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Comparative analysis of morphometric parameters of intercondylar notch in patients with and without anterior cruciate ligament tears

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Original Article

Abstract

BACKGROUND: Anterior cruciate ligament (ACL) injury is the most common type of ligament injury whose prevalence is higher in athletes. There are different external risk factors for this injury. However, it is important to find its physiological risk factors, as well. This study assessed the relationship between morphometric parameters of intercondylar notch and ACL tears in patients suffering from knee complications.

METHODS: Patients with or without ACL tears who had undergone knee magnetic resonance imaging for any reason were recruited based on inclusion criteria. Intercondylar notch width, femoral bicondylar width, and intercondylar notch index were calculated in both groups. Then, significant variables from univariate analysis were entered in multiple regression analysis with intercondylar notch width, femoral bicondylar width, and intercondylar notch index being assumed as dependent variables.

RESULTS: Overall, 199 participants, including 81 patients with ACL tear and 118 without ACL tear, were evaluated. Multiple regression analysis revealed intercondylar notch width and intercondylar notch index to be less common among women and subjects with ACL tears ($P < 0.001$).

CONCLUSION: Based on the results of this study, there are relationships between ACL tears and being female and intercondylar notch width. Therefore, intercondylar notch index can be used for screening athletes and people at risk of ACL tears.

KEYWORDS: Anterior Cruciate Ligament Tear, Intercondylar Notch, Femoral Bicondylar Width, Intercondylar Notch Index

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Introduction

The knee anterior cruciate ligament (ACL) tear is one of the most serious knee ligament damages that causes short-term functional instability and long-term degenerative joint disease.[1] The incidence of ACL injury among high risk populations has been reported as 70-85 cases per one hundred thousand people.[2-5] About half of patients will develop osteoarthritis over 10-20 years after ACL injury.[6] On the other hand, available ACL reconstructive surgeries are expensive and associated with high levels of morbidity.[7-10]

Risk factors for ACL injury are categorized in two groups of internal and external factors. External risk factors include types of activities especially exercise, clothing, footwear, and

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environmental causes. Internal causes include anatomical, hormonal, and neuromuscular risk factors.[4] Identifying these risk factors, particularly in athletes, can help predict ACL injury and facilitate the use of preventive measures.

Research has indicated a significant relationship between ACL injuries and morphological parameters of the knee joint, especially intercondylar notch width (INW) index.[11-19] However, a number of studies have failed to find a significant difference in the frequency of ACL injury in patients with or without marked stenosis of intercondylar notch.[20-22] While some previous studies have reported significant large values of most morphometric parameters of the knee joint (e.g. INW and ACL width) in men,[1,15,16,23-25] a few others have rejected such a difference between the two sexes.[26] Similarly, a number of researchers have accepted a family history of ACL injury to increase the risk of ACL injury,[8,27] but others have reported no statistically significant relation between these two.[28]

Considering the inconsistencies in the results of previous studies, further research seems necessary to verify the significance of the mentioned factors in diagnosis of people who are at risk of developing ACL injuries. This study aimed to investigate the relationship between femoral intercondylar notch stenosis and ACL injury in patients with knee problems who referred to Imam Reza Hospital (Kermanshah, Iran) during 2009-10.

Materials and Methods

This cross-sectional, descriptive-analytical study included patients with ACL tear in magnetic resonance imaging (MRI) and individuals who underwent knee MRI for other reasons but did not have ACL tear. Diagnostic criteria included being clinically suspected to ACL tear or showing signal changes in MRI sequence. MRI sequences were produced using a one-tesla MRI scanner (Philips Medical Systems). Morphometric parameters of the intercondylar notch were determined based on T2 axial and T2 coronal sequences. INW (C to D) and femoral bicondylar width (A to B) were calculated according to figure 1. bicondylar width was then divided by INW to calculate the intercondylar notch index. The exclusion criteria were obvious osteoarthritis in MRI, connective tissue diseases, systemic bone diseases, and a history of knee fracture or surgery.

