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RESEARCH ARTICLE

ROLE OF T2*CARTILAGE MAPPING IN EARLY DETECTION OF CHONDRAL LESIONS AND ITS COMPARISON WITH ROUTINE MR SEQUENCES

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ABSTRACT

Objective

- To evaluate role of T2*cartilage mapping in early detection of chondral lesions before they are detected on conventional morphologic sequences(fat saturated proton density sequence)
- To compare T2* Cartilage mapping with routine MR sequences (FSPD)

Materials and Methods: This prospective study was done on 100 cases who underwent MRI knee,in which FSPD images were compared with the T2* maps.

A Pilot study of 10 normal (young asymptomatic)subjects was done initially to define range and mean of normal values and artifacts. A sub study of 15 cases was also done comparing FSPD images, T2* maps with arthroscopy, to determine relative accuracy of either technique against the gold standard of arthroscopy. Clinical history of patients was taken before examination. MRI was performed with a Siemens AvantoMagnetom 1.5 TESLA MR scanner with dedicated phased-array receive-only knee coils. The patient was placed in the supine position with the knee placed within knee coil in neutral position. MR images were systematically obtained without administration of contrast material.

Results: The range of normal T2* values determined from pilot study on normal subjects was 20-26.60

Msec. The mean T2* value of patellar and trochlear cartilage was found to be 24.30 + 3.8msec and this value was taken as reference normal T2* value. On comparison of corresponding T2* map and FSPD images in patellar and trochlear quadrants, overall complete match of chondral lesions was found in 65.30% of quadrants, no match was found in 30.50% of quadrants, partial match was found in 3.80% of quadrants, partial match reverse was found in 0.20 % of quadrants and no match reverse was found in 0.20% of quadrants.

Conclusion: T2*cartilage mapping is sensitive to early cartilage changes and even changes not visible in high resolution MRI might be detectable with quantitative T2* cartilage mapping. It is more beneficial for detection of early chondral lesions/ changes in region of trochlear groove, lateral trochlear facet and patellar ridge areas where early lesions are more likely to be missed on conventional morphological sequences. T2* images were also found to be useful in the detection of early lesions in the mid third medial trochlear facet and upper third lateral patellar facet.

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INTRODUCTION

MRI of the knee is the most frequently requested MRI joint study in musculoskeletal radiology with diverse indications. It provides a comprehensive examination of the knee, giving information that cannot obtain clinically or noninvasively and provides a road map for performing arthroscopic or open surgery (Musculoskeletal MRI by Clyde A. Helms, *2nd edition*). Amongst pathologies in the knee, patellofemoral degeneration is the most common, and likely cause of symptoms. Our study is focused on cartilaginous lesions of the patellofemoral joint. Current clinical MRI evaluation of articular cartilage relies primarily on identification of morphological changes in damaged cartilage. These include determination of cartilage thickness, signal and detection of superficial cartilage lesions, primarily with two-dimensional proton density-weighted fast spin-echo sequences (Timothy *et al*., 2004) New MRI parametric mapping techniques, such as cartilage transverse relaxation time (T2 and T2*) mapping exploit the sensitivity of MRI to biochemical and biophysical changes in the extracellular matrix of articular cartilage, giving it the potential to noninvasively detect the earliest stages of matrix degeneration that precede visible cartilage damage (Timothy *et al*., 2004), in addition to morphologic information, such as fissuring and the presence of partial- or full-thickness cartilage defects. In vivo techniques have been developed for cartilage T2 and T2* mapping of human joints. In addition these techniques have important role in development of chondroprotective pharmaceuticals, surgical techniques for

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preserving cartilage, better understanding of arthritis, cartilage aging, and response of cartilage to exercise[2]. Both T2 and T2* relaxation parameters demonstrated a similar response in the assessment of articular cartilage and cartilage repair tissue. (Mamisch *et al*., 2011) Our study is based on T2* mapping for assessment of articular cartilage of patellofemoral joint .The potential advantages of T2*-mapping of cartilage include faster imaging times, and better signal to noise ratio, thereby providing greater spatial resolution. (Mamisch *et al*., 2011; Tallal Charles Mamisch *et al*., 2012)

MATERIALS AND METHODS

Initially a Pilot study of 10 normal subjects was done to define range and mean of normal values and artifacts. This was followed by prospective main study over a period of one year on 100 cases, including all patients presenting for knee MR, in which FSPD images were compared with the T2* maps. Comparison of FSPD images and T2* maps with arthroscopy was done in 15 cases, to determine relative accuracy of either technique against the gold standard of arthroscopy. MRI was performed with a Siemens AvantoMagnetom 1.5 TESLA MR scanner with dedicated phased-array receive-only knee coils. The patient was placed in the supine position with the knee placed within knee coil in neutral position.

MR imaging protocol used in study

Conventional sequences

1. Sagittal fat saturated proton density sequence with 3mm slices with 10mm interslice gap, with the following parameters- TR/TE/FA-3100ms/26/170, FOV-160x160, Matrix 384x288
2. Sagittal T2* cartilage mapping sequence, amulti echo gradient recalled sequence, obtained with 3mm slices with 10mm interslicegap, the parameters used were - TR/TE/FA – 440ms / 4.2,11.3,18.5,25.6,32.7/ 60, FOV 160x160, Matrix 256x256.This sequence was taken at end of examination with purpose of taking advantage of unloading for better differentiation between normal and abnormal cartilage in late unloading than early acquisition. (Apprich *et al*., 2012; Tallal C. Mamisch *et al*., 2010)

Inline processing of the multi-echo sequence lead to parametric maps. Patella and trochlea were divided into 9 quadrants each as shown below:

Colour coding

Normal cartilage was displayed as uniform/homogenous blue colour with smooth surface. Proper windowing and centering is very important to differentiate normal from abnormal cartilage. During our pilot study, we found that a windowing value at 66 and centering value 44, was optimal for the colour map used on this study

