MR imaging of the knee is sensitive for the demonstration of meniscal tears, but discrepancies between MR imaging and arthroscopy still remain (1–5). Although high accuracy of detection of tears has been shown, normal anatomic structures of the knee may simulate meniscal tears and may be common sources of false-positive diagnosis of internal derangements (6–8). These potential pitfalls in interpretation may be caused by structures with low signal intensity; such as the transverse ligament, the meniscofemoral ligament, and the popliteus tendon; and by volume-averaging artifact due to the concavity of the outer margin of the meniscus. These structures potentially mimic variable appearance meniscal tear (6–8); transverse ligament can stimulate oblique or vertical tear of anterior horn of meniscus, meniscofemoral ligament, and the popliteus tendon; and by volume-averaging artifact due to the concavity of the outer margin of the meniscus.
ligament can stimulate vertical tear of posterior horn
of lateral meniscus, while popliteus tendon can mimic
oblique tear of posterior horn of lateral meniscus.

In everyday practice of reading knee MR images, we
encountered a truncated triangle-like blunting of the
tip of the meniscus at the anterior horn, oftentimes
only on coronal images, on evaluation of knee MRIs
over the years, which we frequently gave the reading
of “suspicious radial tear”; these were not always seen
on other sequences. However, after arthroscopy for
other pathologies, the results showed that these were
not true radial tears.

To our knowledge, there has been no previous report
about this finding of a truncated triangle appearance
“pseudoradial tear” at the anterior horn to body of
the medial meniscus on coronal MR images, which
could be a potential pitfall and should be differenti-
ated from true radial tear.

Being aware of the normal variation in this region,
preoperative diagnostic accuracy of radial tears may
improve and false positive diagnosis of radial tears
should decrease, thereby avoiding unnecessary
surgery.

The purpose of this study was to determine the
incidence of truncated triangle appearance of anterior
horn to body of the medial meniscus and determine its
clinical significance.

**MATERIALS AND METHODS**

485 consecutive sets of MRI examinations of the
knee performed between January and December 2011
at our institution were reviewed retrospectively. The
age range of the 485 patients was 3–84 years (277/208
men/women; mean, 34.5 years). All patients
underwent MRI of the knee in coronal, axial, and
sagittal planes on a 1.5-T Intera scanner (Philips
medical systems, Best, the Netherlands) and 3.0-T
Achieva scanner (Philips medical systems, Best, the
Netherlands) with a knee coil. Each 1.5-T study
consisted of coronal and sagittal proton density-
weighted (PDW) (TR/TE, 3000/20), sagittal T1-
weighted (T1W) (400/10), sagittal fat saturated T2-
weighted (T2W) (2300/50), and axial fat saturated
PDW (2700/12) images. Each 3.0-T study consisted of
coronal and sagittal turbo spin-echo (TSE) PDW
(2600/10), sagittal spectral presaturation inversion
recovery (SPIR) T2W (2500/60), sagittal TSE T1W
(580/10), and axial SPIR PDW (3200/20) images.
Imaging parameters were as follows: FOV 150–160
mm, Slice thickness 3 to 4 mm with a 10% interslice
gap, ETL= 3 for T1W, 10 for PDW, 12 for all other
sequences; 272 × 272 matrix for sagittal images, 400 × 384 matrix for the coronal images.

Two musculoskeletal radiologists evaluated the MR
images. After consensus training session, all cases
were reviewed in a blinded retrospective fashion with
special attention to the appearance of the anterior
horn to body of the medial meniscus for the presence
of truncated triangle appearance, blinded to the
clinical information. The MR imaging criteria of
“pseudoradial tear” was truncated triangle appearance
of the tip of anterior horn to body of the medial
meniscus on one or more coronal MR images and/or
adjacent fluid signal intensity at the blunted tip on
proton density or T2-weighted images (Figs. 1 and 2).

![Fig. 1. Pseudoradial tear at the junction of anterior horn to body of the medial meniscus in a 11-year-old girl on proton density-weighted spectral presaturation inversion recovery (SPIR) coronal image (TR/TE, 2718/7.617; 3-mm section thickness) shown as blunting of the tip of the medial meniscus (arrow). Meniscus was intact at arthroscopy.](http://www.ksmrm.org)
In case of ambiguity, T2-weighted fast spin-echo sequences were analyzed. Sagittal and axial sequences were also checked to exclude true radial tears.

