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Research

Comparative efficacy of uterine artery embolization versus laparoscopic myomectomy in treating uterine fibroids: a propensity score matched analysis

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Abstract

Objective The aim of this study was to comparatively analyze the therapeutic effects of uterine artery embolization (UAE) and laparoscopic myomectomy (LM) on uterine fibroids to determine which treatment method is more beneficial for patients.

Materials and methods A retrospective study was conducted on 396 patients who underwent UAE (n = 153) or LM (n = 243) treatment from April 2010 to September 2019. After 1:1 propensity score matching (PSM), a comparative analysis was conducted on surgical trauma magnitude, postoperative recovery time, improvement in associated symptoms and quality of life, surgical adverse events, recurrence rates, and further interventions.

Results In PSM, 66 pairs (132 patients) were successfully matched. Both treatments significantly alleviated symptoms and enhanced quality of life. Compared to the LM group, the UAE group had less intraoperative bleeding ($P < 0.001$), a lower rate of hemoglobin decrease ($P < 0.001$), shorter operation, postoperative, and overall hospital stays ($P < 0.001$), and a lower postoperative recurrence rate ($P < 0.05$), all statistically significant. Moreover, the UAE group showed notable advantages in postoperative activities ($P < 0.05$). However, UAE patients faced higher hospitalization costs ($P < 0.001$). Adverse event rates (7.6% vs. 9.1%) and postoperative reintervention rates (7.6% vs. 7.6%) were relatively low and not significantly different between groups ($P > 0.05$).

Conclusion Both UAE and LM can significantly improve patient symptoms and enhance their quality of life, and both treatment methods have low rates of adverse events and reinterventions. Compared to LM, UAE treatment for uterine fibroids presents advantages such as less trauma, faster recovery, and lower recurrence rate, but has higher treatment costs.

Keywords Uterine artery embolization · Laparoscopy · Propensity score matching · Uterine fibroids · Long-term follow-up

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1 Introduction

Uterine leiomyomas are the most common benign tumors in women, originating from the clonal expansion of a single cell in the uterine muscle layer [1, 2]. In China, the incidence rate is over 50% based on autopsy statistics [3]. Symptomatic uterine fibroids adversely affect women's physical, social, and psychological functioning, decrease their income and diminish their work efficiency [4, 5]. With the development of interventional radiology and surgery, uterine artery embolization (UAE) and laparoscopic myomectomy (LM) have become recognized as safe and effective treatments for uterine fibroids [1]. Although both UAE and LM are suitable for most patients with uterine fibroids [6, 7], the therapeutic advantages and disadvantages of these two treatment strategies are still the subjects of debate. Propensity score matching (PSM) can eliminate the inherent indication bias caused by observational nonrandom data and more accurately assess the impact of treatment on outcomes, resulting in its increasing application in clinical research [8, 9]. We conducted a retrospective comparative analysis of the therapeutic effects and symptom improvements of UAE and LM for uterine fibroids based on the PSM method, aiming to determine which treatment method is more beneficial for patients.

2 Materials and methods

2.1 Study subjects

We retrospectively collected data from 970 patients with uterine leiomyomas who underwent UAE or LM at a certain University Affiliated Hospital from April 2010 to September 2019. The study was approved by the institution's Medical Ethics Committee (approval number: JD-HG-2021-39).

LM surgical indications: (1) Reproductive age patients with uterine fibroids, symptomatic with heavy uterine bleeding or bulk related symptoms (e.g., pressure, pain, fullness, and symptoms affecting the bowel or bladder); (2) Reproductive age patients with uterine fibroids and experiencing reproductive dysfunction; (3) Postmenopausal patients in whom fibroids continue to grow despite the absence of hormone replacement therapy. The indications for UAE are largely consistent with those for LM; however, the primary distinction is that UAE is typically employed in patients who do not wish to preserve fertility.

We excluded patients who underwent other surgeries or procedures during hospitalization for UAE or LM, those with coexisting conditions (such as adenomyosis, cervical lesions, or intrauterine or pelvic adhesions) that could affect treatment efficacy, and those with missing or incomplete data. Fertility function was not a primary outcome measure in this study, and patients in the LM group with fertility preservation needs were not excluded.

Ultimately, 396 patients were included in the study, with 153 in the UAE group and 243 in the LM group. These study participants can be summarized as symptomatic uterine fibroid patients without fertility preservation needs and without other significant comorbidities.

