPS in the adult ovine knee and adult canine knee and to compare these TPS values to those reported for the human knee. Based upon our knowledge of TPS reported in the human and canine knees and our subjective observation of the ovine knee, we hypothesized that, compared to the canine, the TPS of the ovine would more closely resemble the human knee.

Methods: Study Design: Twenty pelvic limbs (n = 20) were harvested from 10 healthy skeletally mature Columbia x Rambouillet cross ewes euthanatized for reasons unrelated to this investigation in accordance with the University Institutional Animal Care and Use Committee policy. Digital medio-lateral radiographs were made of each ovine pelvic limb. Similarly positioned radiographs of twenty pelvic limbs (n = 20) from 16 skeletally mature female Labrador retriever dogs that presented to the University Veterinary Teaching Hospital for evaluation of ACL tear were obtained for TPS measurement (previous work by Reif, et al has shown that TPS of the healthy canine knee does not differ from that of the ACL-deficient knee).1

Tibial Plateau Slope (TPS) Measurement: Tibial plateau slope (TPS) was measured using the “tibial plateau tool” in an orthopedic presurgical planning software application (OrthoPlanner™ software, Sound-Eklin, Carlsbad, CA). The anatomic landmarks for TPS measurement described for the human knee by Genin, et al were identifiable in the ovine and canine knees.2 Three investigators performed the ovine and canine TPS measurements by consensus to ensure accurate identification of the defined anatomic landmarks (Fig 1).

Statistical Analysis: Descriptive statistics including mean, range and standard deviation were calculated for ovine and canine knees.

Results: The mean (± SD) radiographic TPS of canine and ovine knees was 24.7 ± 2.3° (range: 19 - 28°) and 12.9 ± 1.4° (range: 10-16°), respectively. The mean (± SD) radiographic TPS reported by Genin, et al for the human knee was 7.0 ± 3.2° (range: -1° - 19°) - Figure 2.

Discussion: Compared to the canine knee, the TPS of the ovine more closely resembles the human knee. There was considerable overlap (6°) in the range of measured TPS between the ovine and human knees. The mean TPS of the ovine knee was 1.8 times greater than that of the human. In contrast, there was no overlap in the range of measured TPS between the canine and human knees and the mean TPS of the canine was 3.5 times greater than that of the human.

Large animal models are essential for effective preclinical comparative orthopedic research. Both canine and ovine models are commonly used in studies investigating new therapeutic options for disease or injury of the human knee. A relatively steep TPS has been reported for the canine and the findings of the present study are consistent with those previously reported. The present study also shows that, compared to the canine knee, the ovine knee more closely approximates the TPS of the human knee. Close approximation of human TPS is a desirable feature of the ovine model since increased TPS can increase risk of ACL injury, induce anterior tibial subluxation, reduce joint flexion following arthroplasty and alter femoro-tibial joint contact location, contact area and contact pressures. The ovine model has additional advantages of social acceptance, reduced cost of purchase and care and closer approximation of human body weight and knee joint size.

Measurement of TPS using radiography, computed tomography and magnetic resonance imaging as well as direct measurement from anatomic specimens has been described. Additionally, various anatomic landmarks have been used to measure TPS in the human. We chose the radiographic method and anatomic landmarks described by Genin, et al because of the ready availability of radiography and the adaptability of the described human anatomic landmarks to the canine and ovine knees.

Significance: Compared to the canine knee, the TPS of the ovine knee more closely resembles the human knee. This evidence strengthens the translation of preclinical ovine knee model research findings to the human.

Acknowledgments:
Figure 1: TPS measurement in the ovine (A) and canine (B) knees. The tibial mechanical axis was defined by a line drawn from the center of the proximal tibial articular surface through the center of the distal tibial articular surface. The tibial plateau was defined by a line drawn between the anterior and posterior articular margins of the medial tibial plateau. TPS was measured as the angle formed between a line perpendicular to tibial mechanical axis and the line of the medial tibial plateau slope.
Tibial Plateau Slope

Figure 2: Box and whisker plot identifying TP range, upper quartile, lower quartile and median values for ovine, canine and human knees. Statistical outliers identified by "x".

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