DIAGNOSTIC ULTRASOUND IN THE ASSESSMENT OF PATELLAR INSTABILITY: A SYSTEMATIC REVIEW

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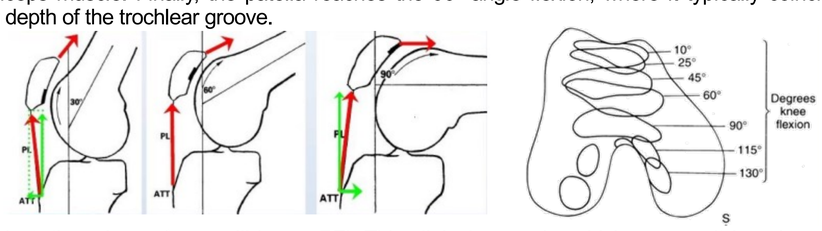
INTRODUCTION

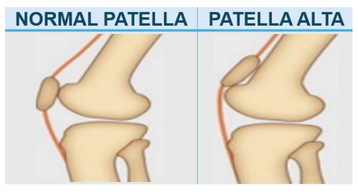
The knee is located in the middle third of the lower limb, between the hip joint (coxofemoral) and the ankle joint (tibioperoneal-astragalinus), playing a leading role in major movements, such as walking or running. Likewise, it is comprised of four bones (tibia, fibula, femur, and patella), which interact through the tibio-femoral, patello-femoral, and tibio-peroneal joints. The focus of this project will be on the patello-femoral joint (PFJ), where the following structures can be found femoral trochlea, patella, quadriceps tendon, medio-lateral patellar retinaculum.

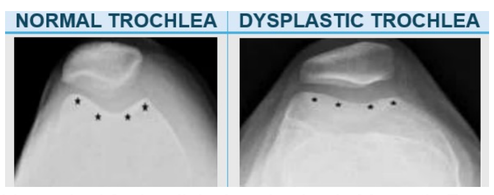
In order to understand the conditions that affect the PFJ, it is important to first comprehend the physiological PFJ biomechanical characteristics. In this way, when the knee is fully extended, the patella does not lie in the femoral groove, and is during the 20º-30º angle flexion that them start to engage. Thus, beyond this flexion, the bony structures provide most of the patellofemoral stability, while the medial patellofemoral ligament (MPFL) functions as the primary stabilizer in 0º-30º flexion angle, where the MPFL assembly counteracts the lateralizing vector of the quadriceps muscle. Finally, the patella reaches the 90º angle flexion, where it typically coincides with the maximum depth of the trochlear groove.



In this project, the primary focus will be on PFI. This clinical scenario, which can result in pain and significant functional limitations, occurs when the patella does not properly glide on the articular surface of the femoral trochlea because of a deficiency in the active and/or passive natural constraints, favoring an escape of the patella from the femoral groove towards the lateral edge.

Taking into account the etiology of this condition is multifactorial and has multiple risk factors, such us: **patella alta**: an abnormally proximal patellar position, that favors the patella to be outside the trochlear concavity for a larger part of the flexion-extension movement; **trochlear dysplasia**: a sulcus depth reduction, that may decrease the retention of the patella to the lateral region; or **increased tibial tubercle-trochlear groove (TT-TG distance)**: the medial-lateral distance of the patellar tracking during extension movement.





Regarding the diagnosis, although nowadays the gold standard for its clinical evaluation is Magnetic Resonance Imaging (MRI), US could be an interesting alternative not only because of its invasiveness, lack of radiation or affordability, but also because the knee anatomic elements being examined are situated superficially (less interference with US waves). Moreover, it provides the possibility to study the knee under dynamic loading conditions, as well as in the initial degrees of flexion, when the instability tends to occur.

OBJECTIVES

GENERAL OBJETIVE

to conduct a systematic review to evaluate the utility of ultrasound in the clinical diagnosis of patellofemoral instability.

SPECIFIC OBJETIVES

- Collect the scientific evidence on femoropatellar instability and ultrasonography, to determine the scientific evidence about its use as a diagnostic method.

- Evaluate the relationship between risk factors and patellofemoral instability in the diagnosis of patellofemoral instability.

- Determine if ultrasound can be a cost-effective diagnostic technique and alternative to other diagnostic imaging methods.

