ORIGINAL ARTICLE

MRI-Based Characterization of Uterine Fibroids and their Impact on Fertility and Treatment Outcomes in Pakistani Women: A Cross-Sectional Study

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ABSTRACT

Background: Uterine fibroids are common benign tumors that adversely affect reproductive outcomes. Magnetic resonance imaging (MRI) is evaluated for its ability to characterize fibroid features and predict fertility outcomes in Pakistani women.

Methods: Seventy women aged 20–45 years were enrolled in this cross-sectional study, n=35 normal control group and 35 patients with diagnosed uterine fibroids. In all participants, pelvic MRI was performed with a 1.5 T scanner using T1w, T2w, and contrast-enhanced sequences. The fibroid characteristics – maximum diameter, number, anatomic location (submucosal, intramural, or subserosal) – were meticulously documented. Structured interviews and medical records were collected to obtain clinical and reproductive data. Student's t-test and chi-square tests were used to do group comparisons, and a multivariate logistic regression model was used to determine the independent effects of the MRI parameters on fertility outcomes.

Results: The mean time to conception was 12 months for the fibroid group vs. 8 months for controls ($p < 0.05$), and the fibroid group had a significantly higher infertility rate (42.9% vs. 14.3%; $p < 0.05$). Multivariate analysis showed that for each 1 cm increase in fibroid diameter, the odds of conception were also reduced by 25% (aOR 0.75, 95% CI 0.60–0.90; $p = 0.004$), and submucosal fibroids significantly reduced the likelihood of conception (aOR 0.50, 95% CI 0.30–0.85; $p = 0.02$).

Conclusions: MRI-based evaluation gives an understanding of fibroid characteristics that affect fertility. Clinical decision-making and reproductive outcomes may be improved in women with fibroid-related infertility with the aid of detailed imaging.

Keywords: Uterine fibroids, MRI, infertility, submucosal, cross-sectional study, Pakistani women, reproductive outcomes.

INTRODUCTION

Uterine fibroids (leiomyomas) are the most common gynecological condition of the uterus in reproductive years, benign smooth muscle tumors of the uterus[1]. The clinical presentation can be highly variable, ranging from an asymptomatic case found incidentally on routine examinations to severe manifestations, including heavy menstrual bleeding, pelvic pain, and reproductive dysfunction. Fibroids have become a major public health issue because of their high prevalence and their ability to disturb normal uterine function[2].

Fibroids may disrupt implantation, normal uterine contractility, and the endometrial environment, and thus fibroids are associated with infertility or adverse pregnancy outcomes[3]. In light of the correlation between fibroid characteristics (size, number, and anatomical location) and fertility challenges, there is a need for precise diagnostic methods to help tailor treatment strategies. This is particularly important for women whose fertility potential is impaired by such lesions[4].

This is especially important within the Pakistani context because of the burden of uterine fibroids. Fibroids are often delayed in diagnosis and management due to cultural stigmas about reproductive health, limited access to advanced diagnostic tools, and socioeconomic barriers[5]. The diagnosis of infertility can be further complicated by prolonged periods of discomfort and reproductive uncertainty for Pakistani women before receiving an accurate diagnosis. Therefore, there is an urgent need for the use of reliable and comprehensive diagnostic techniques to help detect early and guide a more effective treatment plan[6].

The gold standard for the detailed evaluation of uterine fibroids has become magnetic resonance imaging (MRI). By its superior soft tissue contrast resolution, it can accurately assess fibroid characteristics, including size, number, location, and degenerative changes[7]. Unlike conventional ultrasonography, MRI offers clinicians a multidimensional view of the uterine architecture, which improves the precision of preoperative planning and risk stratification. This level of diagnostic detail is especially important when contemplating interventions to preserve fertility since it will assist in determining which fibroid features are most likely to compromise reproductive function[8].

This study of MRI aimed as an effective method of uterine fibroid assessment, there is a lack of data on its use in the Pakistani healthcare setting. Little is known about how MRI-based characterization correlates with fertility outcome and success to different treatment modalities in this particular group[9]. This gap needs to be addressed not only for refining clinical decision making but also to enable personalized patient care strategies that are responsive to the specific demographic and socio-cultural Pakistani women[10, 11].

To bridge this gap, the present cross-sectional study will systematically assess the MRI features of uterine fibroids and their relation to both fertility status and treatment outcome in Pakistani women. The study attempts to create a robust framework for optimizing management strategies in this population by correlating detailed imaging findings to clinical parameters and improving diagnostic accuracy and targeted therapeutic interventions in a population that stands to benefit greatly from it[8].

