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Original Article

Effect of focused ultrasound ablation and myomectomy on pelvic adhesions in patients with uterine fibroids

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Abstract: Objective: To investigate the effects of focused ultrasound ablation (FUSA) versus conventional myomectomy on pelvic adhesions and fertility in the treatment of uterine fibroids. Methods: The clinical data of 114 patients with uterine fibroids admitted to Northwest Women's and Children's Hospital from February 2020 to January 2023 were retrospectively analyzed, among which 61 cases were treated with FUSA and 53 cases received myomectomy. The length of surgery, bleeding, hospitalization days, incidence of pelvic adhesions, and ovarian reserve function indexes (FSH (Follicle Stimulating Hormone), LH (Luteinizing Hormone) and E2 (Estradiol)) were compared between the two groups. Results: Compared to the myomectomy group, the FUSA group had shorter operation time ($P<0.001$), no bleeding ($P<0.001$), less hospitalization ($P<0.001$), lower incidence of pelvic adhesion ($P = 0.020$), and less impairment of ovarian reserve function (Increased FSH, LH and E2, all $P<0.001$). Logistic regression analysis showed that the maximum diameter of leiomyoma ≥5 cm ($P = 0.008$), the number of pregnancies ≥3 ($P = 0.003$) and intraoperative hemorrhage ($P = 0.004$) were independent risk factors for pelvic adhesion. Conclusions: FUSA is a safe and effective non-invasive method for the treatment of uterine fibroids that reduces postoperative complications and protects fertility potential, especially for female patients with fertility concerns. Future studies need to overcome existing limitations to improve reliability of evidence.

Keywords: Uterine fibroids, myomectomy, focused ultrasound ablation, pelvic adhesions, reproductive function

Introduction

Uterine fibroids are the most common benign tumors in women, consisting primarily of smooth muscle and connective tissue, and are clinically diagnosed in approximately 25% of women [1]. The prevalence may be as high as 77% on pathologic examination after hysterectomy [2]. This tumor usually occurs in women between the ages of 30 and 50 and is especially common between the ages of 40 and 50, with a lower incidence in those under the age of 20 [3]. Uterine fibroids can cause pelvic pain, abnormal uterine bleeding, and pressure on nearby organs, which can affect fertility [4]. Although the exact etiology has not been clearly defined, the occurrence of fibroids has been linked to female hormones, especially in women of reproductive age [5]. A study has shown [6] that the concentration of estrogen and its receptors is significantly higher in leiomyoma tissue than in normal myofibroblasts, and the proliferative activity associated with progesterone suggests that progesterone may promote leiomyoma formation and growth by stimulating somatic cell mutation and mitosis.

For patients who do not wish to undergo hysterectomy and still wish to reproduce, traditional myomectomy is a common treatment that removes fibroids without removing the uterus [7]. In recent years, focused ultrasound ablation (FUSA) has emerged as a promising technique in the treatment of various medical conditions, particularly in oncology and gynecology [8]. Its clinical applications extend beyond uterine fibroids to include the treatment of tumors in organs such as the liver, breast, and brain [9]. The key advantages of FUSA are its non-invasive nature, its ability to precisely target and destroy pathologic tissue while sparing surrounding healthy tissue, and its reduced risk of complications such as infection and bleeding. In addition, FUSA reduces hospital stays and allows for faster patient recovery compared to traditional surgical methods [10]. FUSA has been widely used to treat uterine fibroids by using high-intensity ultrasound waves to focus on the area of the fibroids and irradiate the target area at high temperatures, resulting in coagulative necrosis of the fibroid without damage to surrounding healthy tissue [11]. Postoperative pelvic adhesions are a common complication of gynecologic surgery and can lead to abdominal pain, bowel obstruction, and increase in the complexity and cost of subsequent surgery [12]. For the treatment of uterine fibroids, such as after myomectomy, pelvic adhesions can interfere with normal uterine function, increase the risk of reoperation, and affect fertility [13]. Among the strategies to prevent adhesions, the use of improved surgical techniques and the use of anti-adhesive agents are current directions of treatment.

The innovation of this study is a detailed comparative analysis of FUSA versus traditional myomectomy, with a particular focus on its efficacy in reducing post-operative pelvic adhesions. While FUSA is already recognized for its minimal invasiveness and safety, our study is a novel contribution since it is the first to explore its potential for fertility preservation, a critical concern for many women with uterine fibroids. This aspect of FUSA has not been thoroughly explored in previous research

By focusing on the reduction of pelvic adhesions, which are a significant postoperative complication affecting fertility, our research aims to provide valuable insight into optimizing fibroid treatment for women of reproductive age. This approach not only addresses an important clinical need, but is also consistent with the current trend toward more patient-centered, fertility-sparing treatment modalities.

