

# Comparison of Knee SPECT and MRI in Evaluating Meniscus Injuries in Soldiers

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**ABSTRACT:** **Background:** Medical evaluation of a suspected meniscus injury begins with a history-taking and physical examination. Suspected meniscus injuries not responding to treatment are usually sent for imaging to confirm the diagnosis before arthroscopy. Tc-MDP bone single photon emission computed tomography (SPECT) scan has been suggested as an alternative to magnetic resonance imaging (MRI) in evaluating suspected knee meniscus tears.

**Objectives:** To examine the accuracy of knee SPECT as a tool to identify meniscus tears versus that of MRI as compared to the gold standard of arthroscopy.

**Methods:** The Israel Defense Forces database for 2005 through 2009 was searched using the key words: knee MRI, knee SPECT and knee arthroscopy. We identified 330 subjects who had undergone both a single knee SPECT and a single knee MRI prior to knee surgery. The medical files of 193 of the 330 subjects were randomly selected for review. A comparison was made between the preoperative SPECT and MRI studies and the arthroscopic finding. The sensitivity, specificity and accuracy were calculated.

**Results:** The subjects' age was  $21.3 \pm 3.9$ . The agreement between SPECT and arthroscopy was 0.14 for the medial meniscus and 0.29 for the lateral meniscus. The agreement between MRI and arthroscopy was 0.59 for the medial meniscus and 0.69 for the lateral meniscus. SPECT scan was found to be 61% sensitive, 54% specific and 58% accurate in detecting common knee pathology, whereas MRI was found to be 95% sensitive, 67% specific and 85% accurate.

**Conclusions:** Knee SPECT has a lower sensitivity, specificity and accuracy than MRI in evaluating meniscal injuries and its use can result in increased unnecessary surgery.

*IMAJ* 2014; 16: 703–706

**KEY WORDS:** meniscal tear, anterior cruciate ligament (ACL) tear, knee magnetic resonance imaging (MRI), knee Tc-MDP bone single photon emission computed tomography (SPECT), knee arthroscopy

**K**nee meniscus tears are usually the result of trauma in the young population but are more likely to be associated with material fatigue failure in the older population [1]. When a meniscus tear is clinically suspected, physical diagnosis includes determining the presence of joint line tenderness and performing the McMurray test. Both of these tests have been found to have low likelihood ratios [2]. When a patient with a suspected meniscus tear does not respond to conservative treatment, arthroscopic surgery should be considered. To confirm the suspicion of a meniscus tear prior to surgery, imaging studies are usually ordered.

There are several diagnostic imaging tools available to evaluate a suspected meniscus tear. Magnetic resonance imaging has the advantage of being able to evaluate all the soft and hard tissues around the knee in addition to meniscus pathology. Ultrasound can identify tears of the meniscus, but it has a much lower specificity than MRI and requires a skilled operator [3]. Neither of these examinations exposes patients to ionizing radiation. Tc-MDP bone single photon emission computed tomography (SPECT) may also be used to diagnose meniscus tears. Its advantages are that it examines both the right and left knee and simultaneously evaluates other joints and parts of the skeleton for pathology [4]. However, it exposes subjects to substantial amounts of ionizing radiation [5]. When evaluating postoperative knees, computed tomography arthrography has been reported to have greater accuracy than MRI [6]. This technique involves radiation exposure and requires an intra-articular injection of contrast, which may result in patient discomfort until the contrast is fully reabsorbed.

In a 1998 prospective study from Britain, bone SPECT was found to be a suitable alternative to MRI with comparable diagnostic ability to detect meniscal tears [7]. Its use is recommended when MRI is unavailable or unsuitable. Since this study, both SPECT and MRI technology have advanced. In Israel, bone SPECT has been widely used for the evaluation of suspected meniscus tears. It is less costly than MRI, requires no special approval from the health insurance funds, and the waiting time to obtain an exam is short. To determine if the current use of bone SPECT in evaluating suspected meniscus tears in a young

population is justified, we undertook a study to compare the sensitivity and specificity of the knee MRI with that of bone SPECT in diagnosing meniscus tears in a population of Israeli soldiers.

