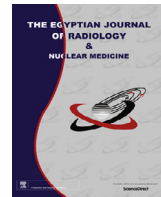




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Original Article

Value of magnetic resonance imaging signs in diagnosis of bucket handle tear



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ABSTRACT

Objective: To detect the value of magnetic resonance imaging (MRI) signs in the diagnosis of bucket-handle meniscal tears of the knee.

Patients and methods: Fifty-five patients were included in this study whose MRI was read as bucket handle tear. Their ages ranged from 19 to 50 years. All patients had subsequent arthroscopy for surgical confirmation.

Results: 37 cases were proved as bucket-handle tears (true surgical positive) by arthroscopy and 18 cases were proved as non bucket handle (true surgical negative). The specificities of MRI signs alone were absent bow tie 44.4%, fragment in notch 77.8%, coronal truncation 77.8%, anterior flipped meniscus 88.9%, double PCL 100%, double anterior horn 100%, disproportional posterior horn 100%. The specificity of absent bow tie with fragment in notch was 83.3%, with anterior flipped meniscus was 94.4% and with coronal truncation was 100%. Specificity was 94.4% for combined absent bow tie, fragment in notch, coronal truncation while combined absent bow tie, anterior flipped meniscus, fragment in notch as well as absent bow tie, double anterior horn, fragment in notch revealed 100% specificity.

Conclusion: MRI is highly specific in diagnosing meniscal bucket handle tears in the knee, particularly, when signs are combined.

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1. Introduction

Magnetic resonance imaging is now the best imaging method for assessment of meniscal abnormalities as it is non invasive and has a great degree of specificity and sensitivity [1,2]. The previously reported accuracy of MRI for diagnosis of meniscal lesions ranged between 45% to 98% [3–5].

Bucket-handle meniscal tear is defined as a vertical, longitudinal, or oblique tear with an attached fragment that displaced away from the meniscus. It commonly affects the medial meniscus more than the lateral meniscus [6].

It is commonly seen in young adults after trauma. The incidence of a bucket-handle tear is 10–26% [7].

The term bucket handle is got from the appearance of the tear as the internally displaced fragment looks like a handle and the peripheral non displaced part resembles the bucket [8].

The great clinical importance of bucket handle tear lies in the fact that locking of the knee joint frequently happens and requires arthroscopic correction of the tear [9].

The sensitivity of MRI for the detection of meniscal bucket-handle tears is approximately 84% to 93%. Even so, this pattern of meniscal tear is one of the most commonly missed tear types in MRI. It is probably overlooked because of the parallel direction of the tear as for the sagittal image plane [10,11].

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There are many MR signs that are previously described and commonly used in the diagnosis of bucket handle tear, these signs include the absence of bow tie, fragment within the intercondylar notch, double posterior cruciate ligament (PCL) and anterior flipped meniscus signs. Other less commonly used signs are double anterior horn, coronal truncation and disproportional posterior horn signs [12–14].

The absence bow tie sign, is defined as that meniscal body segment appears in only one or no images (instead of two images) in the peripheral sequential sagittal MR images [5,10,12].

Double posterior cruciate ligament (PCL) sign implies a displaced meniscal fragment which lies anterior and inferior to the PCL [15].

Fragment within the intercondylar notch sign means a meniscal fragment at the intercondylar notch [16].

Flipped meniscus sign occurs when there is the vertical juxtaposition of the displaced fragment to the ipsilateral anterior horn giving the appearance of a large anterior horn. Double anterior horn sign, occurs if the displaced fragment and the anterior horn are not vertically juxtapositioned and instead located next to each other in the same horizontal plane [16,17].

Disproportional posterior horn sign implies the presence of a large meniscal posterior horn in the central section than that in the peripheral section of the sagittal MR image and this is due to a miniscule fragment displaced posterior and centrally [18].

The scope of this study was to detect the sensitivity and specificity of various MRI signs in the diagnosis of bucket handle meniscal tear in the knee, both alone and in combination.

