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Width of the Femoral Intercondylar Notch in Relation to Anterior Cruciate Ligament Injuries

Mohamed Osama Khalifa, Elsayed Elforse, Mohamed Hosney, Mostafa Ayoub

Orthopedic surgery, Department of Orthopedic Surgery, Tanta University, Egypt.

Abstract: Background: An important step in preventing ACL is the determination of the risk factors for these injuries. An increase in the risk of anterior cruciate ligament (ACL) injury may be attributed to the narrowing in the intercondylar notch, but the data are contradicts. A small notch problem has been defined as a difficult of impingement of the notch on the ACL in hyperextension or the lateral femoral condyle on the ACL leading to cutting or break during twisting maneuvers. This would indicate a pathological relationship among the ACL and its adjacent bony vault. **Materials and Methods:**102 male patients with and without non-contact ACL injuries, who were referred to the Department of Orthopaedic at Tanta university from January 2018 to December 2018, were included in the patient and control groups, respectively, MRI was performed using 1.5 Tesla or 3 Tesla MRI with the patient's knee in an extended location. the femoral notch width Index was measured in all patients. **Results:** Fifty-one participants were included in each group. The Notch width and Notch Width Index (NWI) was narrowed in the patients significantly than in the normal controls. **Conclusion:** The findings of MRI measurements showing that NWI is narrowed significantly in individuals with ACL ruptures paralleled with the control patients with intact ACL, suggesting that a narrow notch is accompanied with an elevation in the risk of injury in ACL.
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Key Words: ACL, Knee, Sports injury, Intercondylar notch width index, Arthroscopy knee.

1. Introduction

Physically active adolescents and adults are exposed usually to the sever injuries in anterior cruciate ligament (ACL), The ACL is considered one of the four main ligaments that constant the knee joint [1,2].

An elevation in the numbers of ACL injuries was observed over the past two decades as recorded by physicians which concerned with young athletes, this is due to increased adolescents participating in high-demand sports at an earlier age, developing number of adolescents and children contributing in organized sports, and a high precisely in diagnosis and great advancement in the tools and instruments used for scanning and imaging helping in accurate diagnosis of injuries and also, due to increased consciousness for ACL injuries that can happen in skeletally immature individuals. [3,4]

There are a great attention was paid to identify the actual predisposing factors causing ACL injuries in athletes. Many investigators have reported that the incidence of ACL rupture in women was higher than in men. This data has provoked a lot of investigation for identification for the physiological and anatomical differences between the athletes gender that might be accountable for the elevated rates of ACL ruptures in females. [5,6,7]

Many researchers have studied static anatomic variations among athletes like joint hyperextension, subtalar pronation and notch width, as well as extrinsic differences such as shoe-surface interaction, qualifications of coaches and trainers, development of hamstring muscle strength and hamstring muscle tightness, and preseason conditioning programs. [8,9,10]

An intrinsic anatomic variation which may connected with elevation in the frequency of ACL ruptures may be related to the intercondylar notch width of the femur which appears as an expected probability, where it has been an anatomic place of attention as it households the ACL and give it the space to move and operate [11].

The current study was aimed to recognize the relations among ACL injury and notch width, We measured the NWI on magnetic resonance (MR) scans to decide whether variations present among patients with and without ACL rupture, We moreover paralleled the effects of these anatomic differences on ACL rupture.

2. Patient and methods:

This retrospective case-control study comprised 102 subjects with and without ACL rupture from January 2018 to December 2018. All patients' injuries were non-contact in nature. The patient group had

acute ACL tear as diagnosed clinically and by MR scans, and the participants in the control group have intact ACl. Patients with Age less than 18 years old or more than 50 years old**,** Female patients**,** chronic traumatic ACL tear more than one year ago, patients with any contraindication for MRI examination**,** congenital or acquired lower limb deformity**,** direct contact injuries or high-energy violence injuries, knee surgery or knee osteoarthritis were omitted from the investigation. Gender, age, body mass index (BMI) and affected knee, were estimated for all members in both groups. This study was approved by the ethics committee of our hospital. Informed approval was gotten from all subjects involved in the investigation.

