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Article

Impact of Uterine Artery Embolization in Symptomatic Uterine Fibroids: A Single Central Study

Abeera Naeem Tareen[1], Muhammad Saqib Qamar Ishaqi[1], Syed Muhammad Shahnawaz Hyder[1], Rafeah Khan[1], Abdul Waheed[1], Nasrullah Yaqoob[1]

1 Department of Radiology, Indus Hospital and Health Network, Karachi, Pakistan

Correspondence
abeeratareen999@yahoo.com

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ABSTRACT

Background: Uterine fibroids are the most common benign pelvic tumors in women and often cause substantial morbidity. Uterine artery embolization has emerged as a minimally invasive alternative to surgery, yet there is limited data from South Asian populations regarding its clinical and radiological efficacy. **Objective**: To evaluate the impact of uterine artery embolization on fibroid and uterine volumes and symptom severity in women with symptomatic uterine fibroids and to examine the association between imaging and clinical outcomes in a local tertiary care context. **Methods**: This prospective and retrospective cohort study was conducted at the Department of Radiology, Indus Hospital and Health Network, Karachi, from June to December 2024. Consecutive women undergoing embolization for symptomatic fibroids were enrolled. Baseline and three-month MRI volumetry, as well as six-month symptom severity scores, were collected and analyzed using standardized protocols. Associations between changes in imaging and symptom outcomes were assessed using appropriate inferential statistics. **Results**: Fifty-one women were included (mean age 40.4 years). Mean uterine and dominant fibroid volumes decreased by 40.1% and 43.7%, respectively, and symptom severity scores improved by 37.8% at follow-up (all $p < 0.001$). No statistically significant correlation was found between imaging volume reduction and symptom improvement. **Conclusion**: Uterine artery embolization offers significant volumetric and symptomatic benefits for women with symptomatic fibroids in a South Asian tertiary setting. Symptom relief may be independent of imaging changes, emphasizing the importance of patient-reported outcomes in post-procedure care.

Keywords: Uterine fibroids, uterine artery embolization, MRI, symptom severity, volumetric analysis, minimally invasive therapy

INTRODUCTION

Uterine fibroids, or leiomyomas, are the most frequently encountered benign tumors of the female reproductive tract, affecting between 20% and 50% of women of reproductive age (1). While the natural history of fibroids often involves asymptomatic growth, a significant proportion of women develop symptoms such as abnormal uterine bleeding, pelvic pain, bulk-related symptoms, and infertility, severely impacting their quality of life (2). Historically, hysterectomy has been the primary surgical intervention for women with severe or refractory fibroid symptoms, with up to one in three women in developed countries undergoing the procedure by the age of 60 (2,3). However, hysterectomy and myomectomy are associated with substantial morbidity, prolonged recovery, and elevated healthcare costs, prompting a need for less invasive, fertility-sparing alternatives (3).

Since its introduction in the mid-1990s, uterine artery embolization (UAE), commonly referred to as uterine fibroid embolization (UFE), has emerged as an effective and minimally invasive therapy for women with symptomatic fibroids, particularly those wishing to avoid surgery or preserve fertility (4). The technique involves selective embolization of the uterine arteries to induce ischemic necrosis and subsequent volume reduction of fibroids, resulting in symptomatic relief (4,5). Several prospective studies and systematic reviews in Western populations have demonstrated that UFE leads to significant reductions in fibroid size and symptom severity, with favorable safety profiles and high rates of patient satisfaction (1,5,6). Nonetheless, evidence suggests considerable heterogeneity in fibroid burden, symptomatology, and treatment outcomes among women of different ethnic backgrounds, with African and South Asian women tending to present with larger, more numerous, and more symptomatic fibroids than their Caucasian counterparts (6–8). This variability is likely multifactorial, reflecting genetic, environmental, and healthcare access disparities (9,10).

