Section: Radiodiagnosis

Original Research Article

QUANTITATIVE ADC VALUES AND CONTRAST ENHANCEMENT RATIOS CORRELATED WITH FUNAKI CLASSIFICATION IN UTERINE LEIOMYOMAS: IMPLICATIONS FOR TREATMENT STRATIFICATION

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ABSTRACT

Background: The Funaki classification based on T2 signal intensity is the established method for predicting high-intensity focused ultrasound (HIFU) treatment outcome for uterine fibroids. It provides only a qualitative estimate. Quantitative apparent diffusion coefficient (ADC) values and fibroid-to-myometrium contrast enhancement ratios may provide more objective and reproducible tissue characterisation to supplement Funaki classification for treatment planning. The aim is to correlate quantitative ADC values and contrast enhancement ratios with Funaki classification in uterine fibroids; to explore their potential for treatment stratification; and to propose an integrated classification system for clinical decision-making. **Materials and Methods:** Retrospective cross-sectional study of 46 MRI-diagnosed uterine fibroid cases at PESIMSR, Kuppam. Multisequence MRI including T1WI, T2WI, DWI with ADC maps, GRE sequences, and post-contrast T1WI was assessed. Funaki classification was assigned from T2 signal intensity relative to myometrium and skeletal muscle. ADC values were extracted from ADC maps using ROI placement. Fibroid-to-myometrium contrast enhancement ratios were calculated from post-contrast signal intensities. FIGO classification was documented. Correlations between Funaki type, ADC, contrast ratio, degeneration status, DWI restriction, and GRE blooming were analysed. **Results:** Mean age was 46.3±9.2 years. Funaki distribution: Type 1, 13 (28.3%); Type 2, 23 (50.0%); Type 3, 10 (21.7%). ADC values showed a progressive increase across Funaki types: Type 1 (1039±206), Type 2 (1189±197), Type 3 (1480±300 $\times 10^{-6}$ mm²/s). Contrast enhancement ratios paralleled this gradient: Type 1 (0.781±0.099, hypo-enhancing), Type 2 (0.831±0.149, iso-enhancing), Type 3 (0.924±0.144, near hyper-enhancing). DWI restriction increased progressively with Funaki type (0%, 15.8%, 50.0%). GRE blooming was present in 5/45 (11.1%). Degenerated fibroids had significantly higher ADC (1441±333 vs 1137±199). The ADC-ratio correlation was weak (r=0.102), confirming these parameters as complementary. **Conclusion:** ADC values and contrast enhancement ratios are objective quantitative extensions of the qualitative Funaki classification, each characterising different tissue properties: cellularity and vascularity respectively. An integrated five-group treatment stratification system combining ADC, contrast ratio, Funaki type, and FIGO classification is proposed to enable individualised treatment selection between HIFU, UAE, myomectomy, and conservative management.

INTRODUCTION

Uterine leiomyomas (fibroids) are the most common benign uterine tumours, identified in up to 70–80% of women by the age of 50 years and representing the most frequent indication for hysterectomy.[1]

As treatment options for uterine leiomyomas have expanded to include MR-guided high-intensity

focused ultrasound (MR-HIFU), uterine artery embolisation (UAE), radiofrequency ablation, and selective myomectomy, accurate pre-procedural tissue characterisation has become critical for appropriate patient selection and treatment optimisation.

Funaki et al,[2] established the T2-signal intensity–based Funaki classification system as the principal method for predicting fibroid response to MR-HIFU: Type 1 fibroids (signal intensity lower than myometrium and skeletal muscle, dense fibrous composition) are the best HIFU candidates and achieve the highest non-perfused volume ratios (NPVr); Type 2 fibroids (signal intensity lower than myometrium but higher than skeletal muscle, intermediate cellularity) are intermediate candidates; Type 3 fibroids (signal intensity similar to or higher than myometrium, cellular or fluid-rich) are poor HIFU candidates, for whom UAE is preferred.[3,4] Despite its widespread clinical adoption, the Funaki classification is qualitative, subjective, dependent on scanner parameters, and relies primarily on a single qualitative parameter for tissue assessment.

Two quantitative MRI parameters can supplement the Funaki classification. Apparent diffusion coefficient (ADC) values, derived from diffusion-weighted imaging (DWI), quantify water molecule diffusivity and reflect tissue composition from dense fibrous through cellular to fluid-rich or degenerated states. Sainio et al,[5] demonstrated that ADC classification achieved an AUC of 0.79 for predicting HIFU outcome, outperforming the Funaki classification (AUC 0.62). Slotman et al,[6] confirmed statistically significant ADC differences between myometrium and fibroid tissue and between Funaki types ($p<0.001$).

The fibroid-to-myometrium contrast enhancement ratio, measured on post-contrast T1-weighted images, provides a standardised, scanner-independent measure of relative fibroid vascularity: a ratio below 0.8 indicates hypo-enhancement, 0.8–1.0 indicates iso-enhancement, and above 1.0 indicates hyper-enhancement.[7,8]

Together, these parameters provide complementary structural and functional tissue information.