Materials and methods

Ethical information

The study was conducted through the approval of the Medical Ethics Committee of Northwest Women's and Children's Hospital.

Sample collection time

The medical records of patients with uterine fibroids admitted to Northwest Women's and Children's Hospital from February 2020 to January 2023 were collected for a retrospective study.

Clinical data collection

Clinical data, surgical data, and indicators of ovarian reserve function were collected from electronic medical records and outpatient clinic records. Clinical data included age, disease duration, BMI, lesion location, maximum lesion diameter, number of abortions, number of deliveries, number of pregnancies, history of hypertension, history of diabetes mellitus, rate of pelvic adhesions, degree of pelvic adhesions, and clinical outcome. Surgical data included operative time, intraoperative bleeding, and hospital length of stay. Indicators of ovarian reserve function included FSH (follicle stimulating hormone), LH (luteinizing hormone), and E2 (estradiol).

Inclusion exclusion criteria

Inclusion criteria: (1) patients with uterine fibroids diagnosed by MRI (magnetic resonance imaging), ultrasound, or postoperative pathology [4]; (2) patients with a history of only one myomectomy or FUSA with no other pelvic or uterine surgery; (3) patients with fibroids of a maximum diameter ranging from 2 to 12 centimeters; (4) patients with a complete clinical history; (5) patients with reoperation consisting of either hysterectomy, myomectomy, or cesarean section; (6) patients with reoperation using laparoscopic or open surgery; (7) patients with no preoperative history of pelvic adhesions.

Exclusion criteria: (1) patients with a history of pelvic inflammatory disease, reproductive tuberculosis, or endometriosis; (2) patients with uterine malignancy; (3) patients with other treatments such as radiofrequency ablation (RFA), microwave ablation (MWA), or uterine artery embolization (UAE) after FUA or myomectomy; (4) patients with presence of submucosal fibroids or uterine cervical leiomyosarcoma; (5) patients with pelvic adhesions not documented in detail in the operative note; (6) patients with presence of pelvic adhesions at initial surgery; (7) patients with uterine fibroids associated with adenomyosis.

Sample screening and grouping

In this study, we screened a total of 184 samples that met the requirements of the inclusion