Criteria defining chondral lesions

Criteria for chondral lesions on T2* maps

1. Colour - Altered colour/ gradation, focal or diffuse (colour other than blue)
2. Altered thickness- thinning- thickening
3. Subchondral signal change –on T2* base images

Criteria for chondral lesions on FSPD sequence

1. Signal change
2. Swelling
3. Thinning

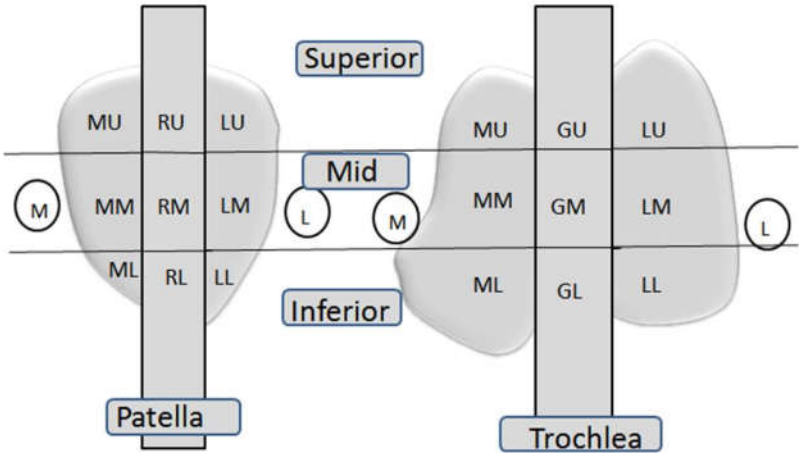


Figure 1. Patellar And Trochlear Quadrants As Described In Study: MU-medial upper, MM-medial middle, ML-medial lower, LU-lateral upper, LM-lateral middle, LL-lateral lower, RU-ridge upper, RM-ridge middle, RL-ridge lower, GU-groove upper, GM-groove middle, GL-groove lower

4. Superficial irregularity / chondral fibrillation
5. Fissuring
6. Chondral defects- acute/ chronic
7. Subchondral signal change

Grading of chondral lesions was done by Modified Outerbridge Classification (Lars V von Engelhardt *et al*., 2010)

Counting of chondral lesions on T2* maps and FSPD

One focal area of abnormal colour/ signal was counted as one lesion. Diffuse alteration of colour/ diffuse signal change within a quadrant was also counted as single lesion. A larger area of altered colour/ signal alteration extending beyond two contiguous sagittal cuts with an intervening area of normal color/signal was counted as two lesions. Large focal area of altered colour/ signal alteration extending into two quadrants

was counted as one lesion in each quadrant. T2* relaxation time values were assessed in the patellar and trochlear cartilage by placing region of interests (ROIs) at selected places. Differentially altered T2* values were marked as abnormal.

Internal standard: One T2 * value measurement was taken from patella and trochlea each in every case, by placing ROI on an area appearing perfectly normal morphologically as well as in colour pattern .This was used as an internal standard for normal.

Comparison of T2* and FSPD images for chondral lesions

Initially T2* map with proper windowing and centering and T2* base images were assessed for chondral lesions and T2* values of lesions were obtained. This was followed by separate assessment of FSPD images for chondral lesions and findings were recorded on master chart. Finally a quadrant wise comparative assessment ofT2* map and FSPD images was done by placing corresponding sagittal sections of two sequences in side by side layout on monitor. This was done to assess degree of match or mismatch between corresponding images of two sequences. Terms used for comparison results and in statistical analysis were as follows:

COMPLETE MATCH (CM):- Number, location and morphology of chondral lesions matches perfectly between two sequences

NO MATCH (NM):- Chondral lesion/lesions on T2*map with normal corresponding FSPD image.

NO MATCH REVERSE (NMR):- Chondral lesion/ lesions on FSPD images, corresponding T2* map images appear normal

PARTIAL MATCH (PM):- Number of chondral lesions on T2* map images of a quadrant is greater than number of lesions on corresponding FSPD images with one or more matching lesions.

PARTIAL MATCH REVERSE (PMR):- Number of chondral lesions on FSPD images of a quadrant is greater than number of lesions on corresponding T2* map images with one or more matching lesions. Arthroscopic follow up was obtained in some patients where it was done after MR imaging and the findings were correlated as below:

COMPLETE MATCH (CM): - The number of lesions on T2* map or FSPD images of a quadrant is same as on arthroscopy

PARTIAL MATCH (PM):- Greater number of lesions in a quadrant on arthroscopy than number of lesions seen on T2* map or FSPD images of that quadrant.

NO MATCH (NM):- One or more lesions in a quadrant seen on arthroscopy, no lesion seen on T2* map or FSPD images of that quadrant.

OBSERVATIONS AND RESULTS

Observations in our study as depicted in above tables and graphs

- The mean T2* value of patellar and trochlear cartilage from pilot study on healthy asymptomatic volunteers was found to be 24.30 + 3.8 and this value was taken as reference normal T2* value.
- On comparison of corresponding T2* map and FSPD images in patellar and trochlear quadrants, overall complete match of chondral lesions was found in 65.30% of quadrants, no match was found in 30.50% of quadrants, partial match was found in 3.80% of quadrants, partial match reverse was found in 0.20 % of quadrants and no match reverse was found in 0.20% of quadrants.
- In case of patellar quadrants, "complete match'' of chondral lesions was observed in 86% of medial upper, 84% of medial middle, 89% of medial lower,59% of upper and lower quadrants of ridge each ,70% of ridge middle,64% of lateral upper, 82% of lateral middle and 79% of lateral lower quadrants. "No match'' was observed in 14% of medial upper,12% of medial middle, 11% medial lower, 36% of ridge upper, 25% of ridge middle, 37% of ridge lower ,26% of lateral upper, 11% of lateral middle and 11% of lateral lower quadrants. "Partial match'' of chondral lesions was observed in 4% of medial middle,5% of ridge upper, 5% of ridged middle, 4% of ridge lower, 10% of lateral upper, 5% of lateral middle and 10% of lateral lower quadrants."Partial match reverse'' was seen in only 2% of lateral middle quadrants. None of the patellar quadrants showed "no match reverse''. (*Table 1/ Graph 1)*
- In case of trochlear quadrants, "complete match'' of chondral lesions was observed in 73% of medial upper, 58% of medial middle, 81% of medial lower, 38% of groove upper, 34% of groove middle,53% of groove lower,65% of lateral upper, 46% of lateral middle and 56% of lateral lower quadrantss. "No match'' was observed in 24% of medial upper, 39% of medial middle, 17% medial lower, 60% of groove upper, 66% of groove middle, 47% of groove lower, 29% of lateral upper, 44% of lateral middle and 40% of lateral lower quadrants. "Partial match'' of chondral lesions was observed in 2% of medial upper, 2% of medial lower, 2% of groove upper, 6% of lateral upper, 10% of lateral middle and 3% of lateral lower quadrants. "Partial match reverse'' was seen in only 2% of medial middle quadrants. "No match reverse'' was seen in 1% of medial upper, medial middle and lateral lower quadrants each. (*Table2/Graph 2*)
- On comparison of arthroscopic findings with T2* map findings in 15 cases, results were as follows:

Patellar quadrants

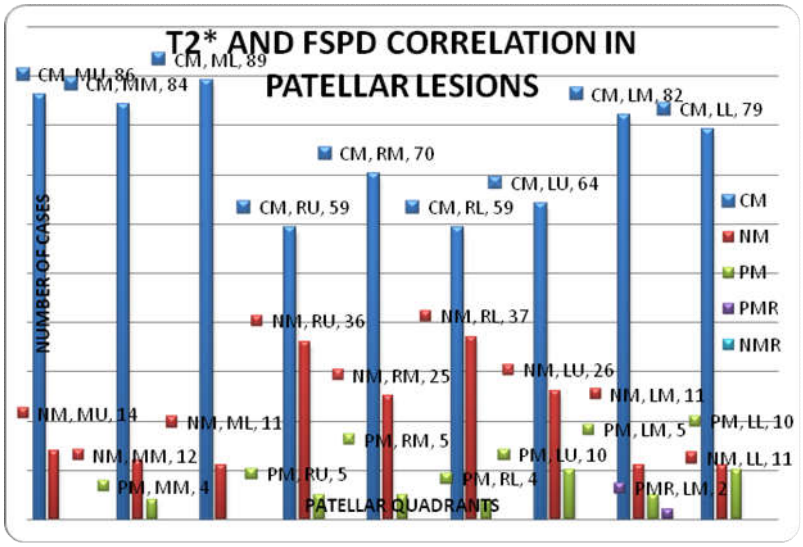
- Matching chondral lesions were seen in 93.3 % of medial upper, 93.3 % of medial middle, 86.7% of medial lower, 100 % of ridge upper, 73.3% ridge middle, 86.7% ridge lower,100% of lateral upper, 80% of lateral middle and 93.3 % of lateral lower quadrants. Additional lesionson arthroscopy with apparently normal corresponding cartilage areas on T2* map (No match of chondral lesions) were observed in 6.7% of medial upper and medial middle quadrants each, 13.3% of medial lower, 26.7% of ridge middle, 13.3% of ridge lower and 20% lateral middle quadrants. Partial match of chondral lesions was seen in 6.7 % of lateral lower quadrants. (***Graph 3***)

Table 1. T2* AND FSPD correlation in patellar lesions

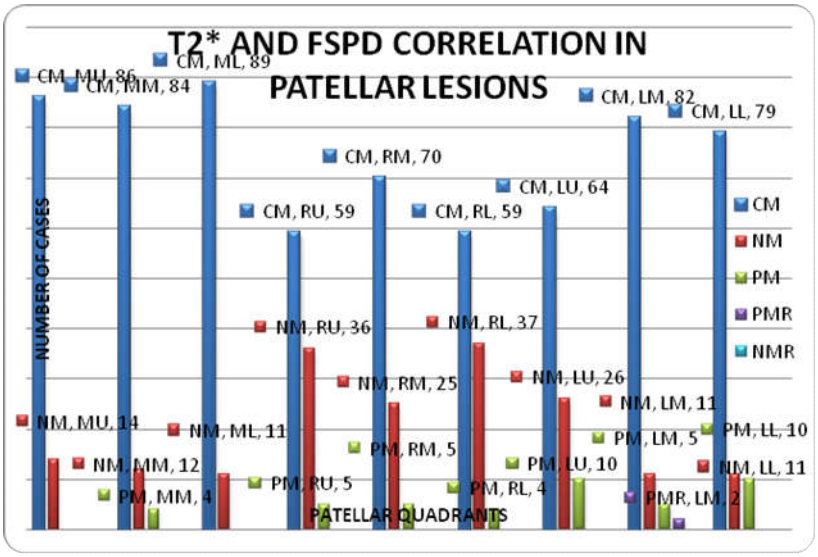
T2* AND FSPD CORRELATION IN PATELLAR LESIONS					
QUADRANTS	CM	NM	PM	PMR	NMR
MU	86	14	0	0	0
MM	84	12	4	0	0
ML	89	11	0	0	0
RU	59	36	5	0	0
RM	70	25	5	0	0
RL	59	37	4	0	0
LU	64	26	10	0	0
LM	82	11	5	2	0
LL	79	11	10	0	0