### PATIENTS AND METHODS

The study received institutional review board approval from the Israeli Defense Forces Medical Corps and the Assaf Harofeh

**Table 1.** Relationship between Cohen’s Kappa and qualitative strength of agreement

Strength of agreement	Cohen’s Kappa
Poor	-1.00–0.99
Slight	0.00–0.20
Fair	0.21–0.40
Moderate	0.41–0.60
Substantial	0.61–0.80
Almost perfect	0.81–1.00

**Table 2.** Mechanism and circumstances of injury

Mechanism		Circumstances	
Military training	35 (19%)	In army training or barracks	60 (33%)
Ball games	47 (26%)	En route to army	4 (2%)
Other sports including horse riding	15 (8%)	Preexisting situation worsened in army	4 (2%)
Tripping/direct injury	30 (16%)	Civilian injury	66 (36%)
Motor vehicle accident	14 (8%)	No injury was recalled	11 (6%)
Stated that no injury was recalled	21 (11%)	No injury was recalled, but was associated with military service	4 (2%)
Brawling	2 (1%)		
Not stated	18 (10%)	Not stated	33 (18%)
Total	182 (100%)	Total	182 (100%)

**Table 3.** Agreement between SPECT and arthroscopy vs. MRI and arthroscopy

		SPECT			MRI		
		Normal	Pathol	Kappa (CI)	Normal	Pathol	Kappa (CI)
Medial meniscus	Normal	70	22	0.14 (-0.04–0.31)	80	5	0.59 (0.45–0.73)
	Pathol	25	15		20	32	
Lateral meniscus	Normal	75	20	0.29 (0.11–0.46)	88	9	0.69 (0.55–0.82)
	Pathol	19	19		9	32	
ACL	Normal	81	31	0.12 (-0.04–0.29)	85	5	0.77 (0.66–0.89)
	Pathol	11	9		9	40	

Values presented are Cohen Kappa values with 95% confidence intervals  
 SPECT = Tc-MDP bone single photon emission computed tomography, MRI = magnetic resonance imaging, ACL = anterior cruciate ligament, Pathol = pathological, CI = confidence interval

Medical Center. The Israel Defense Forces digital database from May 2005 to December 2009 was searched using the key words: knee MRI, knee SPECT, and knee arthroscopy. By crossing the three search terms 330 subjects were identified who had undergone both a single knee SPECT and a single knee MRI prior to arthroscopic knee surgery. Excluded were patients who had undergone more than one of each imaging modality before surgery or more than one operation, with the exception of an arthroscopy which was followed by anterior cruciate ligament (ACL) reconstruction. The medical files of 193 of the 330 subjects were randomly selected for review.

A comparison was made between the preoperative SPECT and MRI studies and the intra-operative arthroscopic finding. The arthroscopic findings were considered to be the “gold standard.” The sensitivity, specificity and accuracy of MRI and knee SPECT were calculated. Agreement between the imaging modalities and the arthroscopic “gold standard” was assessed using Cohen’s Kappa and 95% confidence intervals. The correlation between the numerical Cohen’s kappa value versus the strength of agreement is shown in Table 1. Comparison of Kappa values between institutions was done using the two-paired *t*-test.

### RESULTS

After reviewing the medical files of the 193 subjects, data for 11 of these (6%) were found not to meet the study criteria. In 10 cases the pathology was in a site other than the knee and in one case documentation was incomplete. Of the 182 subjects who constitute the basis of the evaluation, 160 were male (88%). The mean age at the time of injury was 21.3 ± 3.9 years, median age 20.1, interquartile range 19–21 and the age range 17–43.

The right knee was injured in 53% of the subjects. The injury mechanism is presented in Table 2, showing that the most frequent mechanism was playing ball sports, followed by military training injuries. In 172 the scan was followed by MRI and in 10 the MRI was followed by a scan. The first operation was arthroscopy in 144 subjects and a reconstruction in 38. The MRI studies were performed in eight different institutions, 52% from a single institution. The SPECT studies were performed in 10 different institutions, 63% from a single institution.

The agreement between SPECT and arthroscopy was 0.14 for the medial meniscus, 0.29 for the lateral meniscus and 0.12 for the ACL [Table 3]. There was no statistically significant difference between the Kappa values for agreement with arthroscopic ACL, lateral meniscus and medial meniscus combined findings between institutions where the SPECT was performed.

The agreement between MRI and arthroscopy was 0.59 for the medial meniscus, 0.69 for the lateral meniscus, and 0.77 for the ACL. The institution where the majority of the MRIs were performed had a lower Kappa value for agreement with the arthroscopic ACL, lateral meniscus and medial meniscus

**Table 4.** Sensitivity, specificity and accuracy of knee SPECT and MRI for assessing the medial meniscus, lateral meniscus, and the ACL

		Sensitivity (%)	Specificity (%)	Accuracy (%)
Medial meniscus	SPECT	37	76	64
	MRI	61	94	82
Lateral meniscus	SPECT	50	79	71
	MRI	78	91	87
ACL	SPECT	45	72	68
	MRI	82	94	90
All (any) of the above	SPECT	61	54	58
	MRI	95	67	85

combined findings ( $0.5371 \pm 0.1007$ ) than that of the other institutions ( $0.7736 \pm 0.07878$ ) ( $P = 0.038$ ).