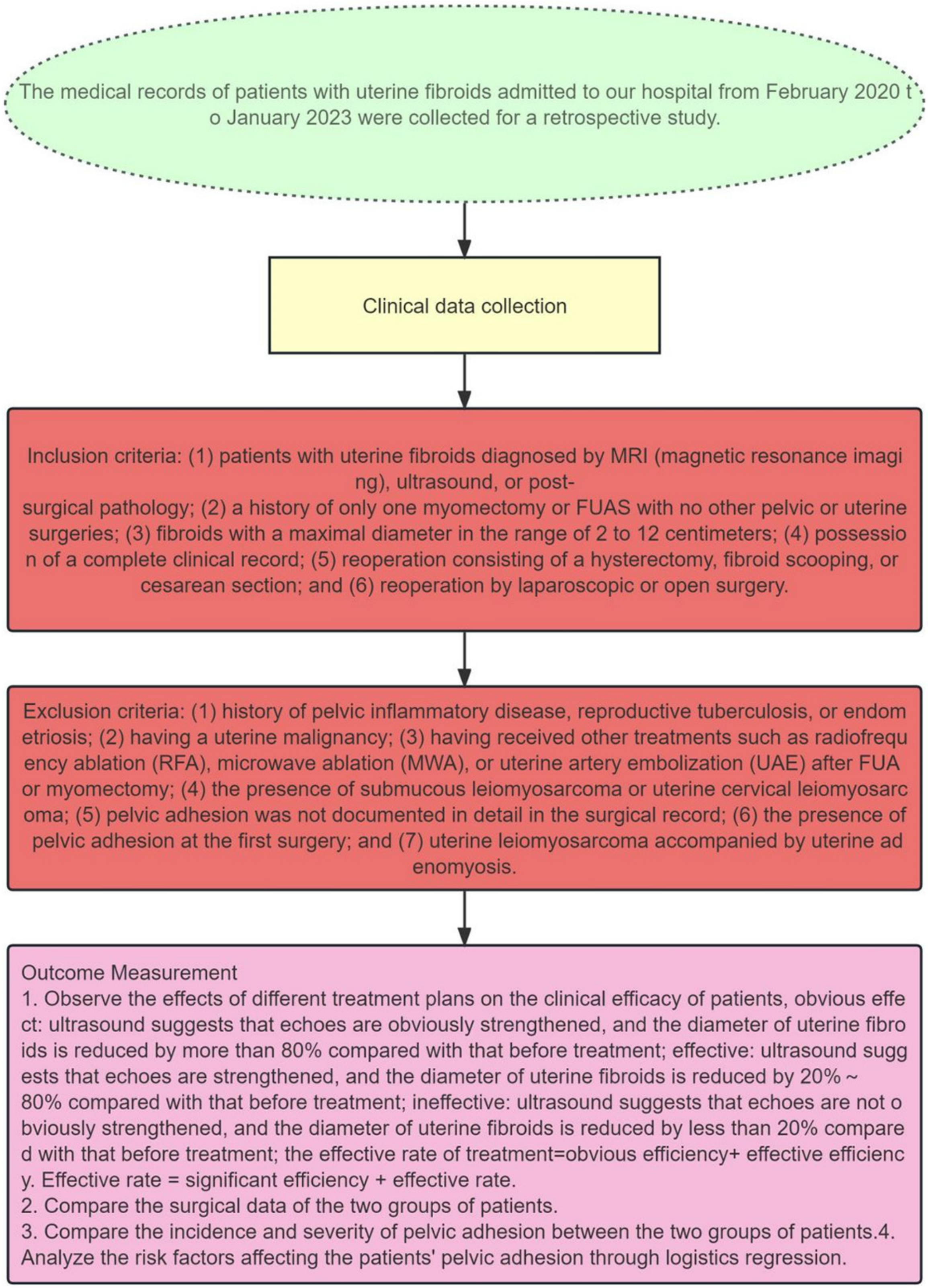

Figure 1. Sample screening and study flowchart.

criteria, and then we screened a total of 114 samples after applying the exclusion criteria (**Figure 1**). Statistically, the patients were divided into the FUSA group (n = 61) and the myomectomy group (n = 53) according to the treatment plan. In addition, we divided the patients into a group without pelvic adhesions (52 cases) and a group with pelvic adhesions (62 cases) according to their postoperative status. We followed the patients for at least 6 months postoperatively to accurately assess the occurrence of pelvic adhesions.

Outcome results

1. The effects of different treatment plans on the clinical efficacy of patients were compared. Obviously effective: Ultrasound suggests that echoes are obviously strengthened, and the diameter of uterine fibroids is reduced by more than 80% compared with that before treatment. Effective: Ultrasound suggests that echoes are obviously strengthened, and the diameter of uterine fibroids is reduced by 20%~80% compared with that before treatment; ineffective: Ultrasound suggests that echoes are not obviously strengthened, and the diameter of uterine fibroids is reduced by less than 20% compared with that before treatment. The effective rate of treatment = (cases with obvious effective + cases with effective)/ total cases * 100% [14].

2. The surgical data of the two groups of patients were compared.

3. The incidence and severity of pelvic adhesions between the two groups of patients were compared [15].

4. The risk factors affecting the patients' pelvic adhesions were analyzed by logistic regression.

Statistical analysis

SPSS 26.0 was used for data processing and analysis in this study. The Shapiro-Wilk test was used to determine whether the data conformed to a normal distribution. Measured data that conformed to a normal distribution were expressed as mean ± standard deviation (mean ± sd) and compared using t-test. A non-parametric test, namely the Mann-Whitney U test was used for comparisons between two independent samples that do not conform to a normal distribution. Counted data were expressed as a rate (%) and tested using chi-square test. To identify independent risk factors for pelvic adhesions in patients, logistic regression analysis was used. Differences were considered significant with a *P* value of less than 0.05.

Results

Comparison of clinical data

The clinical data of the two groups were compared. We found that there was no statistical difference between the ultrasound ablation group and the myomectomy group in terms of age, disease duration, BMI, lesion location, maximum lesion diameter, number of miscarriages, number of deliveries, number of pregnancies, history of hypertension, or diabetes mellitus (all $P>0.05$, **Table 1**).

Clinical efficacy assessment

The clinical efficacy of the two groups of patients after treatment was compared. The results showed that the overall clinical efficacy rate of patients in the FUSA group was significantly higher than that of patients in the myomectomy group ($P = 0.007$, **Table 2**), and the overall clinical efficacy rate was also statistically higher than that of patients in the myomectomy group ($P = 0.019$, **Table 2**).

Comparison of general surgical data

Operating time, intraoperative bleeding, and hospital stay were compared between the two groups. The results showed that the operative time ($P<0.001$), intraoperative bleeding ($P<0.001$), and hospital stay ($P<0.001$) of the patients in the FUSA group were shorter than those of the myomectomy group (**Table 3**).

Comparison of pelvic adhesion rate and degree of adhesion in patients

The pelvic adhesion rate and the degree of adhesion were compared between the two groups of patients. The results showed that the rate of postoperative pelvic adhesions in the FUSA group was significantly lower than that of the myomectomy group ($P = 0.020$, **Table 4**), and the degree of postoperative pelvic adhesions was significantly lower in the FUSA group than that in the myomectomy group ($P = 0.035$, **Table 5**).