No published study has simultaneously correlated quantitative ADC values, contrast enhancement ratios, DWI restriction, GRE blooming, and Funaki classification in a single cohort with FIGO staging. The present study aims to fill this gap, determine whether these quantitative parameters add clinically meaningful information for treatment stratification, and propose an integrated characterisation system for clinical decision-making.

MATERIALS AND METHODS

Study Design and Population: This retrospective cross-sectional study was conducted in the Department of Radiodiagnosis and Imaging, PESIMSR, Kuppam, Andhra Pradesh, India. The study included 46 female patients with MRI-diagnosed uterine fibroids. As this was a retrospective analysis of anonymised imaging data acquired during routine clinical care, with no patient identifying information (names, hospital identifiers, or telephone numbers) disclosed in the manuscript or its illustrative material, the study was conducted in accordance with the ethical standards of the responsible institutional committee and with the Declaration of Helsinki (2013 revision). The retrospective design and exclusive use of de-identified data did not constitute any deviation from established ethical norms; accordingly, the requirement for written informed consent was waived.

Inclusion and Exclusion Criteria

Female pelvic MRI scans performed between January 2024 and January 2026 for diagnosed pelvic pathologies were retrospectively reviewed. Patients with MRI-confirmed uterine fibroids measuring between 1.0 cm and 10.0 cm in maximum dimension were included. Fibroids smaller than 1.0 cm or larger than 10.0 cm, and patients with incomplete imaging sequences precluding Funaki classification, were excluded.

MRI Protocol

Given the retrospective design, patients had received varying pelvic MRI sequences based on clinical indication, including T1-weighted imaging (T1WI), T2-weighted imaging (T2WI), diffusion-weighted imaging (DWI) with ADC mapping (b values of 0 and 800 s/mm²), gradient recalled echo (GRE) susceptibility sequences, and post-contrast fat-saturated T1WI after gadolinium-based contrast agent administration.

Image Analysis

Funaki classification was assigned based on T2 signal intensity relative to myometrium and skeletal muscle by two radiologists in consensus. ADC values ($\times 10^{-6}$ mm²/s) were measured by placing a region of interest (ROI) on the solid portion of each fibroid on ADC maps, avoiding haemorrhagic or necrotic areas. Post-contrast signal intensity was measured for both the largest fibroid and the adjacent myometrium. The fibroid-to-myometrium contrast enhancement ratio was calculated as: Ratio = Signal intensity of fibroid / Signal intensity of myometrium (post-contrast). FIGO classification was documented. Up to four fibroids per patient were individually characterised with separate Funaki type, ADC, and contrast enhancement measurements.

Statistical Analysis

Descriptive statistics (mean, standard deviation, median, range) were computed. Pearson correlation coefficient was used for the ADC–ratio correlation analysis. Sub-group analyses were performed by Funaki type, FIGO type, and degeneration status. Statistical analysis was performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA).

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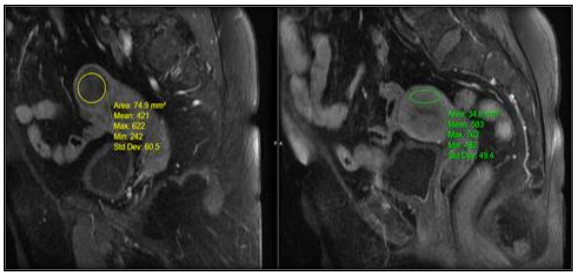

Figure 1: ROI placement for contrast enhancement measurement. Left: ROI placed over the fibroid covering at least 80% of the lesion area. Right: ROI placed within the myometrium, excluding the transitional zone. The fibroid-to-myometrium contrast enhancement ratio is calculated from these signal intensity values.

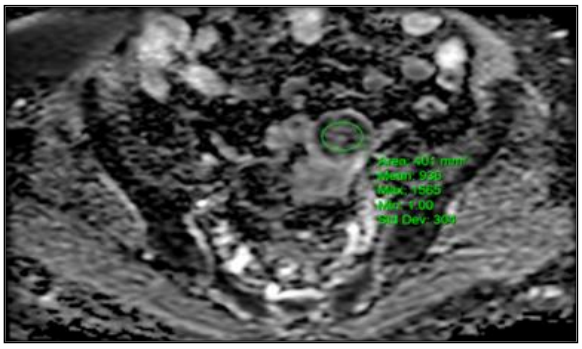

Figure 2: ROI placement on the ADC map covering at least 80% of the fibroid area in a representative section, used to derive the mean ADC value for quantitative tissue characterisation

RESULTS

Demographics and Clinical Profile

The study comprised 46 female patients with a mean age of 46.3±9.2 years (range 23–71). The most common age group was 41–50 years (n=21, 45.7%). Postmenopausal bleeding was the most frequent presenting complaint (n=14, 30.4%), followed by heavy menstrual bleeding (n=9, 19.6%), anaemia (n=7, 15.2%), and abdominal pain (n=6, 13.0%). Single fibroids were identified in 32 patients (69.6%) and multiple fibroids in 14 (30.4%). By location, subserosal fibroids predominated (n=24, 52.2%), followed by intramural (n=17, 37.0%) and submucosal (n=5, 10.9%).

