

## MRI of Bucket-Handle Tears of the Meniscus of the Knee<sup>1</sup>

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**Purpose:** To determine the frequency of the MRI signs of meniscal bucket-handle tears already known as the double PCL sign, the flipped meniscus sign, the absent bow-tie sign, and the fragment-in-notch sign, and to compare the sagittal with the coronal images.

**Materials and Methods :** We retrospectively reviewed the MR findings of 37 patients in whom an initial interpretation of MR images had suggested meniscal bucket-handle tears. All underwent subsequent arthroscopic evaluation and in 28, bucket-handle tears were confirmed. Sagittal double-echo and coronal fat-suppressed double-echo T2-weighted images were obtained. Sagittal images were evaluated to determine whether or not signs of bucket-handle tear were evident, and coronal images were checked for a torn meniscus with displaced fragment. We also evaluated the MR findings of the nine false positive cases.

**Results :** The prevalence rate of absent bow-tie, double PCL, fragment-in-notch, and flipped meniscus signs was 96.4%, 53.6%, 17.9%, and 10.7%, respectively. The detection rate for displaced fragment was higher with coronal images (92.9%) than with sagittal images (78.6%). Among the nine false positive cases, a longitudinal tear in the discoid meniscus was most common. A false-positive diagnosis was much more frequent on sagittal than on coronal images.

**Conclusion:** The prevalence rate of absent bow-tie sign was very high, but was accompanied by a relatively high rate of misinterpretation. Coronal fat-suppressed T2-weighted images provided more reliable clues for the diagnosis of bucket-handle tears, with a high detection rate of displaced fragment.

**Index words :** Knee, MR  
Knee, ligaments, menisci, and cartilage

A bucket-handle tear is a longitudinal, vertical or oblique tear of the meniscus with an attached fragment displaced away from the donor meniscus (1,2). In order

that surgical intervention is appropriate, it is important to visualize the displaced meniscal fragment as well as determine the type of meniscal injury(1,3).

Several magnetic resonance imaging (MRI) findings have been used for the diagnosis of bucket-handle tears: (1) the double posterior cruciate ligament (PCL) sign, which indicates a meniscal fragment flipped anterior to the PCL, simulating two ligaments (1,2,4); (2) the flipped meniscus sign, which indicates a fragment flipped ante-

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riorly so the anterior horn appears large (5); (3) the absent bow-tie sign, which means that only one slice or none of the body segment is seen on sagittal images (6); and (4) the fragment-in-notch sign, representing the fragment which is located in the intercondylar notch and does not lie in the same sagittal plane as the PCL (1).

In the detection of bucket-handle tears, the sensitivity of MRI has varied. The purpose of this study was to determine the prevalence of the above MRI signs in the diagnosis of bucket-handle meniscal tears and to compare their prevalence between sagittal and coronal images.

**Materials and Methods**

We retrospectively reviewed the MR findings of 37 patients, in whom an initial interpretation of MR findings had suggested bucket-handle tears. All underwent subsequent arthroscopic evaluation. In 28, bucket-handle tears were confirmed by arthroscopy. The remaining nine patients had tears which were not the bucket-handle type. Among the 28 patients with arthroscopically-proven bucket-handle tear, 25 were male and three were female patients, and their ages ranged from 14 to 64 (average 33) years. Fifteen right and 13 left knees were involved and medial menisci (n= 19) were torn more commonly than lateral menisci (n= 9).

MR examination was performed using a 1.5T scanner (GE Medical Systems, Milwaukee, U.S.A.), and images were obtained in both the sagittal and coronal planes. Sagittal dual-echo (TR/TE= 2500/15,60) images and

coronal fat-suppressed dual-echo (TR/TE= 2500/17,60) images were obtained with a 16cm FOV, 3mm slice thickness with a 1mm gap, 1NEX, and a 256X192 matrix.

For retrospective review, settings were different for each sagittal and coronal plane interpretation. The authors determined whether or not the following MRI findings were visible on sagittal images: the double PCL sign, the flipped meniscus sign, the absent bow-tie sign, and the fragment-in-notch sign (Fig. 1-3). Coronal images were evaluated to determine whether they provided information about bucket-handle tears, including a displaced meniscal fragment as well as a deficient or truncated torn meniscus. In nine cases in which findings of bucket-handle tear were false-positive, images obtained in both the sagittal and coronal planes were retrospectively evaluated.

**Results**

The prevalence of each MRI sign is shown in Table 1. The most sensitive finding was an absent bow-tie sign,

Table 1. Prevalence of MR Signs of Meniscal Bucket-Handle Tears on Sagittal Images (n= 28)

MR Sign	Cases	Prevalence (%)
Absent bow-tie sign	27	96.4
Double PCL sign	15	53.6
Fragment in notch sign	5	17.9
Flipped meniscus sign	3	10.7



Fig. 1. A bucket-handle tear of medial meniscus.  
 A. Far medial sagittal image (left) reveals absent bow-tie sign at body segment and more internal image (right) shows double PCL sign.  
 B. On serial coronal images, the torn donor meniscus (short arrow) is truncated and the displaced fragment (long arrow) is located in same orientation as PCL.

but this was also seen in other types of tear, including three which were longitudinal and one which was peripheral (Fig. 4). The double PCL sign was found only in medial meniscal tears. Supposing that a bucket-handle tear with any sign can be diagnosed on sagittal images regardless of number or kind, the detection rate of bucket-handle tears as seen on sagittal images was higher (96.4%) than when visualised on coronal images (92.8%). With regard to the detection of displaced fragments, these were clearly visualized on coronal images in 26 of 28 cases, and on sagittal images in 22 cases (Fig. 5).

