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The Pelican Sign: Case Series Demonstrating A Unique Description of an Anteriorly Flipped Bucket-Handle Meniscal Tear of the Knee

Ali Shah[1] Karthikeyan P. Iyengar[2] Sai Niharika Gavvala[3] Amit Shah[4] David Beale[5] Rajesh Botchu[1]

[1] Department of Musculoskeletal Radiology, Royal Orthopaedic Hospital NHS Foundation Trust, Birmingham, United Kingdom
[2] Southport and Ormskirk Hospital NHS Trust, Southport, United Kingdom
[3] Department of Radiology, Kurnool Medical College, Kurnool, Andhra Pradesh, India
[4] Department of Musculoskeletal Radiology, University Hospitals of Leicester, Leicester, United Kingdom
[5] Heath Lodge Clinic, Knowle, United Kingdom

Address for correspondence Rajesh Botchu, MBBS, MS (Orth), MRCSEd, FRCR, Department of Musculoskeletal Radiology, Royal Orthopedic Hospital, Bristol Road South, Northfield, Birmingham B312AP, United Kingdom (e-mail: drbrajesh@yahoo.com).

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Abstract

Introduction Bucket-handle tears (BHTs) of the menisci are not uncommon and can occur in isolation or in conjunction with other injuries. The torn fragment can be displaced within the intercondylar notch or flipped anteriorly. In case of anterior flipped fragment, appearances of such tears on magnetic resonance imaging (MRI) scan have been described as various signs in literature (for example double posterior cruciate ligament sign, double delta sign) but mostly in the sagittal or coronal planes.

Purpose The aim of this study was to describe a unique ancillary sign that helps to identify this injury on the axial MRI plane where the anterior flipped BHT figuratively resembles a "pelican bird."

Materials and Methods A retrospective review of MRI sequences of 10 consecutive patients over a 3-month period referred following a traumatic knee injury with anterior flipped meniscal tears was performed. Demographic details, clinical indication, and other associated features on the MRI were correlated following the observation of characteristic MRI appearance of a BHT.

Results All 10 patients (M:F = 7:3) with a mean age of 24.7 (17–38 years) presented following a twisting injury. 6 out of 10 patients had associated soft-tissue injuries in the knee visualized on the MRI. All patients demonstrated the distinctive "pelican bird" sign on the axial sequences of anterior flipped BHT of either menisci. This was not present with BHTs with displaced fragment within the intercondylar notch.

Conclusion We conclude that the "pelican sign" on an axial sequence when present correlates well with a BHT and its anterior displaced/flipped meniscal fragment. This ancillary sign can complement other previously described signs on different MRI sequences used to confirm a displaced BHT.

Keywords
- knee injuries
- bucket-handle tear
- double flipped meniscus sign
- lateral meniscus
- medial meniscus
- magnetic resonance imaging

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Introduction

A bucket-handle tear (BHT) in the knee is a displaced vertical or oblique longitudinal tear of the meniscus propagating through the body and extending up to the anterior horn.[1] BHT of the meniscus is a significant subgroup pattern of meniscal injury seen in 10- 26% of meniscal tears.[2] Typically seen in young middle-aged males, these can occur as isolated injuries or in conjunction with other internal derangements of the knee especially anterior cruciate ligament (ACL) tears (11–48%).[3]

Meniscal tears mostly happen following a simple, twisting injury with the foot planted on the ground or during sports; however, there may be no history of known trauma in up to 20% of patients.[4] Patients typically present with symptoms of pain, swelling, giving-way, catching, or a frank "locked knee" typically seen in an BHT due to entrapment of the torn fragment preventing full extension of the knee.

Apart from mechanical symptoms, the significance of BHT is due to the injury in the relative avascular white or white on red zone of the meniscus with a poor propensity to "self-heal." The menisci are essential for knee joint load transmission, shock absorption, stability and kinematic function of the lower limb. Consequently, conservation of meniscal tissues to maintain biomechanical function of knee is necessary for a good functional outcome.[5] Early detection of such BHT to direct clinical management is imperative.