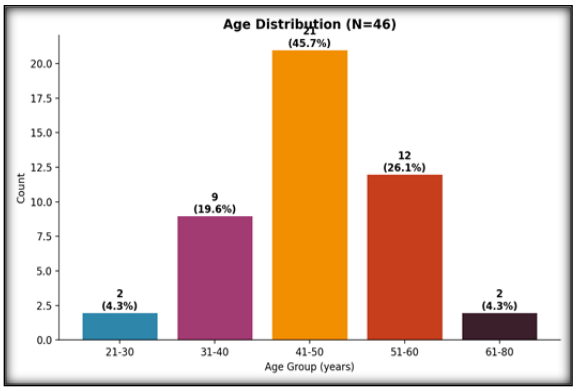

Figure 3: Age distribution of study population (N=46)

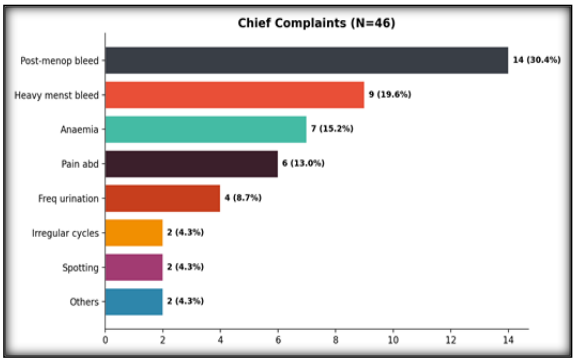

Figure 4: Distribution of chief complaints (N=46).

FIGO Classification

FIGO classification was available for 44 patients. FIGO type 5 (subserosal with >50% intramural component) was the most common (n=11, 25.0%), followed by FIGO 6 (subserosal, ≤50% intramural; n=10, 22.7%), FIGO 4 (intramural; n=9, 20.5%), FIGO 3 (contacting endometrium; n=6, 13.6%), FIGO 1 (≥50% submucosal; n=4, 9.1%), FIGO 2 (<50% submucosal; n=2, 4.5%), FIGO 0 (pedunculated intracavitary; n=1, 2.3%), and FIGO 7 (pedunculated subserosal; n=1, 2.3%).

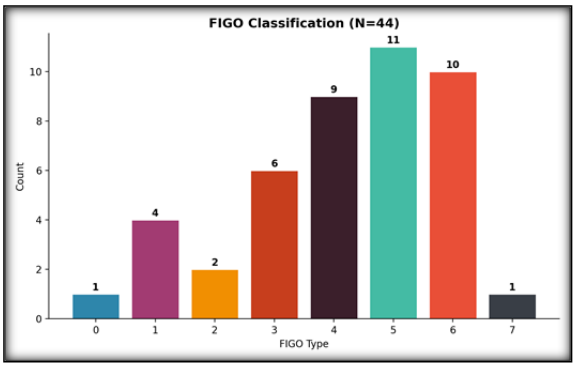

Figure 5: FIGO classification distribution (N=44)

Conventional Sequence Findings

On T1WI (N=46), the majority of fibroids were isointense (n=39, 84.8%) with no T1 hyperintensity observed. On T2WI (N=46), fibroids were predominantly hypointense (n=39, 84.8%), with 4 (8.7%) hyperintense, 2 (4.3%) intermediate, and 1 (2.2%) showing peripheral hypointensity with central irregular hyperintensity. On GRE (N=45 assessable), no blooming was seen in 40 cases (88.9%); blooming was positive in 5 (11.1%). On DWI (N=40 assessable), no restriction was present in 33 (82.5%), restriction in 5 (12.5%), and mild restriction in 2 (5.0%); total DWI restriction was seen in 7/40 (17.5%). Degenerative changes were present in 12/46 (26.1%), comprising cystic degeneration in 6, necrosis in 2, hyaline degeneration in 1, and unspecified in 3.

Funaki Classification

Funaki Type 1 was identified in 13 fibroids (28.3%), Type 2 in 23 (50.0%), and Type 3 in 10 (21.7%). The predominance of Type 2 (50.0%) distinguishes this cohort from several published series in which

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Type 1 predominates. Representative MRI examples of each Funaki type are shown in [Fig-6] to [Fig-8].

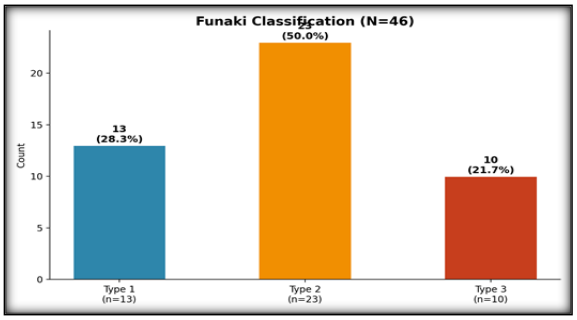

Figure 6: Funaki Type 1 — Coronal T2-weighted MRI pelvis. The fibroid shows uniformly hypointense signal lower than both myometrium and skeletal muscle, consistent with dense fibrous tissue composition (optimal HIFU candidate)