SPECT scan was found to be 61% sensitive, 54% specific and 58% accurate in detecting common knee pathology [Table 4], including medial meniscus tear, lateral meniscus tear and ACL tear. MRI was found to be 95% sensitive, 67% specific and 85% accurate in detecting the same knee pathology.

## DISCUSSION

The partial reliance in Israel on knee SPECT instead of MRI to evaluate suspected tears of the meniscus differs from the Western European or North American approach which is heavily MRI dependent. In this study knee SPECT was found to have a markedly lower sensitivity, specificity and accuracy than MRI in assessing medial meniscus, lateral meniscus and ACL pathology in a young population. On this basis alone MRI is preferred, because substantially fewer patients will undergo unnecessary surgery.

In addition, knee SPECT involves a patient radiation exposure of about 4.2 mSv. This dose is equivalent to 200 chest X-rays and is associated with an approximate long-term cancer mortality risk per scan of 1 per 4742 [5]. This complication would usually be seen only 20 to 25 years after the exposure. This radiation exposure is a factor to be considered when evaluating suspected meniscus tears in a young population.

Two prior studies reported a higher sensitivity and specificity for bone SPECT in diagnosing meniscal tears than was found in the current study. Ryan et al. [7] performed a prospective comparison of the use of MRI and bone SPECT in evaluating meniscal injuries in 100 consecutive adult patients referred to a specialist knee clinic that used arthroscopy as a gold standard [7]. The study population was between 20 and 65 years of age, but no details are given as to the mean, median or standard deviation of age. They found bone SPECT to have a comparable or even slightly higher sensitivity, specificity and positive and negative predictive accuracies than MRI. In a study at Guy's Hospital in London [8], 60 patients aged 17–50 (average age

32) with suspected meniscus tears underwent preoperative bone SPECT. The results were compared with the arthroscopic findings [8]. A 77% sensitivity, 74% specificity, 65% negative predictive value and 83% positive predictive value were found. What is the reason for the discrepancy between the results of the current study and these prior studies?

A possible explanation is the difference in accuracy of imaging modalities in studies done in academic institutions versus community settings [9]. The knee SPECT and MRI studies in the current work were performed in several centers, varying from for-profit institutions to university hospitals. The studies of Ryan et al. [7] and Grevitt et al. [8] were hospital based and therefore may have higher quality imaging studies. Another possible explanation is that in the current study the population evaluated was younger and there was usually a history of trauma. It has been shown that the incidence of meniscal tears increases with increasing age. The incidence of meniscus tears among asymptomatic community-living adults for the age bracket 50–59 years was found by MRI to be 32% for males and 19% for females [1]. The studies of Ryan et al. and Grevitt et al. evaluated older patients and therefore the likelihood of a false positive result was low. No patient clinical data were included in these studies. A third possible explanation is that in the current study the results were evaluated individually for the medial meniscus, the lateral meniscus and the anterior cruciate ligament, an analysis that was not reported in either the Ryan or Grevitt studies. The study of Ryan et al [7] classified scans into categories of definite tears, probable tears and no tears, but it does not report the results according to these categories.

Ben-Galim and colleagues [10] published a study on the accuracy of MRI of the knee based on a group of Israeli soldiers who underwent surgery in 1997–1998. They found 52% accuracy in evaluating the medial meniscus. The accuracy in the current study was 82%. They reported an accuracy for the lateral meniscus of 82% compared to 87% in the current study. For the ACL their accuracy was 80% compared to 90% in the current study. On the basis of these data it would seem that the overall accuracy of MRI in diagnosing meniscus injuries in Israel has increased over the last decade and a half. This improvement may be attributed to the use of more accurate diagnostic criteria and/or better hardware. The knee MRIs performed by one institution in this study were found to have only moderate agreement with arthroscopic findings, while the knee MRI studies performed by the other institutions in this study had substantial agreement. The reason for the lower performance in one institution needs to be investigated.

In view of the radiation exposure and the lower accuracy of knee SPECT found in the current study using community-based imaging, there would seem to be little reason to medically justify large-scale use of knee SPECT to evaluate meniscus pathology in young patients. A better alternative would be to use MRI, which has higher sensitivity, specificity and accuracy,

and therefore will facilitate better medical practice concerning suspected meniscus injuries in this population.

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