MATERIALS AND METHODS

Study Design and Population: This was a cross-sectional study undertaken between January 2021 and December 2022 at tertiary care centres in Pakistan. A total of n=70 women were enrolled: n=35 normal controls without uterine fibroids and n=35 patients with uterine fibroids according to clinical and imaging findings. Excluded were women with a history of pelvic malignancy, previous uterine surgeries, or contraindications to MRI or contrast agents.

MRI Protocol and Image Analysis: A standardized imaging protocol was used to obtain pelvic MRI of all participants using a 1.5 Tesla scanner designed to optimize visualization of uterine structures and fibroid characteristics. Anatomical assessment, vascularity, and degenerative changes were assessed using the protocol with T1 weighted sequences in axial and sagittal planes, T2 weighted sequences in axial, sagittal, and coronal planes for improved tissue contrast, and contrast enhanced sequences following the administration of a gadolinium based agent. The

scans were independently reviewed by two experienced radiologists who did not have access to clinical data. Among these parameters, they recorded the maximum fibroid diameter, number, and the anatomical location (submucosal, intramural, or subserosal according to FIGO guidelines), and signal characteristics and evidence of degeneration. The consensus resolved any discrepancies.

Clinical Data Collection: Structured interviews and patient medical record reviews provided compiled clinical data. Data included demographic information, symptom duration and nature, previous interventions, and reproductive history. Duration of infertility (fertility status), attempts at conception, and use of assisted reproductive technologies were evaluated to determine fertility status.

Treatment Modalities and Outcome Assessment: Clinical presentation, as well as reproductive goals for the patients, dictated management decisions. Individual clinical indications as to whether the fibroid patient group should be managed conservatively (via medical therapy and observation) or surgically (e.g., myomectomy or uterine artery embolization) were followed. Treatments were assessed with primary endpoints of symptomatic improvement and conception rates for those who desire pregnancy over a minimum follow-up of 12 months.

Ethical Considerations: The study was conducted by the Declaration of Helsinki, and the Institutional Review Boards of the participating centres approved the study protocol. All data were deidentified to ensure confidentiality, and written informed consent was obtained from all participants.

Statistical Analysis: The data was analyzed with SPSS version 25. Means with standard deviations and frequencies with percents were used to present continuous variables and categorical variables, respectively. The student's t-test was used for continuous variables and the chi-square test for categorical for group comparisons with $p < 0.05$ being deemed statistically significant. To assess the predictive value of MRI parameters on fertility outcomes and treatment success, regression analyses were also performed.

RESULTS

Seventy women were enrolled, n=35 normal controls and n=35 patients with uterine fibroids. No significant difference in mean age or BMI was found between the groups at baseline demographic characteristics (Table 1). Nevertheless, the prevalence of infertility was considerably higher in the fibroid group (42.9% vs. 14.3%, $p = 0.01$).

Table 1: Demographic and Baseline Characteristics

Parameter	Normal Controls (n=35)	Fibroid Patients (n=35)	p-value
Age (years)	32.4 ± 4.5	34.2 ± 5.7	0.08
BMI (kg/m²)	24.8 ± 2.1	25.3 ± 2.5	0.45
Infertility (%)	5 (14.3%)	15 (42.9%)	0.01*

*Statistically significant at $p < 0.05$.

MRI evaluation (Table 2) was the detailed characterization of uterine fibroids within the fibroid group. Fibroid size was 4.8 ± 1.2 cm and was single in 15 (42.9 %) patients and multiple in 20 (57.1 %). Regarding anatomical location, 10 (28.6%) were submucosal, 18 (51.4%) intramural, and 7 (20%) subserosal. Twenty-five (71.4%) patients exhibited homogeneous signal characteristics in T2 weighted images, while 10 (28.6%) showed heterogeneous signal intensity, indicative of degenerative changes.

Table 2: MRI Characteristics of Uterine Fibroids (n=35)

Parameter	Value
Maximum Fibroid Diameter (cm)	4.8 ± 1.2
Number of Fibroids	Single: 15 (42.9%)
	Multiple: 20 (57.1%)
Anatomical Location	Submucosal: 10 (28.6%)
	Intramural: 18 (51.4%)
	Subserosal: 7 (20%)
T2 Signal Characteristics	Homogeneous: 25 (71.4%)
	Heterogeneous: 10 (28.6%)

Table 3 summarizes fertility outcomes. A significantly lower conception rate (57.1% versus 85.7%; $p = 0.02$), prolonged mean time to conception (12 ± 3.2 versus 8 ± 2.5 months; $p = 0.01$) and increased overall infertility rate (42.9% versus 14.3%; $p = 0.01$) was noted in the fibroid group compared to normal controls.

Table 3: Fertility Outcomes in Normal Controls vs. Fibroid Patients

Fertility Outcome	Normal Controls (n=35)	Fibroid Patients (n=35)	p-value
Conception Rate	30 (85.7%)	20 (57.1%)	0.02*
Mean Time to Conception (months)	8 ± 2.5	12 ± 3.2	0.01*
Infertility Rate	5 (14.3%)	15 (42.9%)	0.01*

*Statistically significant at $p < 0.05$.

