

# The Effect of the Intercondylar Notch Shape and Notch Width Index on Anterior Cruciate Ligament Injuries

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## ABSTRACT

**Background:** Anterior cruciate ligament is one of the commonly injured ligaments in knee. The shape and dimension of the femoral notch has been linked with the risk of anterior cruciate ligament injury. The aim of this study was to study the risk of Anterior cruciate ligament injury with notch morphology in the Nepalese population.

**Methods:** This study is a case control study. Cases undergoing arthroscopic surgery at 2 tertiary level centers were enrolled. Patients with arthroscopic confirmation of Anterior cruciate ligament tear were taken as case and those without tear were taken as control. Axial Magnetic resonance Imaging sequence was used to study notch. Sections at the level of popliteal groove was taken for study and shapes were identified as A, U and W type, and notch width index was calculated. These variables were correlated with presence or absence of Anterior cruciate ligament tear.

**Results:** Out of 118 cases, 59 had tear, and 59 had no tear. Tear was found in 74% of Type A notch compared to 30.15% in Type U notch. The femoral notch width index was low in 42.59% of A type notch patients compared to 20.63% with U type notch. Analysis of notch width index among patients with Anterior cruciate ligament tears, showed that 40.67% of Anterior cruciate ligament torn knee had narrow notch compared to 22% in non-injured group, which was statistically significant.

**Conclusions:** Type A notch and narrow notch both are risk factors for Anterior cruciate ligament tear.

**Keywords:** Anterior cruciate ligament; injury; notch.

## INTRODUCTION

Anterior cruciate ligament (ACL) is one of the major stabilizers of knee joint. ACL tear has long term disability in young adults and needs surgical reconstruction.<sup>1</sup> It is difficult to replace native ACL in its structure and function.<sup>2,3</sup> Various intrinsic and extrinsic factors are associated with ACL injury.<sup>2</sup> Among intrinsic factors, intercondylar notch shape and notch width index (NWI) are known risk factors for ACL injury.<sup>1-9</sup>

It has been shown that narrow notch houses thinner ACL, and has high chance of ACL- notch impingement during knee movement.<sup>10-12</sup> Also, shorter people are said to have narrower notch.<sup>13,14</sup> Nepalese are smaller in physique than western population, so they may have narrow notch, thus increasing the risk of ACL injury. We have very scarce data regarding ACL injury and notch morphology in Nepalese population. Thus, we performed

this study to find out relation of notch morphology with ACL injury in this population.

## METHODS

Case-control study was carried out from August 1st, 2017 to January 1st, 2018 among the cases undergoing arthroscopic knee surgery. Cases with arthroscopic confirmation of ACL injuries, with or without meniscus injury, were taken as case and cases with intact ACL were taken as controls. Patients with traumatic knee injury undergoing knee arthroscopy were included in the study.

Exclusion criteria were knee deformities or dysplasia, connective tissue or hematologic disorders, fractures involving articular surfaces, prior knee arthroscopy surgery or patients with severe osteoarthritis, patients with multi-ligamentous injuries and patients not giving

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consent for the study.

MRI (1.5 tesla) was done following regular protocol of the institution. Axial T2 weighted images were selected. The section of the notch, seen at the level of the popliteal groove in the lateral femoral condyle, was identified and notch morphology at various levels were assessed.

The femoral notch was classified as Type A, Type U or Type W, depending upon the notch shape as described by Van Eck et al.<sup>5</sup> The Type A notch (Figure 1a) is described as a stenotic notch that appears narrow from the base to the midsection as well as at the apex. In the Type U femoral notch (Figure 1b), the midsection does not taper, allowing for a wider contour to the notch than Type A. The Type W femoral notch (Figure 1c) has characteristics of Type U, but with two apparent apices.

