Comparison of dStream Flex M coil and dStream MSK M coil for MR imaging of Knee at 1.5T in Tertiary care Hospital.

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ABSTRACT

Retrospective and qualitative study was done with the purpose to assess feasibility of RF coils for imaging knee where 25 subjects were taken as sample of the study. Shoulder coil (dStream Flex M coil) and dedicated knee coil (dStream MSK M coil) were the two RF coils with different configuration used for the experiment. Two sequences STIR (Short TI Inversion Recovery) and T1 weighted were applied while using each of the coils during knee MRI scan of every patient. Signal-to-noise ratio (SNR) and Specific Absorption Rate (SAR) were measured to obtain statistically significant difference between dStream Flex M coil and dStream MSK M coil. Image quality of two sets of images obtained from each one of the coils was analysed. Two licensed skilled radiologists had evaluated the images acquired by using both coils with the help of grading method. During T1 weighted sequence slightly increased SNR value was observed with knee coil as compared to SNR obtained while using shoulder coil. No change was observed in SNR value obtained while using both shoulder and knee coil during STIR sequences. Constant SAR of <1.6 W/Kg was observed with both shoulder and knee coil during STIR sequences, similarly SAR of <1.7 W/Kg was observed during T1 weighted sequences with both shoulder and knee coil. Good or excellent similarity was found on the basis of qualitative analysis of images through grading method done by the two radiologists R1 and R2. On the basis of qualitative analysis, it was evident that both coils can be used for knee MRI scans.

KEYWORDS: MRI, dStream MSK M coil, dStream Flex M coil, CNR, SAR

INTRODUCTION

MRI is a imaging technique which uses radio-frequency waves, magnetic field gradients, strong magnetic field, and computers to generate cross- sectional images of the organs of the body. Use of magnetic field and radio-frequency pulse prevents harmful effects from ionizing radiation. While the risks associated with the use of ionizing radiation are well controlled in CT, still MRI may be seen as superior and preferable choice than a CT scan [1].MRI scan can be used to diagnose specific types of heart disease, infertility, tumours, cysts, congenital anomalies, metabolic disorders, internal auditory canal pathology, stroke, infection, inflammation, tumour, multiple sclerosis, post-trauma, congenital malformations, vascular pathology, pituitary fossa pathology, nerve palsies, etc. Those people who have implants inside their body are not allowed inside the bore. If in case any ferromagnetic substance enters the vicinity of MRI machine it will get strongly pulled by the strong magnetic field, which results into injury to the patient and damage to the MRI machine [2]. Active shielding from external magnetic field is achieved by using additional coils which are used to place inside the magnet assembly, currents in coil produce magnetic field which reduces the external magnetic field [3]. In MRI transmitter coils are used to apply radio frequency pulses. Gradients are applied with the help of gradient amplifiers by applying electric current to the electromagnetic coil windings within main magnetic field. Weak radio frequency signals are generated by the nuclear spins can be detected by the receiver coils. This signal is then amplified, filtered and digitized by the receiver [4].

History of MRI starts when Nikola Tesla first observed rotating magnetic field in 1892 [5]. Then in 1897 Larmor relationship was given by Sir Joseph Larmor [6]. In 1937, Professor Isidor I. Rabi measures that magnetic moment of nucleus coins “magnetic resonance”. In 1972 Damadian discovers or invents that as tumours contain more oxygen, signal of hydrogen in cancerous tissue is different from that of healthy tissue. The bath of radio waves will linger longer in cancerous tissue than from the healthy tissues when machine was switched off [7] Magnets, Gradient coils, Shim coils, Radio-Frequency coils, Magnetic field shielding and Computer System are the components of MRI unit. Magnets are the main component of MRI, dimension and orientation of the working volume, field strength, stray field dimensions, operating costs, weight of the magnet, bore size, spatial homogeneity are the specifications which are used for the correct choice of the magnets [3,8].