Table 2. T2* AND FSPD correlation in trochlear lesions

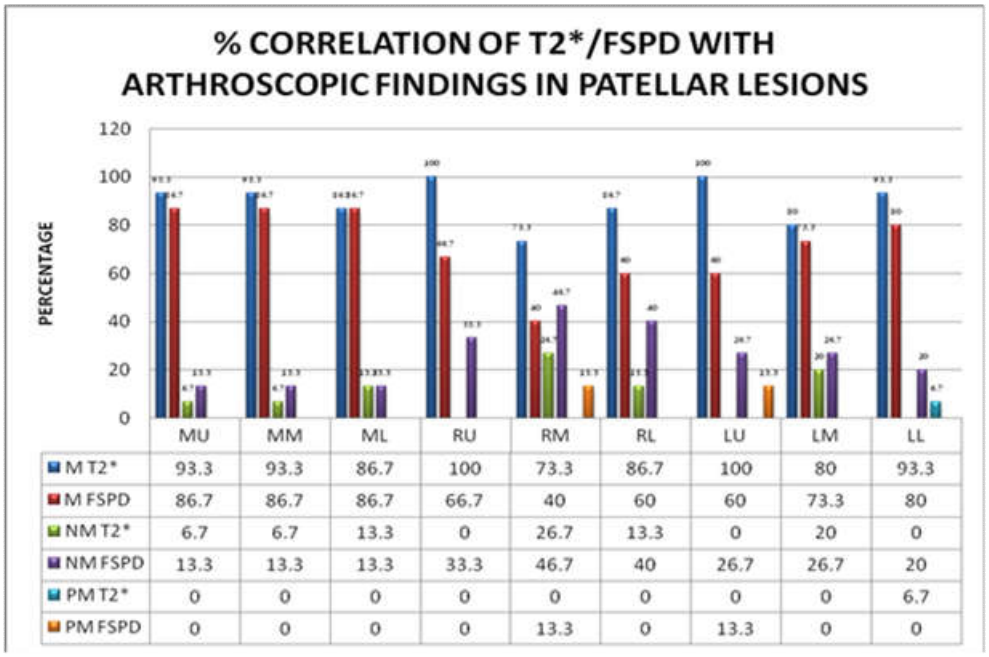
T2* AND FSPD CORELATION IN TROCHLEAR LESIONS					
QUADRANTS	CM	NM	PM	PMR	NMR
MU	73	24	2	0	1
MM	58	39	0	2	1
ML	81	17	2	0	0
GU	38	60	2	0	0
GM	34	66	0	0	0
GL	53	47	0	0	0
LU	65	29	6	0	0
LM	46	44	10	0	0
LL	56	40	3	0	1



Graph 1. T2* and FSPD correlation in patellar lesions

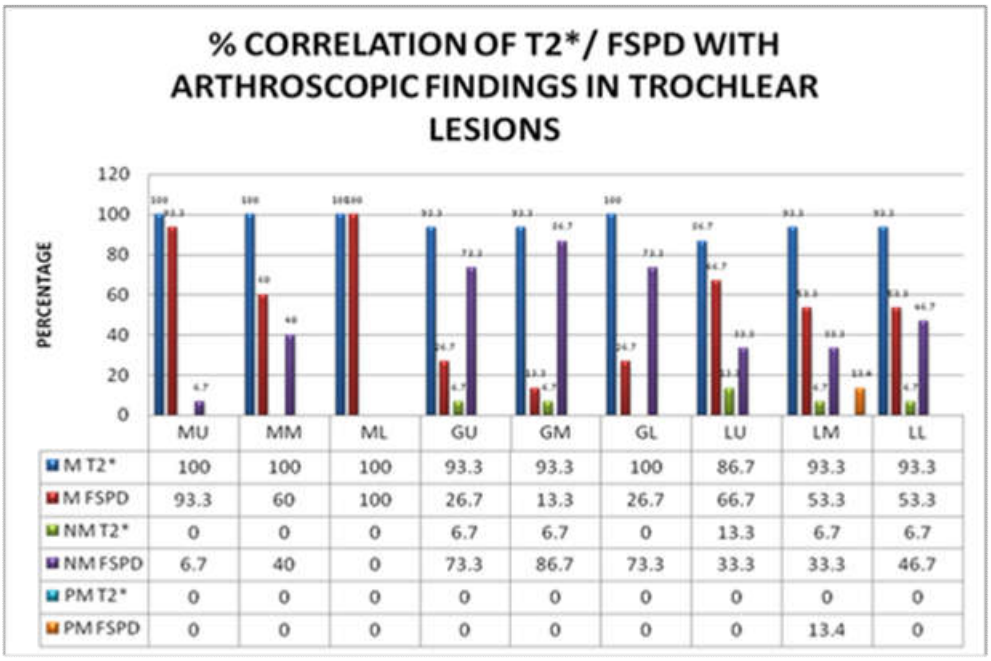


Graph 2. T2* and FSPD correlation in trochlear lesions



	MU	MM	ML	RU	RM	RL	LU	LM	LL
M T2*	93.3	93.3	86.7	100	73.3	86.7	100	80	93.3
M FSPD	86.7	86.7	86.7	66.7	40	60	60	73.3	80
NM T2*	6.7	6.7	13.3	0	26.7	13.3	0	20	0
NM FSPD	13.3	13.3	13.3	33.3	46.7	40	26.7	26.7	20
PM T2*	0	0	0	0	0	0	0	0	6.7
PM FSPD	0	0	0	0	13.3	0	13.3	0	0

Graph 3. % correlation of t2*/FSPD with arthroscopic findings in patellar lesions



	MU	MM	ML	GU	GM	GL	LU	LM	LL
M T2*	100	100	100	93.3	93.3	100	86.7	93.3	93.3
M FSPD	93.3	60	100	26.7	13.3	26.7	66.7	53.3	53.3
NM T2*	0	0	0	6.7	6.7	0	13.3	6.7	6.7
NM FSPD	6.7	40	0	73.3	86.7	73.3	33.3	33.3	46.7
PM T2*	0	0	0	0	0	0	0	0	0
PM FSPD	0	0	0	0	0	0	0	13.4	0

Graph 4. % correlation T2* / FSPD with arthroscopic findings in trochlear lesions

Trochlear quadrants

- Matching chondral lesions were seen in 100% of medial upper, middle and lower quadrants each, 93.3% of groove upper and middle quadrants each, 100% of groove lower, 86.7% of lateral upper and 93.3% of lateral middle and lateral lower quadrants each. Additional lesions on arthroscopy with apparently normal corresponding cartilage areas on T2* map (No match of chondral lesions) were observed in 6.7% of groove upper and middle quadrants each, 13.3 % of lateral upper and 6.7% of lateral middle and lateral lower quadrants each. Partial match was not observed in any of the trochlear quadrants. (***Graph 4***)
- On comparison of arthroscopic findings with FSPD image findings in 15 cases, results were as follows:

Patellar quadrants

- Matching chondral lesions were seen in 86.7 % of medial upper, middle and lower quadrants each, 66.7 % of ridge upper, 40% of ridge middle, 60% of ridge lower, 60% of lateral upper, 73.3% of lateral middle and 80 % of lateral lower quadrants. Additional lesions on arthroscopy with apparently normal corresponding cartilage areas on FSPD images (No match of chondral lesions) were observed in 13.3% of medial upper, middle and lower quadrants each, 33.3% of ridge upper, 46.7% of ridge middle, 40% of ridge lower, 26.7% of lateral upper, 26.7 % lateral middle and 20% of lateral lower quadrants. Partial match of chondral lesions was seen in 13.3 % of ridge middle and lateral upper quadrants each. (***Graph 3***)

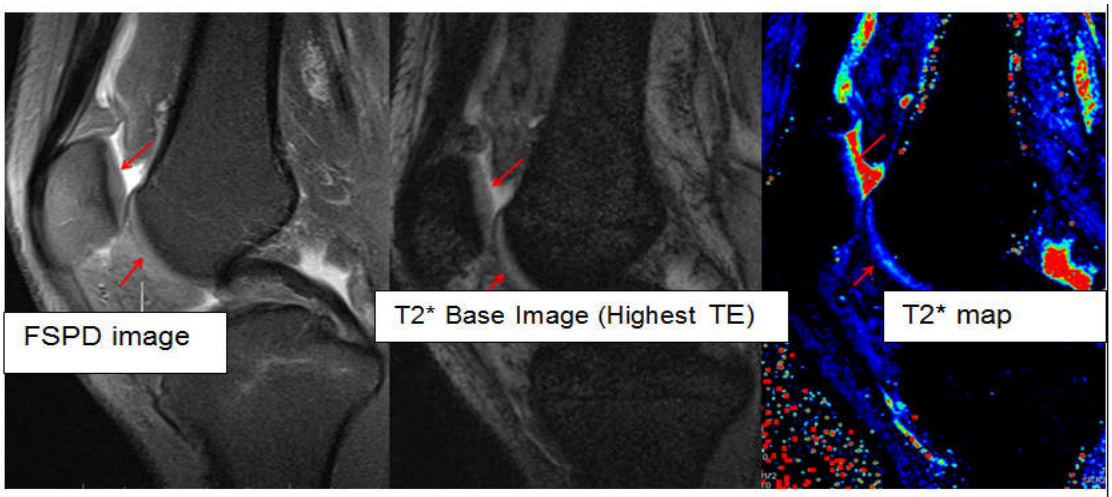


Figure 2: ***Normal cartilage****: sagittal images through patellar ridge /trochlear groove of 27yr old healthy male volunteer from our pilot study. FSPD and Highest TE T2* base images showing trilamellar normal trochlear cartilage with thin hypointense superficial lamina, deep hypointense lamina at the junction of the cartilage and subchondral bone and moderately high signal intensity intermediate lamina in between. T2* map image shows normal appearance of cartilage with smooth intact surface and uniform blue colour.*

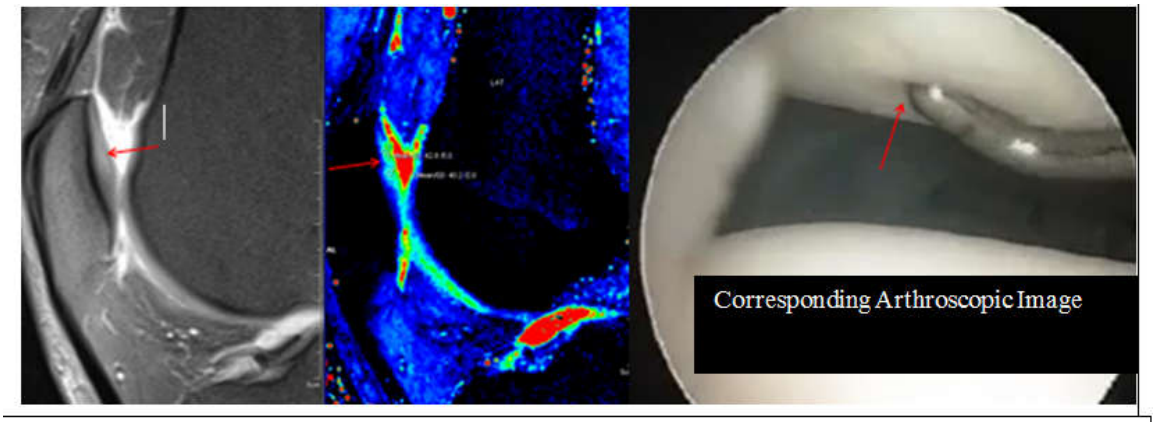


Figure 3: ***matching Grade I lesion****-Corresponding sagittal images and arthroscopic image of lateral patellar facet of a 29yr old female.FSPD-focal hyperintense signal in intermediate lamina of upper quadrant cartilage .T2* map -focal altered graded colour in upper quadrant cartilage. Arthroscopy - chondral softening with intact smooth surface in upper quadrant cartilage.*