2. Patients and methods

This retrospective study was carried out at the time from August 2014 to February 2016. The ethics committee of our faculty approved the study.

Fifty-five consecutive patients with arthroscopically confirmed diagnoses and whose MRI was read as bucket-handle tears were included in this study.

Mean time between MR imaging and subsequent Arthroscopy was 40 days (range 3–120 days).

Inclusion criteria are as follows:

- Patients whose MR examinations read as displaying evidence of a bucket handle tear.
- Patients had subsequent arthroscopic follow-up for surgical confirmation.

Exclusion criteria are as follows:

- Patients whose MRI showed no evidence of bucket handle tear.
- Patients had prior surgery on the knee in question.
- Patients who do not have subsequent arthroscopic follow-up.

The age of these 55 patients ranged from 19 to 50 years (mean age 28.5 years). There were 40 males and 15 females.

All patients in this study were examined with 1.5 T MRI system (Achieva, Philips Medical Systems) using the knee coil.

*MRI protocol included the following:

T1-weighted spin-echo images in sagittal and coronal planes (repetition time of 650 ms, echo time of 18 ms). T2-weighted fast spin-echo images in sagittal and coronal planes (repetition time of 3000 ms, echo time of 100 ms).

Proton density weighted fast spin-echo images in the sagittal plane (repetition time of 5000 ms, echo time of 30 ms).

Proton density weighted fast spin-echo images with fat saturation in coronal and axial planes (repetition time of 3000 ms, echo time of 30 ms).

For all images and planes the field of view was 18 cm and slice thickness was 3.5 mm.

*Interpretation of MRI:

The MRI was analyzed regarding the following findings: absence of bow tie sign, fragment within the intercondylar region, the presence of double posterior cruciate ligament (PCL) sign, flipped meniscus sign, double anterior horn sign, disproportional posterior horn sign and coronal truncation sign.

The menisci firstly investigated in the sagittal PD images. We counted the numbers of body segments in each meniscus and also we inspected the meniscus for any abnormal signal. The meniscus was reported as normal if the body of the meniscus was demonstrated in two successive images (bow tie appearance) with no evidence of a meniscal tear [10].

The image was considered positive for the absent bow tie sign, if the sagittal images revealed only one or no body segments.

Then the images were inspected for a displaced fragment either in the intercondylar region or anteriorly (the anterior flipped meniscus sign or double anterior horn sign) or anterior and parallel to the PCL (the double PCL sign).

The coronal images were inspected for coronal truncation sign, and reported as positive if they revealed an amputated meniscus with blunted edge and deficient meniscal body tissue.

The presence of joint effusion was recorded in 55 patients and also the anterior cruciate ligament (ACL) was inspected for the presence of tear, as it might be the reason for conceivable faults as mentioned by DeSmet and Graf [19].

3. Results

Of the 55 patients with possible bucket-handle tears by MRI, 39 cases (70.9%) involved the medial meniscus and 16 (29.1%) involved the lateral meniscus.

Thirty-seven (67.3%) of the 55 cases were proved as bucket-handle tears by arthroscopy (true surgical positives) and 18 (32.7%) cases were proved not to be

bucket-handle tears by arthroscopy (true surgical negative).

Of the 37 arthroscopically proven bucket-handle tears, medial meniscus was involved in 26 cases (70.3%) and lateral meniscus in 11 cases (29.7%).

Absent bow tie sign was seen in 33 (89.2%) of true surgical positive and in 10 (55.6%) of true surgical negative cases; fragment in intercondylar notch sign was seen in 31 (83.8%) of true surgical positive and in 4 (22.2%) of true surgical negative cases; coronal truncation sign was seen in 24 (64.9%) of true surgical positive and in 4 (22.2%) of true surgical negative cases; anterior flipped meniscus sign was seen in 22 (59.5%) of true surgical positive and in 2 (11.1%) of true surgical negative cases; double PCL sign was seen in 20 (54%) of true surgical positive cases [all were in medial meniscus] while none of the true surgical negative cases revealed double PCL sign. Double anterior horn sign was seen in 9 (24.3%) of true surgical positive cases while not seen in true surgical negatives and dispro-

portional posterior horn sign was found in 4 (10.8%) of true surgical positive cases and in none of true surgical negatives (Table 1).