MRI of the knee was performed for all patients participating in the study. The MRI images were accomplished supine, sagittal T1 and T2 weighted, coronal T1 and T2 weighted and axial proton density (PD) weighted, images were taken. Notch width (NW) measurements were performed. By using MRI, notch width (NW) was measured, where the ratio of the width of intercondyler notch to the width of distal femoral condyles at the level of the popliteal groove is known as the notch Width Index (NWI), The preliminaryscan showed permanence in the lateral and medial condyle in which notch shape was seemed apparent and popliteus tendon sulcus which located on the lateral condyle was taken as the standard. Two lines can be drawn A and B. Line I was demarcated as the line amide the inferior points of cartilage surface of lateral and medial condyle. While designated as the line B which was drawn parallel to line I on the popliteus tendon sulcus. The space between the crossing point of the lateral and medial walls of the femoral intercondylar notch and line B as intercondylar notch width (NW) was determined (line A), the space of line II was measured as bicondylar width (BCW), the ratio between (NW) and (BCW) was calculated as notch width index (NWI) (figure1) [(12-16)], finally the shape of notch was demonstrated (figure 2). "A" shaped: the tip of the notch is small and pointed**,** inverted "U" shaped: the tip of the notch is large and dull, while inverted "w": two tops; there are two tip edges.

Fig. (1) Measurement of NW (line A) and bicondylar width (line B), Line I is the line drawn within the inferior points of cartilage surface of lateral and medial condyle (black arrow). A line parallel to line I on the popliteus tendon sulcus will be drawn, and nominated as line B (white arrow) [(12)].

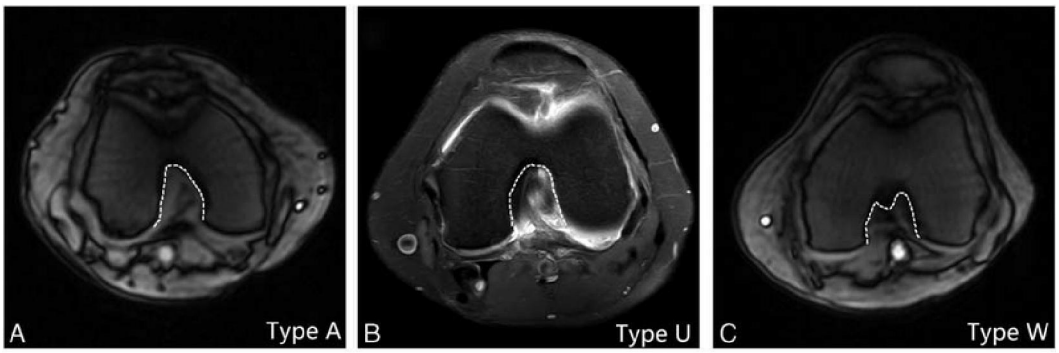

Fig. (2) Shapes of intercondylar notch [(16)].

Statistical analysis:

The obtained data were tabulated and analyzed statistically, by the using of SPSS 24 (IBM Corp-Chicago- IL- USA). The means and the standard deviations (M±SD), and student t-test was measured. Categorical variables were presented as numbers and percentage and compared with Chi-square. P-value <0.05 was considered significant difference.

3. Results:

A total of 102 subjects were participating in this work. The case group consists of 51 male their ages

ranged from 19–40 years and averaged 24.48 ± 5.1 years, whereas, the control group included 51 participants (mean age, 27.42 ± 6.27 years; range, 18–43 years). As shown in table 1, there were no baseline variations in the following sex, age, notch shape, body mass index or affected knee among the cases and control groups. conversely, there was a statistically significant variations were present between the case and control groups regarding NWI (p = 0.006) and NW (p = 0.004) (Tables 1,2). As observed from the collected data as seen in table (3), there was a non-significant difference between the case and control groups concerning The BCW.

Table 1: Mean NWI in patients with and without ACL tear

ACL	Notch width index		
	Mean	SD	P-value
Normal ACL	0.3016	0.0225	0.0006
Ruptured ACL	0.272	0.0321	

Table 2: Mean of NW in patients with and without ACL tear

ACL	Notch width		
	Mean	SD	P-value
Normal ACL	22.84	1.89	0.004
Ruptured ACL	20.88	2.5	

Table 3: Mean of BCW in patients with and without ACL tear

ACL	Bicondylar notch		
	Mean	SD	P-value
Normal ACL	75.48	4.08	0.34
Ruptured ACL	76.52	3.42	

4. Discussion:

The main problem that leads to rupture of ACL during twisting or cutting maneuvers are returned mainly to the small notch which considered as a difficulty of impingement of the notch on the ACL in hyperextension [17] or are due to the deviation of the lateral femoral condyle on the ACL. This would involve a pathological relationship among the ACL and its adjacent bony structures [17].