We excluded the first consecutive image immediately after the insertion site of following transverse ligament of anterior horn of the medial meniscus, which could cause an artifact at the meniscal tip due to partial volume (9). The following were evaluated: 1) the presence of pseudoradial tear at the anterior horn to body of the medial meniscus 2) the incidence according to age group 3) the location of blunted tip 4) the number of consecutive images on which a pseudoradial tear was present in each case. We excluded the following cases: patients with prior meniscal surgery, underlying meniscal degeneration, contusion, or tear in the anterior horn and/or anterior horn to body of the meniscus, tibial plateau fracture, difficult meniscal evaluation due to excessive large field of view (more than 200 mm) or artifacts hindering proper evaluation.

MR imaging findings were correlated with arthroscopy reports to determine the exact location and extent of any medial meniscal tears. Arthroscopies were performed by an experienced arthroscopic surgeon with full knowledge of MRI findings in 96 patients. The surgeon made note of the exact location of each meniscal tear detected using meniscal diagrams completed immediately after surgery.

Inter- and intra-observer agreements were calculated using kappa coefficients.

RESULTS

In the 485 consecutive MR examinations, a pseudoradial tear (Figs. 1, 2) in the anterior horn to body of the medial meniscus was present in 381 (78.6%) patients (221 men/160 women; mean age, 33.5 years). The incidence according to age group (Table 1), location (Table 2), and number of consecutive sections (Table 3) of the pseudoradial tear of the medial meniscus are listed in Tables. The incidence of truncated triangle appearance of medial meniscus was 80.1% (177/221) on 4-mm slice thickenss 1.5T MRI examination and 77.3% (204/264) on 3-mm slice thickness 3.0T MRI examination; there was no significant difference in the incidence between the two groups (P > 0.05).

Table 1. Incidence of Pseudoradial Tear According to Age Group

| Decade       | Pseudoradial tears/ Total numbers of MRI |
|--------------|------------------------------------------|
| First        | 14/20 (70%)                              |
| Second       | 80/94 (85%)                              |
| Third        | 71/87 (82%)                              |
| Fourth       | 78/93 (84%)                              |
| Fifth        | 76/96 (79%)                              |
| Sixth        | 39/55 (71%)                              |
| Seventh or more | 23/40 (57%)                          |

Table 2. Locations of Pseudoradial Tear of the Medial Meniscus

| Location                  | Number of cases |
|---------------------------|-----------------|
| Anterior horn             | 112 (29.4%)     |
| Anterior horn to body     | 143 (37.5%)     |
| Body                      | 126 (33.1%)     |
Arthroscopic results were as follows: among the total 96 patients, normal medial meniscus was found in 65 cases (67.7%), medial meniscus tears in 31 cases (32.3%); 2 (6.5%) in body, 7 (22.5%) in body to posterior horn, and 22 (71%) in posterior horn. On arthroscopy, anterior horn of medial meniscus was normal in all patients and none of the pseudoradial tears were proven as true radial tears.

Interobserver agreement was almost perfect (kappa value 0.99) for the presence and moderate (kappa value 0.43) for the number of sections of pseudoradial tear. Intraobserver agreement was substantial (kappa value 0.73).

| Consecutive sections | Number of cases |
|----------------------|-----------------|
| 1                    | 100 (26.2%)     |
| 2                    | 164 (43.0%)     |
| 3                    | 94 (24.7%)      |
| 4                    | 21 (5.5%)       |
| 5                    | 2 (0.5%)        |

DISCUSSION

Radial tear involves the meniscal free edge and is perpendicular to the long circumferential axis of the meniscus (10–13). It needs surgical debridement and/or resection, therefore the diagnosis of a radial tear is important (14). However, sometimes it is difficult to diagnose them preoperatively. Linear defect of a radial tear may not be seen when it is oriented parallel to the plane of the image. Radial tears in the body of the meniscus may be difficult to characterize in the coronal plane alone; additional use of sagittal and axial images allows more accurate characterization of radial tears (15). Small radial tears (or parrot-beak tear) affecting the free margin of the body of the meniscus are often better visualized on thin coronal cross-sections (10).

Usually the slice thickness most likely affects sensitivity in detection of radial tears; smaller section thickness decreases the effect of the volume-averaging artifact seen on thinner sections, which would theoretically result in increased sensitivity for detection of such tears. In our study, there was no perceivable difference in detection of meniscal truncated triangle appearance regarding slice thickness (3 vs. 4 mm), MR field strength (1.5 T vs. 3 T), or the addition of fat suppression to the imaging protocol. The incidence of meniscal truncated triangle appearance was 80.1% on 4-mm thickness 1.5T MRI examination and 77.3% on 3-mm thickness 3.0T MRI examination. There was no significant difference in the incidence between the two groups (P>0.05).