Table 1. Comparison of baseline data between the two groups

Index	FUSA group (n = 61)	Myomectomy group (n = 53)	X^2-value	*P*-value
Age				
≥40	24	29	2.694	0.101
<40	37	24		
Course of disease				
≥3 years	21	21	0.329	0.566
<3 years	40	32		
BMI				
≥25 kg/m^2	15	11	0.237	0.626
<25 kg/m^2	46	42		
Lesion location				
Broad ligament	12	15	1.236	0.539
Intramuscular wall	18	15		
Serous membrane	31	23		
Maximum diameter of the lesion				
≥5 cm	34	32	0.250	0.617
<5 cm	27	21		
Number of abortions				
≥2	31	24	0.348	0.555
<2	30	29		
Number of deliveries				
≥1	27	28	0.834	0.361
<1	34	25		
Number of pregnancies				
≥3	37	30	0.192	0.661
<3	24	23		
History of hypertension				
Yes	12	6	1.488	0.223
No	49	47		
History of diabetes				
Yes	11	8	0.176	0.675
No	50	45		

Note: BMI, Body Mass Index.

Table 2. Assessment of patients' clinical outcome

Group	Obviously effective	Effective	Ineffective	Overall effectiveness rate
FUSA group (n = 61)	31	27	3	58 (95.08%)
Myomectomy group (n = 53)	16	27	10	43 (81.13%)
X^2/Z value		-2.682		5.462
P-value		0.007		0.019

Comparison of ovarian reserve function indicators

We compared the changes in ovarian reserve function indexes FSH, LH, and E2 before and after treatment in the two groups of patients. We found no significant difference in any of them before treatment in the two groups (all P>0.05). After treatment, it was found that the levels of FSH, LH, and E2 in patients of the FUSA group had significantly increased (all P<0.001). In contrast, there was no significant difference in FSH, LH, or E2 levels before and after treatment in the leiomyosarcoma excision group (all P>0.05). Further comparison revealed that the levels of FSH, LH, and E2 after treatment was significantly higher in the FUSA group than those of the myomectomy group (all P<0.001, **Figure 2**).

Analysis of risk factors affecting pelvic adhesions in patients

Patients were divided into two groups according to whether pelvic adhesion occurred after surgery, including 52 patients without pelvic adhesion and 62 patients with pelvic adhesion. Univariate analysis showed that age ≥40 years (P = 0.007), duration of the disease ≥3 years (P = 0.044), lesions in location of the broad ligament (P = 0.019), maximum diameter of the lesion ≥5 cm (P = 0.002), number of abortions ≥2 (P = 0.022), number of deliveries ≥1 (P = 0.008), number of pregnancies ≥3 (P = 0.004), and intraoperative bleeding (P = 0.010) were more likely to caused pelvic adhesions (**Table 6**). We then assigned values to the meaningful indicators (**Table 7**). Multifactorial

Table 3. Comparison of general surgical data

Group	Surgical time (min)	Intraoperative bleeding (mL)	Length of hospitalization (d)
FUSA group (n = 61)	73.57±13.67	0	3.53±0.74
Myomectomy group (n = 53)	85.91±14.73	38.64±9.55	7.45±2.00
t-value	4.635	31.611	14.280
P-value	<0.001	<0.001	<0.001

Table 4. Comparison of pelvic adhesion rates

Group	With pelvic adhesions	No pelvic adhesions
FUSA group (n = 61)	27	34
Myomectomy group (n = 53)	35	18
X^2-value	5.421	
P-value	0.020	

Table 5. Comparison of the degree of pelvic adhesion

Group	Extent of pelvic adhesions		
	Mild	Moderate	Severe
FUSA group (n = 27)	16	7	4
Myomectomy group (n = 35)	12	11	12
X^2/Z value		2.105	
P-value		0.035	

analysis showed that lesions with a maximum diameter of ≥5 cm (β = 1.135, P = 0.008, OR = 3.110, 95% CI = 1.346-7.186), number of pregnancies ≥3 (β = 1.352, P = 0.003, OR = 3.867, 95% CI = 1.601-9.342), and amount of intraoperative bleeding (β = 1.308, P = 0.004, OR = 3.698, 95% CI = 1.514-9.031) were independent risk factors for pelvic adhesion (**Table 8**).

Discussion

Although the exact cause of uterine fibroids is not fully understood, estrogen is thought to be the main factor driving their growth [16]. Currently, medications are mainly used to shrink fibroids, but they are not curative and fibroids tend to recur. Minimally invasive techniques such as laparoscopic surgery is beneficial for quick recovery but may delay pregnancy and affect ovarian function [17, 18].