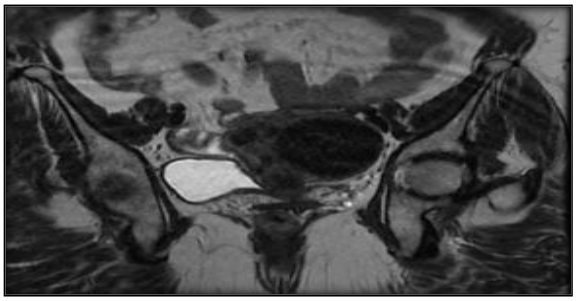

Figure 7: Funaki Type I fibroid

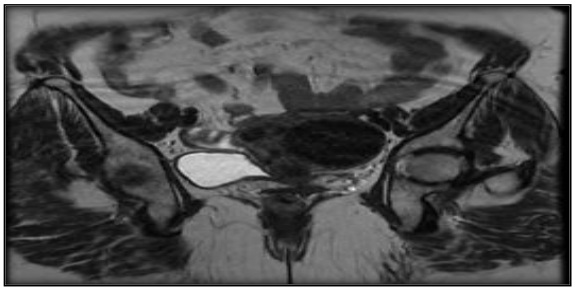

Figure 8: Funaki Type II — Coronal T2-weighted MRI pelvis. The uterine fibroid shows signal intensity lower than myometrium but higher than skeletal muscle, consistent with intermediate cellularity (Funaki Type 2)

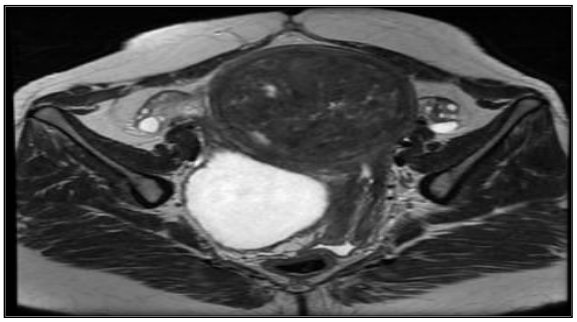

Figure 9: Funaki Type III — Axial T2-weighted MRI pelvis. The fibroid shows signal intensity similar to or higher than myometrium, consistent with cellular or fluid-rich tissue (UAE preferred over HIFU)

DWI and GR Findings by Funaki Type

DWI restriction rate increased progressively with Funaki type: Type 1, 0/13 (0.0%); Type 2, 3/19 (15.8%); Type 3, 4/8 (50.0%). Zero Funaki 1 fibroids showed restriction, consistent with the dense fibrous, low-cellularity composition of Type 1. GRE blooming showed a different distribution: Type 1, 2/13 (15.4%); Type 2, 1/23 (4.3%); Type 3, 2/10 (20.0%), with the lowest rate in Funaki 2.

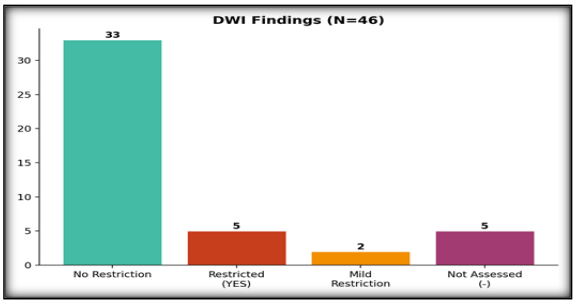

Figure 10: DWI findings distribution across study population (N=40 assessable).

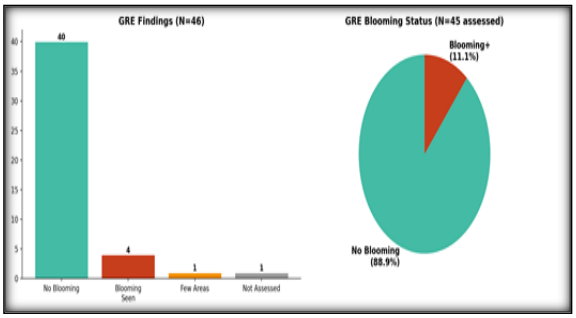

Figure11: GRE findings distribution (N=45 assessable). Blooming positive in 5/45 (11.1%).

ADC Values by Funaki Type

ADC values were available for 34 patients (first fibroid analysis). The overall mean ADC was 1226±279 $\times 10^{-6}$ mm²/s (range 790–1974). A clear progressive gradient was observed across Funaki types: Type 1 (n=9): mean 1039±206, median 1056, range 790–1293; Type 2 (n=16): mean 1189±197, median 1209, range 910–1575; Type 3 (n=9): mean 1480±300, median 1414, range 1129–1974 (all in $\times 10^{-6}$ mm²/s). When all individually characterised fibroids were pooled (N=46), the same progressive gradient was confirmed: Funaki 1 (n=13): 1053±181; Funaki 2 (n=22): 1170±202; Funaki 3 (n=11): 1434±274 $\times 10^{-6}$ mm²/s.