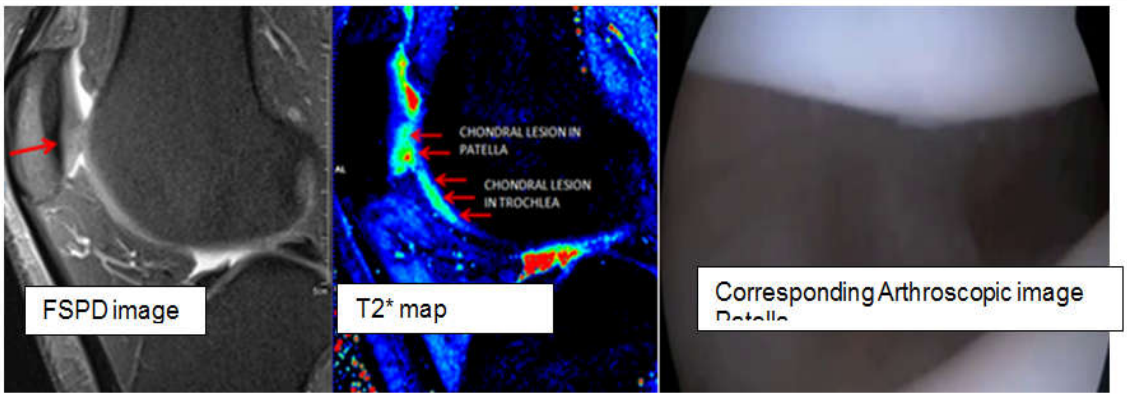


Figure 4: ***matching Grade II lesion Patella****-Corresponding sagittal images and arthroscopic image of lateral patellar facet of a 23yr old male. FSPD-focal discontinuity in superficial hypointense lamina with subjacent focal hyperintense signal in intermediate lamina of lower quadrant cartilage .T2* map-focal altered graded colour in lower quadrant cartilage. Arthroscopy- superficial chondral fibrillation in lower quadrant cartilage. A non-matching Grade I lesion is also seen in middle quadrant of trochlea.*

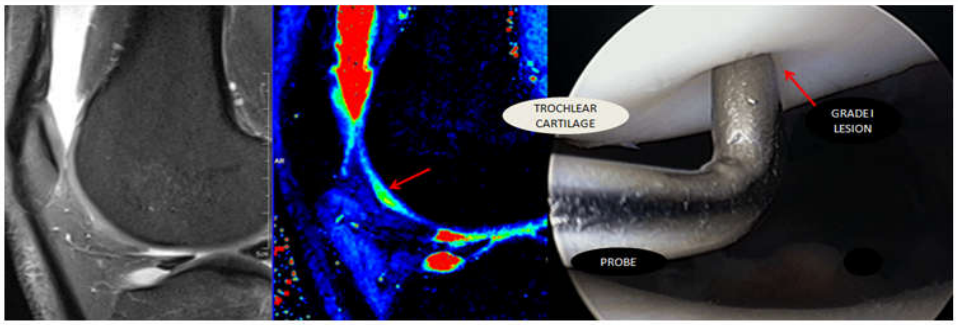


*Figure 5¦ **No match, Grade I lesion**-Corresponding sagittal images and arthroscopic image of lateral trochlear facet of a 27yr old male.FSPD-aparently normal trochlear cartilage.T2* map-altered graded colour in middle lateral trochlear quadrant cartilage. Arthroscopy - chondral softening with intact smooth surface in middle lateral trochlear quadrant cartilage.*

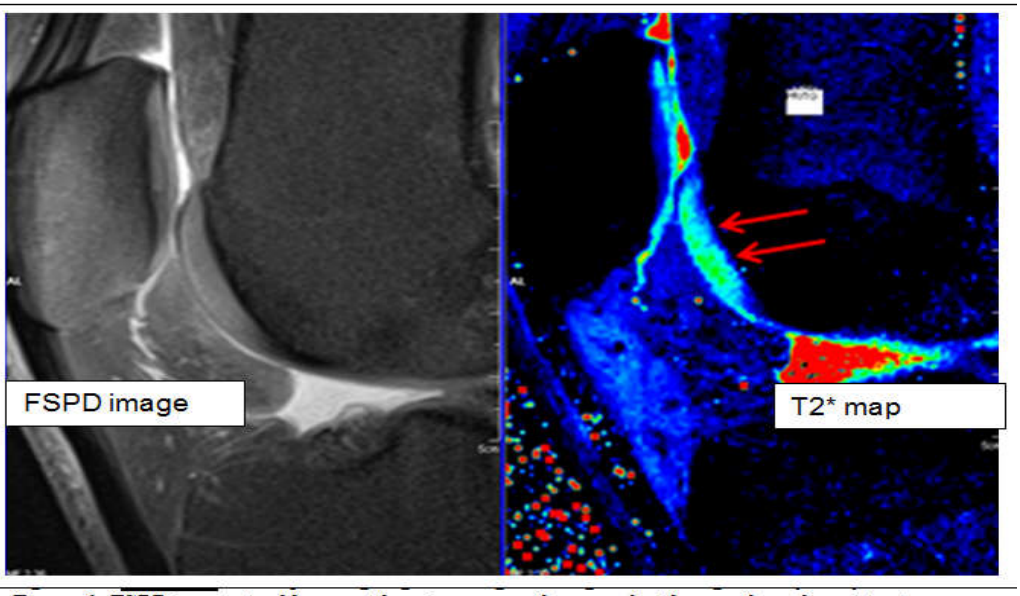


Figure 6 :FSPD image trochlear cartilage is apparently normal with smooth surface, intact superficial and deep hypointense laminae and normal signal intermediate lamina. On T2 map, cartilage shows normal thickness and smooth surface but with diffuse alteration of normal graded colour suggestive of early (Grade I) chondromalacia.*

