A Comparative Study on the Diagnostic Value of Conventional Spin Echo Proton Density and Fast Spin Echo Proton Density Sequences of Magnetic Resonance Imaging in Diagnosis of Meniscal Tear

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Abstract

Background & Objectives: Knee is the largest synovial joint in the body. Although FSE PD (fast spin echo proton density) imaging technique for the diagnosis of meniscal tear has replaced CSE PD (conventional spin echo proton density) technique in many MRI centers, several studies have questioned the effectiveness of FSE PD technique in diagnosis of meniscal tear. In this study, the diagnostic values of CSE PD and FSE PD techniques in evaluation of meniscus tear are compared.

Materials: In this study, using CSE PD and FSE PD techniques, MRI was performed on 67 knees of patients with suspected meniscal tear referring to the MRI Center of Imam Reza Hospital (Kermanshah, Iran). Diagnostic arthroscopy was also performed for all patients. The data were entered SPSS version 20, and finally the results of MRI reports of the two techniques were compared in evaluation of meniscal tear taking into account the arthroscopic findings as the gold standard.

Results: According to the results of this study, no significant difference was found in specificity and positive predictive value of the two techniques. However, the sensitivity and negative predictive values were significantly different, in such a way that the related values were 97% and 97% in the CSE PD technique and 69% and 73% in the FSE PD technique, respectively.

Conclusion: Due to low sensitivity and high false negative results, MRI using FSE PD technique is not recommended as an alternative for CSE PD technique in evaluation of meniscal tear.

Keywords: *Meniscal Tear, Knee MRI, Spin-echo*

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Background

Knee is the largest synovial joint of human body. The main proportion of body weight is on knee which makes knee thus relatively vulnerable[1]. The methods of diagnosis of knee injuries such as meniscal tear include physical examination, MRI as

well as arthroscopy. Since the first application for examination of meniscus in 1984, knee MRI has acquired remarkable development. Because of less reliability, physical examination cannot be used as the only diagnostic method for meniscal tear and diagnostic arthroscopy is less welcomed by patients due to being invasive and expensive. However, knee MRI is very welcomed at the present time thanks to non-invasiveness and high precision[2-5]. MRI is considered a great transformation in knee imaging. Meniscus tear which is diagnosed through pain and instability in knee is the most common indication for performance of knee MRI[6-7]. With its high negative predictive value, MRI can play an important role in avoiding unnecessary diagnostic arthroscopy[8-11]. MRI determines the main features of meniscal tear (location, shape, length and depth of laceration) that play a significant role in correct treatment of patients[7,12].

In addition to being multi-planar, other benefits of knee MRI include: lack of exposure of ionizing radiation on patients, usually intravenous contrast material is not required, there is no need for joint manipulation, and it is without pain and can be performed in a short time. Furthermore, unlike arthrography, there is no need to inject intra articular contrast material. However, arthrography MRI is used for evaluation of recurrent meniscal tear as well as for diagnosis of the remaining meniscus after surgery because MRI is singly unable to diagnose both cases[13-16]. Sagittal sections of CSE PD technique are typically used in MRI for evaluation of meniscal tear[7]. According to some studies, the results of the FSE PD technique in evaluation of meniscal tear are comparable with the results of the CSE PD technique[17-20]. However, some other studies have reached opposite conclusions and do not consider the accuracy of FSE PD technique equal to CSE PD technique in evaluation of meniscal tear[7,21,22]. Furthermore, some studies have suggested high sensitivity and specificity for the CSE PD technique and do not recommend FSE PD technique due to blurring in this technique regardless of less time needed for its performance[23-27]. Since less time is needed to perform the FSE PD technique compared with the CSE technique, several other studies have compared diagnostic values of FSE PD sequence and CSE PD techniques and have obtained different results[28,29]. Thus, considering the mentioned advantages and non-invasiveness of MRI and given that it is much cheaper than diagnostic arthroscopy[5] and there is controversy about the diagnostic accuracy of FSE PD sequence and CSE PD technique to examine meniscal tear, comparative study of diagnostic value of these sequences may be important so that CSE PD technique, which needs more time for performance, can be avoided for diagnosis of meniscal tear provided that the diagnostic value of FSE PD sequence is more or equal to that of CSE PD technique. Furthermore, FSE PD technique can be avoided in case its diagnostic value is low. Accordingly, the main objective of this study is to determine whether the FSE PD sequence has different sensitivity and specificity in diagnosis of meniscal tear compared with the CSE PD technique, and whether it can be recommended for evaluation of meniscal tear?