This study included 102 patients with non-contact knee joint trauma, Regarding the relationship among NW, NWI and the rate of ACL tear, the data revealed that there are a significant difference in the mean NW and NWI in individuals with and without an ACL rupture, suggesting that patients with narrow notch width have more risk for ACL injury.

Studies done by many researchers have shown a relationship between femoral notch morphology and ACL tear:

- Palmer et al.,1938, for the first time proposed that a narrow NW is accompanied with an increased incidence of ACL tear [18].
- Souryal et al., 1993, showed a significant association using direct radiographs amide narrow NW and bilateral ACL tears [12].
- Domzalski reported, a significant diminish in NWI in patients with ACL tears in comparison with the control group [19]. Also, the presence of narrowing in NWI is considered risk factor for ACL tear [20].
- Anderson et al reported that anterior outlet notch stenosis increases the risk of ACL injury [21].
- individuals who possess smaller notch dimensions appear to be at greater risk of ACL injury as reported by Ireland et al irrespective of gender [31].
- LaPrade and Burnett also found that intercondylar notch stenosis in athletes was associated with elevated risk for noncontact ACL tears [11].
- Shelbourne et al. in addition concluded that in patients who sustain ACL tears, they observed a narrower in notch width (NW) in contrast with control group [33].
- The small notch width is considered as an anatomic intrinsic risk factor for induction of ACL ruptures [22].
- Souryal et al. also proposed that notch width index (NWI) can be a taken as marker applied for preventing ACL ruptures [23].
- Many investigators didn't found a significant relationship among the risk of ACL injury a and the narrowing in NWI in contract with the above mentioned results presented within many previous studies.

- Herzog et al. They found a non-significant relationship between ACL injury and NWI as estimated by direct radiographs and MRI. [13]
- Some authors showed a non-significant variations among patients suffering from either unilateral or bilateral complete tears of the ACL and accomplished that measurements of intercondylar notch detected by radiographs may not be dependable pointer for ACL rupture [24]. Also, a non-significant variation was found regarding NWI value among ACL injured and non-injured groups [25]. Also, in professional male basketball players a non-significant variation not detected between NWI and the incidence of ACL ruptures [26].
- In addition, NWI max and NSI max in a study carried by Stijak et al. not recorded any significant differences in ACL ruptured or control groups [27].

The imaging modality which usually performed as routine work for the measurement of NW their results remain contradicts, where in a study carried by Shellbourne et al., they showed a link between the preoperative and intraoperative radiographic NW measurements [33].

Other authors suggested that intercondyler notch width measurements by MRI are more precise than plain radiographs measurements [21] because conventional radiographs may be influenced by many factors such as experience of the radiology technician, technical aspects and the variability in patient positioning and compliance which finally leads to a non-accurate and non-standardized measurement results, therefore, we preferred to use routine coronal MRI for measurements in this study [21].

In this study, it was found no significant difference for bicondylar width between two groups, this result are in contrast to the finding by Vrooijink et al [28], although it was found that the intercondylar notch shape and body mass index did not contribute to ACL injury, The relationship between notch type and ACL injury has been controversial, Osama et al. [29] found that the form A notch appeared to be a risk factor for ACL tear, Keays et al. [30] found that type "A" notch may also be a contributing factor to ACL injuries. Because the cause of the ACL injury is multifactorial, while several studies have been carried out to confirm the linked amide notch type and ACL rupture, but the results have been conflicting [11,31], Uhorchak et al. [32] found that a higher than normal BMI significantly increase risk of ACL injuries.

Trials were proposed for preventing ACL injuries such as the use of bracing which aimed to avoid ACL tear from the bony impingement of a small notch [14]. Also, other investigators suggested prophylactic notch plasty in individuals with stenotic notches at the time of an arthroscopy [12]. Prophylactic notch plasty will help in stopping of ACL injuries in subjects diagnosed with small notches not proved until now.