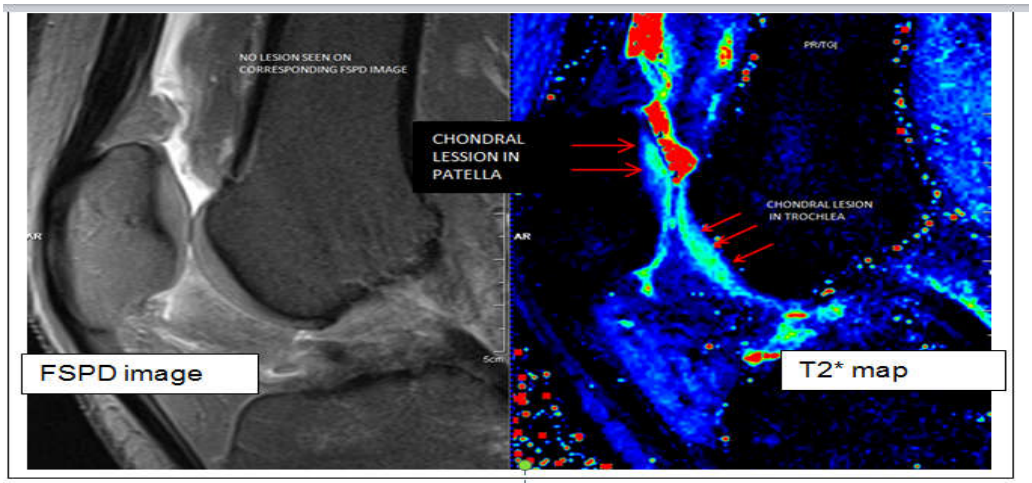


*Figure 7: **No match**-Corresponding sagittal images through patellar ridge-trochlear groove of a 38yr old female: on FSPD image patellar and trochlear cartilage is apparently normal with smooth surface, intact superficial and deep hypointense laminae and normal signal .On T2* map, cartilage shows normal thickness and smooth surface but with diffuse alteration of normal graded colour in trochlea and upper quadrant of patella suggestive of early (Grade I) chondromalacia*

Trochlear quadrants

- Matching chondral lesions were seen in 93.3% of medial upper, 60% of medial middle, 100% of medial lower, 26.7% of groove upper, 13.3% of groove middle, 26.7% of groove lower, 66.7% of lateral upper, 53.3% of lateral middle and 53.3% of lateral lower trochlear quadrants. Additional lesions on arthroscopy with apparently normal corresponding cartilage areas on FSPD images (No match of chondral lesions) were observed in 6.7% of medial upper, 40% of medial middle, 73.3% of groove upper, 86.7% of groove middle, 73.3% of groove lower, 33.3 % of lateral upper and middle quadrants each and 46.7% of lateral lower quadrants. Partial match was observed in 13.4 % of lateral middle quadrants. (Graph 4)
- Range of abnormal T2* values of chondral lesions determined from our observed values for patellar and trochlear lesions was 31.40-75.20 msec and mean T2* value was 42.31msec + 9.97 msec.
- We also found a small number of foci of dystrophic chondral calcification which were not well detected on T2* map images although they were well seen on T2* base images. These lesions appeared as dark foci within deep cartilage with adjacent blue coloured normal cartilage on T2 * map images. These foci showed significantly reduced T2* relaxation value with mean value of 17.13 msec.
- We also observed that sub-chondral cystic changes were not well depicted on T2* map although they were well seen on T2* base images.

DISCUSSION

- Our study was a prospective T2* cartilage mapping study of patellofemoral joint. We conducted a Pilot study in the beginning on 10 healthy asymptomatic volunteers (age group 15-30 yrs. 5 male,5 female) to determine a reference range of normal T2* values for patellar and trochlear cartilage. The range of normal T2* values was determined to be 20-26.60 msec while the mean T2* value was found to be 24.30 + 3.8 msec and this value was taken as reference normal T2* value. This is in contrast with T2* value of 30.9 +6.6 msec found in an earlier study by Welish *et al*. (2010) Variation in sequence design & machine used may be responsible for this difference.
- In our study we made a quadrant wise assessment, dividing patella and trochlea into 9 quadrants each. To our knowledge nine quadrant assessment has not been done so far in any study.
- On comparison of corresponding T2* map and FSPD images in patellar and trochlear quadrants, although good match was observed between two sequences in many patellar and trochlear quadrants, we found a significant number of additional chondral lesions on T2*map images only with apparently normal corresponding cartilage areas on FSPD, resulting in some discordance. Most of these additional non matching chondral lesions were areas of focal or diffuse colour alteration in a quadrant with intact and smooth cartilage surface (Grade I lesions), most of such lesions were found in the patellar ridge, trochlear groove and the lateral trochlear facet.
- In case of patellar cartilage, maximum discordance in patella was for quadrants of patellar ridge where extra chondral lesions were seen on T2*map with no visible lesions on corresponding FSPD images (no match) in maximum percentage of quadrants (36% upper ridge, 37% lower ridge).
- In case of trochlear cartilage, maximum discordance was in region of trochlear groove followed by majority of lateral trochlear facet quadrants where extra chondral lesions were found on T2* map with no lesions on corresponding FSPD images in maximum percentage of quadrants (60% upper groove, 66% middle groove and 47% lower groove,44% lateral middle, 40% lateral lower).
- Thus more early chondral lesions were detected on T2* cartilage mapping than on FS PD images. This observation was in concordance with an earlier study on T2 mapping of patellar lesions conducted by Hannila *et al*. (2007).
- Another important aspect of our study was calculation of T2* relaxation values of lesions. An important feature of T2* value of a lesion is that it remains constant and is not influenced by windowing or centering. In our study we obtained T2* value of all patellar and trochlear lesions individually and calculated range of abnormal values from them. Internal standard for normal T2* value was also obtained in every case. The range of T2* values of lesions was 31.40-75.20 msec and mean T2* value of lesions was 42.31msec + 9.97 msec.
- Range of T2* value of chondral lesions was significantly higher than reference normal range. This observation was in concordance with earlier studies conducted by Hannila *et al*. (2007), Apprich *et al*. (2012) and Dunn *et al*. (2010).
- Arthroscopy is considered as gold standard for evaluation of chondral pathology, however because of its invasive nature it is usually a last resort investigation and is used only in diagnostically difficult cases or with therapeutic intention. In a limited number (15) of our patients, arthroscopic follow up was done. A blank pictorial graph representing nine quadrant surface anatomy of patella and trochlea was provided to two arthroscopic surgeons and surgeons marked presence and number of lesions on it according to modified Outerbridge classification.
- The nine quadrant pictorial graphs of arthroscopic findings were compared separately with corresponding T2*map and FSPD image findings in a quadrant wise manner.
- A good correlation was observed between arthroscopic findings and findings on corresponding T2 * map images although a few additional lesions not picked on T2* map were found on arthroscopy.
- In case of patella, percentage of quadrants with matching chondral lesions was good for medial facet (93.3% upper and middle each, 86.7% lower), majority of ridge quadrants (100% upper, 73.3% middle and 86.7% lower) and lateral facet (100% upper, 80% middle and 93.3% lower quadrants).Partially matching chondral lesions were seen in 6.7 % of lateral lower quadrants. Percentage of quadrants with additional lesions on arthroscopy and apparently normal corresponding cartilage areas on T2* map (no match)

