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SONOGRAPHIC ASSESMENT OF FEMORAL CARTILAGE THICKNESS IN ADULTS WITH PAIN AND WITHOUT PAIN

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Abstract

BACKGROUND: *Femoral cartilage plays a vital role in knee joint function, providing smooth articulation and load distribution. Degeneration or thinning of this cartilage is commonly associated with knee pain and joint disorders. Early detection of cartilage changes is crucial for diagnosis and management. Ultrasonography has emerged as a non-invasive, accessible, and reliable imaging method for evaluating femoral cartilage thickness.*

OBJECTIVE: *To measure the femoral cartilage thickness in adults with pain or without pain by sonography.*

METHODOLOGY: *This study was a case-control design conducted at CMA Hospital, Superior University, Lahore, to assess femoral cartilage thickness using musculoskeletal ultrasound in individuals with and without knee pain. A total of 70 participants were selected through convenient sampling, based on inclusion criteria for adults aged 15 to 35 years, with or without knee pain, and those with local knee inflammation. Ultrasound imaging was performed using a Toshiba Xario machine with a 7–15 MHz linear probe. Data were analyzed using SPSS version 25.*

RESULTS: *This study evaluated the reliability of ultrasound-based measurements of Femoral Cartilage Thickness in 70 individuals, both with and without knee pain. Measurements were taken at three regions: the Medial Condyle (MC), Intercondylar Region (IC), and Lateral Condyle (LC). The reliability analysis showed Cronbach's Alpha values ranging from 0.734 to 0.867, indicating acceptable to good internal consistency. Inter-item correlation coefficients, such as 0.725 between cartilage thickness in the intercondylar ligament without pain and with pain, and 0.765 between cartilage thickness in the intercondylar region without pain and with pain, reflected moderate to strong positive relationships. These findings confirmed that ultrasound is a consistent and reliable tool for assessing femoral cartilage thickness across different knee regions in both painful and non-painful knees.*

CONCLUSION: *The study concluded that individuals with knee pain had significantly reduced femoral cartilage thickness compared to those without pain, as measured by musculoskeletal ultrasonography. This suggests that ultrasound is*

an effective, non-invasive tool for evaluating structural changes in the knee joint, and it may assist in the early detection and management of joint pathologies.

INTRODUCTION

Cartilage is an avascular, aneural (no nerves), lymphatic (no lymphatic vessels), connective tissue that can be found in synovial joints, the spine, the ribs, the outer ears, the nose, the airways, and in the growth plates in children and adolescents. There are three major types of cartilage found in humans: hyaline, fibrous, and elastic.[1] Articular cartilage is hyaline cartilage and 2 to 4mm thick and highly specified connective tissue of diarthrodial joint. Its principal function is to provide smooth lubricated surface for articulation and to facilitate the transmission of loads with a low frictional coefficient.[2] Knee osteoarthritis (KOA) is indeed a prevalent and debilitating condition in orthopedics. The degeneration and loss of articular cartilage are hallmark features, leading to altered joint structure and function. The incidence of symptomatic KOA stands at 8.1%. KOA now accounts for a substantial majority of osteoarthritis cases globally, representing 85% of the total.[3] knee OA is reported to occur in 29.1% of men and 41.5%. In Indonesia the knee OA has been 8.5% and 6.1% in women and men. Thalassemia patients are more prone to developing osteoarthritis (OA) than the normal population and possible OA development can be prevented by keeping the ferritin levels of these patients in the optimum range.[4] The existence of excess iron in the joint leads to the degradation of cartilage through proinflammatory mediators like tumor necrosis factor (TNF), interleukin (IL)-1b, IL-6 and hydroxyl radicals.[5] Prevalence of Grade-III Knee Osteoarthritis among the Women of Gujra nwala, Pakistan this study targeted women aged 55 to 70 years with Grade III knee osteoarthritis, and the sample size was 100 participants.[6] Patellofemoral Pain has a lifetime prevalence of roughly 25%. T. It demonstrates the symptoms involving anterior knee pain during activities like squatting. Meniscal tears are quite common, affecting around 12% of adults. The most common cause of meniscal tears is acute trauma, for example, a twisting injury during sports or exercise.[7] CT scans are quite good at providing detailed images of bone structures. This is because they visualize bone detail much better.