MR imaging criteria used for diagnosis of a radial tear were those outlined by Tuckman et al; truncation, abnormal morphology and/or lack of continuity or absence of the meniscus on one or more MR images (12). An additional criterion used was abnormal increased signal in that area on fat-saturated PD or T2W coronal and sagittal images (15). Other useful radiologic signs were described by Harper et al as follows: truncated triangle, cleft, marching cleft, and ghost meniscus signs (13). Truncation of the meniscal triangle is a useful morphologic sign of a radial tear; however, meniscal truncation is sometimes difficult to differentiate from simple fraying or fibrillation of the meniscus on MR images (1). In a study by Justice et al, false-positive interpretations of tears of the inner third of medial meniscus was found at arthroscopy to be frayed and not frankly torn; differentiation on MRI between meniscal fraying and tears sometimes is impossible (2).

Thus, keys to interpretation of radial tears are recognition of these signs; however, in our study truncated triangle appearance of the anterior horn to body of the medial meniscus were frequently seen on coronal MR images and mimicked true radial tears. In our study, truncated triangle appearance of the anterior horn to body of the medial meniscus was seen on coronal MR images in 381 (78.6%) patients; however, in our study, none of the truncated triangle appearance of the anterior horn to body of the medial meniscus was proven as true radial tears on arthroscopy. From the results of our study, we suggest that this relatively common and potentially confusing finding may be called a “pseudoradial tear” and may be another pitfall to be aware of and be differentiated from true radial tears.

There are several limitations to our study, first of
which is the retrospective design. Secondly, arthroscopically confirmed cases were relatively small (96 cases) but there was no rationale for making patients undergo arthroscopy, if they had no definite evidence of internal derangement of the knee. Another limitation of this study was the absence of size quantification of truncated triangle appearance of the medial meniscus, i.e. we did not measure the widths of the blunted portion of the meniscal tip. However, measurement of exact width of blunted meniscal portion on coronal MR image was difficult because meniscal blunting was seen as an abrupt termination at the meniscal tip.

In conclusion, truncated triangle appearance of the tip of anterior horn to body of the medial meniscus on one or more coronal MR images and/or adjacent fluid signal intensity at the blunted tip on PD or T2W images, so called “pseudoradial tear”, mimicking a true radial tear was frequently seen on coronal MR images. Awareness of this pitfall in this region should improve preoperative diagnostic accuracy of radial tears, thereby avoiding unnecessary surgery.

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내측반월상 연골의 가성방사파열: 비교적 흔한 진단상 함정

목적: 무릎관절 자기공명영상에서 내측 반월상연골 전각의 끝이 잘린 삼각형 모습 (truncated triangle appearance)의 빈도와 그 임상적 가치에 대하여 알아보고자 하였다.

대상과 방법: 위 연구는 기관윤리심의위원회 (IRB)의 승인을 받았으며, 사전동의를 받아 진행하였다. 가성방사파열로 판단하는 기준은 내측 반월상연골 전각부터 중심부에서 끝이 잘린 삼각형 모습과 흔적해진 끝 주변에 물과 같은 신호강도가 한 개 또는 그 이상의 관상면 영상에서 보일 경우로 하였다. 두 명의 근골격계를 전공한 영상의학과 의사가 후향적으로 485개의 무릎관절 자기공명영상들을 독립적으로 내측 반월상연골의 가성방사파열의 유무와 위 소견이 보이는영상의 개수를 자기공명영상의 양자밀도강조 관상영상을 이용하여 평가하였다. 관찰자간 일치도와 관찰자내 일치도는 카파 계수로 평가되었고, 관절경 소견과 연관시키기 위하여 의무기록을 참조하였다.

결과: 내측 반월상연골의 가성방사파열은 381명 (78.6%)의 환자에서 관찰되었다. 병변의 위치는 내측 반월상연골의 전각에 112명 (29.4%), 전각부터 중심부에 143명 (37.5%), 중심부에 126명 (33.1%)에서 각각 나타났다. 가성방사파열의 소견이 보이는 연속적인 단면 영상의 개수는 100명 (26.2%)에서 1개, 164명 (43.0%)에서 2개, 94명 (24.7%)에서 3개, 21명 (5.5%)에서 4개, 2명 (0.5%)에서 5개로 각각 나타났다. 관찰자간 일치도는 병변의 유무에 대해서는 0.99, 가성방사파열의 소견이 보이는 단면영상의 개수에 대해서는 0.43로 각각 나타났다. 관절경은 96명의 환자에서 시행되었고, 관절경상에서 모든 내측 반월상연골은 정상소견을 보였다.

결론: 무릎 자기공명영상영상에서 내측 반월상연골의 전각과 중심부의 가성방사파열은 흔히 보이는 소견으로써 실제 방사파열과 감별이 필요한영상의학과 의사가 알고 있어야 할 진단상 함정으로 사료된다.