was highest for middle ridge (26.7%) followed by lateral middle quadrant (20%), lower ridge (13.3%) and medial lower quadrant (13.3%).Thus except for ridge middle and lateral middle quadrants where correlation between T2* map and arthroscopic findings was little lower, matching lesions were found in 86-100% of rest of patellar quadrants.

- In case of trochlea, percentage of quadrants with matching chondral lesions was very good for medial facet (100% upper, middle and lower each), good for groove (93.3% of groove upper and middle each, 100% of groove lower), and lateral facet (86.7% upper , 93.3% middle and lower each) .Partial match was not observed in any of the trochlear quadrants. Percentage of quadrants with additional lesions on arthroscopy and apparently normal corresponding cartilage areas on T2* map (no match) was low, with a maximum of 13.3% in lateral upper quadrant.
- Correlation between arthroscopic findings and MR analysis on FSPD images showed good match in certain quadrants and poor match in certain quadrants.
- In case of patella, percentage of quadrants with matching chondral lesions was good for medial facet (86.7% upper, middle and lower each) and majority of lateral facet (60% upper, 73.7% middle and 80% lower) while this percentage was low for patellar ridge (66.7% upper, 40% middle and 60% lower). Partially matching lesions were found in 13.3% of ridge middle and lateral upper quadrants each. Percentage of quadrants with lesions on arthroscopy and apparently normal corresponding FSPD images (no match) was highest for ridge (33.3% upper, 46.7% middle and 40% lower quadrants) followed by lateral facet (26.7% upper, 26.7% middle and 20% lower quadrants). From these observations it was obvious that maximum discordance was in region of patellar ridge
- In case of trochlea, percentage of quadrants with matching chondral lesions was good for majority of medial facet (93.3%upper, 100%lower, 60%middle) while this percentage was very low for groove (26.7% upper, 13.3% middle and 26.7% lower quadrants) and low for majority of lateral facet (66.7% upper, 53.3% middle and 53.3% lower quadrants). Partially matching chondral lesions were seen in only 13.4% of lateral middle trochlear quadrants. Percentage of trochlear quadrants with chondral lesions on arthroscopy and apparently normal corresponding FSPD images was highest for trochlear groove (73.3% upper, 86.7% middle and73.3%) followed by lateral trochlear facet (33.3% upper, 33.3% middle and 46.7% lower) and medial middle quadrant (40%).
- From above discussion it was obvious that greater number of chondral lesions was detected on T2* cartilage mapping sequence than FSPD imaging sequence in almost all patellar and trochlear quadrants with significantly increased detection of lesions in certain quadrants. This fact was proved to some extent by better concordance of T2* map findings with arthroscopic findings than that of FSPD findings in limited number of patients with arthroscopic follow up. Detection of chondral lesions was statistically significantly better on T2 * map in following patella and trochlear quadrants .Ridge upper P –value= 0.04 *, Lateral upper quadrant of patella P-value=0.01*, medial middle quadrant of trochlea P -value =0.01*, groove upper P –value = .0005 *** (highly significant), groove middle P -value = 0.0001****(highly significant), groove lower p-value= 0.0001 **** (highly significant), lateral middle trochlea p-value = 0.03*, lateral lower trochlea p-value = 0.03*
- In our study, we found a small number of foci of dystrophic chondral calcification which were not well detected on T2* map images although they were well seen on T2* base images. These lesions appeared as dark foci within deep cartilage with adjacent blue coloured normal cartilage on T2 * map images. These foci showed significantly reduced T2* relaxation value with mean value of 17.13 ms. We also observed that subchondral cystic changes were not well detected on T2* map and were better appreciated on T2* base images and FSPD images. These observations emphasize the fact that T2* base images also have a significant role in detection of chondral lesions, especially higher grade lesions, subchondral cystic change and dystrophic chondral calcification and therefore should not be ignored.
- There were few limitations in our study. Our study was a single observer study. Foci of dystrophic chondral calcification and subchondral cystic changes were suboptimal visualized on T2* map although they were well seen on T2* base images. Arthroscopic follow up was limited.

Conclusion

In our prospective study of T2* cartilage mapping of patellofemoral joint for chondral lesions we observed that greater number of early chondral lesions was detected on T2* cartilage mapping sequence than FSPD sequence in all the nine quadrants of patella as well as trochlea. Although complete match of chondral lesions was found overall in 65.34% of quadrants, additional chondral lesions were detected on T2*cartilage mapping in 30.50% of patellofemoral quadrants with apparently normal corresponding cartilage on FSPD images. Better detection of early chondral lesions on T2* cartilage mapping was statistically significant in following patellar and trochlear quadrants. Upper quadrant of ridge, upper quadrant of lateral patellar facet, middle quadrant of medial trochlear facet, upper, middle and lower quadrants of trochlear groove, middle and lower quadrants of lateral trochlear facet. Also from our sub study observation on patients with arthroscopic follow up,T2*cartilage mapping sequence showed better concordance with arthroscopy than FSPD imaging sequence with statistically significantly better concordance in above mentioned quadrants. The above mentioned quadrants of patellofemoral joint are actually more vulnerable to degeneration and need to be viewed with high degree of suspicion on conventional sequences. We recommend routine use of T2* cartilage mapping, so as to detect early chondral lesions which may explain cause of pain in many patients and help in planning chondroprotective strategies.

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