The diagnostic performance of MR signs was calculated and is summarized in (Table 2).

Criteria to qualify for LR+ are as follows:

- >10: large conclusive increase in likelihood of bucket handle tear.
- 5–10: moderate increase in likelihood of bucket handle tear.
- 2–5: small increase in likelihood of bucket handle tear.
- 1–2: minimal increase in likelihood of bucket handle tear.
- 1: no diagnostic value.

Criteria to qualify for LR– are as follows:

- 1: no diagnostic value.
- 0.5–1: minimal decrease in likelihood of bucket handle tear.
- 0.2–0.5: small decrease in likelihood of bucket handle tear.
- 0.1–0.2: moderate decrease in likelihood of bucket handle tear.
- <0.1: large and conclusive decrease in likelihood of bucket handle tear.

Twenty-six (70.3%) of true surgical positive and 3 (16.7%) of the true surgical negative cases demonstrated both absent bow tie and fragment in notch signs. The absent bow tie with anterior flipped meniscus were seen in 21 (56.8%) of true surgical positive and in 1 (5.6%) of true surgical negative cases. Twenty (54%) of the true surgical positive while none of the true surgical negative cases demonstrated absent bow tie with coronal truncation signs. Double PCL with a fragment in notch signs were seen in 20 (54%) of the true surgical positive while in none of the true surgical negative cases.

Absent bow tie, fragment in notch and coronal truncation signs were seen in 19 (51.3%) of true surgical positive and in 1 (5.6%) of true surgical negative cases.

Absent bow tie, anterior flipped meniscus and fragment in notch were seen in 18 (48.6%) of true surgical positive cases while not seen in true surgical negative cases.

Table 1
Distribution of MR signs in the study population.

MR sign	Arthroscopy proved bucket handle (37 cases)	Arthroscopy proved not bucket handle (18 cases)
Absent bow tie		
Yes	33	10
No	4	8
Fragment in intercondylar notch		
Yes	31	4
No	6	14
Coronal truncation		
Yes	24	4
No	13	14
Anterior flipped meniscus		
Yes	22	2
No	15	16
Double PCL		
Yes	20	0
No	17	18
Double anterior horn		
Yes	9	0
No	28	18
Disproportional posterior horn		
Yes	4	0
No	33	18

Table 2
Diagnostic performance of MR signs in diagnosis of bucket handle tear.

MR sign	SN % (95% CI)	SP % (95% CI)	PPV % (95% CI)	NPV % (95% CI)	Acc (95% CI)	+ve LR (95% CI)	–ve LR (95% CI)
Absent bow tie	89.2%	44.4%	76.7%	66.7%	74.5%	1.6	0.24
Fragment in intercondylar notch	83.8%	77.8%	88.6%	70%	81.8%	3.7	0.21
Coronal truncation	64.9%	77.8%	85.7%	51.9%	69.1%	2.9	0.45
Anterior flipped meniscus	59.5%	88.9%	91.7%	51.6%	69.1%	5.3	0.45
Double PCL	54.1%	100%	100%	51.4%	69.1%	Inf	0.45
Double anterior horn	24.3%	100%	100%	39.1%	49.1%	Inf	0.75
Disproportional posterior horn	10.8%	100%	100%	35.3%	40%	Inf	0.89

SN: Sensitivity, SP: Specificity, PPV: Positive Predictive Value, NPV: Negative Predictive Value, Acc: Accuracy, +ve LR: Positive Likelihood Ratio, –ve LR: Negative Likelihood Ratio, 95%CI: 95% Confidence Interval, Inf: Infinity.

Seventeen (45.9%) of the true surgical positive cases and none of the true surgical negative cases showed a combination of double PCL, a fragment in the notch and anterior flipped meniscus signs. All 17 cases were in the medial meniscus.