This study has limitations;

- The small sample size.
- Our targets were not restricted to athletes, may affect the role of narrow NWI in ACL rupture.
- Several other factors apart from the narrow NW, that may probably have an impact on ACL rupture, like the hormonal factors, activity profile and the age, were not put in consideration. The mentioned factors must be taken in consideration to precisely estimate the association among ACL injury and NW measurements.
- No reference gold standard values have been yet established, the results could only be compared between ACL in juried and non-injuried participants, without any reference to established standardized values.
- The gold standard for confirming an ACL tear is through arthroscopy, that may lead to misclassification.
- Another shortcoming of our investigation is the neglected matching between NWI and the width or orientation of ACL, therefore, a further research regarding this issue are required to elucidate our vision on this matter.

Conclusion:

- Identifying the actual causes of ACL in advance and the relationship between intercondylar notch stenosis and noncontact ACL ruptures may markedly decrease the overall ACL injury frequency in the future.
- The findings of MRI measurements showing that NWI is expressively stenosis in individuals with ACL rupture matched with the controls patient with intact ACL, proposed that a limited notch is accompanied with a rose frequency rate of ACL rupture.
- The results, however, must be interpreted with caution, because this study has some limitations and the data are not conclusive enough, Supplementary researches comprising high numbers of participants are required to confirm this hypothesis even however this risk is remain slight. It is concluded from this work and the obtained data to advise patients complaining from ACL rupture and a stenosis NW that they may be at a higher risk for rupturing the ACL in the contra lateral normal knee.

References

1. Amis AA, Dawkins GP. Functional anatomy of the anterior cruciate ligament. Fibre bundle actions related to ligament replacements and

injuries. J Bone Joint Surg Br. 1991;73 (2):260–7.
2. Arnoczky SP. Anatomy of the anterior cruciate ligament. Clin Orthop Relat Res. 1983;172-90.
3. Aglietti P, Buzzi R: Chronic anterior cruciate ligament injuries, in Insall JN, Windsor RE, Scott WH, et al. (eds): Surgery of the Knee. Second edition. New York, Churchill Livingstone, 1993, pp 425–504.
4. Kennedy JC, Weinberg HW, Wilson AS: The anatomy and function of the anterior cruciate ligament. As determined by clinical and morphological studies. J Bone Joint Surg 5 6 A: 1974, 223–35.
5. Baker SJ, Gill GW, Kieffer DA: Race and sex determination from the intercondylar notch of the distal femur, in Gill GW, Rhine S (eds): Skeletal Attribution of Race. New York, Churchill Livingstone, 1995, pp 91–5.
6. Cahill BR, Griffith EH: Effect of preseason conditioning on the incidence and severity of high school football knee injuries. Am J Sports Med 6: 1978, 180–4.
7. Ferretti A, Papandrea P, Conteduca F, et al: Knee ligament injuries in volleyball players. A m J S p o r t s M e d 2 0: 1992, 203–7.
8. Huston LJ, Wojtys EM: Neuromuscular performance characteristics in elite female athletes. Am J Sports Med 2 4: 1996, 427–36.
9. Everhart JS, Flanigan DC, Simon RA, Chaudhari AMW: Association of noncontact anterior cruciate ligament injury with presence and thickness of a bony ridge on the anteromedial aspect of the femoral intercondylar notch. Am J Sports Med. 2010;38: 1667-73.
10. Griffin LY, Agel J, Albohm M, Arendt EA, et al: Noncontact anterior cruciate ligament injuries: risk factors and prevention strategies. J Am Acad Orthop Surg. 2000;8: 141-50.
11. La Prade RF, Burnett QM: Femoral intercondylar notch stenosis and correlation to anterior cruciate ligament injuries. A prospective study. Am J Sports Med 22: 1994, 198–203.
12. Souryal TO, Freeman TR. Intercondylar notch size and anterior cruciate ligament injuries in athletes. A prospective study. Am J Sports Med 1993; 21:535-39.
13. Herzog RJ, Silliman JF, Hutton K, Rodkey WG, Steadman JR. Measurements of the intercondylar notch by plain film radiography and magnetic resonance imaging. Am J Sports Med 1994; 22:204-10.
14. Stijak L, Nikolić V, Blagojević Z, et al. Influence of morphometric intercondylar notch parameters in ACL ruptures. Acta Chir Iugosl 2006; 53:79-83.
15. Boden BP, Sheehan FT, Torg JS, Hewtt TE. Non-contact anterior cruciateligament injuries: mechanisms and risk factors. J Am Acad Orthop Surg 2010; 18: 520-27.
16. Dai B, Herman D, Liu H, Garrett WE, Yu B. Prevention of ACL injury, part I: injury characteristics, risk factors, and loading mechanism. Res Sports Med 2012; 20: 18097.
17. Anderson AF, Dome DC, Gautam S, Awh MH, Rennirt GW. Correlation of anthropometric measurements, strength, anteriorcruciateligament size, and intercondylar notch characteristics to sex differences in anterior cruciate ligament tear rates. Am J Sports Med 2001; 29: 58-66.
18. Palmer I. On the injuries to the ligaments of the knee joint: a clinical study. 1938. Clin Orthop Relat Res discussion 14, 2007; 454: 17-22.
19. Domzalski M, Grzelak P, Gabos P. Risk factors for Anterior Cruciate Ligament injury in skeletally immature patients: analysis of intercondylar notch width using Magnetic Resonance Imaging. Int Orthop 2010; 34: 7037.
20. Sonnery-Cottet B, Archbold P, Cucurulo T et al. The influence of the tibial slope and the size of the intercondylar notch on rupture of the anterior cruciate ligament. J Bone Joint Surg Br 2011; 93: 1475-8.
21. Anderson AF, Lipscomb AB, Liudahl KJ, Addlestone RB. Analysis of the intercondylar notch by computed tomography. Am J Sports Med 1987; 15:547-52.
22. Chung SC, Chan WL, Wong SH. Lower limb alignment in anterior cruciate ligament-deficient versus -intact knees. J Orthop Surg (Hong Kong) 2011; 19: 303-8.
23. Souryal TO, Moore HA, Evans JP. Bilaterality in anterior cruciate ligament injuries: associated intercondylar notch stenosis. Am J Sports Med 1988; 16: 449-54.
24. Schickendantz MS, Weiker GG. The predictive value of radiographs in the evaluation of unilateral and bilateral anterior cruciate ligament injuries. Am J Sports Med 1993; 21: 110-3.
25. Alizadeh A, Kiavash V. Mean intercondyler Notch Width Index in cases with and without anterior cruciat ligament tears. Iran J Radiol 2008; 5: 205-8.
26. Lombardo S, Sethi PM, Starkey C. Intercondylar notch stenosis is not a risk factor for anterior cruciate ligament tears in professional male basketball players: an 11-year prospective study. Am J Sports Med 2005; 33:29-34.
27. Stijak L, Nikolić V, Blagojević Z, et al. Influence of morphometric intercondylar notch parameters in ACL ruptures. Acta Chir Iugosl 2006; 53:79-83.