Materials

This study is of diagnostic value. The patients in the study were suspicious about meniscal lesions and volunteered for arthroscopy and MRI. CSE PD and FSE PD sequences were performed for them before arthroscopy. With 95% reliability and 80% power and according to the results of other studies, the minimum of sample size (using sample size calculation formula to compare two ratios) was estimated 73 subjects to compare the two sequences. Three tools were used in this study: 1- Questionnaire, 2- MRI as a test the diagnostic value of which was evaluated, and 3- Arthroscopy as the gold standard. First, the questionnaires were prepared in two types, one containing personal information as well as the MRI results and the other personal information and arthroscopy result. After reporting the MRI by co-partner, final MRI report of patients was performed by an experienced radiologist in the field

of musculoskeletal. The questionnaires containing the results of arthroscopy were also completed by co-partner orthopedic specialist. These two specialists were unaware about the results of each other and a common code was considered for responses of orthopedist and radiologist. Then, the data were analyzed using SPSS version 20 and considering that the arthroscopy was gold standard, the false positive results, false negative results, true negative results and true positive results were calculated and accordingly the sensitivity, specificity as well as positive and negative predictive values of the two methods were compared.As it generally accepted, we considered a meniscal signal change as tear, only when this signal change has reached to meniscal surface or surfaces, otherwise, when the signal abnormality was confined to inner parts of the meniscus and was not disrupted the meniscal margins; we considered it as intra substance degeneration or degenerative changes and no tearing. (Fig 1 and 2)

Typing of the tears (vertical, horizontal, etc.) was not included in our study. And the only aim of our study was detection of tearing of any type.

Grade I and II signal abnormalities are confined to inner parts of meniscus and consider as

Degenerative changes. Type Grade III signal abnormality reach to meniscus surface and is a tear.

Finding

119 cases of knee MRI were performed in our study. In 36 cases of which no evidence of meniscal tear and abnormal signal change was reported. Furthermore, 16 cases of degenerative changes were reported and ultimately 52 cases were excluded from the study and diagnostic arthroscopy was performed on 67 knees including 34 right knees and 33 left knees (totally 134 menisci). The range of participants ages was 13-68 years (mean age was 33 years) including 35 men (52.2%) and 32 women (47.8%).

The reports results of CSE PD technique obtained from 134 menisci MRI included 73 lacerations (61 medial menisci tears and 12 lateral menisci tears, and 61 healthy cases (6 medial menisci and 55 lateral menisci) respectively.

The results of MRI reports of FSE PD technique included 55 lacerations (43 medial menisci tears and 12 lateral menisci tears), and 79 healthy cases (24 medial menisci and 55 lateral menisci) respectively.

In conducted arthroscopy, out of 61 reported medial menisci tears in CSE PD technique, 54 were confirmed and out of 6 reported normal medial menisci in this technique 5 cases were confirmed, in such a way that in one case which was reported healthy in CSE PD technique, meniscal tear was diagnosed using arthroscopy. Besides, in performed arthroscopy, out of 12 torn lateral menisci diagnosed by CSE PD technique, 11 cases were confirmed and in one case which was reported as torn lateral meniscus, tear was not seen in arthroscopy. In addition, in 55 normal lateral menisci reports using CSE PD sequence, 54 cases were normal in arthroscopy, too, but there was a case of torn meniscus with false normal MRI report.

Out of 43 cases of medial menisci tears reported in FSE PD technique, 38 cases were confirmed in arthroscopy. Only 17 out of 24 cases of healthy medial menisci reported in FSE PD technique were confirmed with arthroscopy. Furthermore, in conducted arthroscopy, out of 12 cases of torn lateral menisci reported in FSE PD, 9 cases were confirmed and the remaining 3 cases were diagnosed as healthy. Furthermore, out of 55 healthy lateral meniscuses reported in FSE PD, 52 cases were confirmed and in 3 of them tears were observed in arthroscopy.