Absent bow tie, double anterior horn, and fragment in notch were seen in 4 (10.8%) of true surgical positive and none of true surgical negative cases (Table 3) (see Figs. 1–5).

The sensitivity and specificity of most combined MR signs are presented in Table 4.

ACL tear was diagnosed by MRI in 11 cases, while at arthroscopy ACL tear was proved in 14 cases, of these cases, 8 were present in true surgical negatives and 6 were present in true surgical positives.

Joint effusion was reported in 45 cases.

4. Discussion

The diagnosis of displaced meniscal tears is very important since they require surgery to remove or reattach the displaced fragment [17].

This is not hard to perceive the meniscal abnormalities which require surgical interference, but the importance is to distinguish between bucket-handle, radial and really complex tears as this supplies the surgeon with a preoperative roadmap [5].

Bucket handle tear is a specific type of displaced meniscal tears, and it may be missed in sagittal plane due to the parallel orientation of the tear regarding the image plane, so coronal images are essential to search for a displaced fragment in another plane [20].

Many signs of bucket-handle meniscus tears are visible on MRI. Although these signs are helpful, one should be aware of the mimics of these signs [21].

The sensitivity of MRI in detecting bucket-handle meniscus tears increases with the presence of more than one sign [22].

There are many studies that discuss the sensitivity of different MRI signs in diagnosing bucket handle tear, but only very few studied that deal with the specificity which is far more important.

Helms et al. [10] found a high sensitivity of absent bow tie sign in MR diagnosis of bucket-handle tear and con-

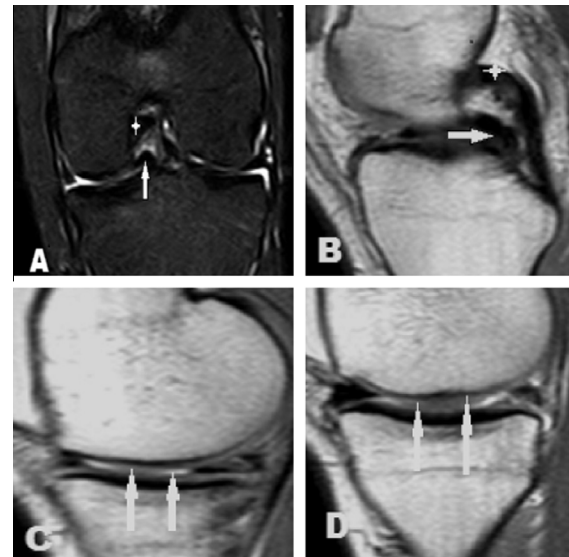


Fig. 1. 23 years old male with bucket handle tear of medial meniscus: (A) Coronal proton density (PD) fat saturation image reveals the fragment in intercondylar notch sign (arrow), fragment is inferior and parallel to the PCL (asterisk). (B) Sagittal PD image demonstrates the double PCL sign (the arrow represents the displaced meniscal fragment and asterisk represents the PCL). (C & D) Sagittal peripheral images show no meniscal body segments (absent bow tie sign) (arrows).

cluded that it poses a higher accuracy rate than other MRI signs, for example, double PCL, flipped meniscus and fragment in notch signs.

The normal meniscal width is about 9–12 mm so the body of the meniscus is expected to be seen in two sequential sagittal MR images (with standard thickness of 4–5 mm) and it has the appearance of a bow tie. When there is a bucket-handle tear, this bow tie sign is absent and the meniscal body appears in only one or no sagittal images [10,17].

In our study, the sensitivity of the absent bow tie sign was 89.2%, this was nearly similar to that in the study of Dorsary and Helms [5] (88.4%) and slightly lower than that found by Helms et al. [10] (97%). However the specificity in our study was 44.4%, which is lower than that previously reported by Dorsary and Helms [5] (64.3%), Helms et al. [10] (64.3%) and Watt et al. [23] (62%).

Table 3

Frequency of most combined MR signs.