Magnetic resonance imaging (MRI) is a crucial modality utilized in the diagnosis of meniscal tears, with a good sensitivity, specificity, and reported to have up to 93% diagnostic accuracy in detecting BHT meniscal tears when compared with arthroscopy.[3,6] A systematic review concluded MRI as a highly accurate and preferable tool for diagnosing meniscal tears.[7] However, even with its high accuracy in detecting displaced meniscal tears, one of its limitations of MRI has been the inability to detect very subtle abnormalities especially due to small tears of questionable clinical significance.[8]

Hence, several MRI findings and signs of BHTs based on morphological rather than signal characteristics have been reported in the literature to aid diagnosis with a variable sensitivity, specificity, and diagnostic accuracy[9–14] (►**Tables 1** and **2**). These are traditionally on sagittal MRI sequences and include "absent bow tie sign," "double posterior cruciate ligament sign," "flipped meniscus sign," "double flipped meniscus sign," "double ACL sign," or on coronal sequences (coronal truncated meniscus sign). Due to the nature of BHT and its longitudinal orientation, sensitivity in sagittal sequences may be low and can lead to misdiagnosis.[8,10] There is a single sign reported on the axial plane imaging described as the "V" sign with a promising outlook.[15]

Dorsay and Helms suggest increased accuracy of MRI in diagnosing BHT especially when two or more of these signs coexist.[1] Therefore, in this study, we describe a new ancillary sign associated with displaced bucket-handle meniscal tears to identify this injury on the axial MRI sequences, where the anterior flipped BHT visually resembles a pelican bird, to increase accuracy of detection of this pathology. Clinical characteristics and MRI findings in a case series of 10 patients are highlighted.

Description of the Pelican Sign on Axial MRI Sequences

The "pelican sign" is seen on axial fluid-sensitive MRI sequence in patients with anterior flipped meniscal tear. The beak of the pelican is formed by the fibrillar pattern of the anterior horn of lateral meniscus or the medial meniscus along with the intermeniscal ligament. The head and neck of the pelican correspond to the anterior half of the body of lateral or medial meniscus. The anterior flipped posterior horn of the meniscus along with medially displaced posterior half of the body of the meniscus forms the superior and anterior part of the body of pelican. The appearance of rest of the body is due to central portion of the tibial plateau (►**Figs. 1** and **2**).

Materials and Methods

Study Design and Patients

Following local hospital committee ethical approval, a retrospective evaluation of our Radiology Information System and Picture Archiving and Communication System was performed to identify 10 consecutive patients with BHT of the menisci on conventional MRI protocol (including proton density [PD] fat sat coronal, PD fat sat sagittal, PD axial, and T1 coronal sequences) with a slice thickness of 3 mm at our center for traumatic knee injuries.

We identified cases of BHTs specifically with anterior flipped fragments that were confirmed on the sagittal MRI sequences.

Inclusion Criteria

- Young-to-middle-aged male or female patients (cutoff age 50 years).
- Traumatic knee injury.
- Suspected meniscal tear on clinical review/referral.
- BHTs of medial or lateral meniscus on MRI.

Exclusion Criteria

- Age more than 50 years.
- Previous history or imaging confirming degenerative changes and/ or degenerative meniscal tears.
- Prior history of arthroscopy or surgical intervention including partial meniscectomy.

Image Analysis

- All images were reviewed independently by two musculoskeletal radiologists and an orthopaedic surgeon (AS, RB, and KI).
- Standard sequences were obtained for all cases including PD fat sat coronal, PD fat sat sagittal, PD axial, and T1 coronal sequences.

Results

All ($n = 10$) presented following a twisting injury. There were seven males and three females with mean age of 24.7 years (17–38 years). Demographic details, clinical characteristics,

Table 1 Traditionally described signs of bucket-handle meniscal tears of the knee on MRI