Radio-Frequency coils consists of loops of wire, when current is applied to pass through these coils, they used to produce B_1 magnetic field which is needed to excite the nuclear spins. These coils are used to transmit and receive signal. RF coils are the essential part of MRI hardware components. They directly impact the spatial and temporal resolution, sensitivity and uniformity in MRI. They are like wireless signal transmitter/receiver of the MRI system. RF coils can be received only, in which case the body coil is used as a transmitter; or transmit and receive(transceiver) [9]. RF coils generate transverse precession magnetization by emitting magnetic field pulses to rotate the net magnetization away from its alignment with the main magnetic field. Surface coils and phase array coils are example of transmit/receive coils which are currently used in MR imaging. **Surface coils** are especially designed small coils consist of partial loop of wire. They provide high Signal-to-noise ratio when tissue placed adjacent to the coil. Commonly used for spines, shoulders, temporo-mandibular joints and for relatively small body parts as highly efficient receive only coils [10]. **Array coils** are formed by combining two or more surface coils to cover the complete interested area for diagnosis. Signal from each of the individual coils are combined by some electronic components to get single image of the coverage area and are further categorized into isolated array coils, coupled array coils, Phased array coils **Volume coils** can completely encompass the anatomy of interest. It provides homogenous RF excitation across large volume and are great for transmitting. Most clinical MRI scanners include a built-in volume coil to perform whole body imaging, and smaller volume coils have been constructed for head and other extremities. Common volume coils are circulatory polarized coil, quadrature coil, bird cage coil, Helmholtz coil, paired saddle coil, single turn solenoid coil, [11] multiple turn solenoid coils. There are some risks associated with MRI some of them are Quenching of the magnetic field, external projectile effect, internal projectile effects, gradient field change, claustrophobia, acoustic noise etc [12].

Above mentioned coils are dedicatedly designed for specific body parts. By using different coils than those designed for study may or may not have some impact on image quality of scan. In order to optimize the coil selection for study of particular region of interest, signal characterization of different coils for that region of interest is necessary. Signal-to-noise ratio need to be obtained to compare the changes by using different coil than that designed for the study. The study was conducted to assess feasibility of dedicatedly designed radiofrequency coils for imaging other organs by comparison of Signal-to-Noise ratio (SNR) and Specific Absorption Rate (SAR) from both radio-frequency coils.

MATERIALS AND METHODS

Retrospective and qualitative study was conducted in Radiology department of a Tertiary care hospital on Philips Multiva 1.5T magnetic resonance imaging system [13] Two RF coils with different configuration were used in the study. One out of the two coils were 8-channel dStream MSK M coil (0.98 Kg light weighted) which was dedicated for knee scan and other one is 2-channel dStream Flex M coil dedicatedly designed for shoulder MRI [14].

Sampling method: Primary data was collected by doing knee MRI of each one of the volunteers after getting written informed consent for research purpose. Two RF coils with different configuration (out of which one is dedicated coil) were used for the experiment. Sequence protocol of study consists of STIR (Short TI Inversion Recovery) and T1 weighted sequences. During sampling of each one of the volunteers, firstly images were acquired by using STIR (Short TI Inversion Recovery) and T1 weighted sequences with dStream Flex M coil (shoulder coil). dStream Flex M coil was replaced with dStream MSK M coil (dedicated knee coil) and the same knee was scanned with same protocols as before.

Study variables: Demographics: Age, gender, type of coil used, on the basis of sequences, SNR (signal-to-noise ratio), and SAR (Specific Absorption Rate). Clinical variables: On the basis of clinical history of patients.

Duration of study: Study was conducted from December 2020 to May 2021.

Sample size: Total 25 volunteers were selected as the sample of the study with their written consent to have MRI scan for research purpose. Volunteers were selected for the study with no age bar. 16 males and 9 females were included in the study.

Technique of study: This was a comparative type of study in which all patients who were referred for knee MRI had undergone knee MRI scans by using both dStream MSK M coil (dedicated knee coil) and dStream flex M coil (shoulder coil) one by one. Two sequences STIR (Short TI Inversion Recovery) and T1 weighted were applied while using both of the coils during experiment. STIR sequences were applied with long TR of 3635 ms and short TE of 30ms. T1 weighted images were obtained by using short TR of 500 ms and short TE of 17 ms. Images were collected on 312*240 matrix size during STIR sequence and on 400*272 matrix size during

T1 weighted sequences. Slice thickness opted for scan was 3.5 mm with an inter slice gap of 0.4 mm. FOV of 190 mm was used in STIR sequences and 180 mm during T1 weighted sequences.

Quantitative analysis: Signal-to-noise ratio (SNR) and Specific Absorption Rate (SAR) were measured to obtain statistically significant difference between dStream Flex M coil (shoulder coil) and dStream MSK M coil (dedicated knee coil).

- Signal-to-noise ratio was obtained by mean signal intensity within defined region of interest by standard deviation of noise [15].
- Specific Absorption Rate (SAR) was also measured during scan with both of the coils.
- Differences between parameters obtained from two coils of different configuration was calculated and analysed.

Qualitative analysis: Image quality of two sets of images obtained from each one of the coils were analysed. Two licensed skilled radiologists with minimum clinical experience of 10 years were requested to evaluate the images acquired by using both coils with the help of grading method. Grading criteria of 1-5 was chosen for comparison of image quality by two senior radiologists [14].