Combined MR signs	Arthroscopy proved bucket handle (37 cases)		Arthroscopy proved not bucket handle (18 cases)	
	N	%	N	%
Absent bow tie, fragment in notch	26	70.3	3	16.7
Absent bow tie, anterior flipped meniscus	21	56.8	1	5.6
Absent bow tie, coronal truncation	20	54	0	0
Double PCL, fragment in notch	20	54	0	0
Absent bow tie, fragment in notch, coronal truncation	19	51.3	1	5.6
Absent bow tie, anterior flipped meniscus, fragment in notch	18	48.6	0	0
Double PCL, fragment in notch, anterior flipped meniscus	17	45.9	0	0
Absent bow tie, double anterior horn, fragment in notch	4	10.8	0	0

N: Number, % percentage.

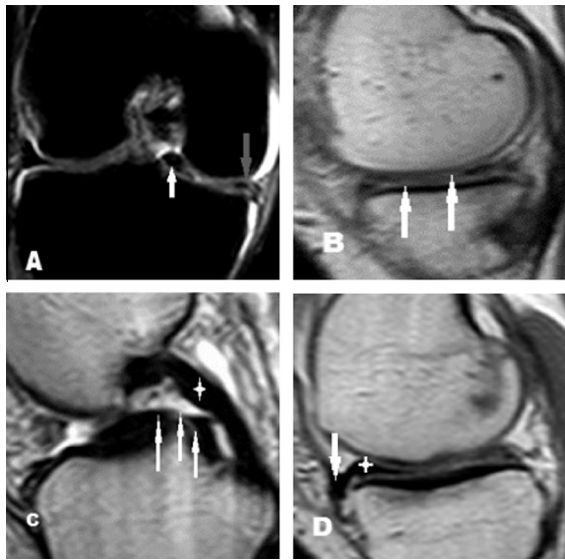


Fig. 2. 34 years old male with bucket handle tear of medial meniscus: (A) Coronal PD fat saturation image shows the fragment in intercondylar notch sign (white arrow) and the coronal truncation sign [gray arrow] (blunted edge of non displaced part of the meniscus). (B) Peripheral sagittal PD image shows absent bow tie sign [arrows]. (C) Sagittal T2W image demonstrates the double PCL sign [arrows represent the displaced meniscal fragment and asterisk represents the PCL]. (D) Sagittal PD image shows double anterior horn sign [arrow represents the displaced meniscal fragment and asterisk represents the anterior horn of medial meniscus].

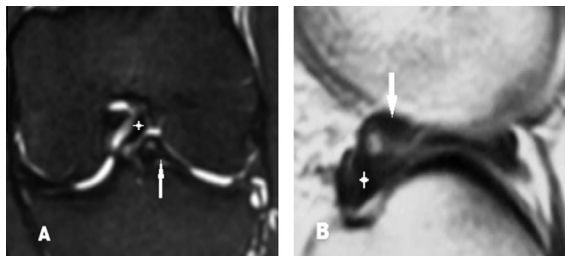


Fig. 3. 28 years old male with bucket handle tear of lateral meniscus: (A) Coronal PD fat saturation image shows the fragment in intercondylar notch sign [the arrow represents the displaced meniscal fragment in intercondylar notch lateral to the ACL (the asterisk)]. (B) Sagittal PD image shows the anterior flipped meniscus sign [the arrow represents the displaced meniscal fragment and the asterisk represents the anterior horn of lateral meniscus].

It is not surprising to establish a low specificity of absent bow tie sign and this is because that there are several pitfalls of the absent bow tie sign.

Absence of the normal bow tie may happen with numerous conditions other than bucket handle tear, such as normal small meniscus (children and small adults) and in advanced osteoarthritis (the mechanism is the progressive fraying of the meniscus after some time which leads to diminished meniscal volume without a dislodged part) [12].

Five of the 10 true surgical negative cases in our study who revealed absent bow tie sign showed evidence of severe osteoarthritis on MRI.