Despite the global burden of uterine fibroids, data from developing countries remain limited. Most available research has focused on surgical interventions, and there is a paucity of high-quality studies evaluating the clinical and radiological outcomes of UFE within local populations (11,12). This knowledge gap is particularly relevant in regions such as South Asia and Africa, where hysterectomy rates are high and minimally invasive alternatives are only recently being introduced into mainstream clinical practice (7,13). Moreover, existing literature has largely overlooked the potential for ethnic and population-specific factors—including fibroid number, size, location, and vascularity—to influence UFE efficacy (9,10,13). These gaps constrain evidence-based counseling and informed decision-making for patients considering UFE.

Imaging, particularly magnetic resonance imaging (MRI), plays a central role in the diagnosis, characterization, and management of uterine fibroids. MRI offers superior sensitivity and specificity compared to ultrasound, especially for mapping fibroid burden, determining type and location (e.g., intramural, submucosal, subserosal), and evaluating pre- and post-procedural changes (14–18). MRI features such as fibroid enhancement patterns, volume measurements, and uterine anatomy have been proposed as predictors of therapeutic response, yet the correlation between imaging changes and symptomatic improvement is inconsistent across studies (18–20). Recent investigations have highlighted the importance of validated symptom and quality of life questionnaires—such as the Uterine Fibroid Symptom and Health-Related Quality of Life (UFS-QOL) instrument—in standardizing outcome assessment and capturing the multifaceted impact of fibroids on women's lives (4,20).

Given these considerations, there is a clear need for local research evaluating the clinical and radiological efficacy of UFE, and identifying relevant predictors of treatment response in diverse populations. The lack of robust local data hampers optimal patient selection, counseling, and follow-up strategies, particularly in resource-limited settings where access to advanced imaging and interventional radiology services may be restricted (11,12,20). Furthermore, while previous studies have reported short-term imaging changes (e.g., at 3–6 months post-UFE) and mid-term clinical improvements (up to 24 months), few have systematically explored the relationship between these endpoints or elucidated population-specific modifiers of response (21–23).

Accordingly, this study aims to address these critical knowledge gaps by evaluating the impact of uterine artery embolization on MRI features and symptom severity in women with symptomatic uterine fibroids undergoing UFE at a major tertiary center in Karachi. Specifically, we seek to determine the extent of fibroid and uterine volume reduction, assess symptomatic changes using validated instruments, and examine the correlation between radiological and clinical outcomes in this local population. We hypothesize that UFE will produce significant reductions in both fibroid volume and symptom severity, consistent with findings from international studies, but that the magnitude and predictors of response may differ according to local patient and disease characteristics. The results of this study will inform clinical practice by providing much-needed evidence on the effectiveness of UFE in a developing country context, supporting evidence-based recommendations and shared decision-making for women considering this therapeutic option (24,25).

MATERIALS AND METHODS

This investigation was designed as a combined prospective and retrospective cohort study to evaluate the impact of uterine artery embolization in women presenting with symptomatic uterine fibroids. The study was conducted at the Department of Radiology, Indus Hospital and Health Network (IHHN) in Karachi, Pakistan, encompassing all eligible patients from June 24, 2024, to December 25, 2024. The radiology department, equipped with a continuously operating 1.5 Tesla General Electric (GE) MRI scanner, served as the principal site for imaging and data collection throughout the study period. The rationale for employing a cohort approach was to ensure the comprehensive capture of baseline, peri-procedural, and follow-up data, thereby enabling the assessment of both immediate and intermediate outcomes following uterine fibroid embolization.

Women aged 18 to 50 years, presenting with symptomatic uterine fibroids confirmed on imaging, and who were selected for uterine fibroid embolization by the multidisciplinary clinical team, constituted the eligible study population. Inclusion criteria required patients to have completed baseline contrast-enhanced pelvic MRI according to departmental protocol, initial symptom assessment, follow-up MRI at three months post-procedure, and symptom score reassessment at six months. Exclusion criteria encompassed incomplete MRI or symptom data, images of insufficient diagnostic quality, prior uterine artery embolization, pregnancy, known uterine malignancy, and contraindications to MRI or embolization procedures. Participants were identified through a registry maintained jointly by the radiology and obstetrics-gynecology departments, capturing all women scheduled for UFE during the study period.