When treating uterine fibroids, the choice of medication or surgery is based on the patient's intent and condition. Conventional surgery, especially laparoscopic myomectomy, although preferred, carries risks and may affect fertility [19]. Focused ultrasound ablation (FUSA), as a non-invasive treatment, eliminates the risks of conventional surgery and offers the advantages of no incision, no pain, and less bleeding, showing promise for improving prognosis [20, 21]. In the present study, we found that patients treated with FUSA for uterine fibroids showed better clinical outcomes than traditional surgical methods, including significantly higher overall efficacy rates and lower rates of postoperative pelvic adhesions. In addition, the FUSA treatment group had a shorter operative time, no intraoperative bleeding, and a shorter hospital stay, underscoring its benefits as a non-invasive treatment option. Most importantly, FUSA showed a significant improvement in ovarian reserve function indicators compared to myomectomy, which is particularly important for women who wish to preserve their fertility. These results support FUSA as an effective and safe option for the treatment of uterine fibroids, particularly for patients who wish to minimize surgical risk and preserve fertility potential. Notably, our findings are consistent with those of Liu et al. [22] who also observed comparable long-term efficacy of FUSA and conventional myomectomy in the treatment of uterine fibroids. Liu et al. [22] found that FUSA was similar to myomectomy in terms of symptom relief and retreatment frequency. In addition, their data also showed an advantage of FUSA in reducing postoperative adhesions and other complications. This finding is consistent with our data and further supports the value and safety of FUSA as a non-invasive therapy for the treatment of uterine fibroids. When comparing noninvasive FUSA with conventional surgical approaches, our results showed that FUSA had significant advantages in preserving ovarian function and reducing postoperative complications. Similarly, Li et al. [23] showed that high-intensity focused ultrasound also demonstrated lower postoperative complications in the treatment of uterine submucosal fibroids, with recurrence and pregnancy rates similar to those of hysteroscopic leiomyomectomy, al-

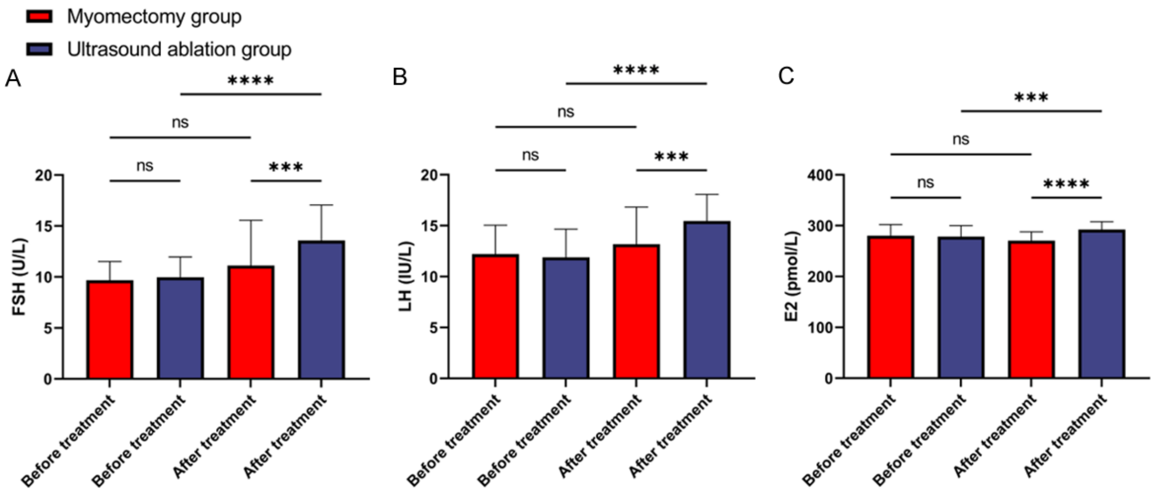

Figure 2. Comparison of ovarian reserve function indexes before and after treatment. A. Comparison of FSH indexes before and after treatment between the two groups of patients. B. Comparison of LH indexes before and after treatment in the two groups. C. Comparison of E2 indexes before and after treatment in the two groups. Note: FSH, Follicle Stimulating Hormone; LH, Luteinizing Hormone; E2, Estradiol; ns P>0.05, ***P<0.001, ****P<0.0001.