METHODOLOGY

Systematic Review

Database	Search strategy	Nº
PUBMED	((patella* or patellofemoral AND (instability OR instabilities OR instable OR malalignment OR alignment OR maltracking OR tracking OR tilt OR dislocation)) OR ("patellar dislocation" [MeSH Terms])) AND ("Ultrasonography" [Mesh] OR ultrasound* or ultrasonograph* or sonograph*). Last done: 21 June 2023.	194
WoS	ALL=(((patella* or patellofemoral) AND (instability OR instabilities OR instable OR malalignment OR alignment OR maltracking OR tracking OR tilt OR dislocation)) AND (ultrasonograph* OR ultrasound OR sonograph*))	183
Scopus	(TITLE-ABS-KEY ((patella OR patellofemoral AND (instability OR instabilities OR instable OR malalignment OR alignment OR maltracking OR tracking OR tilt OR dislocation))) AND TITLE-ABS-KEY (ultrasonograph* OR ultrasound OR sonograph*))	187

ABSTRACT

Patellofemoral instability (PFI) is a generic term used to describe an abnormal displacement between the patella and the femoral trochlea, in which the patella tends to escape from the femoral groove to the lateral edge. This can lead to significant functional limitations, especially in severe or refractory cases.

Currently, the gold standard for its clinical evaluation is Magnetic Resonance Imaging (MRI). However, ultrasound imaging (US) has also been employed to provide similar information in a more accessible, economical, and immediate way. Therefore, a systematic review of the published literature was conducted to analyse the US clinical diagnostic utility in the PFI approach.

A systematic review of previously published scientific articles was performed, according to PRISMA checklist. PUBMED, Scopus and Web of Sciences databases were examined for relevant studies by applying pre-defined search terms. NHLBI tool was used to assess the quality of the included studies.

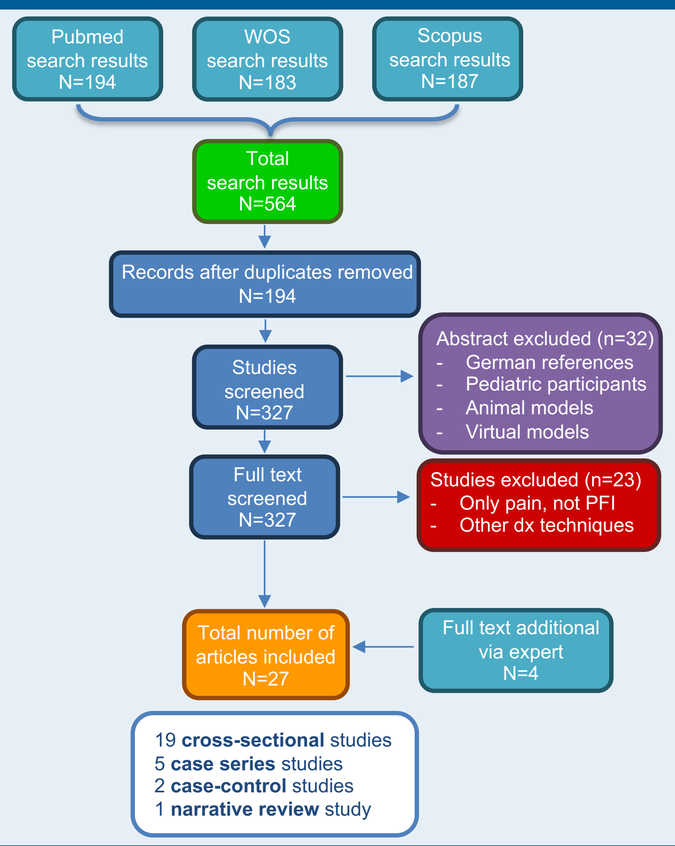
This systematic review was registered in PROSPERO (International prospective register of systematic reviews); ID: CRD42023429012

The systematic review included 27 articles after the article selection process of 564 studies initially screened. The evidence from these investigations have revealed the effectiveness of US in evaluating the PFJ and suggest that it could be incorporated into the PFI knee examination Due to data heterogeneity, a metanalysis was not performed.

US is a non-invasive and reliable diagnostic technique to dynamically examine the knee and has been proven to be useful in the PFI assessment, especially in the acute setting. However, further studies with robust designs are needed to establish a standardized diagnostic methodologies and provide evidence-based recommendations for use un PFI cases.