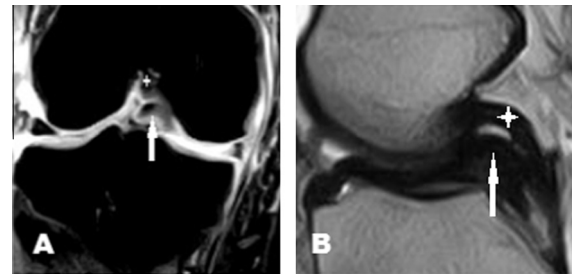


Fig. 4. 19 years old male with bucket handle tear of medial meniscus: (A) Coronal PD fat saturation image reveals the fragment in intercondylar notch sign (fragment [the arrow] is inferior and parallel to the PCL [asterisk]). (B) Sagittal T2 W image demonstrates the double PCL sign [the arrow represents the displaced meniscal fragment and asterisk represents the PCL].

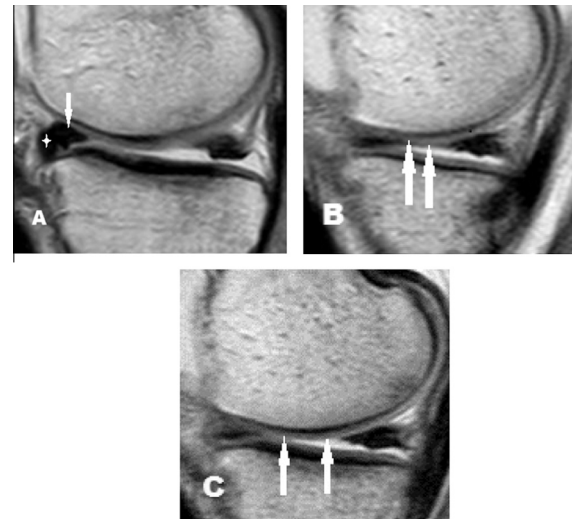


Fig. 5. 39 years old male with bucket handle tear of medial meniscus: (A) Sagittal PD image reveals anterior flipped meniscus sign [the arrow represents the displaced meniscal fragment and the asterisk represents the anterior horn of medial meniscus]. (B) & (C) Peripheral sagittal PD images reveal absent bow tie sign [the arrows].

Table 4

Sensitivity and specificity of the most combined MR signs of bucket handle tears.

MR signs	Sensitivity (%)	Specificity (%)
Absent bow tie, fragment in notch	70.3	83.3
Absent bow tie, anterior flipped meniscus	56.8	94.4
Absent bow tie, coronal truncation	54	100
Double PCL, fragment in notch	54	100
Absent bow tie, fragment in notch, coronal truncation	51.3	94.4
Absent bow tie, anterior flipped meniscus, fragment in notch	48.6	100
Double PCL, fragment in notch, anterior flipped meniscus	45.9	100
Absent bow tie, double anterior horn, fragment in notch	10.8	100

A radial tear may also demonstrate an absent bow tie sign due to the way that coronal and sagittal images, go through the radial tear lead to small discrete bow tie. With careful understanding of the absent bow tie sign and absence of displaced fragment (unlike the bucket handle tear), a diagnosis of the radial tear can be supported [23].

This accounts for one of the true surgical negative cases in our study.

Post-surgical changes (partial meniscectomy) may also produce an absent bow tie sign [12]. This pitfall is avoided in our study by selecting patients with no previous surgery for menisci.

Bucket-handle tears in discoid menisci can happen with normal number of body sections due to their abnormal large size [24]. This was found in two true surgical positive cases in our study and bucket handle was diagnosed by the presence of a double anterior horn and fragment in notch signs.

Singson et al. found that a displaced meniscus fragment in bucket handle may be simply in the form of a free fragment displaced away from the tear, usually into the intercondylar notch [8].

In this study, we reported a fragment in the intercondylar notch in 31 (83.8%) of true surgical positive cases and in 4 (22.2%) of the true surgical negative cases with sensitivity of 83.3% and specificity of 77.8%.