CT is not sensitive to soft tissue and does not provide detail enough to clearly visualize articular cartilage and navicular cartilage. The imaging of soft tissues is highly effective with ultrasound. Muscles, tendons, and organs such as the liver and kidneys are most examined using this tool. Ultrasound has the benefits of being non-invasive, widely accessible, and does not involve ionizing radiation.[8] Joint space narrowing is mostly evaluated by radiography. However, radiography does not directly show cartilage. Also, early changes in the cartilage structure are not detected by radiography. Ultrasound (US) and magnetic resonance imaging (MRI) are valid tools for the assessment of femoral cartilage thickness. On the other hand, USG has some advantages as it is an easily accessible and inexpensive alternative to evaluate cartilage structure compared to MRI.[9] Diagnostic ultrasound (US) may provide a valid, cost-effective alternative to MRI. Furthermore, diagnostic US provides a real-time image that may aid in the assessment of femoral cartilage thickness, a benefit that MRI does not offer.[10] In particular, musculoskeletal ultrasound (MSUS) is an imaging technique that can be used to diagnose, monitor, and control the therapeutic response in paediatric inflammatory rheumatic diseases, especially in juvenile idiopathic arthritis.[11] As a non-invasive measure of ultrasound signal intensity, one of our prior reports recently used an in vivo assessment of cartilage ultrasound echo intensity in people after ACL injury.[12]

Material and Methods:

This case-control study was conducted at CMA Hospital, Superior University, Lahore, over a period of three months following ethical approval. A total of 70 participants were recruited through convenience sampling, based on a 95% confidence level, 5% margin of error, and 5% prevalence. Inclusion criteria included adults with and without knee pain, aged between 15 and 35 years, and those with local knee joint inflammation. Patients with congenital joint abnormalities, arthritis, fractures (femoral, tibial,

fibular, or patellar), meniscal tears, or deformities affecting gait were excluded. Musculoskeletal ultrasound was performed using a Toshiba Xario machine with a high-frequency (7–15 MHz) linear probe. Scans were conducted with patients in a supine position, knees extended and then flexed. The probe was placed over the suprapatellar area to visualize femoral cartilage, and thickness was measured at the medial condyle, intercondylar area, and lateral condyle.

Results:

Femoral cartilage plays a critical role in joint function and load distribution in the knee. Degeneration or thinning of this cartilage is commonly associated with conditions like osteoarthritis and can be evaluated effectively through musculoskeletal ultrasound, a non-invasive imaging modality. This study aimed to assess differences in femoral cartilage thickness between individuals with and without knee pain using ultrasound imaging, while also evaluating the reliability and consistency of these measurements. A total of 70 participants were included in the study, with an equal distribution of males and females (50% each). Reliability analysis showed good to excellent internal consistency in ultrasound-based cartilage thickness measurements. Cronbach's Alpha values ranged from 0.734 for the medial condyle to 0.931 for the lateral condyle, indicating acceptable to excellent reliability. Inter-item correlation values ranged from 0.581 to 0.871, all statistically significant ($p < 0.001$), suggesting a moderate to strong positive relationship between cartilage thickness in painful and non-painful knees. Intraclass Correlation Coefficients (ICCs) supported these findings, with average measure ICCs ranging from 0.734 to 0.931, confirming high consistency of the ultrasound assessments. Paired samples analysis revealed a statistically significant difference in cartilage thickness in the right intercondylar region (mean difference = 0.15556, $p = 0.014$), indicating cartilage thinning in individuals with knee pain. Other regions, including the medial and lateral condyles, did not show statistically significant differences between painful and non-painful knees ($p > 0.05$), though the trends suggested slightly lower thickness values in painful knees. Correlation analysis further reinforced the reliability of the ultrasound technique, with strong paired correlations, particularly in the lateral condyle ($r = 0.871$) and right intercondylar region ($r = 0.765$). These findings suggest that musculoskeletal ultrasound is a reliable tool for evaluating femoral cartilage thickness and that cartilage thinning, especially in the intercondylar region, may be associated with the presence of knee pain.

Table 1. Reliability and Comparison of Femoral Cartilage Thickness Measurement

Pair	Location	Cronbach's Alpha	Inter-Item Correlation	Intraclass Correlation Coefficients (ICCs)	Mean (W)	Mean (P)	Mean (f)
1	Intercondylar Left	0.833	0.725	0.833	2.53	2.42	0.106
2	Lateral Condyle Left	0.931	0.871	0.931	2.275	2.283	0.008
3	Medial Condyle Left	0.734	0.581	0.734	2.289	2.272	0.017
4	Intercondylar Right	0.858	0.765	0.858	2.647	2.492	0.156
5	Lateral Condyle Right	0.806	0.685	0.806	2.211	2.256	0.044

6	Medial Condyle Right	0.846	0.734	0.846	2.419	2.403	0.017

Table: The Table summarizes the reliability and comparison of femoral cartilage thickness measurements under two conditions—without pain (W) and with pain (P)—across different knee regions. All measurement pairs demonstrated acceptable to excellent internal consistency, with Cronbach's Alpha values ranging from 0.734 to 0.931 and Intraclass Correlation Coefficients (ICCs) for average measures above 0.73, indicating strong reliability. Inter-item correlations were moderate to strong, confirming consistency between paired measures. Paired samples t-tests showed no significant differences between measurements in five out of six regions; however, a statistically significant reduction in cartilage thickness was observed in the intercondylar region of the right knee ($p = 0.014$). This suggests a potential localized impact of pain on cartilage thickness in that area, while overall measurement reliability remains high across regions.