Grading criteria from 1 to 5 was prepared where:

- Grade “1” indicates unacceptable quality of images
- Grade “2” indicates poor but acceptable quality of images
- Grade “3” indicates average quality of images
- Grade “4” indicates good quality of images
- Grade “5” indicates very good quality of images

❖ At last qualitative and quantitative data obtained from two different coils was analysed by using descriptive statistical tools, excel sheets, frequency mean and percentage.

RESULTS

Results showed that during T1 weighted sequences, knee coil yielded slight increased SNR value as compared to SNR obtained by using shoulder coil. Homogenous value of SNR that is 1 was observed during STIR sequence with both coils. Slight loss of 0.03 in SNR value was observed while using shoulder coil during T1 sequences in most of the patients. Constant SAR of <1.6 W/Kg was observed with both shoulder and knee coil during STIR sequences, similarly SAR of <1.7 W/Kg was observed during T1 weighted sequences while using both shoulder and knee coil.

Table 1. Demographic representation of SNR and number of patients while using dStream Flex M coil.

	Number of Patients	
SNR	**STIR**	**T1**
Less than 1	0	24
Equal to 1	25	1
More than 1	0	0

Table 2. Demographic representation of SNR and number of patients while using dStream MSK M coil.

	Number of Patients	
SNR	**STIR**	**T1**
Less than 1	0	1
Equal to 1	25	22
More than 1	0	2

Table 3. Demographic representation of SAR and number of patients while using dStream Flex M coil.

	Number of Patients	
SNR	**STIR**	**T1**
Less than 1.5	0	0
Equal to 1.5	0	0
More than 1.5	25	25

Table 4. Demographic representation of SAR and number of patients while using dStream MSK M coil.

	Number of Patients	
SNR	**STIR**	**T1**
Less than 1.5	0	0
Equal to 1.5	0	0
More than 1.5	25	25

Scans obtained by using two different coils were qualitatively analysed by two radiologists R1 and R2. On a dedicated knee coil images during STIR sequences, radiologist R1 had given mean grading of 4.56 and radiologist R2 had given mean reading of 4.6. On images obtained by using shoulder coil during STIR sequences, radiologist R1 has given mean reading of 4.12 and radiologist R2 had given mean reading of 4.32. On a dedicated knee coil images during T1 weighted sequences, radiologist R1 given mean grading of 4.92 and radiologist R2 had given mean reading of 5. On images obtained by using shoulder coil during T1 weighted sequences, radiologist R1 given mean reading of 4.84 and radiologist had given mean reading of 4.84.

Mean difference between grading given by R1 and R2 radiologists during STIR sequences with knee coil and shoulder coil is 0.04 and 0.2. Mean difference between grading given by R1 and R2 radiologists during T1 weighted sequences with knee coil and shoulder coil is 0.08 and 0 respectively.

Table 5. Mean grading given by Two radiologists during qualitative analysis while using dStream Flex M coil.

	Mean Grading	
Sequences	**R1**	**R2**
STIR	4.12	4.32
T1	4.84	4.84

Table 6. Mean grading given by Two radiologists during qualitative analysis while using dStream MSK M coil.

	Mean Grading	
Sequences	**R1**	**R2**
STIR	4.56	4.6
T1	4.92	5

Knee MRI images results using STIR sequences with knee coil possess an average SNR of 1, this value is similar to MRI images of knee using STIR sequences with shoulder coil. Similarly, Knee MRI images results using T1 weighted sequences with knee coil possess an average SNR of 1, this value is higher than MRI images of knee using T1 weighted sequences with shoulder coil with an average value of 0.97. Overall mean difference between grades given to images obtained by using knee coil and images obtained by using shoulder coil by R1 and R2 radiologist is 4.77. Mean difference between grades indicates that quality of images obtained by using both of the coils was almost equal.

Good or excellent similarity was found on the basis of qualitative analysis of images by grading method between the two radiologists R1 and R2. On the basis of qualitative analysis, it was evident that both dStream MSK M coil (dedicated knee coil) and dStream MSK M coil (shoulder coil) can be used for knee MRI scans.

Figures 4. Knee MRI images of male patient captured during T1 weighted sequence by using knee coil (A) and shoulder coil (B).