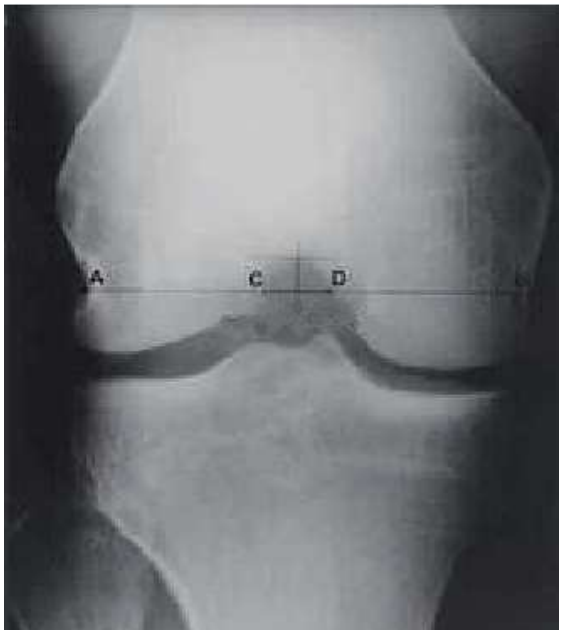

Figure 1. Femoral bicondylar width (A to B) and intercondylar notch width (C to D) were calculated as seen in the figure

Although 260 people had been admitted to the hospital, 61 patients were excluded (48 due to osteoarthritis, seven due to history of a previous surgery, and six due to a history of fracture) and 199 subjects were finally evaluated. Since in this study no intervention was performed on patients and the results were attained based on routine diagnostic procedures, there was no ethical limitation. Nevertheless, patients signed an informed consent after they had been ensured about the confidentiality of their personal information. Although the participants were allowed to quit the study at any point, all subjects completed the study.

The data was entered into SPSS for Windows (version 11.5, SPSS Inc., Chicago, IL, USA). The

mean values of INW, femoral bicondylar width, and intercondylar notch index in the two groups with and without ACL injuries were compared using Student's independent t-test. Chi-square test was used to analyze qualitative variables. Significant variables in univariate analysis were entered in multiple regression model with INW, mean femoral bicondylar width, and intercondylar notch index as dependent variables.

Results

This study included 199 patients (81 cases with ACL tear and 118 cases without ACL tear) of whom 75 subjects (37.7%) were female. The mean age of patients was 32.6 ± 7.9 years. The two groups had no significant differences in terms of gender distribution (P = 0.18) or mean age (P = 0.91). Knee trauma was due to tensile stress in 51 patients (25.6%) and a direct blow to the knee in 70 patients (35.2%) (Table 1).

No statistically significant difference was observed between the two groups regarding the distribution of injury to the bones adjacent the knee. The group with tear had a greater percentage of trauma to bones surrounding the knee (P < 0.001). The two groups were significantly different regarding the distribution of fractures in the bones adjacent to the knee and the group with tear had a greater percentage of rupture in bones surrounding the knee (P < 0.008). However, there was no significant correlation between these two variables (Table 2).

The mean INW was 22.63 ± 3.25 and 21.4 ± 2.78 mm in the groups with and without ACL tear, respectively (P = 0.004). The mean femoral bicondylar width was 76.00 ± 5.97 mm and 79.39 ± 5.38 mm in the groups with and without ACL tear, respectively (P < 0.001). The mean intercondylar notch index was 0.30 ± 0.04 and 0.27 ± 0.03 in the groups with and without ACL tear, respectively (P < 0.001) (Table 1). The mean INW and intercondylar notch index were significantly lower in women than in men (P < 0.001). Multiple regression analysis showed that INW and intercondylar notch index in women with ACL tear were lower than other groups (Table 3).

Table 1: Characteristics of the two groups with and without anterior cruciate ligament (ACL) tears

Variable	Without ACL tear (n = 118)	With ACL tear (n = 81)	P
Sex			
Female	49 (41.5%)	26 (32.1%)	0.170
Male	69 (58.5%)	55 (67.9%)	
Injury to the bones adjacent to the knee			
Yes	8 (6.8%)	24 (29.6%)	< 0.001
No	110 (93.2%)	57 (70.4%)	
Breaking the bones adjacent to knee			
Yes	1 (0.8%)	7 (8.6%)	0.008
No	117 (99.2%)	74 (91.4%)	
Age (year)	32.5 ± 8.0	32.7 ± 7.6	0.910
Intercondylar notch width (mm)	22.63 ± 3.25	21.40 ± 2.78	0.004
Femoral bicondylar width (mm)	76.00 ± 5.97	79.39 ± 5.38	< 0.001
Intercondylar notch Index	0.30 ± 0.04	0.27 ± 0.03	< 0.001

Values are n (%) or mean ± SD; ACL: Anterior cruciate ligament

Table 2. The morphometric parameters of femoral bicondylar and intercondylar notch in the two sexes