Table 6. One-way analysis of variance

Group	Without pelvic adhesions (n = 52)	With pelvic adhesion group (n = 62)	X^2/Z/t value	*P*-value
Age				
≥40	35	26	7.318	0.007
<40	17	36		
Course of disease				
≥3 years	14	28	4.043	0.044
<3 years	38	34		
BMI				
≥25 kg/m²	10	16	0.695	0.405
<25 kg/m²	42	46		
Lesion location				
Broad ligament	10	17	7.972	0.019
Intramuscular wall	10	23		
Serous membrane	32	22		
Maximum diameter of the lesion				
≥5 cm	31	35	9.529	0.002
<5 cm	21	27		
Number of abortions				
≥2	19	36	5.248	0.022
<2	33	26		
Number of deliveries				
≥1	18	37	7.114	0.008
<1	34	25		
Number of pregnancies				
≥3	23	44	8.344	0.004
<3	29	18		
History of hypertension				
Yes	7	11	0.390	0.532
No	45	51		

History of diabetes				
Yes	7	12	0.707	0.400
No	45	50		
Surgical time	79.26±15.83	79.37±15.02	0.037	0.970
Intraoperative bleeding	22.45±21.11	12.62±18.34	2031.500	0.010
FSH	9.64±1.97	10.08±1.84	1.207	0.230
LH	11.88±2.97	12.24±2.55	0.692	0.490
E2	280.83±20.91	277.39±22.82	0.834	0.406

Table 7. Assignment table

Factor	Assignment
Pelvic adhesion	Present = 1, absent = 0
Age	≥40 = 1, <40 = 0
Duration of illness (years)	≥3 years = 1, <3 years = 0
Lesion location	Broad ligament = 0, intermuscular wall = 1, plasma membrane = 2
Maximum diameter of lesion (cm)	≥5 cm = 1, <5 cm = 0
Number of abortions	≥2 times = 1, <2 times = 0
Number of deliveries	≥1 time = 1, <1 time = 0
Number of pregnancies	≥3 times = 1, <3 times = 0
Intraoperative bleeding (mL)	≥24.50 = 1, <24.50 = 0
Treatment plan	Ultrasound ablation group = 0, myomectomy group = 1

Table 8. Multifactor logistic regression analysis

Index	β	Standard error	Chi-square value	*P*-value	OR value	95% CI	
						Lower limit	Upper limit
Treatment plan	-0.382	1.027	0.138	0.710	0.683	0.091	5.108
Age	-0.681	1.292	0.278	0.598	0.506	0.040	6.368
Course of disease	0.413	0.821	0.253	0.615	1.511	0.303	7.547
Lesion location	0.261	0.420	0.388	0.534	1.299	0.570	2.958
Maximum diameter of the lesion	1.135	0.427	7.054	0.008	3.110	1.346	7.186
Number of abortions	0.177	1.068	0.027	0.869	1.193	0.147	9.670
Number of deliveries	0.304	0.984	0.095	0.758	1.355	0.197	9.321
Number of pregnancies	1.352	0.450	9.032	0.003	3.867	1.601	9.342
Intraoperative bleeding	1.308	0.456	8.240	0.004	3.698	1.514	9.031

though with a higher re-intervention rate. This further highlights the value of high-intensity focused ultrasound as a safe and effective non-invasive treatment option. Taken together, these data support the value of FUSA in minimizing surgery-related risks and protecting fertility potential, particularly for patients considering fertility treatment.

The mechanism of formation of pelvic adhesions is not fully understood, but is considered to be associated with a variety of biologic processes including inflammation, coagulation, and fibrinolysis [24, 25]. It is widely accepted that injury to the peritoneum and the subsequent repair process are key components in the formation of adhesions [26]. Surgical injury, thermal injury, radiation injury, pelvic inflammatory disease, and endometriosis may contribute to adhesions, with surgery being the most direct causative factor [27]. As a common benign tumor in gynecologic surgery, uterine fibroid treatment may be associated with the risk of pelvic adhesions, a complication that can have a profound impact on a woman's health, potentially causing bowel obstruction, infertility, chronic abdominal or pelvic pain, and increased difficulty in reoperation [28]. In this study, statistics on the occurrence of pelvic adhesions and their subsequent logistic regression analysis revealed several key factors. Large diameter lesions (≥5 cm) demonstrated more significant peritoneal injury, as larger tumors require more extensive surgical manipulation, which increases the extent of tissue damage and in turn promotes adhesion formation. Multiple pregnancies (≥3), on the one hand, can affect the pelvic environment, since the performance of surgery increases the risk of adhesions. Intraoperative bleeding, on the other hand, is directly related to the precision of the surgical maneuver and degree of trauma, and heavy bleeding may imply a greater inflammatory response and need for repair, creating conditions for adhesion formation. Together, these factors contribute to an increase in the risk of pelvic adhesions. Previously, the study by Liu et al. [29] further confirmed that FUSA treatment did not significantly increase the risk of pelvic adhesions, which is consistent with our findings. In addition, their study also observed no significant effect of treatment regimen on the risk of pelvic adhesions, which is consistent with our findings by multifactorial logistic regression analysis. Study of Trew et al. [30] noted how factors such as duration of surgery, amount of bleeding during surgery, and length of uterine incision affected the formation of de novo adhesions, which is consistent with our findings. In addition, there are reports [31] showing that the diameter of leiomyomas and the number of leiomyomas removed also affect the incidence of postoperative adhesions. This is because after excavation of large-diameter fibroids and multiple fibroids, it is difficult to form a smooth and flat wound due to excessive protrusion of the plasma layer. This leads to an increased inflammatory response to the wound, thus increasing the incidence of pelvic adhesions.