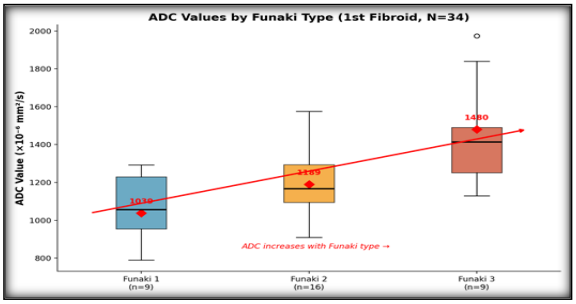

Figure 12: Box plot of ADC values by Funaki type (first fibroid per patient, N=34). The progressive ADC gradient is evident: Type 1 < Type 2 < Type 3.

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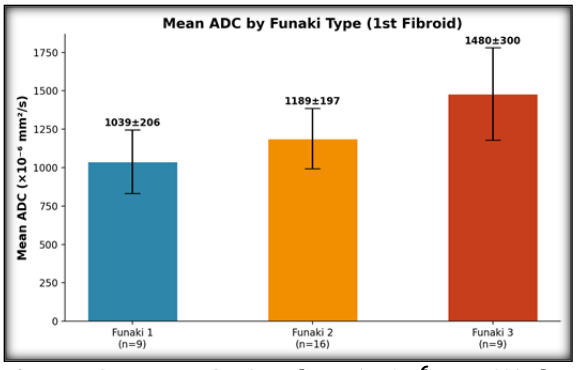

Figure 13: Mean ADC values (×10⁻⁶ mm²/s) by Funaki type with standard deviation error bars (first fibroid, N=34).

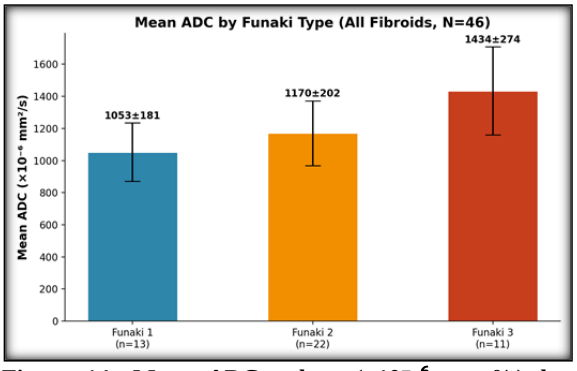

Figure 14: Mean ADC values (×10⁻⁶ mm²/s) by Funaki type (all individually characterised fibroids pooled, N=46)

Contrast Enhancement Ratio by Funaki Type

Contrast enhancement ratios (fibroid/myometrium) were available for 32 patients. The overall mean ratio was 0.839±0.141 (range 0.507–1.133). A parallel progressive gradient was observed: Funaki Type 1 (n=10): mean 0.781±0.099 (hypo-enhancing); Funaki Type 2 (n=14): mean 0.831±0.149 (iso-enhancing); Funaki Type 3 (n=8): mean 0.924±0.144 (near iso/hyper-enhancing). Overall, 16/32 (50.0%) were hypo-enhancing (ratio <0.8), 13/32 (40.6%) iso-enhancing (0.8–1.0), and 3/32 (9.4%) hyper-enhancing (>1.0); all three hyper-enhancing fibroids were Funaki Type 3. Mean myometrial contrast enhancement signal intensity was 741±216 (range 466–1676, N=32).

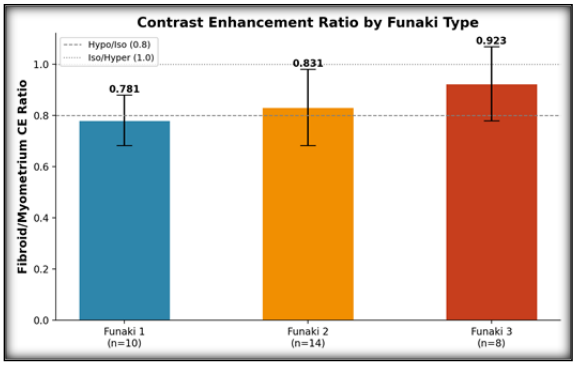

Figure 15: Contrast enhancement ratio (fibroid/myometrium) by Funaki type. Progressive gradient: Type 1 (hypo-enhancing) < Type 2 (iso-enhancing) < Type 3 (near hyper-enhancing)

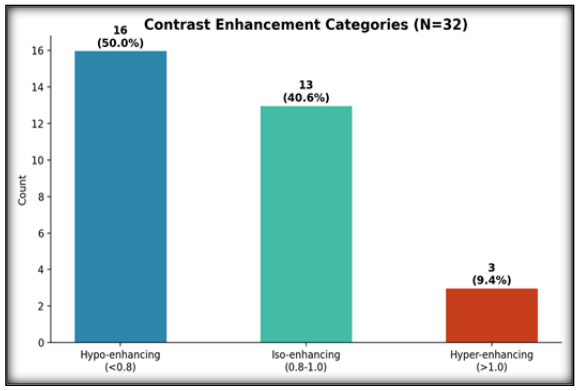

Figure 16: Distribution of contrast enhancement ratio categories: hypo-enhancing 16/32 (50.0%), iso-enhancing 13/32 (40.6%), hyper-enhancing 3/32 (9.4%)

ADC–Contrast Ratio Correlation

Of 46 patients, 24 had data for both ADC and contrast ratio measurements. Pearson correlation coefficient was r=0.102 (weak positive). This near-independence is a key finding, indicating that ADC and the contrast ratio largely reflect different tissue properties and are therefore complementary: ADC characterises tissue cellularity and water diffusivity (structural axis), while the contrast ratio characterises vascularity and perfusion (functional axis).