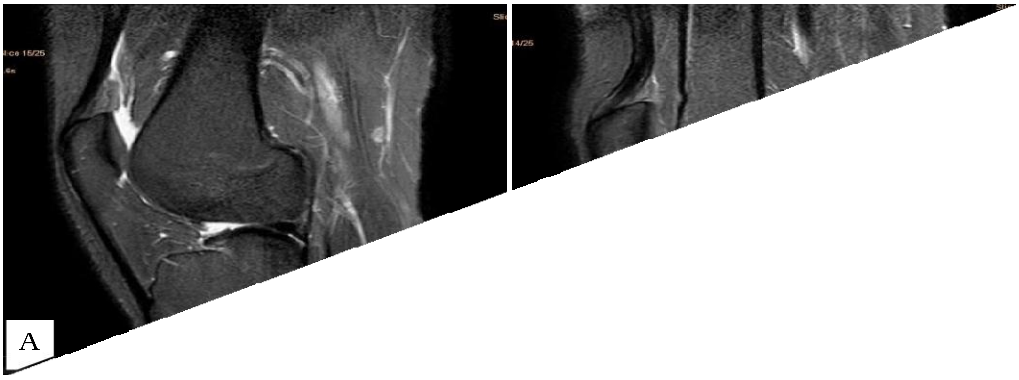

Figure 5. Knee MRI images of patient captured during STIR sequence by using knee coil (A) and shoulder coil (B).

DISCUSSION

During MRI scan RF coils plays an important role in displaying disease properly. Nowadays, multiple coils with different geometries or structure are being opted for better resolution imaging. Most of the coils are dedicatedly built for specific part of the body which makes necessary that dedicated coil should be applied for particular part of the body. Geometry of coil sometimes can prevent its use for number of studies like small wrist coil cannot be use for cervical scanning or shoulder scanning.

When comparing present study with the previous work done by D. Nespor by comparing slotted tube, parallel plate and saddle coil in 2014,[16] it is found that similar results were obtained, as in both of the studies roughly equal SNR was observed for RF coils of different configuration.

On the other hand, significant difference in spatial resolution and SNR was found while comparing surface coil with body and head coil in previous work done by Patton on technical consideration of coils [15]. In negligible difference was found by measuring SNR of two different coils.

Significant difference in SNR values of surface coil and head coil during particular sequence was found in previous study of TMJ joint done in 2019 by Qi sun.[13] Study concluded that both the coils, 15-channel phased array head coil and 6-channel dStream Flex M Surface coils were efficient for temporo-mandibular joint scanning and present study demonstrates that both dStream MSK M coil (dedicated knee coil) and dStream MSK M coil (shoulder coil) can be used for knee MRI scans.

The results of the study done in 2019 by Samsun [14] shows that marked difference in SNR obtained by using knee coil and surface coil was found. SNR with knee coil was found to be higher than SNR with knee coil while in present study no significant difference in SNR of two RF coils was found which indicates that both dStream MSK M coil and dStream M Flex coil provides almost same spatial resolution.

Qualitative analysis of this study was done by evaluating image quality of two sets of images obtained from each one of the coils. Two licensed skilled radiologists named as (R1) and (R2) evaluated the images acquired by using both coils with the help of grading method. Grading criteria of 1-5 was chosen for comparison of image quality by two senior radiologists.

Study done Sri Mulyati Jakarta showed that better signal-to-noise ratio was observed with the surface coil as compare to M flex coil, it concluded that shoulder coil had provided better image quality than M flex coil [17] while in present study slight difference in magnitude of signal-to-noise ratio was observed and almost same quality of images were obtained from both of the coils. On the basis of administration of coils, knee coils can be easily applied to the patient and comfortable to wear during knee scan. They provide better stability in their attachment to the patient during knee MRI scan as compare to shoulder coil, which must be adjusted above or below the knee of patient and taped in that position to avoid instability of coil, this decreases the coil displacement and make it easier to maintain desired position of patient. On the basis of both qualitative and quantitative analysis it was evident that both dStream MSK M coil (dedicated knee coil) and dStream Flex M coil (shoulder coil) can be used for knee MRI.

CONCLUSION

Study demonstrates that dedicated knee coil during STIR sequence and shoulder coil during STIR sequence had significantly same SAR value for specific application of knee MRI scan.

With no difference in SNR value of knee anatomy by using knee coil and shoulder coil during STIR sequences and with negligible difference of 0.03 in SNR value of knee anatomy by using knee and shoulder coil during T1 weighted sequences indicates that both knee coil and shoulder coil are equally suitable for high resolution imaging of knee. With mean difference of 0.04 and 0.02 in grading during STIR sequences by using knee coil and shoulder coil and with mean difference of 0.08 and 0 in grading during T1 weighted sequences by using shoulder and knee coil, it was clarified that negligible difference in quality of images was found, which demonstrates that both coils dStream MSK M coil (dedicated knee coil) and dStream Flex M coil (shoulder coil) were of same advantageous properties for knee scanning. So, both coils can be used for knee MRI imaging. In future we aim to further improve the design and apply the coil during scan of other body parts also with scanning of body parts coil is dedicated with.

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