The nine misinterpreted cases involved three longitudinal tears in discoid menisci, three radial tears, two longitudinal tears in non-discoid menisci, and one pe-

ripheral tear (Fig. 4). This misinterpretation was more common on sagittal images (9/9) than on coronal images (2/9).

### Discussion

A bucket-handle tear is the most frequent pattern of displaced meniscal injury, and results from a longitudinal tear (1,2). The medial meniscus is more frequently involved. In the detection of a bucket-handle tear by MRI, sensitivity varied between 64% and 97% (1-6). The MRI findings of bucket-handle tears have been described. The double PCL sign (1,2,4), the flipped meniscus sign (5), and the absent bow-tie sign (6) are mostly



Fig. 2. A medial meniscal bucket-handle tear with flipped meniscus sign. A. On sagittal image, the posterior horn is hardly visible while anterior horn looks larger due to torn and anteriorly flipped posterior horn. B. The anterior and posterior coronal images reveal torn donor segment (short arrows) and anteriorly displaced fragment (long arrow).



Fig. 3. Fragment-in-notch sign in bucket-handle tear of lateral meniscus. A. The lateral meniscus is macerated with the displaced fragment (arrow) located in the intercondylar fossa on serial sagittal images. B. The torn fragment (arrows) of lateral meniscus is located in the notch, displacing the ACL medially and lying in different orientation from PCL.

seen on sagittal images, while the fragment-in-notch sign (1) and a truncated or small remnant meniscus can be seen in both the sagittal and coronal planes.

The diagnosis of bucket-handle tears through the identification of displaced fragments is difficult. In spite of the involvement of a relatively long segment, tears

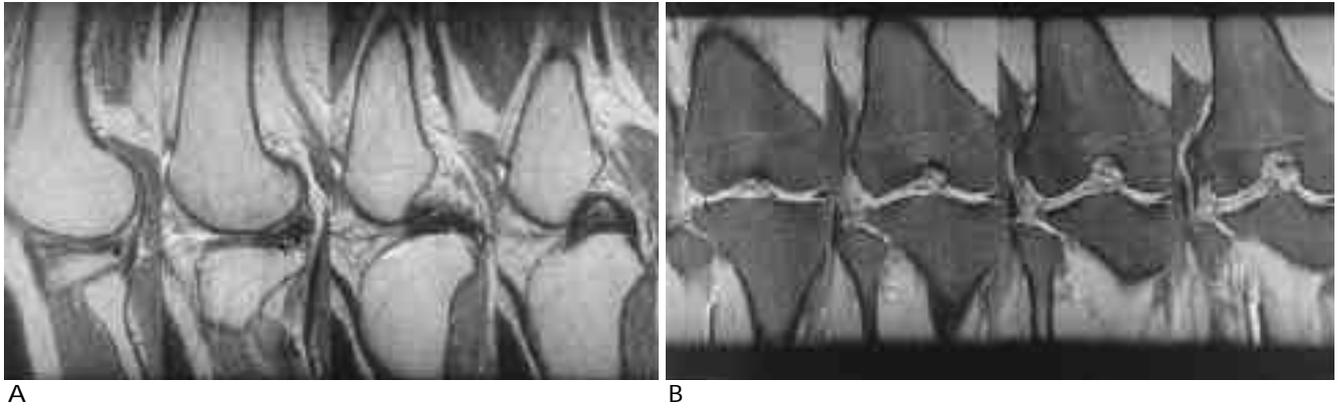


Fig. 4. False positive case: Peripheral tear in lateral discoid meniscus.

A. The serial sagittal images show absent bow-tie sign, obliquely oriented tear line (arrows) and double PCL sign-like appearance. B. On all serial coronal images, the lateral meniscus keeps the appearance of bow-tie, suggesting discoid meniscus, and shows peripheral tear (arrows).