	Name	MRI sequence	Description	Significance/ Assesses	Reference
Sagittal views					
1	Absent bow tie sign		Standard sagittal images should reveal the body of the meniscus on two successive cuts as a "Bow Tie." When only one or no body segment is seen it is the "Absent bow tie sign"	Displaced BHT of the meniscus	Helms et al[10]
2	Double PCL sign		A low signal band parallel and anterior to the PCL caused by a displaced BHT displacing in the intercondylar notch	Almost exclusively with BHT of the MM	Wright et al[8]; Singson et al[12]
3	The flipped meniscus sign		The meniscal fragments, in the BHT rather than migrating toward the intercondylar notch, move anteriorly to sit directly on the anterior horn of the ipsilateral meniscus (LM or MM) meniscus	Displaced BHT of the meniscus	Haramati et al[9]
4	The double flipped meniscus sign		Displaced double longitudinal tear of the LM and locked within the intercondylar notch	Displaced double BHT of the LM	Ahn et al[11]
5	The double ACL sign		A BHT of LM with a fragment entrapped behind and parallel to the ACL appearing as another ACL	Displaced BHT of either LM or MM	Takayama et al[13]; Al-Ahaidib et al[14]
6	Double delta sign		A BHT in which the inner meniscal fragment is flipped anteriorly adjacent to the anterior horn of the ipsilateral meniscus		Haramati et al[9]
Coronal views					
1	Coronal truncated meniscus sign	Coronal fast spin echo T2-weighted MR image with fat saturation	A truncated, deformed meniscus that has deficient body meniscal tissue	Displaced BHT of either LM or MM	Dorsay and Helms[1]
		Axial views			
1	V-sign		The acute angle created seen in BHT meniscal tears at the junction of the flipped meniscal fragment with the ipsilateral meniscus in place	Displaced BHT of either LM or MM	Rao et al[15]

Abbreviations: ACL, anterior cruciate ligament; BHT, bucket-handle tear; LM, lateral meniscus; MM, medial meniscus; MRI, magnetic resonance imaging; PCL, posterior cruciate ligament.

Table 2 Sensitivity and specificity of signs describing bucket-handle meniscal tears of the knee on MRI

MRI sign	Sensitivity	Specificity
Absent bow tie	88.4	64.3
Double PCL	32.6	100
Coronal truncation	65.1	71.4
Flipped meniscus sign	60.5	89.7
Double delta	76.7	82.1
Flipped fragment in Intercondylar notch	76.7	82.1

Abbreviations: MRI, magnetic resonance imaging; PCL, posterior cruciate ligament.

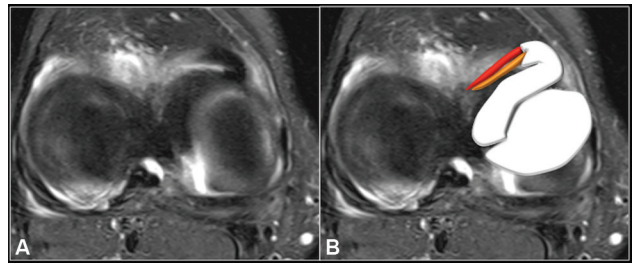

Fig. 1 PD fat sat axial (**A**) showing anterior flip tear of medial meniscus with pelican sign (**B**).

and MRI findings of 10 patients with pelican sign are summarized in ►**Table 3**. There were seven cases of lateral and three cases of medial meniscus tears. Additional internal ligament injuries included five cases of ACL tears, with 60% associated with lateral meniscus. These were compared with 10 additional cases of BHT of meniscus where the meniscal fragment was in the intercondylar notch. Pelican sign was absent in all of these cases. The pelican sign was identified with robust inter- (100%) and intraobserver reliability (100%) in all cases of anterior flipped BHTs among the readers (►**Fig. 3**).

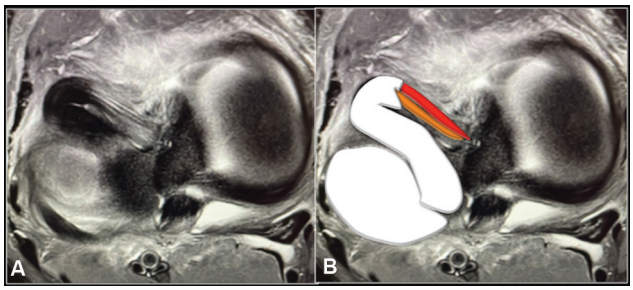

Fig. 2 PD fat sat axial (**A**) showing anterior flip tear of lateral meniscus with pelican sign (**B**).