Finally, the MRI reports were considered as the presence of meniscal tear and lack of meniscal tear in any of the CSE PD and FSE PD techniques and the results were evaluated with arthroscopic findings and considering the true positive and false positive as well as true negative and false negative in both techniques, the sensitivity, specificity, positive predictive value, negative predictive value and validity of each of the techniques are presented. In the table 3 we summarized match results and area under the curves of the methods Arthroscopy and CSE. In the table 4 we summarized Match Results and Area under the Curves of the Methods Arthroscopy and FSE, as well as in the Diagrams 1 we presented results of ROC Curve Arthroscopy and CSE and in the Diagrams2 we presented results of ROC Curve Arthroscopy and FSE Results of MRI reports and arthroscopies are summarized. In the tables 1 we reported frequency distribution of results Arthroscopy and CSE. In the table 2 we reported frequency distribution of results Arthroscopy and FSE. Since the results of sensitivities, specificities, positive predictive values, negative predictive values, and the areas under ROC curves in both techniques are more than 0.5, the validities of both CSE and FSE techniques against the arthroscopy as gold standard are significant ($P<0.05$). Diagnostic value of CSE PD technique is higher than FSE PD technique because the differences of sensitivity, specificity, positive predictive value, negative predictive value, and the area under ROC curve are more than 0.5 and closer to 1, in this technique. In addition we presented 2 figures. In the Fig 1 we showed FSE image, an oblique tear is faintly visible in Posterior horn of medial meniscus and in the Fig 2 we showed CSE image, the same tear is clearly visible

Table 1- Frequency Distribution of Results Arthroscopy and CSE

arthroscopy				Diagnostic Method
Total	Healthy	Tear	Result	CSE
73	8	65	Tear	
61	59	2	Healthy	
134	67	67	Total	

Table 2- Frequency Distribution of Results Arthroscopy and FSE

arthroscopy				Diagnostic Method
Total	**Healthy**	**Tear**	**Result**	**FSE**
55	8	47	Tear	
79	59	20	Healthy	
134	67	67	Total	

Table 3- Match Results and Area under the Curves of the Methods Arthroscopy and CSE

sig	Area Under the Curve	Negative Predictive Value	Positive Predictive Value	Specificity	Sensitivity
<0.001	92.53%	96.72 %	89.04 %	88.06 %	97.01 %

Table 4- Match Results and Area under the Curves of the Methods Arthroscopy and FSE

Sig	Area Under the Curve	Negative Predictive Value	Positive Predictive Value	Specificity	Sensitivity
<0.001	78.49%	73.42 %	85.45 %	87.88 %	69.12 %