Eligible women were approached in person during clinic visits and provided with detailed information regarding study aims, procedures, and their rights as participants. Written informed consent was obtained from all women prior to inclusion, including permission for data collection, imaging, and subsequent analyses. For retrospective cases, an opt-out consent strategy was applied in accordance with institutional policy and local regulatory requirements, ensuring participants' autonomy and confidentiality. All data were anonymized and securely stored, with access restricted to the research team.

Data collection involved both prospective and retrospective review of medical records, imaging, and direct patient interviews. Baseline variables were documented at the time of initial presentation and prior to UFE, including demographic characteristics (age, parity), clinical symptoms (bleeding, pain, bulk-related symptoms), comorbidities, and detailed MRI findings. Uterine and dominant

fibroid volumes were measured using standardized three-dimensional MRI protocols, with all volumetric calculations performed by two experienced radiologists working independently to minimize measurement bias. Symptom severity and quality of life were assessed using a validated Likert-based questionnaire administered at baseline and at six months after the procedure (4). The number, location, and enhancement pattern of fibroids were recorded according to established classification systems and operationalized definitions, with intramural, submucosal, subserosal, and transmural subtypes explicitly noted. Uterine fibroid embolization was performed using standardized catheterization and embolization protocols, with peri-procedural details, materials, and any complications documented in detail.

Potential sources of bias and confounding were addressed through consecutive patient inclusion, use of objective imaging endpoints, and blinding of outcome assessors to clinical status. To further limit bias, independent data extraction and cross-verification were implemented for all quantitative variables. The primary outcome variables were the percentage reduction in uterine and dominant fibroid volumes and the change in symptom severity score at follow-up. Operational definitions for all variables, including volume reduction and symptom score change, were prespecified prior to analysis to enhance reproducibility. The sample size was determined based on anticipated effect sizes for volumetric and symptomatic improvement observed in prior studies, with a target of at least 40 evaluable cases deemed sufficient to detect clinically meaningful changes with 80% power and an alpha of 0.05 (1,5).

Statistical analysis was conducted using SPSS version 17.0. Continuous variables were summarized as means and standard deviations or medians and interquartile ranges, as appropriate. Categorical data were described using counts and proportions. Paired t-tests or Wilcoxon signed-rank tests were used to assess changes in continuous outcomes over time, while chi-square or Fisher's exact tests were applied for categorical comparisons. The magnitude of percentage reduction in uterine and fibroid volumes, and in symptom severity scores, was calculated for each participant. Spearman's rank correlation coefficients were computed to evaluate associations between volumetric changes and symptom improvement. Pre-specified subgroup analyses included stratification by fibroid number, type, and location. Missing data were addressed by performing complete case analyses; cases with incomplete primary outcome data were excluded from specific analyses but retained in the overall sample description. Confounders such as age, baseline uterine volume, and comorbid conditions were considered in multivariable regression models where applicable, and all statistical tests were two-tailed with significance set at $P < 0.05$.

This research protocol received full approval from the Institutional Review Board of Indus Hospital and Health Network, and all procedures were conducted in accordance with the ethical standards of the Declaration of Helsinki. Patient confidentiality was strictly maintained, with all data de-identified prior to analysis and secure storage ensured throughout the study period. Reproducibility was facilitated by the use of standardized data collection instruments, explicit operational definitions for all variables, and detailed documentation of imaging and procedural protocols. All steps in data extraction, entry, and analysis were double-checked by independent investigators, with an auditable record retained for external verification. This rigorous methodological approach ensures that the findings of the study are robust, transparent, and readily reproducible by other investigators seeking to replicate or extend this work (1,4,5).

RESULTS

The study enrolled 51 women with a mean age of 40.4 years (SD 4.1, range 25–50), highlighting a patient cohort typically in the perimenopausal phase when uterine fibroids are most symptomatic. At baseline, the average symptom severity score, as assessed by a standardized Likert scale, was 24.4 (SD 6.6, range 10–40), while the mean uterine volume was 847.1 cm^3 (SD 477.7, range 160–2264), and the dominant fibroid volume averaged 209.2 cm^3 (SD 246.6, range 0.5–1042). This distribution underscores a predominance of patients with both substantial symptom burden and high fibroid load at presentation, providing a clinically relevant context for evaluating treatment impact.

