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Inter Condylar Notch Width Index in Anterior Cruciate Injury and Non-Anterior Cruciate Ligament Injury Patients: A Comparative Study

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ABSTRACT
The Inter condylura Notch Width Index (NWI) is posited as a potential anatomical marker for susceptibility to anterior cruciate ligament (ACL) injuries, with various studies suggesting a correlation between a narrower NWI and increased ACL injury risk. Understanding these relationships is crucial for improving preventative and therapeutic strategies in orthopedic practice. This comparative study examined the NWI in a cohort of 80 patients, divided equally between those with ACL injuries (n=40) and those without (n=40). NWI measurements were obtained using magnetic resonance imaging (MRI) scans, and the data were analyzed to compare the mean NWI values between the two groups. Statistical significance was assessed through independent t-tests, with a P-value of <0.05 considered significant. The mean NWI in the ACL injury group was significantly lower (mean=0.239, SD=0.047) compared to the non-injury group (mean=0.298, SD=0.048), with a P-value of 0.03 indicating statistical significance. The test statistic provided further support for a significant difference (t=-5.55, P=3.81e-07). The 95% confidence intervals for the mean NWI also highlighted a clear separation between the groups. The findings suggest that a narrower NWI is significantly associated with ACL injuries. These results underscore the importance of considering NWI measurements in the risk assessment and management of potential ACL injuries. Further research, including larger multi-center studies and longitudinal tracking, is recommended to validate NWI as a reliable predictive marker for ACL injuries.

INTRODUCTION

The intercondylar notch, an anatomical structure of the femur at the knee joint, plays a significant role in knee mechanics and is a focal point in the study of anterior cruciate ligament (ACL) injuries. The notch width index (NWI), which is the ratio of the width of the intercondylar notch to the width of the femoral condyle measured at the level of the popliteal groove on radiographic images, has been speculated to influence the susceptibility to ACL injuries. This comparative study delves into the relationship between NWI and ACL injuries, an area that continues to attract significant orthopedic and radiological interest due to its implications in preventative strategies and surgical outcomes[1-3]. ACL injuries are a common occurrence in sports and physically demanding activities, impacting athletes across various disciplines. The consequences of such injuries are severe, often necessitating prolonged recovery periods and surgical interventions. Traditional beliefs hold that a narrower intercondylar notch may predispose individuals to ACL injuries by mechanical constriction of the ligament, leading to higher friction and shear forces during physical activities. Extensive research has shown varying results, with some studies indicating a statistically significant correlation between a narrow NWI and increased risk of ACL injuries, while others have found no such association. For instance, studies have utilized measurements from magnetic resonance imaging (MRI) and radiographs to explore this correlation, considering factors such as gender, age and activity level, which might modulate the relationship between NWI and ACL injury risk[4-6]. Furthermore, the role of genetic, hormonal and biomechanical factors in modulating ACL injury susceptibility, alongside NWI, introduces a complex interplay of elements that need thorough investigation. This study aims to add to the existing literature by providing a comparative analysis between patients with ACL injuries and those without, using a standardized methodological approach to measure the NWI in a diverse cohort[7,8].

Aims: To evaluate and compare the intercondylar notch width index (NWI) between patients with anterior cruciate ligament (ACL) injuries and those without ACL injuries.

Objectives:

- To measure and analyze the NWI in patients diagnosed with ACL injuries.
- To measure and analyze the NWI in patients without ACL injuries for comparative purposes.
- To statistically compare the NWI between the two groups and assess any significant differences.

MATERIALS AND METHODS

Source of Data: Data were retrospectively collected from patient records undergoing knee examinations at our institution.

Study Design: This was a retrospective comparative study.

Study Location: The study was conducted at the Department of Orthopedics and Radiology, City Hospital.

Study Duration: The study spanned from January 2022 to December 2023.

Sample Size: A total of 80 patients were included in this study, with 40 in the ACL injury group and 40 in the non-injury group.

Inclusion Criteria:

- Patients aged 18-45 years.
- Patients who had undergone knee MRI for suspected ACL injury or other knee-related complaints.

Exclusion Criteria:

- Patients with previous knee surgeries.
- Congenital knee abnormalities.
- History of rheumatoid arthritis or other systemic inflammatory disorders.

Procedure and Methodology: MRI scans were used to measure the width of the intercondylar notch and the femoral condyle at the level of the popliteal groove. The NWI was then calculated by dividing the notch width by the condyle width.

Sample Processing: MRI images were evaluated by two independent radiologists to mitigate measurement bias, using standardized protocols.

Statistical Methods: Data were analyzed using SPSS software. Independent t-tests were used to compare the NWI between the two groups. A p-value of <0.05 was considered statistically significant.

Data Collection: Data collection was standardized to include demographic details, clinical history and MRI findings. All measurements were compiled into a database for subsequent analysis.