28. Vrooijink SH, Wolters F, Van Eck CF, Fu FH. Measurements of knee morphometrics using MRI and arthroscopy: a comparative study between ACL-injured and non-injured subjects. Knee Surg Sports Traumatol Arthrosc. 2011; 19: S12-6.
29. Al‐Saeed O, Brown M, Athyal R, Sheikh M. Association of femoral intercondylar notch morphology, width index and the risk of anterior cruciate ligament injury. Knee Surg Sports Traumatol Arthrosc 2013;21:678‐82.
30. Keays SL, Keays R, Newcombe PA. Femoral intercondylar notch width size: A comparison between siblings with and without anterior cruciate ligament injuries. Knee Surg Sports Traumatol Arthrosc 2016;24:672‐9.
31. Ireland ML, Ballantyne BT, Little K, McClay IS. A radiographic analysis of the relationship between the size and shape of the intercondylar notch and anterior cruciate ligament injury. Knee Surg Sports Traumatol Arthrosc 2001; 9:200-5.
32. Uhorchak JM, Scoville CR, Williams GN, Arcerio RA, St Pierre P, Taylor DC. Risk factors associated with noncontact injury of the anterior cruciate ligament: a prospective four-year evaluation of 859 West Point cadets. Am J Sports Med. 2003;31:831-42.
33. Shelbourne KD, Facibene WA, Hunt JJ. Radiographic and intraoperative intercondylar notch width measurements in men and women with unilateral and bilateral anterior cruciate ligament tears. Knee Surg Sports Traumatol Arthrosc 1997; 5:229-33.

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