Tibial Spine Volume is Smaller in ACL-Injured Athletes Than in Healthy Athletes

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INTRODUCTION: The ACL inserts into the tibia at the tibial spine. Previous reports suggest that a small tibial spine area[1], width[2], and medial tibial spine volume[3] are risk factors for ACL injury because they decrease the restraint to translation of the tibia relative to the femur[4]. Less bony restraint would require the ACL to provide more restraint to tibial displacement, increasing the loads placed on the ACL and resulting in an increased risk of ACL injury[3]. However, no previous report assessed the association between the entire tibial spine volume and ACL injury risk. The aim of this study was to investigate whether the entire tibial spine volume is a risk factor for ACL injury. We hypothesized that the tibial spine volume would be smaller in individuals who sustained ACL injury compared to uninjured athletes.

METHODS: Participants were enrolled following institutional review board approval and providing informed consent. CT scans of both knees were acquired for all participants and the images were segmented using Mimics (Materialise) to create 3D subject-specific bone models. In the same software, the tibial spine volume was measured from the 3D bone models of the contralateral knee for the ACL injury group and the left knee for the ACL intact group (Figure 1). Tibial spine volume and tibial spine volume normalized by tibial plateau area were compared between the entire ACL injury group and the entire ACL intact group as well as between men and women from each group using the Mann-Whitney *U*-test.

RESULTS: Fifty-one knees undergoing unilateral anatomical ACL reconstruction (17 female, 34 male: average age 22.0 ± 7.5 yrs.) and 19 knees from healthy collegiate athletes with no previous knee injury (8 female, 11 male: average age 20.1±1.3 yrs.) were included in this study. The tibial spine volume in the ACL injury group (2.14 ± 0.52 cm^3) was significantly smaller than in the ACL intact group (2.70 ± 0.72 cm^3) (p=0.005). This difference remained even when the tibial spine volume was normalized by tibial plateau area (normalized values: 0.59 ± 0.14, 0.77 ± 0.16 mm^3/mm^2; p<0.001) (Figure 2). The tibial spine volume normalized by the tibial plateau area was significantly smaller in the ACL injury group for both men (p<0.001) and women (p=0.004).

DISCUSSION: The main finding of this study was that the tibial spine volume of the ACL injury group was smaller than the ACL intact group. This result reflects previous reports that found correlation between tibial spine anatomy and ACL injury risks[1-3]. A previous study reported smaller medial tibial spine volume in the ACL injury group only in men[3], however, our study suggests that the risk factor is present in both men and women when the entire tibial spine is analyzed and normalized to tibial plateau area. As the insertion of the anteromedial bundle is reported to be in the medial tibial spine and the insertion site of the posterolateral bundle was reported to be in the lateral tibial spine[5], this would suggest that a smaller tibial spine would contribute to decreased ability to restrain tibial displacement, and therefore an increase in risk of ACL injury. The fact that the entire tibial spine was measured in this study and differences were found between ACL-injured and healthy individuals suggests that both the medial and lateral tibial spine may contribute to ACL stability. Further research is needed to determine if there is a threshold for tibial spine volume at which risk for ACL injury increases, or if the increase in injury risk corresponds directly to the decrease in tibial spine volume. Work is also needed to determine if femoral notch size is also an independent risk factor for ACL injury.

SIGNIFICANCE: The entire tibial spine volume may be a useful measurement for assessing ACL injury risk.

REFERENCES: 1) Iriuchishima et al., *KSSTA*, 2022. 2) Iriuchishima et al., *KSSTA*, 2020. 3) Sturnick et al., *J Ortho Res*, 2014. 4) Lansdown et al., *Clin Sports Med*, 2018. 5) Oka et al., *KSSTA*, 2016.

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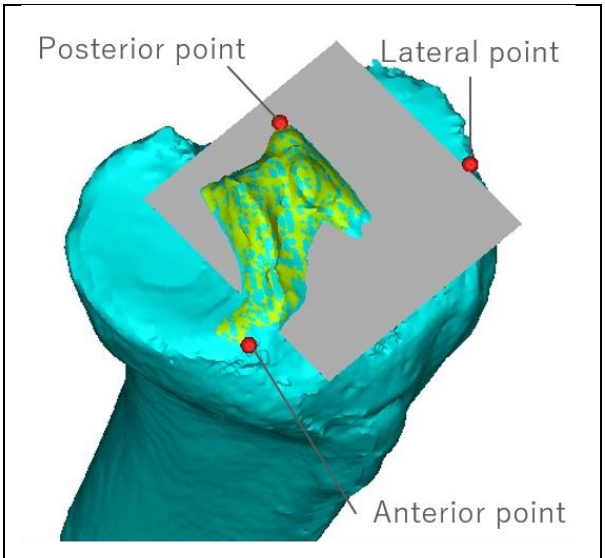

Figure 1. *Tibial spine volume. The tibial spine volume was measured by creating a plane from three points. Lateral point: The most convex point of the lateral tibial plateau. Anterior point: The cross point of the medial tibial spine slope and the medial tibial plateau. Posterior point: The cross point of the posterior tibial spine slope and the lateral tibial plateau.*

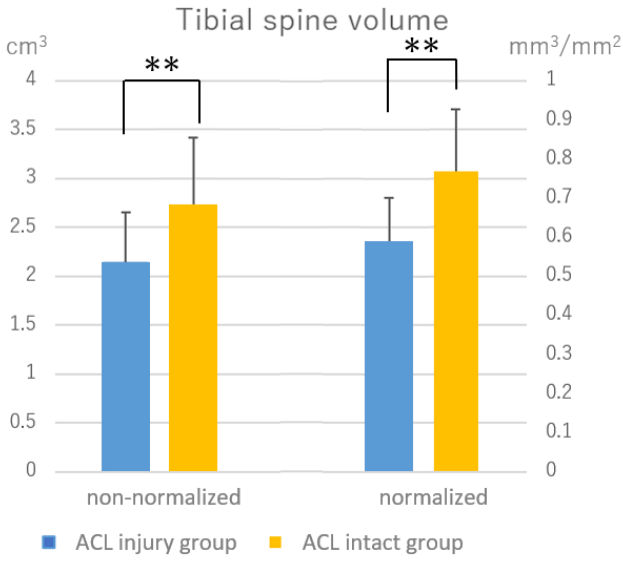

Figure 2*. The tibial spine volume and the tibial spine volume divided by tibial plateau area. Values of the ACL injury group were significantly smaller than the ACL intact group.*