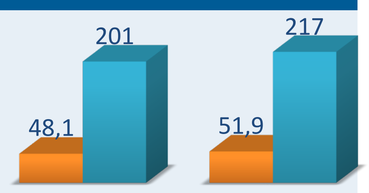
RESULTS

FLOW DIAGRAM



PATIENT´S CHARACTERISTICS

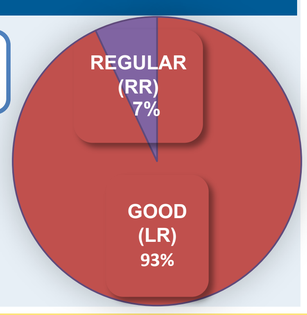
- **481 healthy** knees
- **170** knees **with PFI**
- **Gender and sex variables** was analyzed in **23 of 27 articles.**
- **Mean age was 22.8 years** (17.3-40.3 years). Excludes cadaveric studies



	MEN	WOMEN
%	48,1	51,9
Nº	201	217

NHLBI QUALITY APPRAISAL TOOLS

Most included **studies** have **low risk of bias**



Author	Studied variable	Main results
Santi G, et al 1992.	Relationship between the lateral patellar border and the lateral femoral condyle.	Cases showed more pronounced patellar lateral displacement during in extension, 15º and 30º of flexion in comparison to controls.
Starok M, et al 1997.	Medial and lateral patellar retinaculum anatomy.	"Lateral retinaculum and medial retinaculum: hypoechoic striated bilaminar structure.
Joshi R, et al 1998.	Patellar lateral displacement and sulcus angle	Mean sulcus angles showed a statistically significant difference between groups in each flexion angle (p = 0.001). Patellar displacement showed a statistically significant inter/intraobserver variation, unlike the sulcus angle (r=0.90).
Shih Y, et al 2003.	Total patellar displacement (PD)	Precision of US PCD measurement was validated by MRI and resulted in a mean error of 1.4 ± 3.2 mm. "The patella stayed more laterally in squatting than it did in sitting flexion/extension."
Trikha SP, et al 2003.	Medial retinaculum US findings after acute patellar dislocation	Medial edge patellar ligamentous tearing insertion and knee effusion around MCL were identified in all patients, and haematomas and torn fibres in the VMO (muscle tearing).
Shih Y, et al 2004.	Patella-condyle measure	Movement tasks and knee flexion angle significantly affected the patellar lateral position. Difference between US and MRI measurements was 0.6 ± 1.9 mm (mean error).
Herrington L, et al 2006.	Patella-condyle distance (PCD, US) and lateral patella displacement (LPD, MRI)	LPD and PCD MD assessed by MRI: 2.7 mm ± 2.2 mm (both measures). LPD MD US-MRI: 1.85 mm ± 1.5 mm (0.5 to 6.1 mm) PCD MD US -MRI: 2.3 mm ± 1.6 mm, (0.1 to 5.4 mm.) Good correlation US-PCD and MRI-LPD (r = 0.64, p = 0.003). Excellent US-PCD and MRI-PCD correlation(r = 0.78, p = 0.0001).Good correlation MRI-PCD and MRI-LPD (r = 0.67, p = 0.002).
Herrington L, et al 2007.	Patella-condyle distance (PCD): under maximal VMO and VL contraction	VMO maximal contraction produced a mean patellar medially displacement of 6.8 ± 2.9 mm and VL a mean lateral displacement of 5.6 ± 2.7 mm. Correlation between repetitions was good.
Phornphutkul C, et al 2007.	Description of PFJ medial stabilizing structures (VMO and MPFL)	All medial PFJ stabilizing structures were fully identified using US: insertions and attachments, trilaminar appearance of the MPFL, surrounding bony and soft-tissue landmarks.
Felus J, et al 2008.	Patellofemoral joint injuries using US after traumatic patellar dislocations (TPD)	US identified 91.6% of osteochondral loose bodies, 81.8%, of osteochondral lesion localization and 100% of avulsion fractures in MPFL attachment.
Herrington L, et al 2009.	Patella-condyle distance (PCD): at 20º knee flexion.	Patellar tapping changed patellar position 6.2±1.3 mm prior to application of tape vs 7.9±1.7 mm (p=0.003) Mean patellar position after exercise (7.6±1.7 mm).
Toms AP, et al 2009.	Femoral sulcus angle	The sulcus angle was consistently smaller when measured from subchondral bone compared to cartilage (5–7°).
Kulig K, et al 2010.	Femoral anteversion angle	Mean femoral anteversion angle was 20.7º ± 11 by US and 19º±11.3 by MRI. SEM was 2.2º (US) and 1.9º (MRI). ICC was 0.98 (US) and 0,96 (MRI)
Herrington L, et al 2012.	Patella-condyle distance (PCD): 20º hip adduction, 20º hip abduction and neutral hip.	Mean patellar position: 8.1 mm ± 1.72 mm for neutral hip; 8.9 mm ±1.79 mm for 20º hip abduction; and 7.3 mm ± 1.4 mm for 20º hip adduction. (p < 0.05)
Zhang GY, et al 2013.	MPFL lesions in acute lateral patellar dislocation.	US accuracy for detection on both partial and complete MPFL was 89.9%.