2.2 Surgical procedures

UAE: Bilateral uterine artery embolization was performed routinely via the right femoral artery. Patients were placed in the supine position, and a vascular sheath (4F) was inserted through the right femoral artery puncture. Pigtail catheter angiography showed the bilateral internal iliac arteries and the course of the uterine arteries. After removing the angiographic catheter, a uterine artery catheter (4F) was inserted into the right uterine artery entrance, and a microcatheter was selectively placed in the right uterine artery. Under DSA guidance, embolization microspheres (500–700 μm) were used until blood flow stagnated. The left uterine artery was embolized similarly. After removing the uterine artery catheter, a pigtail catheter was used for angiography at the renal artery level to confirm the presence or absence of ovarian artery supply. If necessary, further embolization of the ovarian artery was performed. Finally, after angiography confirmed no abnormal staining, the catheter was removed, and hemostasis was achieved by compression before returning to the ward.

LM: Routine disinfection and draping were performed, and the patient was placed in the Trendelenburg position. Endotracheal intubation and general anesthesia were administered. Pneumoperitoneum was established, and a Veress needle was inserted and effectively inflated, maintaining an intra-abdominal pressure of 10–13 mmHg. Once the pressure

was normal, a laparoscope was placed. Two incisions, each measuring approximately 0.5 cm, were made in the left and right lower abdomen (at the McBurney and anti-McBurney points), and surgical instruments were inserted. The uterus was visualized under laparoscopy, and after locating the fibroid, the uterine muscle layer was incised at the protrusion site. The lesion was effectively excised using an electrosurgical knife, and the myoma was drilled and removed. Blood in the abdominopelvic cavity was aspirated, and the area was flushed. The remaining gas was discharged, the Veress needle was removed, and the incisions were sutured. After the patient recovered, they were returned to the ward.

2.3 PSM

PSM analysis was performed using SPSS Statistics 26.0. The predictor variables included patient age, follow-up time, maximum fibroid diameter, fibroid location, number of fibroids, disease duration, treatment history, whether the patient had given birth, and history of pelvic surgery. Matching tolerance was set at 0.02, and matching was performed at a 1:1 ratio.

2.4 Outcome measures

The main outcome measures included surgery duration, intraoperative blood loss, hemoglobin decline rate, postoperative hospital stay, total hospital stay, hospitalization cost, physical recovery, improvement of uterine fibroid symptoms and related quality of life, rate of surgery-related adverse events, postoperative recurrence rate, and reintervention rate.

2.5 Statistical methods

Statistical analysis was performed using SPSS Statistics 26.0. Count data were represented by percentages and analyzed using the χ^2 test; measurement data were represented as the mean ± standard deviation and analyzed using the independent samples t test. A $P < 0.05$ was considered to indicate statistical significance.

3 Results

3.1 PSM

The distribution of baseline characteristics in the two groups before PSM is shown in Table 1: the UAE group had a higher average age, shorter follow-up time, higher proportion of patients with multiple fibroids, relatively longer disease duration, and higher proportion of patients who had received prior treatment and given birth ($P < 0.05$).

After 1:1 matching, a total of 66 pairs (132 patients) were successfully matched. As shown in Table 2, there were no statistically significant differences in the predictor variable characteristics of the two study groups ($P > 0.05$) after PSM.

3.2 Surgical trauma and postoperative physical recovery

All 132 patients in both groups successfully underwent surgery. The clinical indicators during hospitalization for the two groups are shown in Table 3: the intraoperative blood loss in the UAE group and LM group was 0 ml and 140.91 ± 201.13 ml ($P < 0.001$), respectively. The surgery duration for the two groups was 58.71 ± 16.49 min and 79.82 ± 36.79 min ($P < 0.001$), respectively (Fig. 1). The hemoglobin decline rates for the two groups were 7.24 ± 8.67% and 13.43 ± 6.04% ($P < 0.001$), respectively (Fig. 2). The postoperative hospital stays for the two groups were 2.67 ± 1.27 days and 4.95 ± 0.64 days ($P < 0.001$), respectively. The total hospital stay for the two groups was 4.50 ± 2.12 days and 7.26 ± 0.95 days ($P < 0.001$), respectively (Fig. 3). The hospitalization costs for the two groups were 24,400.06 ± 6095.98 yuan and 11,815.06 ± 1706.71 yuan ($P < 0.001$), respectively(Fig. 4).