Discussion

BHTs are an important and not infrequent type of injury.[1] They can be associated with pain and disability and often require surgical intervention. MRI has been shown to be accurate and preferable to diagnostic arthroscopy as a first line of investigation given its noninvasive nature and avoidance of surgery associated complications.[1,7]

Many visual aids and signs on various MRI sequences have been reported in literature to identify this injury. These describe characteristic imaging appearances of a displaced fragment of the torn meniscus and considered to be reliable signs of a BHT.[1,9,15] Studies have also been performed to evaluate the sensitivity and specificity of the various signs seen on MRI scans, most of which are visualized either in the coronal or the sagittal plane.[1] However, some of these signs are not without caveats, for example, the "absent bow tie" sign that can also be present with a radial meniscal tear or in patients with postmeniscectomy features or in severe degenerative arthritis.[1] Furthermore, to date there is only a solitary morphological sign described on an axial MRI sequence reported in literature as the "V" sign.[15] Similar to these authors we agree that identification of BHTs, despite the visual aids, can be difficult, and the anterior displaced fragment being very thin may not be fully visible on the coronal or sagittal planes.[15] Therefore, having an adjunct to reporting on axial sequences would increase the specificity of identifying this pathology, especially in conjunction with other associated reported signs.[1] As Dorsay and Helms suggest diagnostic accuracy can only increase when such complementary radiological signs are correlated.

Fig. 3 PD fat sat sagittal showing anterior flipped tear (arrowed) of lateral meniscus.

Table 3 Demographic details, clinical characteristics, and MRI findings of 10 patients with pelican sign summarized

Patient/case number	Age/ Sex	Clinical presentation	Site/side / location of BHT Medial/Lateral	Associated injuries on MRI
1	23/M	Football, twisting injury	Knee/R/LM	None
2	25/M	Football, twisting injury	Knee/R/LM	MCL grade II sprain, ACL full thickness
3	33/F	Twisting injury	Knee/L/LM	MM posterior horn, ACL full thickness
4	19/M	Football injury	Knee/R/MM	LM horizontal, ACL full thickness, edema of popliteus, pivot shift contusions
5	17/F	Twisting injury	Knee/R/LM	No other injuries
6	22/M	Twisting injury	Knee/L/LM	ACL full thickness
7	21/M	Twisting injury	Knee/R/LM	MM
8	38/F	Twisting injury	Knee/L/LM	None
9	29/M	Twisting injury	Knee/R/MM	None
10	20/M	Twisting injury	Knee/R/MM	ACL tear

Abbreviations: ACL, anterior cruciate ligament; BHT, bucket-handle tear; F, female; L, left; LM, lateral meniscus; M, male; MCL, medial collateral ligament; MM, medial meniscus; MRI, magnetic resonance imaging; R, right.

Compared with "V-sign" (72%), our cohort for the unique pelican sign demonstrated 100% correlation with an anterior flipped displaced meniscal tear. This was present with both lateral and medial meniscus tears.

According to textbooks and historical data, BHTs are more common with medial meniscus.[4] Our study found significantly more lateral meniscus tears versus medial meniscus tears (7:3) probably in keeping with the acute traumatic etiology of our cohort. Majority of the ACL injuries were associated with lateral meniscus tears (60%) that are similar to published literature.[16,17]

Given the robust inter- and intraobserver reliability testifies to the strength of our finding, we wish to add this to existing library of orthopaedic and radiological literature to assist with identification and diagnosis of this specific type of BHT. This can help the treating surgeon in understanding the type and position of the tear in the knee. It can allow surgical planning (instruments, sutures) and placement of arthroscopic portals to assist operative management.

Limitations of the Study

We agree that considering the inherent retrospective nature of the study reduces the robustness of findings. However, with robust inter- (100%) and intraobserver reliability among the readers, it gives us confidence of replicability by other clinicians.

This radiological study was conducted at a single center. We focused exclusively on "pelican sign" without comparative assessment against different signs. Hence, we suggest further multicenter studies with larger, prospective cohorts and appropriate surgical correlation to reinforce our findings.

Conclusion

Anterior flip tears associated with BHTs can be difficult to identify on the coronal or sagittal plane MRI scans, especially in the context of acute traumatic injuries. The proposed "pelican sign" identifies and describes the highly specific anterior displaced fragment in a BHT with high specificity.

Its presence on axial MRI imaging would increase the confidence of the reporting radiologist in diagnosing this injury, especially when present in conjunction with other already described radiological signs for displaced BHTs

Informed Consent

Informed consent (patient/guardian), mandatory only for case reports/clinical images—consent was obtained.

Author Contributions

All the authors contributed to conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, resources, software, supervision, validation, visualization, writing and review and editing of the manuscript.

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Conflict of Interest

None declared.

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