Kang SY, et al 2014.	ITB length with Ober's test and the lateral patellar translation with the neutral hip and 0ºº adduction.	Subjects with ITB tightness showed a greater lateral patellar translation (p = 0.000) and a significantly laterally positioned patella at 20° hip adduction (p = 0.044).
Park JH, et al 2016.	ITB length with Ober's test and the PCD: neutral, internal and external tibial rotation.	Adduction angle was significantly greater in N tibial position than in ER (P < 0.05), The PCD was significantly greater in the N position than in IR (P < 0.05)".
Giovagnorio F, et al 2017.	Insall-Salvati (IS) index	Mean IS was 1.10 ± 0.16 (MRI) and 1.17 ± 0.16 (US). P= 0.15. ICC was 0.97 (MRI) and 0.98 (US).
Chen CH, et al 2017.	Patella-condyle distance (PCD): step down with the loading knee in 0° and 20° knee flexion	PCD-knee flexion 0º: 0.5 mm ± 1.5 mm PCD-knee flexion 20º: 0.7 mm ± 1.9 mm
Bailowitz Z, et al 2018.	Patellar lateral translation	In asymptomatic subjects, mean relaxation-contraction delta (RCD) was 0.26 ± 0.15 cm, with a range of 0.01 e 0.47 cm. Females knees had higher RCDs (p > 0.05).
Barroso, et al 2019.	Compiled the evidence of dynamic evaluation methods for PFI.	Shih et al (2004): found significant differences in lateral tracking. Herrington's (2008): Measurements were reported as reliable and reproducible.
Greenberg E, et al 2021.	MPT-CTG and MPT-LTR:	MPT-CTG right 8.4mm ± 3.0, left 8.4mm ± 3.3 (p>0.05) MPT-LTR right 12.2mm ± 2.7, left 11.6mm ± 2.3 ((p>0.05) Inter-rater reliability was moderate to good (0.724 for MPT-CTG ; 0.814 for MPT-LTR). Intra-rater reliability was good to excellent (0.913 for MPT-CTG; 0.794 for MPT- LTR).
Kwan L, et al 2021.	Patella-condyle distance (PCD)	PCD at 20º hip adduction was smaller than in neutral. PCD mean difference between neutral position and 20° hip adduction was 0.18 cm.
Bhimani R, et al 2022.	Medial patellofemoral distance	In unloaded and loaded conditions, medial patellofemoral distance increased in the MPFC-deficient state at all knee angles when compared to the intact state (P=.005 to P<.001)
Kwan L, et al 2022.	Patella-condyle distance (PCD): at neutral and 20º hip adduction	No significant differences between US and direct measurements (0.02 cm in the neutral position and 0.05 cm in 20° hip adduction, respectively), (Pearson correlation= 0.97, p=0.83).
Schluter IM, et al 2022.	Tranvserse patellar diameter at 0º knee flexion and sulcus angle at 100º knee flexion	Patella diameter: 37,52 to 43,55 mm Sulcus angle measures range from 123.81º to 139.66º
Asayama A, et al 2023.	Patellar shift and patellar tilt)	US-tilt: range from 1.6 cm to 2.6 cm. US-lateral distance: range from 0.7 cm to 1.3 cm US-angle: range from 30.1º to 50.4º

CONCLUSIONS

1. Several **US measurements** can be useful and reliable in the diagnosis of PFI, especially in the **acute dislocation scenario.**

2. There **is lack of consensus** on which US diagnostic procedure, protocol or measurements are most suitable for diagnosing PFI. Consequently, clinicians tend to use diagnostic strategies according to their personal preferences rather than evidence-based practice.

3. More studies, incorporating larges series of PFI cases, and ideally, under dynamic conditions are needed in order to obtain more robust data that could led to the recommendation **making of US as a routine** intervention for PFI identification and management

3. It is important that future research efforts consider incorporating as many as possible of the factors that **Muhle** proposed as ideal characteristics for PFI assessments methods: **visualization of full range of patellar motion, active movement, weight bearing (WB) conditions, avoidance of radiation or invasive techniques, short examination time, reproducible, clear view of the PF joint and the femoral condyles, especially in the axial view, good image quality, low cost, high availability, 3D imaging for patellar tracking.**

This Project will be presented in the **XI AEA-SEROD Congress** and it will also be published in **an international journal**. **Contributing to collective knowledge and improving the quality of professional practice is the aim of these steps**.

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