The ring-shaped meniscus is exceedingly uncommon asymptomatic variant which commonly happens in lateral meniscus, but must be considered in the differential diagnosis of bucket-handle tear as it might be symptomatic and shows the fragment in notch sign, as the fragment represents the segment of the unusually formed meniscus nearer to the center of the knee joint; nonetheless, a blunt contour of the edge of the nearby meniscus ought to raise the likelihood of a displaced bucket handle tear [25,26].

In our study, the combination of absent bow tie sign and fragment in intercondylar notch was seen in 26 (70.3%) of true surgical positive cases and in 3 (16.7%) of the true surgical negative cases (in whom, arthroscopy confirmed that the free meniscal fragment is not connected to the meniscus).

That was in agreement with Türkmen et al. who believed that absent bow tie and fragment in intercondylar notch signs seen in MRI were because of displaced bucket-handle tear, while arthroscopy recognized that the findings were because of totally free meniscal fragment which has not any association with the rest of the meniscus [14].

The displaced meniscal fragments in bucket handle tear, instead of dislodged to the intercondylar notch it may migrates anteriorly vertically juxtaposed to the anterior horn of the ipsilateral meniscus, gives rise to abnormally tall (>6-mm) anterior horn creating the anterior flipped meniscus sign that was depicted by Haramati et al. [27].

If the displaced meniscal fragment and the anterior horn are not vertically juxtaposed and lie alongside each other in the same horizontal plane, they produce the double anterior horn sign when imaged in the sagittal plane [27].

Our results show that anterior flipped meniscus sign was present in 22 of true surgical positive and 2 of true

surgical negative cases with 59.5% sensitivity and 88.9% specificity.

That was close to the result reported by Dorsay and Helms who detected 60.5% sensitivity and 89.7% specificity of anterior flipped meniscus sign in the diagnosis of bucket handle tear [5].

Aydingoz et al. reported the double-anterior horn sign in 29% of their arthroscopically proven meniscal bucket-handle tears, and the authors stated that this sign had an essential role in MRI diagnosis of these tears [2].

In our study, we reported the double anterior horn sign in 9 of true surgical positive (24.3%) and none of true surgical negative cases with 24.3% sensitivity and 100% specificity.

The anterior intermeniscal ligament, may mimic the double anterior horn sign. A study reported frequency of 53% for this ligament on MR images [28].

If the displaced meniscal fragment lies antero-inferior to the PCL in the intercondylar notch it gives the appearance of double PCL in sagittal sections.

Double-PCL sign was initially depicted on medial meniscus bucket-handle tears by Weiss et al. who found 100% sensitivity and specificity for this sign. The authors stated that double-PCL sign is characteristic of medial (not lateral) meniscal bucket handle tears which happen in the presence of an intact ACL as the ACL represents a barrier that hinders the medial displacement of the fragment in lateral meniscus bucket-handle tear [15].

In the study of Aydingoz et al. they reported double-PCL sign in 2 patients with lateral meniscus bucket handle tear, one had an ACL tear and the other had intact ACL [2].

In our study, double PCL sign was found in 20 of true surgical positive (all cases were in medial meniscus) and none of true surgical negative cases with 54% sensitivity, that was close to that reported by Wright et al. who found this sign in 53% of medial and none of lateral bucket-handle tears (sensitivity 53%) [16].

The specificity of this sign in our study was 100%, that was similar to that previously reported by other studies [5,15].

The normal accessory meniscomfemoral ligaments (ligament of Humphrey and Wrisberg) represent a probable pitfall of the double PCL sign, these ligaments extend from the posterior horn of the lateral meniscus to the lateral aspect of the medial femoral condyle in close proximity to anterior and posterior margins of PCL [29], and their incidence on MR has been reported as 34% in one study [30]. The ligament of Humphrey is anterior and the ligament of Wrisberg is posterior to the PCL [31]. Normally, Humphrey's ligament is seen as a small rounded structure antero-inferior to the PCL on sagittal images. Sometimes, a short fragment of it might appear as a linear structure parallel to the antero-inferior part of the PCL. This ligament can be differentiated from a bucket-handle fragment as the ligament is thinner, smaller and has an extreme closeness to the PCL. The ligament of Wrisberg appears as a small, low – signal 'dot' posterior–superior to the PCL on sagittal images. Occasionally, it may be seen as a linear band parallel to the PCL if the knee is externally rotated or when the ligament is wavy and lax [29].