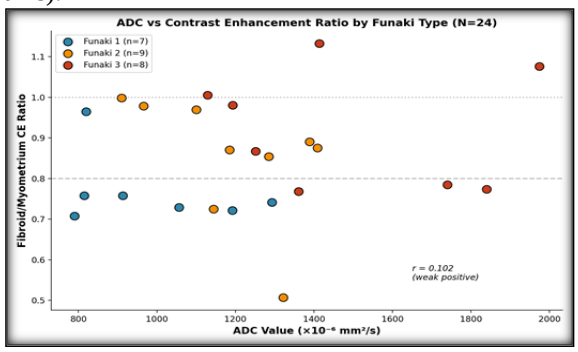

Figure 17: Scatter plot of ADC values vs. contrast enhancement ratio (N=24). Pearson r=0.102, confirming that the two parameters are largely independent and complementary

DWI and GRE Cross-Correlations

DWI restriction rate increased monotonically with Funaki type (0% → 15.8% → 50.0%), whereas GRE blooming showed a non-monotonic pattern, being lowest in Funaki Type 2 (4.3%) and higher in both Type 1 (15.4%) and Type 3 (20.0%). DWI-restricted fibroids had a higher mean contrast enhancement ratio (0.961, n=6) compared to non-restricted fibroids (0.811, n=23), indicating viable, well-perfused tissue with altered microstructure rather than devascularisation. Among DWI-restricted fibroids with ADC data, the mean ADC was 1313±389 versus 1207±262 in non-restricted fibroids. Regarding degeneration, 57.1% of DWI-restricted fibroids (4/7) showed degenerative changes versus 15.2% (5/33) of non-restricted fibroids.

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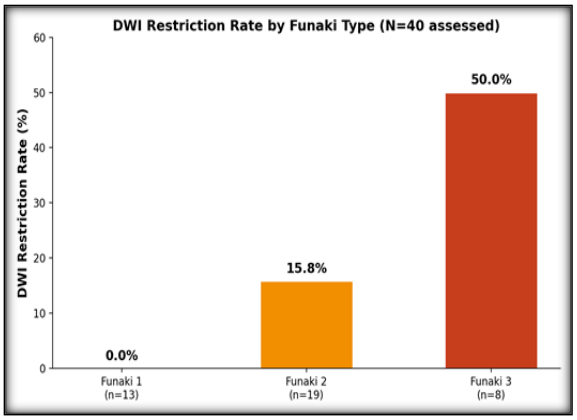

Figure 18: DWI restriction rate by Funaki type. Progressive increase from 0% (Type 1) to 15.8% (Type 2) to 50.0% (Type 3)

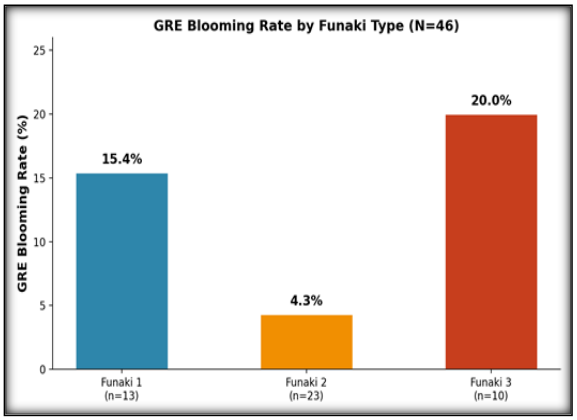

Figure 19: GRE blooming rate by Funaki type. Non-monotonic pattern: Type 2 lowest (4.3%); Type 1, 15.4%; Type 3, 20.0%

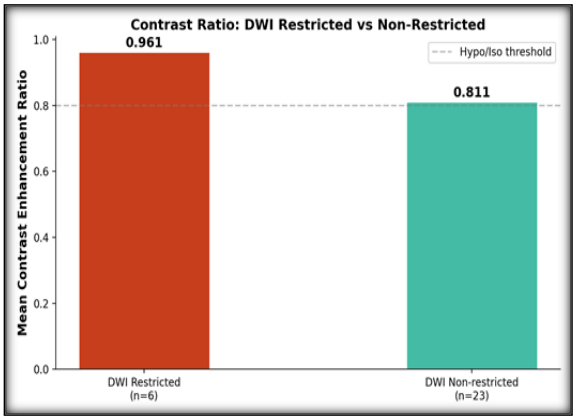

Figure 20: Mean contrast enhancement ratio in DWI-restricted versus non-restricted fibroids (0.961 vs 0.811), indicating viable, well-perfused tissue in restricted fibroids

ADC Values and Degeneration

Degenerated fibroids (n=10) had significantly higher mean ADC (1441±333 $\times 10^{-6}$ mm²/s) compared to fibroids without degeneration (n=24, mean 1137±199), representing a 26.8% increase. The highest ADC in the cohort (1974 $\times 10^{-6}$ mm²/s) was observed in a Funaki 3, FIGO 4 fibroid with cystic degeneration.