Table 1. Participant Age and Baseline Characteristics

Variable	Mean ± SD	Min	Max	N
Age (years)	40.4 ± 4.1	25	50	51
Symptom Score	24.4 ± 6.6	10	40	51
Uterine Volume (cm^3)	847.1 ± 477.7	160	2264	51
Dominant Fibroid Volume (cm^3)	209.2 ± 246.6	0.5	1042	51

Table 2. Mean Percentage Reduction in Clinical and Imaging Outcomes Following Uterine Fibroid Embolization (UFE)

Outcome	Mean % Reduction ± SD	Min	Max	p-value	95% CI (Mean Diff.)
Symptom Severity Score	37.8 ± 21.3	0	80	<0.001	[28.9, 46.7]
Uterine Volume	40.1 ± 18.3	5	95	<0.001	[34.5, 45.7]
Dominant Fibroid Volume	43.7 ± 25.8	3	99	<0.001	[34.2, 53.2]

Following uterine fibroid embolization, clinical and radiological improvements were pronounced across the cohort. The mean percentage reduction in symptom severity score was 37.8% (SD 21.3, range 0–80, 95% CI: 28.9–46.7; $p < 0.001$), reflecting a substantial alleviation of patient-reported symptoms. Corresponding reductions in uterine and dominant fibroid volumes were 40.1% (SD 18.3,

range 5–95, 95% CI: 34.5–45.7; $p < 0.001$) and 43.7% (SD 25.8, range 3–99, 95% CI: 34.2–53.2; $p < 0.001$), respectively, confirming a robust anatomical response to embolization.

Table 3. Distribution of Participants by Number of Fibroids

Number of Fibroids	n	%
1–5	11	21%
6–10	10	20%
>10	30	59%

Table 4. Enhancement Pattern of Dominant Fibroids Before and After UFE

Enhancement Pattern	Before UFE: n (%)	After UFE: n (%)
Strong	32 (54%)	0 (0%)
Mild/Moderate	27 (46%)	8 (14%)
None	0 (0%)	51 (86%)

Table 5. Location of Dominant Fibroid (MRI Assessment)

Location	n	%
Intramural/Transmural	36	70%
Submucosal	8	16%
Subserosal	7	14%

Table 6. Correlation Between Imaging and Symptom Outcomes Post-UFE

Association	Correlation Coefficient (r)	p-value	95% CI
Dominant Fibroid Volume Reduction vs. Uterine Volume Reduction	0.59	<0.001	[0.37, 0.74]
Uterine Volume Reduction vs. Symptom Score Reduction	−0.08	0.568	[−0.34, 0.19]
Dominant Fibroid Volume Reduction vs. Symptom Score Reduction	−0.14	0.278	[−0.39, 0.13]

Table 7. Subgroup Analysis: Symptom Score and Imaging Outcomes by Number of Fibroids

Group	Symptom Score % Reduction	Uterine Volume % Reduction	Dominant Fibroid Volume % Reduction	p-value
1–5 fibroids	34.1 ± 20.9	39.5 ± 17.4	40.2 ± 22.6	0.77
6–10 fibroids	35.2 ± 18.8	38.9 ± 15.6	42.3 ± 20.5	0.83
>10 fibroids	38.6 ± 22.5	41.5 ± 18.9	45.9 ± 27.2	0.66