Multivariate Regression Analysis: A multivariate logistic regression model was constructed to identify independent predictors of conception among patients with uterine fibroids, adjusting for age and BMI. The results are presented in Table 4.

Table 4: Multivariate Logistic Regression Analysis for Predictors of Conception (Fibroid Group, n=35)

Predictor	Adjusted Odds Ratio (AOR)	95% Confidence Interval	p-value
Fibroid Diameter (per cm)	0.75	0.60 – 0.90	0.004
Submucosal Location	0.50	0.30 – 0.85	0.02
Age (per year)	0.95	0.87 – 1.03	0.21
BMI (per kg/m²)	0.98	0.90 – 1.06	0.70

However, independent predictors of reduced conception rates in the multivariate model (Table 4) include larger fibroid diameter and a submucosal fibroid location. In particular, there was a 25 % decrease in the odds of conception for each 1 cm increase in fibroid diameter (aOR 0.75, 95% CI 0.60–0.90, $p = 0.004$). A submucosal fibroid also significantly decreases the chance of conception (aOR 0.50, 95% CI 0.30–0.85; $p = 0.02$). In this model, age and BMI were not found to significantly influence conception outcomes.

The results of this multivariate analysis support the conclusion that fibroid characteristics, as measured by MRI, predict fertility outcomes. The inclusion of Table 4 presents an overall picture of the adjusted effects, aiding the robust statistical approach of our study.

DISCUSSION

Finally, our study presents the first comprehensive evidence that the MRI-based characterization of uterine fibroids is an important predictor of adverse fertility outcomes among Pakistani women. The results showed that patients with uterine fibroids also have much higher rates of infertility, lower conception rates, and longer time to conception than normal controls[12]. Interestingly, independent predictors of reduced fertility included larger fibroid size and a submucosal location. This means that for each 1 cm increase in fibroid diameter, the odds of conception decrease by 25%, and the presence of submucosal fibroids further decreases the likelihood of becoming pregnant[13].

MRI was used to evaluate fibroid characteristics, which are important to patient management with high resolution. Compared to standard ultrasonography, MRI is superior to soft tissue contrast and allows precise definition of fibroid size, number, and anatomic location[14]. The enhanced diagnostic accuracy allows the clinical decision to be informed as to those patients who may benefit from early surgical intervention, particularly for those submucosal fibroids distorting the endometrial cavity, and those that, if smaller, are less likely to disturb the uterine environment and could, therefore, be managed conservatively[15].

Our findings are consistent with previous research, but our study is unique in that it is based on a Pakistani cohort in which socio-cultural factors and limited access to advanced diagnostic tools add further barriers[16]. Early and precise diagnosis of fibroids is crucial, as the higher prevalence of infertility in the fibroid group suggests, to provide a more individualized treatment plan to

preserve reproductive potential. Integrating detailed MRI evaluation into the clinical workup allows clinicians to better counsel patients about their reproductive options and tailor interventions to optimize outcomes[17].

One strength of this study is that the imaging methodology used was robust and that the control group used had been well-defined, which helps to increase the reliability of observed associations between MRI parameters and fertility outcomes. Additionally, the application of multivariate logistic regression allowed for the adjustment of confounding variables (i.e., age and BMI) to isolate the impact of fibroid-specific variables on fertility[18]. However, given the study's cross-sectional design, the results cannot be used to make causal inferences, and the relatively small sample may reduce the generalizability of the findings. The long-term reproductive outcomes would also benefit from a longer follow-up period, especially in the setting of assisted reproductive technologies[19].

In addition, MRI provides valuable diagnostic information, but its limited availability and high cost in resource-limited settings emphasize the importance of developing complementary, inexpensive diagnostic algorithms. Longitudinal studies with larger cohorts should be done in future research to validate these associations and elucidate the impact of different treatment modalities on long-term fertility outcomes[20].

CONCLUSION

Our cross-sectional study validates that the MRI-based evaluation of uterine fibroids offers important information regarding factors that impede fertility in Pakistani women. Independently, larger fibroid size and submucosal location are associated with decreased conception rate and time to conception. These findings suggest that detailed MRI assessments should be integrated into the diagnostic workup of women with suspected fibroids, especially where fertility is an issue. These results need future validation with extended follow-up and larger cohorts to refine treatment strategies and improve reproductive outcomes.

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Authors contribution:

SG: Study design and oversight

SA: Methodology and data interpretation

SG: MRI acquisition and analysis

AM: Imaging protocol development

SM: Patient recruitment and data collection

BZ: Supervision and final approval

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