Other probable pitfall in double PCL sign is the presence of the oblique meniscomeniscal ligament. This somewhat

infrequent anatomic variant has 1%–4% reported frequency, and has one of two configurations, which named with reference to their anterior attachment site [32,33]. The medial oblique meniscomeniscal ligament originates from the anterior horn of the medial meniscus and inserts into the posterior horn of lateral meniscus. The lateral oblique meniscomeniscal ligament originates from the anterior horn of the lateral meniscus and inserts into the posterior horn of the medial meniscus. These ligaments cross the intercondylar fossa, between the ACL and PCL [33]. On sagittal planes, they may be seen under the PCL and look like a double PCL sign. This can be differentiated from bucket handle tear as the ligaments are thinner than the displaced meniscal fragment and tend to lie low in the intercondylar fossa and by the normal shape of the adjacent menisci. Also following the course of ligaments from origin to insertion helps in avoiding this pitfall [32,33].

Any abnormal low-intensity structure in the intercondylar fossa may simulate a double PCL. These include loose bodies, osteophytes and fracture fragments lying inferior to the PCL. A plain X-ray may prove the cause of double PCL to be a fracture fragment, mineralized loose body, or osteophytes [8].

Sometimes, a fat globule looks like a linear low-signal that is parallel to the PCL on fat saturation series. This might be cleared up by assessing other non fat suppression sequences as T1W and T2W, which demonstrate the fat signal [31].

Dorsay and Helms stated that coronal truncation is a supportive while not highly sensitive sign of bucket-handle tear. The coronal images show a deformed truncated meniscus with deficient meniscal body tissue [5]. The authors reported coronal truncation signs in 28 true surgical positive and 8 true surgical negative cases with 65.1% sensitivity and 71.4% specificity.

In our study, we diagnosed coronal truncation in 24 true surgical positive and 4 true surgical negative cases, with sensitivity 64.9% and specificity 77.8%.

Chen et al. stated that the disproportional posterior horn sign is important in the MR imaging diagnosis of meniscal bucket-handle tears [18].

We reported disproportional posterior horn sign in 4 of the true surgical positive and none of the true surgical negative cases in our study with a frequency and sensitivity of 10.8%, which is lower than that previously reported by Aydingoz et al. [2] (27%) and Chen et al. [18] (21%).

Since the previously mentioned MR signs used for diagnosis of bucket-handle tear can be mimicked by several normal and abnormal structures in the knee joint, we found that the combination of these signs is very supportive, helps to make a confident diagnosis of bucket-handle tear of the meniscus and also leads to increased specificity of MRI in diagnosis of bucket handle tear which was in agreement with Lim et al. who concluded that MR imaging is accurate in diagnosing bucket-handle tears of the meniscus and the specificity is increased when a combination of the different MR imaging signs is present [12].

The specificity of the absent bow tie sign alone was 44.4% that is significantly increased when absent bow tie combined with other signs.

The combination of absent bow tie with a fragment in notch sign yielded specificity of 83.3%, with anterior flipped meniscus demonstrated a specificity of 94.4% and with coronal truncation specificity was 100%.

The combination of absent bow tie, fragment in the notch, coronal truncation yielded specificity of 94.4%, while the combination of absent bow tie, anterior flipped meniscus, fragment in notch as well as an absent bow tie, double anterior horn, fragment in notch revealed specificity of 100%.

The double PCL with a fragment in notch signs and also combined double PCL, fragment in the notch, anterior flipped meniscus revealed 100% specificity.

In conclusion, MR imaging is very accurate in diagnosing bucket-handle tears of the meniscus when the radiologist is aware of the different MR signs for bucket-handle tears and their pitfalls and when combined these signs together, the specificity of MRI is significantly increased.

Conflict of interest

The author declared that there is no conflict of interest.

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