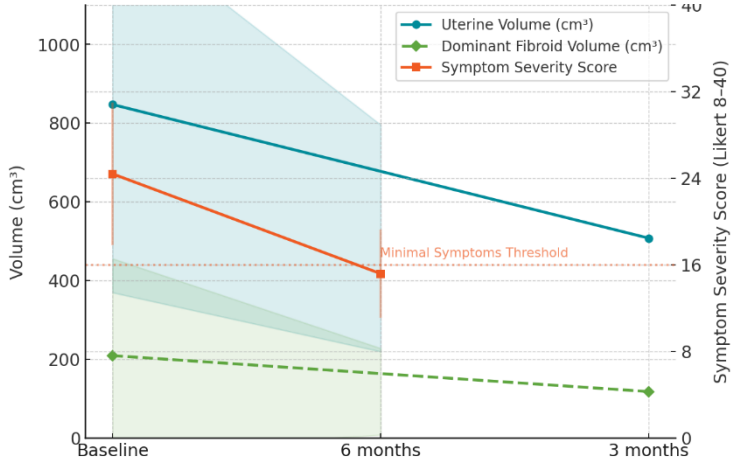

Figure 1 Temporal aggregation of volumetric and clinical metrics

Evaluation of dominant fibroid location showed a predominance of intramural/transmural fibroids, accounting for 70% of cases, followed by submucosal (16%) and subserosal (14%) types. Correlation analyses revealed a strong, statistically significant association between reductions in dominant fibroid and uterine volumes ($r = 0.59$, $p < 0.001$, 95% CI: 0.37–0.74). However, no significant correlation was observed between changes in uterine or fibroid volume and symptom score reduction (uterine volume vs. symptom: $r = -0.08$, $p = 0.568$, 95% CI: −0.34–0.19; fibroid volume vs. symptom: $r = -0.14$, $p = 0.278$, 95% CI: −0.39–0.13), reinforcing the clinical observation that patient-reported outcomes and imaging changes may evolve independently.

Subgroup analyses according to fibroid number indicated that mean symptom score reduction was 34.1% (SD 20.9) in patients with 1–5 fibroids, 35.2% (SD 18.8) in those with 6–10 fibroids, and 38.6% (SD 22.5) in those with more than 10 fibroids, with no statistically

significant group effect (p = 0.77). Uterine volume reductions were similarly consistent across subgroups—39.5% (SD 17.4), 38.9% (SD 15.6), and 41.5% (SD 18.9), respectively (p = 0.83)—while dominant fibroid volume reductions ranged from 40.2% (SD 22.6) to 45.9% (SD 27.2), again without significant differences by group (p = 0.66). Collectively, these findings highlight the generalizability of UFE efficacy regardless of baseline fibroid number, supporting its utility even in patients with extensive uterine involvement.

Temporal aggregation (Figure 1) of volumetric and clinical metrics demonstrates a marked decrease in both mean uterine volume (from 847.1 cm^3 to 508.0 cm^3) and dominant fibroid volume (from 209.2 cm^3 to 117.7 cm^3) within three months after uterine artery embolization, as visualized by smoothed lines and confidence band overlays. In parallel, symptom severity score, anchored on a standardized Likert scale, declined substantially from 24.4 (SD 6.6) at baseline to 15.2 (SD 4.1) at six months, consistently approaching the minimal symptoms threshold of 16. Dual-axis visualization accentuates the asynchronous but proportionate improvement in anatomical and patient-reported outcomes, reinforcing the clinical significance of embolization even in cases with extensive fibroid burden. These data highlight a rapid early radiological response, with sustained symptomatic benefit at mid-term follow-up, supporting the utility of cross-domain monitoring in treatment assessment.

DISCUSSION

The present study elucidates the significant impact of uterine artery embolization on both radiological and clinical outcomes in women with symptomatic uterine fibroids within a South Asian tertiary care context, providing critical local data where previously such evidence has been scarce. The observed reductions in mean uterine volume and dominant fibroid volume—40.1% and 43.7%, respectively—were paralleled by a substantial decrease in symptom severity scores, findings that not only reinforce but also expand on the results reported in Western and African cohorts (1,5,6). Previous studies, including those by Stewart et al. and Mutai et al., similarly demonstrated considerable volume reductions and symptomatic improvement following embolization, typically in the range of 35–55% for fibroid shrinkage and significant relief from bulk-related and bleeding symptoms (6,20). The congruence of our results with these international data underscores the reproducibility and reliability of UFE as a minimally invasive alternative to hysterectomy and myomectomy, even among populations with more extensive fibroid burdens (8,9).