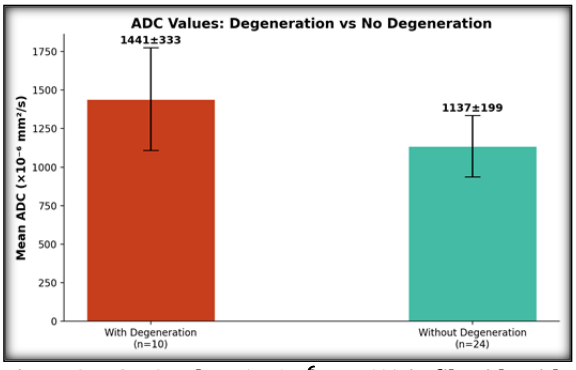

Figure 21: ADC values ($\times 10^{-6}$ mm²/s) in fibroids with and without degeneration. Degenerated fibroids had 26.8% higher mean ADC (1441 vs 1137)

DISCUSSION

The ADC–Funaki Gradient

The progressive ADC increase across Funaki types (1039 → 1189 → 1480 $\times 10^{-6}$ mm²/s) provides a quantitative validation of the qualitative Funaki classification. The gradient reflects the biophysical tissue spectrum: Type 1 (dense fibrous, acellular, restricted water diffusion) → Type 2 (mixed cellularity, intermediate diffusion) → Type 3 (cellular, fluid-rich, or degenerated, free water diffusion). This is consistent with Sainio et al,[5] and Slotman et al,[6] who demonstrated significant ADC differences between Funaki types and proposed ADC cutoffs of 980 and 1800 $\times 10^{-6}$ mm²/s for a three-tier stratification.[5] ADC captures the continuous tissue spectrum that Funaki bins into three discrete categories, enabling finer treatment discrimination.

The Contrast Ratio Gradient

The parallel gradient in contrast enhancement ratios (Funaki 1: 0.781; Funaki 2: 0.831; Funaki 3: 0.924) reflects vascularity: Type 1 fibroids are hypovascular (ratio <0.8), Type 2 moderately vascular, and Type 3 highly vascular. This has immediate treatment implications: for HIFU ablation, low vascularity is desirable since blood flow dissipates thermal energy; the 50.0% hypo-enhancing rate in our cohort defines the potential HIFU-suitable pool. Higher vascularity predicts better UAE response, as embolisation requires a patent vascular bed. All three hyper-enhancing fibroids in our series were Funaki Type 3, supporting the preference for UAE in this group.[7,8]

Complementarity of ADC and Contrast Ratio

The weak correlation (r=0.102) between ADC and contrast enhancement ratio is a notable observation, suggesting that these two parameters largely capture different tissue properties: ADC reflects cellularity and water mobility (structural), and the contrast ratio reflects vascularity and perfusion (functional). A fibroid may have restricted diffusion (low ADC) yet be well perfused (high ratio), or have free diffusion (high ADC) with poor perfusion (low ratio). This near-independence justifies a three-axis

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characterisation framework: T2 signal (Funaki) × ADC (cellularity) × contrast ratio (vascularity).

DWI Restriction and GRE Blooming

The monotonically increasing DWI restriction rate with Funaki type (0% → 15.8% → 50.0%) parallels the quantitative ADC gradient and reinforces that the cellular-versus-fibrous axis is the dominant dimension captured by diffusion imaging. The absence of restriction in any Funaki 1 fibroid confirms that dense fibrous tissue does not restrict diffusion. A practical implication is that DWI restriction in a fibroid classified as Funaki 1 should prompt reassessment of the Funaki assignment. In contrast, GRE blooming showed a non-monotonic pattern (lowest in Funaki 2), reflecting that haemosiderin deposition and dystrophic calcification — the substrates of GRE blooming — depend on the chronicity and vascular history of the fibroid rather than its current cellularity. Correlation of GRE findings with T1WI and DWI, as advocated by the BET1T2ER Check,[9] remains essential to exclude the T2-blackout effect from blood products falsely lowering ADC.

DWI Restriction and Tissue Viability

DWI-restricted fibroids had a higher mean contrast enhancement ratio (0.961) than non-restricted fibroids (0.811), and a threefold higher rate of degenerative changes (57.1% vs 15.2%). This indicates that DWI restriction in fibroids is associated with viable, well-perfused tissue with altered microstructure from cellular change or degeneration, not devascularisation. A restricted, enhancing fibroid is a viable lesion warranting active consideration for intervention.

ADC and Degeneration

The 26.8% higher ADC in degenerated fibroids (1441 vs 1137 $\times 10^{-6}$ mm²/s) confirms that degenerative processes — cell membrane disruption, cyst formation, and necrosis — increase water diffusivity. This has two clinical implications: first, high ADC in a Funaki 3 fibroid may reflect benign degeneration rather than malignant cellularity; second, the Thomassin-Naggara,[10] sarcoma-exclusion ADC threshold (0.905 $\times 10^{-3}$ mm²/s) applies specifically to non-degenerated fibroids, and ADC interpretation must always incorporate degeneration status. Sato et al,[11] reported mean ADC of 0.791±0.145 $\times 10^{-3}$ mm²/s for leiomyosarcoma, versus 1.472±0.285 for leiomyomas, providing a discrimination threshold.