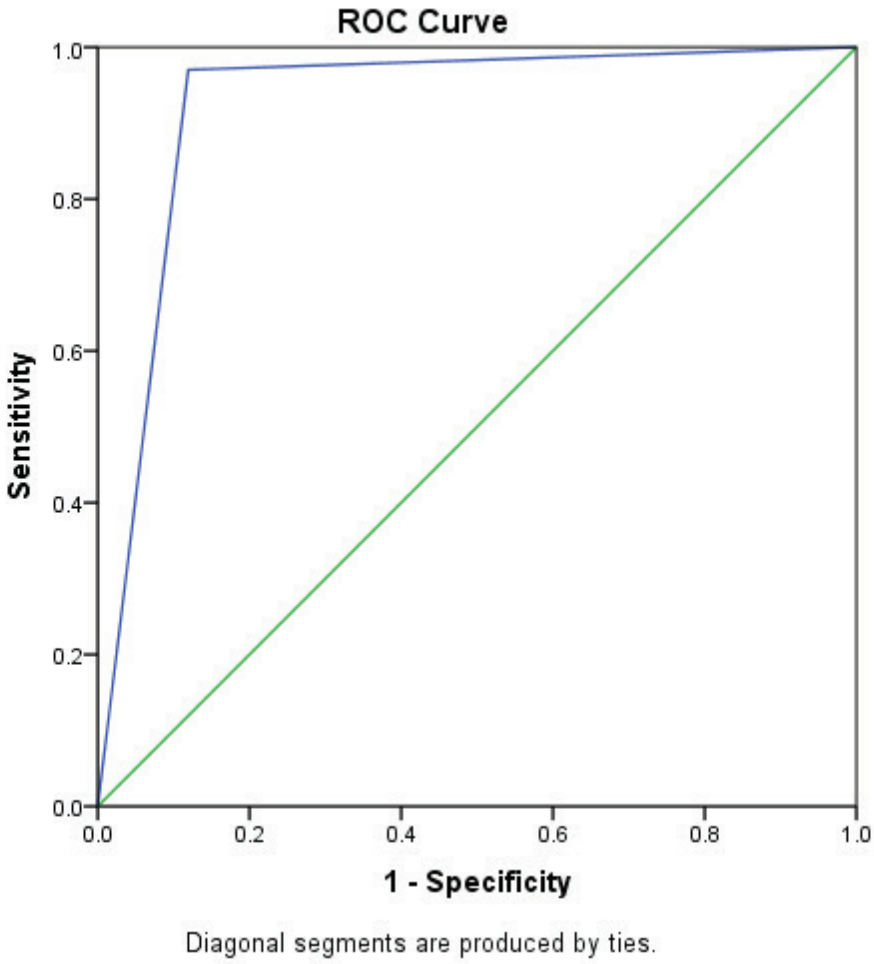

Diagram 1- Results ROC Curve ARTHROSCOPY and CSE

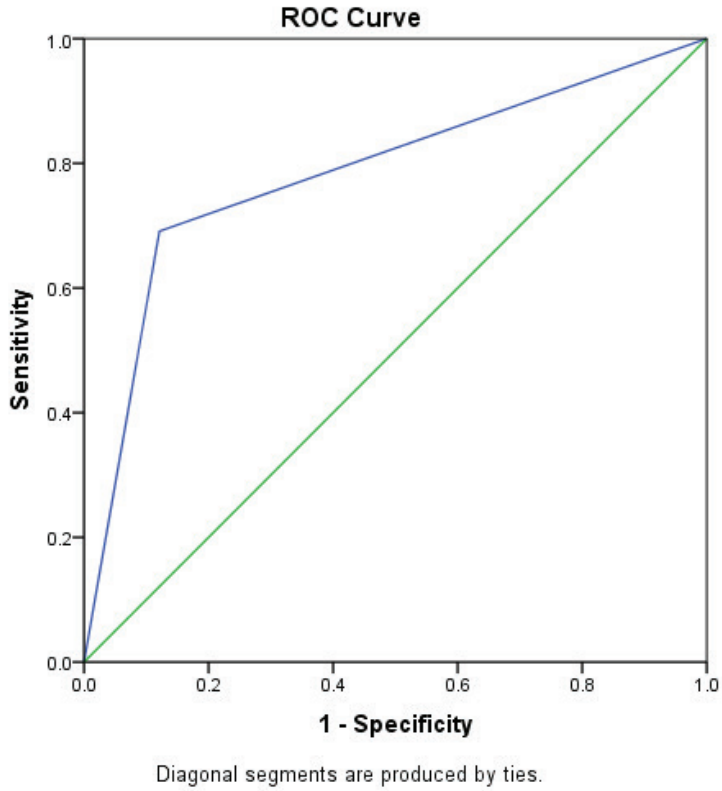

Diagram 2- Results ROC Curve Arthroscopy and FSE

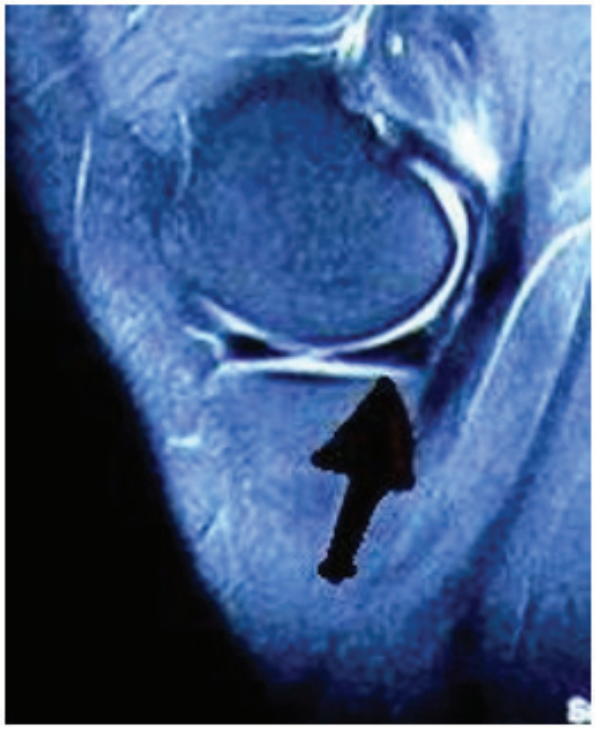

Fig 1 - FSE image, an oblique tear is faintly visible in Posterior horn of medial meniscus

Fig 2 - CSE image, the same tear is clearly visible.