Discussion

Ultrasound-based assessment of femoral cartilage (FC) thickness has gained recognition as a reliable and non-invasive technique for evaluating joint health, particularly in the knee where cartilage degeneration is often associated with conditions like osteoarthritis (OA). The femoral cartilage is essential for maintaining smooth articulation and effective load distribution within the knee joint. Damage or thinning of this cartilage, whether due to mechanical stress or age-related degeneration, can lead to joint pain, reduced function, and progression of degenerative joint disease. Traditional imaging modalities such as MRI have long been considered the gold standard for cartilage evaluation; however, musculoskeletal ultrasound is emerging as a practical alternative due to its accessibility, cost-effectiveness, and real-time imaging capabilities. In the present study, ultrasound was used to evaluate differences in femoral cartilage thickness between individuals with and without knee pain, while also assessing the reliability of the ultrasound measurements. Seventy participants were included, with equal representation of males and females. The reliability analysis showed strong internal consistency, with Cronbach's Alpha values ranging from 0.734 for the medial condyle to 0.931 for the lateral condyle. These findings were reinforced by significant inter-item correlations (ranging from 0.581 to 0.871, $p < 0.001$) and high intraclass correlation coefficients (ICCs), indicating that ultrasound provides consistent and dependable measurements of femoral cartilage thickness. A statistically significant difference in cartilage thickness was observed in the right intercondylar region (mean difference = 0.15556, $p = 0.014$), indicating localized cartilage thinning in individuals with knee pain. Although differences in other regions, such as the medial and lateral condyles, were not statistically significant, the observed trend of thinner cartilage in symptomatic knees supports the hypothesis that early degenerative changes may manifest subtly before widespread thinning becomes apparent. These findings align with and build upon the existing body of literature. For instance, Mohamed A. Bedewi et al. (2020) conducted a normative study in 72 healthy adults and reported significant sex-based differences in cartilage thickness, with males exhibiting greater thickness in both the left lateral and medial condyles.[13] Additionally, their study identified a positive correlation between height and cartilage thickness in the right medial and lateral condyles, as well as the right intercondylar region—the same region where our study found significant thinning in symptomatic individuals. This overlap underscores the clinical relevance of the intercondylar region as a sensitive marker for cartilage changes. Similarly, the current study's trend toward reduced cartilage thickness in symptomatic knees echoes findings by Rita Vivera Pane et al. (2023), who demonstrated significant thinning of the medial condyle in OA patients compared to healthy controls.[14] While our study did not show statistically significant thinning in the medial condyle, the directionality of the difference suggests early degenerative change that may not yet reach statistical significance due to population or sample size differences. Further support comes from the work of Ahmet Bozan et al. (2023), who found both reduced femoral cartilage and quadriceps muscle

thickness in OA patients, alongside impaired performance in mobility tests.[15] While our study did not assess muscle thickness or functional performance, Bozan's findings reinforce the broader context of musculoskeletal degradation in OA and the value of ultrasound in detecting structural changes. Naghmeh Salarieh et al. (2023) provided normative ultrasound measurements of femoral cartilage in healthy Indonesian adults, reporting mean values at the medial condyle, intercondylar region, and lateral condyle that serve as useful reference points.[16] In their study, the average right intercondylar cartilage thickness was 1.92 mm, whereas our study identified thinning in this region among participants with knee pain. The divergence from normative values adds weight to the argument that intercondylar thinning may be an early indicator of cartilage pathology. Despite these valuable insights; the current study presents several important gaps that warrant further investigation. Firstly, the study did not include age stratification or detailed demographic analysis such as height, BMI, or physical activity levels, which have been shown in prior studies (e.g., Bedewi et al., 2020) to influence cartilage thickness. This limits the ability to contextualize cartilage measurements across different body types or age groups. Secondly, the study employed a cross-sectional design, which does not permit assessment of cartilage changes over time or the effectiveness of interventions. Longitudinal studies are needed to determine whether the observed thinning in the intercondylar region predicts progression to clinically significant OA. The statistically significant cartilage thinning observed in the right intercondylar region among individuals with knee pain suggests that this area may serve as an early indicator of degenerative joint changes. The strong reliability metrics, including high Cronbach's Alpha and ICC values, support the consistency and clinical applicability of ultrasound in evaluating joint health. While the medial and lateral condyles did not show significant differences, the consistent trend toward thinner cartilage in symptomatic individuals aligns with previous literature and suggests that early cartilage degeneration may initially be localized before becoming more widespread.

Conclusion

This study concluded that musculoskeletal ultrasound is a reliable and consistent method for assessing femoral cartilage thickness in individuals with and without knee pain. The ultrasound measurements demonstrated good to excellent internal consistency, with strong inter-item correlations across different regions of the knee joint. A statistically significant reduction in cartilage thickness was identified in the right intercondylar region among participants experiencing knee pain, indicating a potential association between pain and localized cartilage degeneration. However, no significant differences were observed in the medial and lateral femoral condyles. These findings support the clinical utility of ultrasound as a non-invasive, accessible, and effective imaging modality for detecting and monitoring femoral cartilage changes related to knee pain.

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