Proposed Integrated Treatment Stratification

Based on the findings of this study and the published literature, a five-group integrated ADC–Contrast Ratio–Funaki treatment stratification system is proposed [Figure 22]. Group 1 (Funaki 1 + ADC <980 + ratio <0.8): optimal HIFU candidate; dense fibrous tissue with low cellularity and low vascularity, no DWI restriction, optimal thermal absorption with minimal perfusion-mediated cooling. Group 2 (Funaki 2 + ADC 980–1800 + ratio 0.8–1.0): HIFU or UAE equally appropriate, with treatment choice determined by patient preference, fibroid location, and FIGO type; this was the largest group in the present cohort (50.0%). Group 3 (Funaki 3 + ADC >1200 + ratio >0.9): UAE preferred; high vascularity dissipates HIFU thermal energy while supporting effective embolisation. Group 4 (any Funaki + ADC >1400 + degeneration confirmed): conservative management or follow-up appropriate; high ADC with confirmed degeneration indicates ongoing tissue remodelling; mean ADC was 1441 in degenerated fibroids in this series. Group 5 (Funaki 3 + low ADC + atypical features): mandatory exclusion of leiomyosarcoma; clinical correlation, consideration of biopsy, and application of the Thomassin-Naggara algorithm,[10] and BET1T2ER Check,[9] are required.

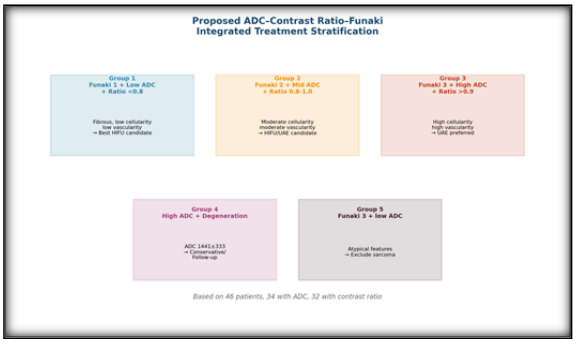

Figure 22: Proposed five-group integrated ADC–Contrast Ratio–Funaki treatment stratification system for uterine fibroids

Group 1: Funaki 1 + ADC <980 + ratio <0.8 → Optimal HIFU candidate. Group 2: Funaki 2 + ADC 980–1800 + ratio 0.8–1.0 → HIFU or UAE. Group 3: Funaki 3 + ADC >1200 + ratio >0.9 → UAE preferred. Group 4: Any Funaki + ADC >1400 + confirmed degeneration → Conservative/follow-up. Group 5: Funaki 3 + low ADC + atypical features → Exclude leiomyosarcoma.

FIGO Context

FIGO type 5 was the most frequent (25.0%), reflecting subserosal fibroid predominance in this referral population. FIGO classification determines surgical access: FIGO 0–2 fibroids are amenable to hysteroscopic myomectomy; FIGO 3–5 to laparoscopic or open myomectomy; FIGO 6–7 to laparoscopic excision.[14,15] The ADC–ratio–Funaki characterisation complements FIGO by adding tissue-composition information, enabling simultaneous anatomical (FIGO) and biological (ADC–ratio–Funaki) preoperative assessment.

Limitations

This study has several limitations. It is a single-centre retrospective study with 46 patients. ADC and contrast ratio data were not available for all patients (34 with ADC, 32 with contrast ratio, 24 with complete triple-correlation data). There was no histopathological correlation and no post-treatment outcome data to validate the proposed stratification. ADC measurements were obtained from a single ROI without histogram analysis. These limitations necessitate larger prospective studies with treatment

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outcome data to validate the proposed integrated stratification system.

CONCLUSION

ADC values show a progressive increase across Funaki types: Type 1 (1039±206) < Type 2 (1189±197) < Type 3 (1480±300 $\times 10^{-6}$ mm²/s), providing a quantitative validation of the qualitative Funaki classification.

Contrast enhancement ratios parallel the ADC gradient: Funaki 1 (0.781, hypo-enhancing) < Funaki 2 (0.831, iso-enhancing) < Funaki 3 (0.924, near hyper-enhancing), providing a second independent quantitative axis.

ADC and contrast ratio are weakly correlated (r=0.102), confirming complementarity: ADC reflects cellularity and contrast ratio reflects vascularity.

DWI restriction rate increased progressively with Funaki type (0% → 15.8% → 50.0%), with zero restriction in Funaki 1.

GRE blooming showed a non-monotonic pattern (Funaki 2 lowest, 4.3%), reflecting haemorrhagic and calcific changes independent of the cellularity gradient.

DWI-restricted fibroids had higher contrast ratios (0.961 vs 0.811) and higher degeneration rates (57.1% vs 15.2%), indicating viable tissue with altered microstructure.

Degenerated fibroids had 26.8% higher ADC (1441 vs 1137 $\times 10^{-6}$ mm²/s); degeneration status must be considered in ADC interpretation.

A five-group integrated ADC–Contrast Ratio–Funaki treatment stratification system is proposed, combining quantitative tissue characterisation with FIGO classification to enable individualised treatment selection.

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