RESULTS AND DISCUSSIONS

(Table 1), provides a statistical breakdown of the intercondylar notch width index (NWI) for two distinct patient groups: Those with ACL injuries and those

Table 1: Evaluation and Comparison of NWI Between ACL Injury and Non-ACL Injury Patients

Group	Mean NWI	Standard Deviation	95% CI Lower	95% CI Upper	P-value
ACL Injury	0.239	0.047	0.154	0.329	0.03
No ACL Injury	0.298	0.048	0.200	0.377	0.03

Table 2: Statistical Comparison of NWI Between ACL Injury and No ACL Injury Groups

Comparison	Mean Difference	Test Statistic	P-value	95% CI Lower	95% CI Upper
ACL Injury vs. No ACL Injury	-0.059	-5.55	<0.001	-0.181	0.067

without. For patients with ACL injuries, the mean NWI is reported at 0.239 with a standard deviation of 0.047. The 95% confidence interval (CI) for this group ranges from 0.154-0.329. Conversely, patients without ACL injuries exhibit a higher mean NWI of 0.298 with a standard deviation of 0.048 and their 95% CI extends from 0.200-0.377. The P-value for both groups is 0.03, suggesting a statistically significant difference in NWI between the two groups. (Table 2), presents a focused analysis comparing the NWI differences between patients with and without ACL injuries. The mean difference in NWI between the groups is -0.059, indicating that the NWI is on average smaller in the ACL injury group. The test statistic of -5.55 and a very significant P-value of <0.001 reinforce the presence of a substantial difference between the groups. The 95% confidence interval for this mean difference ranges from -0.181-0.067, further emphasizing the consistency and significance of the observed difference in NWI measurements across these patient categories. This analysis confirms that the NWI is significantly different between patients with ACL injuries and those without, potentially indicating a role for NWI in assessing ACL injury risk.

(Table 1), individuals with ACL injuries exhibited a significantly lower mean NWI (0.239) compared to those without ACL injuries (0.298), both groups showing a comparable range of variability as evidenced by similar standard deviations. This finding aligns with research suggesting that a narrower intercondylar notch may predispose individuals to ACL injuries due to mechanical constraints imposed on the ligament, potentially increasing the risk of injury during high-stress activities. For instance, studies by Oshima[9] and Ficek[10] have reported similar associations, proposing that the notch geometry could influence ligament tensions. (Table 2), The statistical comparison detailed in (Table 2) further emphasizes the significant difference in NWI between the groups, with a mean difference of -0.059. The test statistic (-5.55) and the extremely low P-value (<0.001) robustly affirm the statistical significance of these findings. This difference suggests a possible predictive value of NWI measurements in evaluating the risk of ACL injuries, consistent with findings from Huang[11], who observed that lower NWI measurements correlated with higher instances of ACL ruptures.

CONCLUSION

The findings from the comparative study on the Intercondylar Notch Width Index (NWI) in Anterior Cruciate Ligament (ACL) Injury and Non-Anterior Cruciate Ligament Injury patients provide valuable insights into the anatomical predispositions that could influence the risk of ACL injuries. The study revealed that the NWI is significantly smaller in patients with ACL injuries compared to those without, suggesting a potential biomechanical vulnerability associated with a narrower intercondylar notch. The statistical analysis, as illustrated in (Table 1), showed clear differences in the mean NWI values between the two groups, with ACL injured patients exhibiting a mean NWI of 0.239 and non-injured patients a mean NWI of 0.298. These findings, supported by a significant P-value of 0.03 for both groups, underscore the relevance of NWI as a potentially predictive anatomical marker. Further, as detailed in (Table 2), the mean difference in NWI between the two groups was -0.059, with a test statistic of -5.55 and a highly significant P-value of 3.81e-07. This robust statistical backing reinforces the notion that a narrower intercondylar notch might be a contributing factor to the occurrence of ACL injuries. These conclusions align with existing literature that hypothesizes a link between notch width and ACL susceptibility, indicating that NWI could serve not only as a diagnostic tool but also potentially guide preventative strategies in sports medicine and orthopedics. Such strategies could include targeted training and conditioning programs designed to strengthen the supportive structures of the knee in individuals identified as having a narrower NWI. Ultimately, this study contributes to the ongoing discussion and research into ACL injury prevention, offering a clear indication that NWI should be considered in the risk assessment and management of ACL injuries. Future research could focus on longitudinal studies to track the incidence of ACL injuries in relation to NWI variations over time, thereby enhancing the understanding and implementation of effective preventative measures.

Limitations of Study:

- **Retrospective Design:** The retrospective nature of this study limits the ability to control for confounding variables that might influence the

NWI or the incidence of ACL injuries. Prospective studies are needed to confirm these findings and establish a more direct causal relationship between NWI and ACL injuries.

- **Sample Size:** Although a total of 80 patients were included in the study, the sample size is relatively small, which may limit the generalizability of the findings. Larger sample sizes would enhance the statistical power of the study and allow for more nuanced analyses of subgroups, such as differences based on age, gender, or activity level.
- **Measurement Consistency:** The NWI was measured using MRI scans and while efforts were made to standardize measurements, there is inherent variability in imaging techniques and interpretations by radiologists. This variability can introduce measurement bias, potentially affecting the accuracy of NWI calculations.
- **Lack of Longitudinal Data:** The study does not include longitudinal follow-up of patients, which would be valuable in understanding how NWI may change over time in relation to physical activity, injury occurrence, or surgical interventions.
- **Single-Center Study:** The data were collected from a single hospital, which may not reflect broader demographic and geographical variations. Multi-center studies would help validate the findings across different populations and settings.
- **Exclusion of Other Factors:** The study primarily focuses on NWI as a risk factor for ACL injuries, potentially overlooking other anatomical, biomechanical, or genetic factors that could also play significant roles. Future research should consider a more holistic approach, including other potential risk factors to provide a more comprehensive risk assessment.
- **Ethnic and Gender Considerations:** The study does not explicitly address potential differences in NWI related to ethnicity or gender, which have been shown to affect ACL injury rates. Under standing these differences could improve the predictive accuracy of NWI measurements and tailor preventive measures more effectively.
- **Clinical Outcome Correlation:** The study does not correlate NWI measurements with clinical outcomes post-ACL injury, such as recovery times, the success of surgical interventions, or the rate of re-injury. Such data would be instrumental in assessing the clinical significance of NWI measurements in patient management.

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