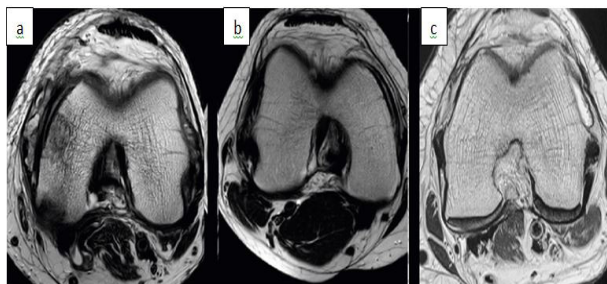


Figure 1. a A shaped notch, b. U shaped notch, c. W shaped notch.

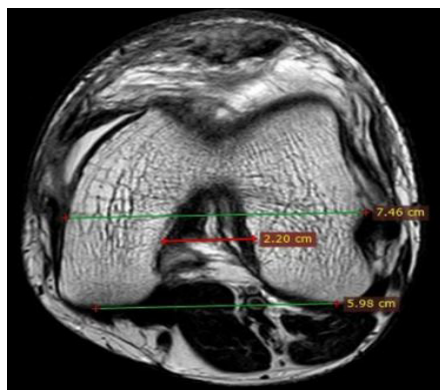


Figure 2. Notch width index measurement technique.

According to the method reported by Souryal et al.<sup>15</sup> the femoral notch width index was calculated by dividing femoral notch width (NW) by the transcondylar or intercondylar width (ICW). The NW was measured as the length between the medial projection of the lateral condyle and lateral projection of the medial condyle of the femur. The ICW was determined by measuring the line passing through the popliteal

groove and running parallel to the line drawn between the condylar ends across the most distal aspect of femur. Both measurements were performed on axial images (Figure 2) using the criteria of Domzalski et al.<sup>5</sup> Value of 0.270 or more for the NWI was considered as normal, whereas values equal to or below 0.269 were considered as low.

All comparisons between categories were made using the chi square test. The p- values <0.05 were considered to be significant.

**RESULTS**

Total of 118 cases, who met inclusion criteria, were included in the study. Fifty-nine cases with ACL injury which was confirmed by arthroscopy, were taken as cases, and 59 cases without ACL injury were taken as controls.

The age range was 15-52 years, with mean age of 29±7.003 years. The mean age of ACL injured group was found to be lower than non-ACL injured group. The NWI of subject (cases and controls) population ranged from 0.19- 0.68. Mean value was found to be 0.28±0.06.

Out of total 54 patients with type A notch, 40 (74%) had ACL tear compared to 19 (30.15 %) of type U notch which was found to be statistically significant. (p-value 0.000).

Table 1. Association between anterior cruciate ligament injury and notch type.

Type	ACL Injury	Non-ACL Injury	TOTAL	P-value
A	40 (74%)	14	54	0.000
U	19 (30.15%)	44	63	
W	0	1	1	

Analysis of NWI with ACL tears showed that 24 (40.67%) of ACL torn knee had narrow notch (NWI< 0.27) compared to 13 (22%) narrow notch in non-ACL injured group which was also found to be statistically significant (p-value 0.029).

Table 2. Association between anterior cruciate ligament injury and NWI

NWI Cut off value	ACL Injury	NON-ACL Injury	Total	p-value
≥0.27	35(59.32%)	46(77.96%)	81	0.029
<0.27	24(40.67%)	13 (22%)	37	
Total	59	59	118	

Analysis of NWI with notch type showed that the femoral NWI was low in 23 (42.59%) among A type notch compared to 13 (20.63%) among U type notch which was also statistically significant (p-value 0.013).