Although our study demonstrates the benefits of FUSA in the treatment of uterine fibroids, there are certain limitations, including a limited sample size, the single-center retrospective design of the study, the primary focus on short-term effects, and the failure to fully adjust for all possible confounders. Future studies should increase the sample size, adopt a multicenter randomized controlled design, extend the follow-up period to assess long-term effects, and more carefully control for confounders to improve the validity and generalizability of the study and ensure the robustness and credibility of the findings.

In conclusion, FUSA is a safe and effective non-invasive method for the treatment of uterine fibroids that reduces postoperative complications and protects fertility potential, especially for female patients with fertility concerns. Future studies need to overcome existing limitations to provide more reliable evidence.

Disclosure of conflict of interest

None.

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References

[1] Schiffman M and Lamparello N. Uterine-artery embolization or myomectomy for uterine fibroids. N Engl J Med 2020; 383: 2186-2187.
[2] Donnez J, Taylor HS, Stewart EA, Bradley L, Marsh E, Archer D, Al-Hendy A, Petraglia F, Watts N, Gotteland JP, Bestel E, Terrill P, Loumaye E, Humberstone A and Garner E. Linzagolix with and without hormonal add-back therapy for the treatment of symptomatic uterine fibroids: two randomised, placebo-controlled, phase 3 trials. Lancet 2022; 400: 896-907.
[3] Slomski A. Relugolix combination therapy for uterine fibroids. JAMA 2021; 325: 1602.
[4] Stewart EA, Laughlin-Tommaso SK, Catherino WH, Lalitkumar S, Gupta D and Vollenhoven B. Uterine fibroids. Nat Rev Dis Primers 2016; 2: 16043.
[5] Cerdeira AS, Tome M, Moore N and Lim L. Seeing red degeneration in uterine fibroids in pregnancy: proceed with caution. Lancet 2019; 394: e37.
[6] Sobel M, Hobson S and Chan C. Uterine fibroids in pregnancy. CMAJ 2022; 194: E775.
[7] Baxter BL, Seaman SJ, Arora C and Kim JH. Radiofrequency ablation methods for uterine sparing fibroid treatment. Curr Opin Obstet Gynecol 2022; 34: 262-269.
[8] Qu K, Mao S, Li J, Wang J, Ouyang G, Wang Z, Wang Z, Xiong Y and Zhang L. The impact of

