Femoral Intercondylar Notch Morphology as a Possible Risk Factor for Anterior Cruciate Ligament Injury: Time to Think Inside the Notch

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Anterior cruciate ligament (ACL) injuries are among the most common and debilitating sports-related injuries in young population, frequently requiring surgical treatment to restore knee stability and function.[1] While extrinsic factors, such as the type of playing surface and the demands of the sport played contribute to injury risk, recent research has highlighted the role to intrinsic anatomical characteristics.[2] Femoral intercondylar notch morphology, particularly its width and anatomical shape, has emerged as a significant intrinsic factor in ACL injury risk,[3] shifting the scientific focus from the extrinsic factors to what's happening "inside the notch".

The femoral intercondylar notch is a groove at the distal part of the femur, housing vital stabilizing anatomical structures, such as cruciate and meniscofemoral ligaments.[4] Van Eck et al. described a classification of femoral notch shapes based on arthroscopic evaluation, categorizing them as A-shaped, U-shaped and W-shaped notch.[5] Their study found that the A-shaped notch is more common than the other two shapes. Additionally, patient heigh was shown to influence notch shape, with taller patients more likely to have U- or W-shaped notch. Variations in the shape of the intercondylar notch, especially the A-shaped notch, are associated with increased risk of ACL tear up to 73%, while U- and W-shaped notches are linked to a lower risk of around 32.5%.[3,5]

Additionally, literature suggets that a decreased transverse notch angle (TNA) and an increased sagittal notch angle (SNA), especially in narrower A-shaped intercondylar notch, are associated with degeneration of ACL.[5-8] Kim et al. recognized the association of a decreased TNA (≤ 47.4°) and the presence of mucoid degeneration in patients with ACL pathology.[6] Similarly, Raja et al. found statistically significant decreased intercondylar notch angle, averaging 49.3° in axial plane, among individuals with ACL injuries via magnetic resonance imaging.[7] Alentorn-Geli et al. also found that ACL-injured patients had a significantly narrower TNA of 46.5°, compared with 50.7° in uninjured individuals.[8] Regarding the SNA, Fernandez-Jaen et al. found notable differences between individuals with intact and torn ACLs, with mean angles of 56.2° and 57.5°, respectively.[9] In the same way, Bouras et al. observed a slightly greater SNA in the injured ACL group (44°) compared to the group with an intact ACL (43°).[10] In contrast, Huang et al. reported a smaller SNA in patients with ACL injury (38.5°) than in controls without ACL injury (41.1°), based on sagittal MRI measurements.[11] Interestingly, despite using similar measurement techniques, these studies demonstrated inconsistent results, indicating that SNA is not a reliable indicator of ACL injury. Therefore, further studies are needed to clarify the clinical relevance of SNA in the context of ACL injuries.

There have been a large number of investigations related to the notch width index (NWI) and notch shape index (NSI) as risk factors for ACL injury, using both radiographic and MRI modalities.[3,6-8] The literature reports that a smaller NWI is associated with an increased risk of sustaining an ACL injury.[3] Kim et al. observed that a decreased NWI of 0.271 is significantly associated with the presence of mucoid degeneration of the ACL on MRI.[6] Raja et al. used MRI to assess the NWI and found it to be 0.272 in patients with ACL injures, compared to 0.285 in the control group. They also reported smaller NSI values in ACL-injured patients, with measurements of 0.624 in the axial plane and 0.700 in the coronal plane, compared to 0.661 and 0.709, respectively, in the control group.[7] Also, Ficek et al. evaluated both NWI and NSI on axial and coronal MRI sections in patients with with cyclops syndrome following ACLr, in patients with ACL injuries and in controls subjects. They found significant differences in both NWI and NSI.[10] Specifically, the NWI was significantly lower in ACL-injured patients (0.286) compared to controls (0.298) in axial plane. Similarly, the NSI was significant lower in cyclops-ACLr patients (0.580) and ACL-injured patients (0.628) compared to controls (0.664) in the axial plane. These findings suggest that the geometry of intercondylar notch is associated with an increased risk of both cyclops lesion formation and ACL injury. In contrast, Alentorn-Geli et al. reported no significant association between NWI and ACL injury, with values of 0.230 in ACL-injured individuals and 0.240 in those without ACL injures,[8] highlighting the controversial nature of this parameter.

Today, it is increasingly important to “think inside the notch”. Variations in the shape of the femoral intercondylar notch have been associated with an increased risk of ACL injury. These anatomical differences can influence intra-operative decision-making during ACLr, particularly in regard to the morphology of the intercondylar notch. In this context, selective notchplasty may play a critical role in protecting the ACL graft and reducing the risk of re-injury during the post-operative healing phase.

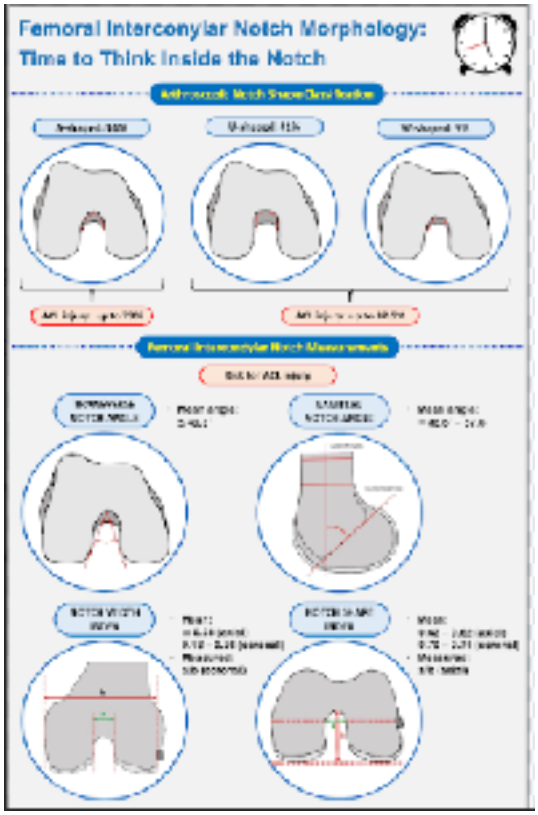

Figure 1: Femoral intercondylar notch morphology as a possible risk factor for anterior cruciate ligament injury. Abbreviations: ACL, anterior cruciate ligament.

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