Discussion

The results of this study indicated that, the sensitivity, specificity, positive predictive value and negative predictive value in CSE PD technique are respectively 97%, 88%, 89%, and 96.7% and in FSE PD technique are respectively 69%, 87.8%, 85.4%, and 73.4% in comparison whit arthroscopy as gold standard. In addition, the validity of MRI using CSE PD and FSE PD techniques in diagnosis of meniscal tear is obtained 92.5% and 78.5% respectively.

As previously mentioned, MRI is a useful method in evaluation of meniscal tear[1,2,4,5,30]. Henning *et al.* first proposed the FSE technique[31]. In the spin-echo technique, after 90° pulse, magnetic field in homogeneity results in rapid protons de phasing thus by sending a 90° pulse, transverse magnetization is made but no image is produced, because of its rapid decay. Then the 180° pulse brings the protons in phase again and a strong signal is generated. In fact, the 180° pulse compensates magnetic field in homogeneity. In FSE technique or turbo spin-echo after a single 90° pulse, multiple 180° pulses are transmitted and finally multiple echoes are produced per one TR, instead of one echo in conventional spin echo. Since the multiple lines of phase encoding per one TR interval are obtained, thus the FSE technique can significantly reduce the imaging time[32]. Several studies have compared the two FSE and CSE techniques[7-11] and different results have been obtained. In this study, we investigated the diagnostic value of both CSE PD and FSE PD techniques in diagnosis of meniscal tear. The intensity of magnetic field of MRI machine in this study was 1.5 Tesla and similar to many previous studies. The age range of participants of this study

was 13-68 years (mean age of 33 years) and about 82.1% of meniscal tear diagnosed in arthroscopy was related to medial meniscus which was consistent with previous studies[33]. Since the results of sensitivities, specificities, positive predictive values, negative predictive values, and the area under ROC curves in both techniques were more than 0.5, therefore the validities of both CSE PD and FSE PD sequences are significant compared with that of gold standard arthroscopy (P<0.05). However, given the fact that if the mentioned values are greater than 0.5 and are closer to 1 thus the value of that diagnosis technique is more, the value of CSE PD sequence is higher than FSE PD sequence and the results are not in line with the findings of Escobedo *et al.* as well as that of Andrew *et al.* and Kojima *et al*[7,34,35]. As the result of Escobedo et al.'s study, the specificity was obtained 90% for both techniques and sensitivity was obtained 88% for CSE technique and 82% for FSE technique in diagnosis of meniscal tear. Ultimately, the FSE technique is considered an appropriate alternative for CSE technique in diagnosis of meniscal tear. In the study conducted by Andrew *et al.* - their study was retrospective reviewing CSE-T1 and FSE PD techniques - the diagnostic value of FSE-PD sequence was not considered less than CSE-T1 and the evaluation of meniscus using this technique is considered unnecessary. On the other hand, the results of our study are in line with the studies conducted by Rubin *et al.* and Anderson *et al*[21,36]. Similarly, in the Clyde *et al.*'s study, the sensitivity and specificity of CSE PD technique were 93% and 97% respectively and the sensitivity of FSE PD was 80%. In addition, there was almost 17% difference in CSE PD and FSE PD techniques and this difference was statistically significant[37].

Conclusion

The FSE technique may significantly reduce imaging time. This decrease of MRI time and thus avoidance of artifacts due to patient movement have made advocates for FSE PD technique as an alternative for CSE PD. However, given the significant difference of diagnostic value of the two studied sequences as well as low sensitivity and negative predictive value in FSE PD technique, FSE PD sequence is not recommended for evaluation of meniscal tear.

Conflict of Interest: The authors declare that there is no conflict of interest

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Availability of data and material: The data used to support the findings of this study are available from the corresponding author upon request

Ethical Clearance: The Kermanshah University of Medical Science Ethics Committee endorsed the study. Objectives of the study were stated for all samples, emphasized the confidentiality of their

Specifics and responses, and informed written consent was obtained from all participants

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