ultrasound-guided high-intensity focused ultrasound for uterine fibroids on ovarian reserve. Int J Hyperthermia 2020; 37: 399-403.
[9] Yue X, Li Z, Yin H, Xiao Y, Yang L, Chen M, Huang H, Yang H, Wang Z and Zhang C. Focused ultrasound ablation surgery for multiple breast fibroadenomas: pathological and follow-up results. Int J Hyperthermia 2023; 40: 2202372.
[10] Liao M, Du J, Chen L, Huang J, Yang R, Bao W, Zeng K, Wang W, Aphan BC, Wu Z, Ma L and Lu Q. Sono-activated materials for enhancing focused ultrasound ablation: design and application in biomedicine. Acta Biomater 2023; [Epub ahead of print].
[11] Patel N, Chaudhari K, Patel D and Joshi J. High-intensity focused ultrasound ablation of uterine fibroids: a review. Cureus 2023; 15: e44680.
[12] Zhang PP, He XP, Tang W, Chen HW and Han YY. Alterations in vaginal microbiota in uterine fibroids patients with ultrasound-guided high-intensity focused ultrasound ablation. Front Microbiol 2023; 14: 1138962.
[13] Kondratovich LM, Kozachenko AV, Adamyan LV and Stepanian AA. The expression of the proliferation marker Ki-67 tissue of the uterine fibroids and fiber adhesions in patients with uterine fibroids in reproductive age. J Minim Invasive Gynecol 2015; 22: S234.
[14] Matlac DM, Tonguc T, Mutschler N, Recker F, Ramig O, Strunk HM, Dell T, Pieper CC, Coenen M, Fuhrmann C, Vautey O, Egger EK, Küppers J, Conrad R, Essler M, Mustea A and Marinova M. Study protocol of a prospective, monocentric, single-arm study investigating the safety and efficacy of local ablation of symptomatic uterine fibroids with US-guided high-intensity focused ultrasound (HIFU). J Clin Med 2023; 12: 5926.
[15] Wang L, Guo C and Cao H. Effect of hysteroscopic adhesiolysis on recurrence, menstruation and pregnancy outcomes in patients with different degrees of intrauterine adhesions. Am J Transl Res 2022; 14: 484-490.
[16] Yang Q, Ciebiera M, Bariani MV, Ali M, Elkafas H, Boyer TG and Al-Hendy A. Comprehensive review of uterine fibroids: developmental origin, pathogenesis, and treatment. Endocr Rev 2022; 43: 678-719.
[17] Corrigendum to: 2020 ESC Guidelines for the diagnosis and management of atrial fibrillation developed in collaboration with the European Association of Cardio-Thoracic Surgery (EACTS). Eur Heart J 2021; 42: 546-547.
[18] Kirschen GW, AlAshqar A, Miyashita-Ishiwata M, Reschke L, El Sabeh M and Borahay MA. Vascular biology of uterine fibroids: connecting fibroids and vascular disorders. Reproduction 2021; 162: R1-R18.
[19] Pereira K, Morel-Ovalle LM, Taghipour M, Sherwani A, Parikh R, Kao J and Vaheesan K. Superior hypogastric nerve block (SHNB) for pain control after uterine fibroid embolization (UFE): technique and troubleshooting. CVIR Endovasc 2020; 3: 50.
[20] Lazaridis A, Hirsch M, Pistofidis G and Odejinmi F. Surgical management of uterine fibroids. Curr Opin Obstet Gynecol 2023; 35: 440-445.
[21] Zhang X, Xu W, Sang G, Yu D and Shi Q. A measure for perioperative anxiety symptoms in patients with FUSA - treated uterine fibroids: development and validation. Int J Hyperthermia 2022; 39: 525-529.
[22] Mounien D, Martel C and Faller E. Laparoscopic ultrasound-guided radiofrequency ablation of uterine fibroids. Gynecol Obstet Fertil Senol 2023; 51: 384-386.
[23] Li W, Yang Z, Gao B, Zou L, Xu D, Liu L, Gu P and Deng X. Comparison of ultrasound-guided high-intensity focused ultrasound ablation and hysteroscopic myomectomy for submucosal fibroids: a retrospective study. Int J Hyperthermia 2021; 38: 1609-1616.
[24] Wang PY, Lee YC, Liu WM and Chen CH. Surgical outcome of benign cases with pelvic adhesions undergoing robotic total hysterectomy. J Chin Med Assoc 2022; 85: 853-858.
[25] Capmas P, Payen F, Lemaire A and Fernandez H. Adhesions in abdomino-pelvic surgeries: a real economic impact? PLoS One 2022; 17: e0276810.
[26] Koninckx PR and Gomel V. Introduction: quality of pelvic surgery and postoperative adhesions. Fertil Steril 2016; 106: 991-993.
[27] Dawood AS, Elgergawy AE and Dawood AS. Association between characteristics of previous cesarean delivery and pelvic adhesions: a case-controlled study. Ginekol Pol 2023; 94: 51-56.
[28] Canis M, Botchorishvili R, Bourdel N, Gremeau AS, Curinier S and Rabischong B. Pelvic adhesions and fertility: where are we in 2018? J Visc Surg 2018; 155 Suppl 1: S11-S15.
[29] Liu X, Dong X, Mu Y, Huang G, He J and Hu L. High-intensity focused ultrasound (HIFU) for the treatment of uterine fibroids: does HIFU significantly increase the risk of pelvic adhesions? Int J Hyperthermia 2020; 37: 1027-1032.
[30] Trew G, Pistofidis G, Pados G, Lower A, Mettler L, Wallwiener D, Korell M, Pouly JL, Coccia ME, Audebert A, Nappi C, Schmidt E, McVeigh E, Landi S, Degueldre M, Konincxk P, Rimbach S, Chapron C, Dallay D, Roemer T, McConnachie A, Ford I, Crowe A, Knight A, Dizerega G and

Dewilde R. Gynaecological endoscopic evaluation of 4% icodextrin solution: a European, multicentre, double-blind, randomized study of the efficacy and safety in the reduction of de novo adhesions after laparoscopic gynaecological surgery. Hum Reprod 2011; 26: 2015-2027.

[31] Takeuchi H, Kitade M, Kikuchi I, Shimanuki H, Kumakiri J and Takeda S. Influencing factors of adhesion development and the efficacy of adhesion-preventing agents in patients undergoing laparoscopic myomectomy as evaluated by a second-look laparoscopy. Fertil Steril 2008; 89: 1247-1253.