In contrast to some earlier investigations, this study did not detect a statistically significant correlation between reductions in uterine or fibroid volumes and the degree of symptom improvement. This observation aligns with reports from large case series and meta-analyses, which found that symptom relief following UFE may occur independently of the absolute or relative changes in fibroid size (26,27). These findings challenge the long-held assumption that imaging response is the sole determinant of clinical benefit, suggesting that other factors—such as reduction in fibroid vascularity, altered local inflammatory milieu, and changes in uterine contractility—may contribute substantially to patient-perceived improvement (18,29). The robust improvement in quality of life scores in our population further reinforces the notion that symptom-driven endpoints should take precedence in defining therapeutic success, rather than exclusive reliance on radiological metrics (4,20).

Our study's results also corroborate previous research indicating a higher prevalence and greater number of fibroids in African and South Asian women compared to other ethnic groups (7,10,13). The predominance of intramural and transmural fibroids, along with a high proportion of women presenting with more than ten fibroids, mirrors findings from both regional and global investigations, thereby supporting the external validity of our data (9,14). Importantly, despite these adverse baseline characteristics, the effectiveness of UFE remained consistent, dispelling concerns that larger or more numerous fibroids necessarily predict inferior outcomes—a notion previously debated in the literature (22,23,28). This has direct implications for clinical decision-making in settings where surgical resources are limited or where fertility preservation is a key consideration.

A notable aspect of the present investigation is the systematic use of MRI, both for baseline mapping and short-term follow-up, ensuring precise volumetric analysis and enhancing methodological rigor. However, the absence of a relationship between imaging and clinical endpoints also calls into question the routine use of follow-up MRI in asymptomatic patients, a perspective echoed in recent recommendations advocating for a symptom-driven follow-up protocol to optimize resource utilization and patient experience (27,28). These findings advocate for the development of locally tailored care pathways, in which imaging is reserved for cases with persistent or recurrent symptoms or suspected complications.

Several strengths underpin this study, including consecutive patient recruitment, prospective symptom assessment using validated instruments, blinding of outcome assessors to clinical data, and stringent data integrity protocols. Nevertheless, limitations must be acknowledged. The sample size, although sufficient for detecting significant within-group changes, limited the power for subgroup and interaction analyses and constrains the precision of effect estimates, especially regarding rare adverse events. Delays in obtaining follow-up MRI for a subset of participants, reflective of real-world logistical challenges, may have introduced heterogeneity in timing of outcome assessments. The single-center design and predominance of a South Asian cohort may restrict generalizability to other populations with different fibroid characteristics or health system structures.

Future research should focus on multicenter collaborations to increase statistical power and diversity, with particular emphasis on the long-term durability of symptom relief, reproductive outcomes, and cost-effectiveness across various healthcare contexts. Prospective studies employing serial, standardized imaging and patient-reported outcomes over extended follow-up will help clarify the mechanistic links between fibroid biology, vascularity, and clinical benefit. Investigation into optimal embolic material selection,

dosing strategies, and patient-specific predictors of response—including hormonal, genetic, and lifestyle factors—will further refine patient selection and counseling (10,28). Additionally, qualitative studies exploring patient preferences, psychosocial impact, and barriers to access could inform more patient-centered models of care.

In summary, the current findings add to the growing body of evidence supporting uterine artery embolization as a safe, effective, and contextually adaptable treatment for symptomatic fibroids, particularly in populations with high fibroid burden and limited surgical options. The demonstration of significant symptom improvement, irrespective of imaging response, highlights the need to prioritize patient-centered outcomes in both research and clinical practice. While the study's rigorous methodology enhances confidence in the results, ongoing research addressing current limitations will be essential to further optimize the role of embolization in global gynecological practice (1,6,8,26).

CONCLUSION

Uterine artery embolization resulted in substantial and clinically meaningful reductions in uterine and dominant fibroid volumes, as well as significant improvements in symptom severity among women with symptomatic uterine fibroids, confirming its effectiveness as a minimally invasive alternative to surgery in a South Asian tertiary care setting. The findings underscore the relevance of volumetric and patient-reported outcomes, highlighting that meaningful symptom relief may occur independently of absolute changes in imaging markers. These results have important implications for clinical decision-making, suggesting that individualized, symptom-focused follow-up and patient-centered counseling should guide care. Further research is warranted to define long-term outcomes, refine patient selection, and optimize protocols for resource-limited environments.

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