The postoperative physical recovery indicators for the two groups are shown in Table 4: the time to ambulation after surgery for the UAE group and LM group was 14.54 h and 28.34 h ($P < 0.001$), respectively(Fig. 5); the time to resume self-care after surgery was 7.05 days and 9.18 days ($P < 0.001$), respectively; the time to complete simple household tasks after surgery was 9.96 days and 15.34 days ($P < 0.05$), respectively; and the time to resume work or social activities after surgery was 16.42 days and 27.70 days ($P < 0.001$), respectively(Fig. 6).

Table 1 Distribution of the baseline characteristics in the two groups before PSM

Predictor variables	UAE group (n = 153)	LM group (n = 243)	t/χ^2 value	P value
Age (years)	40.0 ± 5.5	38.4 ± 6.0	2.764	0.006
Follow-up time (years)	4.0 ± 2.2	7.6 ± 2.4	15.306	< 0.001
Maximum fibroid diameter[a] (cm)	6.5 ± 5.8	6.0 ± 1.4	0.960	0.339
Fibroid location			0.414	0.813
Intramural	89 (58.2%)	149 (61.3%)		
Subserosal	15 (9.8%)	21 (8.6%)		
Mixed[b]	49 (32.0%)	73 (30.0%)		
Number of fibroids			7.762	0.005
One	39 (25.5%)	95 (39.1%)		
More than one	114 (74.5%)	148 (60.9%)		
Disease duration (years)			30.644	< 0.001
≤ 2	38 (24.8%)	97 (39.9%)		
> 2, ≤ 5	51 (33.3%)	105 (43.2%)		
> 5	64 (41.8%)	41 (16.9%)		
Treatment history			21.137	< 0.001
Yes	69 (45.1%)	56 (23.0%)		
No	84 (54.9%)	187 (77.0%)		
Reproductive history			13.985	< 0.001
Yes	146 (95.4%)	201 (82.7%)		
No	7 (4.6%)	42 (17.3%)		
Pelvic surgery history			0.387	0.534
Yes	33 (21.6%)	59 (24.3%)		
No	120 (78.4%)	184 (75.7%)		

[a]The maximum fibroid diameter for multiple fibroids refers to the maximum diameter of the largest fibroid

[b]The "mixed" fibroid location refers to multiple fibroids occurring in different locations

3.3 Improvement of fibroid symptoms and health-related QoL

Improvements in fibroid symptoms and quality of life were investigated. Among all 132 patients, a total of 76 patients completed the UFS-QOL questionnaire, with 41 in the UAE group and 35 in the LM group. The baseline scores of the UFS-QOL before treatment for both groups are shown in Table 5. There were no statistically significant differences between the UAE and LM groups in terms of UFS8 scores, HRQL scores, and HRQL subdomain scores ($P > 0.05$).

The changes in UFS-QOL scores after treatment for the UAE and LM groups are shown in Table 6. The UFS8 score in the UAE group decreased by 28.43 ± 2.43 points ($P < 0.001$), the total HRQL score increased by 26.28 ± 2.26 points ($P < 0.001$), and the scores in each HRQL domain also significantly increased ($P < 0.001$); the UFS score in the LM group decreased by 30.80 ± 2.29 points ($P \leq 0.001$), the total HRQL score increased by 22.21 ± 2.58 points ($P < 0.001$), and the scores in each HRQL domain also significantly increased ($P < 0.05$).

The postoperative UFS-QOL scores for the two groups are shown in Table 7. The UFS8 scores for the UAE and LM groups were 8.83 ± 1.12 and 10.18 ± 1.18 ($P > 0.05$), respectively, and the total HRQL scores were 87.25 ± 1.91 and 82.73 ± 1.80 ($P > 0.05$), respectively. In the six HRQL subdomains, the energy/mood scores were 87.63 ± 2.46 and 79.49 ± 2.20 ($P < 0.05$), and the self-concern scores were 87.60 ± 2.45 and 80.00 ± 2.90 ($P < 0.05$), while there were no significant differences in the other four domains ($P > 0.05$).

In summary, as shown in Tables 5, 6, 7, 8 and Fig. 7, both UAE and LM can significantly improve patient symptoms ($P < 0.05$) and significantly enhance patient quality of life ($P < 0.05$). The overall treatment efficacy of the two groups in improving symptoms and enhancing quality of life was similar ($P > 0.05$), but UAE had advantages in the energy/mood and self-concern subdomains of HRQL ($P < 0.05$).