Variable	Gender		P
	Male	Female	
Intercondylar notch width (mm)	23.36 ± 3.06	20.09 ± 1.93	< 0.001
Femoral bicondylar width (mm)	77.71 ± 6.23	76.84 ± 5.49	0.310
Intercondylar notch index	0.302 ± 0.041	0.262 ± 0.027	< 0.001

Values are mean ± SD; SD: Standard deviation

Table 3. The morphometric parameters of femoral bicondylar and anterior cruciate ligament (ACL) tears in the two sexes

Variable		Beta coefficient value		Beta confidence interval		P	R^2
		Standardized	Non- Standardized	minimum	maximum		
Intercondylar notch width	Constant coefficient	24.056	-	23.492	24.620	< 0.001	
	ACL tear	-1.563	-0.247	-2.303	-0.823	< 0.001	0.319
	Being female	-3.421	-0.532	-4.172	-2.670	< 0.001	
Femoral bicondylar width	Constant coefficient	76.239	-	74.986	77.491	< 0.001	
	ACL tear	3.334	0.275	1.690	4.978	< 0.001	0.080
	Being female	-0.555	-0.045	-2.221	1.112	0.512	
Intercondylar notch index	Constant coefficient	0.316		0.309	0.324	< 0.001	
	ACL tear	-0.032	-0.383	-0.042	-0.023	< 0.001	0.359
	Being female	-0.043	-0.498	-0.052	-0.033	< 0.001	

ACL: Anterior cruciate ligament

Discussion

The most common type of ACL injury is ligament damage which was reported in about 3.2% of men and 3.5% of women over a four-year period.[29] It is more common in athletes and has several environmental risk factors.[6,8,30,31] Recognizing the physiological risk factors of this problem can help identify and protect people at risk.

We found significantly higher INW and intercondylar notch index in the group without ACL tear than in those with the tear. However, the mean width of femoral bicondylar was significantly higher in the group with ACL tear than in the other group. In multiple regression analysis, INW and intercondylar notch index were lower in subjects with ACL tear and women than in other groups.

Several studies with contrasting results have been conducted in this field. Lombardo et al. did not find a significant difference in mean intercondylar notch index in athletes with and without ACL injuries (0.235 vs. 0.242).[20] However, Schickendantz and Weiker[21] and Teitz et al.[22] reported a significant difference in intercondylar notch index between people with and without ACL tears. Souryal et al. calculated the mean intercondylar notch index as 0.2238 in the normal group, 0.2248 in the acute tear group, and 0.1961 in patients with two-sided ACL injuries and suggested the difference between the first and third groups to be statistically significant.[12] Good et al. reported the mean INW as 16.1, 18.1, and 20.4 mm in patients with chronic ACL injuries, acute injuries, and normal knees, respectively.[14] In another study, Souryal et al. reported that people with smaller intercondylar notch are less likely to suffer from traumatic knee injuries. They thus introduced the mean intraocular notch stenosis as a risk factor for noncontact tensile ACL injuries.[15] As we obtained similar results, this index can be used to identify and screen athletes vulnerable to ACL tears. It can also be considered as a risk factor for posterior cruciate ligament (PCL) tear since Davis et al. showed a significant relationship between ACL and PCL.[16] Wada et al. suggested the mean INW to be significantly lower in knees with ACL laxity or tear than in those with normal ACL.[17] Stijak et al. observed a significant difference in intercondylar notch index between people with ACL injury and those without it.[18]

In the only available Iranian study in this field, Alizadeh and Kiavash showed the mean intercondylar notch index to be significantly different in healthy subjects and the group with ACL tear (0.298 vs. 0.296).[19] The age range of the participants in the mentioned study increased the probability of osteoarthritis and might have been a confounding factor. However, the exclusion criteria and the restricted age range in the present study reduced the effects of age as a confounding factor. While the findings of Alizadeh and Kiavash[19] were not consistent with ours, various studies have indicated a

relationship between intercondylar notch stenosis and ACL tear.[32] Stijak et al. showed that the INW and ACL are significantly higher in men than in women.[1] Souryal et al.[12] and Dienst et al.[24] found higher intercondylar notch index in men than in women. Murshed et al. reported similar results about the INW and epicondylar notch width.[23]

Since the current study had a cross-sectional design, it could not precisely prove the cause. Hence, obtaining more accurate results requires further comprehensive, cohort studies on athletes to measure these indexes before starting professional sport careers and evaluate the level of ACL injuries.

Conclusion

Based on the results of this study, ACL tears are related with being female and intercondylar notch stenosis. Therefore, this index can be used for screening athletes and people who are at risk of developing ACL tears.

Conflict of Interests

Authors have no conflict of interests.

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