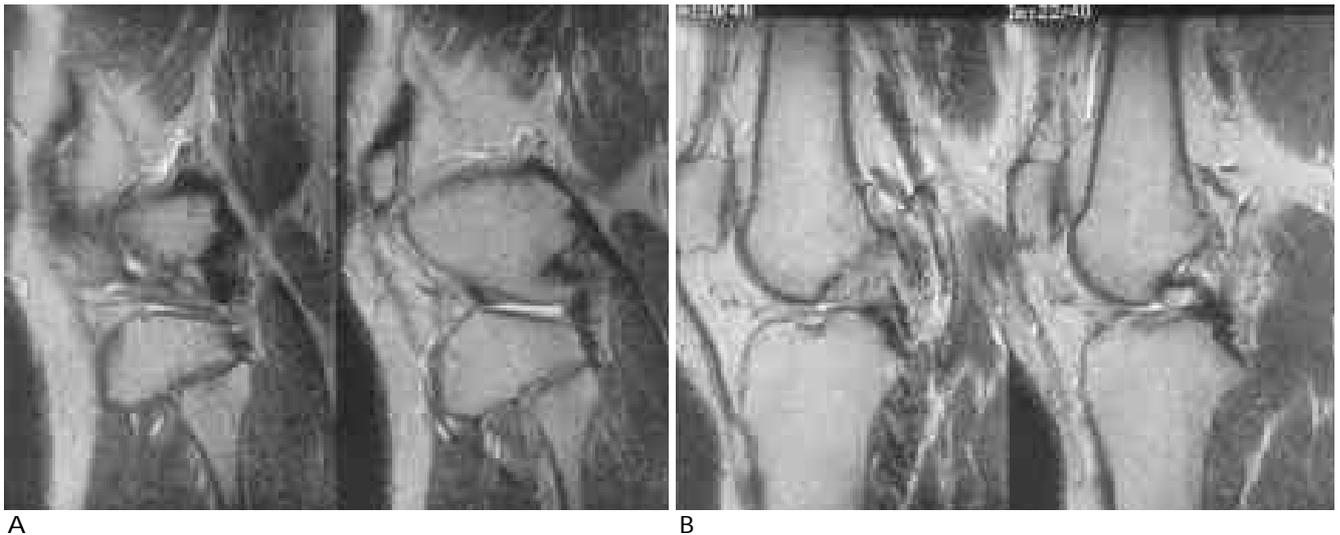
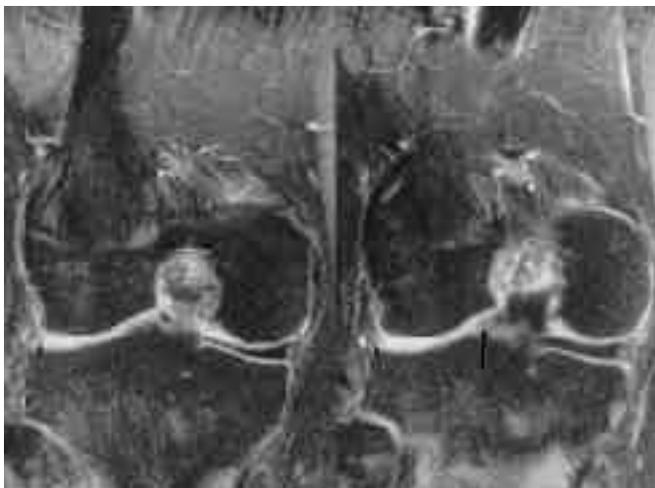


Fig. 5. The far lateral sagittal images (A) reveal absent bow-tie sign suggesting tear of body segment. More medial sagittal images (B), however, don't disclose the fragment clearly. On coronal images (C), the donor segment (short arrow) of bucket-handle tear looks small and truncated. Note the displaced fragment (long arrow) just lateral to the midsubstance of the PCL.



may be overlooked because they run parallel to the sagittal plane (1,7,8).

In this study, the bow-tie sign was absent in 27 of 28 cases of bucket-handle tears. The application of the absent bow-tie sign to the diagnosis of bucket-handle tears must be based on a knowledge of meniscal anatomy. The average width of a normal meniscal body is 9-12 mm, and 4- or 5-mm thick sagittal images should reveal the body of the meniscus on two successive images (6,9). In most cases of bucket-handle tears with free edge deficit of the meniscal body, no body segment, or one, will be seen. This highly sensitive sign does not indicate a torn, displaced fragment, but implies a torn body segment, and this makes it non-specific for bucket-handle tears.

As opposed to previous reports of high sensitivity of the double PCL sign for bucket-handle tears (2,4), our study revealed a sensitivity of 53.6%. This sign was seldom present in bucket-handle tears of the lateral meniscus or with the fragment displaced more posteriorly than anterointernally and oriented differently from the PCL. Moreover, a non-bucket-handle tear developed in the discoid meniscus showed a positive result. The fragment-in-notch sign may also be positive in cases other than bucket-handle tears.

Many authors have emphasized the importance of coronal images in diagnosing bucket-handle tears (9,10). Coronal imaging is to some extent superior because it can reveal both the bucket and the handle of the torn meniscus quite well. The torn donor segment is truncated or smaller. In this study, the displaced fragment could in most cases be easily detected using double-echo, fat-suppressed T2-weighted coronal imaging.

In summary, the absence of a bow-tie sign on sagittal images was most prevalent in bucket-handle tears, though this was offset by a high rate of false-positive interpretation. The prevalence of other MR signs suggestive of a displaced fragment were low. Coronal fat-suppressed T2-weighted imaging provided a higher detection rate of displaced meniscal fragment and a lower rate of misinterpretation. We therefore suggest that for the accurate diagnosis of bucket-handle tears, both coronal and sagittal images are evaluated.

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