## DISCUSSION

The incidence of ACL injuries is increasing because of increased participation of young adults in sporting activities. The majority of ACL injury occurs in young population and ACL is a ligament injury of necessity. Thus, ACL injury is associated with major morbidity and financial burden to most active group of population.<sup>1</sup>

The above-mentioned factors have led to increased interest in search of risk factors for ACL injury. Many intrinsic and extrinsic factors have been described as risk factors of ACL injury. The factors such as lower extremity malalignment, posterior tibial slope, intrinsic ACL material properties, patellar tendon tibia shaft angle, ACL elevation angle, hormonal variation, neuromuscular control related biomechanical factors and intercondylar notch size has been suggested as possible intrinsic risk factors for ACL injury in literature.<sup>2,3,6</sup>

One of the intrinsic factors that is creating both significant interest and debate on this topic is association of notch morphology and notch dimensions with ACL injury. The role of narrow intercondylar notch with ACL injury was first recognized by Palmer in 1938.<sup>16</sup> Various notch parameters e.g.; notch shape, notch shape index, NWI, notch area, notch area index has been identified as a risk factor.<sup>17</sup> Among all these parameters, notch shape and NWI are most important.

The mean NWI of our population was found to be  $0.28 \pm 0.06$ . This value falls under low normal value for NWI according to Domzalski et al.<sup>5</sup> These findings may be because of the fact that average height of Nepalese population is lower than western population, thus leading to narrower notch as shown by study of Charlton et al.<sup>13</sup>

We studied the relation between notch shape and notch width index in our study. Van Eck et al described femoral notch shapes as types 'A', 'U' and 'W'. They described Type A as a narrow notch (narrowed in all dimensions) compared with the Types U or W.<sup>14</sup> Our study also showed that A type notch had 42.59 % cases with narrow notch compared to 21.87% in non-A types. Shelbourne et al<sup>10</sup> have shown that narrow notch houses thinner ACL and Zhang et al<sup>11</sup> have shown more chance of ACL - notch

impingement on movement in narrow notches, leading to increased risk of ACL injury.

Many authors have suggested that a narrowed femoral notch has high risk of ACL injury.<sup>2,7,18, 19</sup> Al-Saeed et al in 2013 had 73% ACL tears in type A notch compared to 32% in non-type A (U and W) notch.<sup>1</sup> Our study also had 74 % of type A notch having ACL injury compared to 30.15% in non-type A notch. This finding may be helpful in identifying at risk population and take the preventive measures for ACL tear. Further this finding may be helpful to reduce re- ruptures of reconstructed ACL and to prevent tear in contralateral knee.

Another debated subject is the association between NWI and ACL injury. There have been conflicting reports on association between NWI and ACL injury.<sup>4,5,7,11,19-21</sup> Numerous attempts have been made to establish the cut off value of NWI that qualifies for the narrow notch. Uhorchak et al<sup>22</sup> proposed 0.18, LaPrade et al<sup>9</sup> proposed 0.19, Domzalski et. al.<sup>5</sup> proposed 0.27 and Souryal et al<sup>15</sup> proposed 0.2. However, NWI index measurements have been obtained differently in various studies. Some studies have based it on measurements on plane x-ray (notch view); some on CT scans, while some based-on MRI. Both coronal and axial MRI sequence has been used in studies.<sup>1-19</sup> The similarity in all these studies was that the measurements were taken at the level of popliteal hiatus. We used Domzalski et al<sup>5</sup> cut off value to define narrow notch and we had 40.67% ACL tear in narrow notch group compared to 22% in non-narrow notch as described by NWI cut off value, which was found to be statistically significant.

Fu FH et al<sup>14</sup> studied on notch shape and dimensions arthroscopically; they further emphasized the role of narrow notch on risk of ACL injury. Additionally, they mentioned some disadvantages of narrow notch during surgery compared to wider notch. They mentioned difficult vision from anterolateral portal while making femoral tunnel and inability to perform usual double bundle ACL reconstruction in narrow notched knees because of lesser space for two bundles to accommodate. They emphasized that surgeon may need to perform notchoplasty to have better vision and to accomplish double bundle reconstruction.<sup>14</sup>

## CONCLUSIONS

Mean NWI of Nepalese population is  $0.28 \pm 0.06$ . Type A notch is present in 74% of patients with ACL injury. Narrow notch is present in 40.67% ACL torn knees. Type A notch and narrow notch both are risk factors for ACL tear.

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