Table 2 Distribution of the baseline characteristics in the two groups after PSM

Predictor variables	UAE group (n = 66)	LM group (n = 66)	t/χ^2 value	P value
Age (years)	38.6 ± 5.7	39.4 ± 5.7	0.877	0.382
Follow-up time (years)	5.4 ± 2.5	6.0 ± 2.7	1.331	0.185
Maximum fibroid diameter [a](cm)	5.9 ± 2.3	5.9 ± 1.3	0.066	0.948
Fibroid location			1.139	0.566
Intramural	40 (60.6%)	43 (65.2%)		
Subserosal	10 (15.2%)	6 (9.1%)		
Mixed[b]	16 (24.2%)	17 (25.8%)		
Number of fibroids			0.140	0.709
Single	22 (33.3%)	20 (30.3%)		
Multiple	44 (66.7%)	46 (69.7%)		
Disease duration (years)			5.201	0.074
≤ 2	24 (36.4%)	13 (19.7%)		
> 2, ≤ 5	28 (42.4%)	31 (47.0%)		
> 5	14 (21.2%)	22 (33.3%)		
Treatment history			3.337	0.068
Yes	18 (27.3%)	28 (42.4%)		
No	48 (72.7%)	38 (57.6%)		
Reproductive history			1.731	0.188
Yes	59 (89.4%)	63 (95.5%)		
No	7 (10.6%)	3 (4.5%)		
Pelvic surgery history			0.634	0.426
Yes	15 (22.7%)	19 (28.8%)		
No	51 (77.3%)	47 (71.2%)		

[a]The maximum fibroid diameter for multiple fibroids refers to the maximum diameter of the largest fibroid

[b]The "mixed" fibroid location refers to multiple fibroids occurring in different locations

Table 3 Surgery-related and in-hospital clinical indicators for the UAE and LM groups

Indicator	UAE group (n = 66)	LM group (n = 66)	t value	P value
Blood loss (ml)	0.00	140.91 ± 201.13	6.692	< 0.001
Median	0.00	50.00		
Interquartile range	0.00–0.00	30.00–100.00		
Surgery duration (minutes)	58.71 ± 16.49	79.82 ± 36.79	4.254	< 0.001
Median	60.00	72.50		
Interquartile range	50.00–60.00	53.25–95.00		
Hemoglobin decline rate[a]	7.24 ± 8.67	13.43 ± 6.04	4.759	< 0.001
Median	8.65	14.33		
Interquartile range	6.28–10.21	9.34–17.50		
Postoperative hospital stay (days)	2.67 ± 1.27	4.95 ± 0.64	13.066	< 0.001
Median	2.00	5.00		
Interquartile range	2.00–3.25	5.00–5.00		
Hospital stay (days)	4.50 ± 2.12	7.26 ± 0.95	9.639	< 0.001
Median	4.00	7.00		
Interquartile range	3.00–5.00	7.00–7.00		
Hospitalization cost[b] (yuan)	24,400.06 ± 6095.98	11,815.06 ± 1706.71	− 16.151	< 0.001
Median	23,800.50	11,510.50		
Interquartile range	20,047.75–28,153.75	10,765.75–12,763.00		

[a]Hemoglobin decline rate = [(preoperative hemoglobin value−postoperative hemoglobin value)/preoperative hemoglobin value] × 100%

[b]Hospitalization cost refers to the total expenses incurred by the patient during hospitalization, including both insurance-covered and out-of-pocket costs

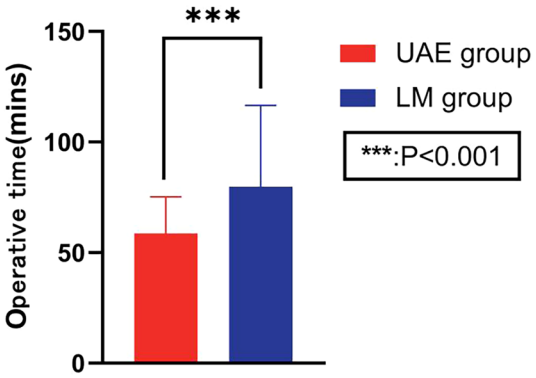

Fig. 1 Comparison of surgery duration between the two groups

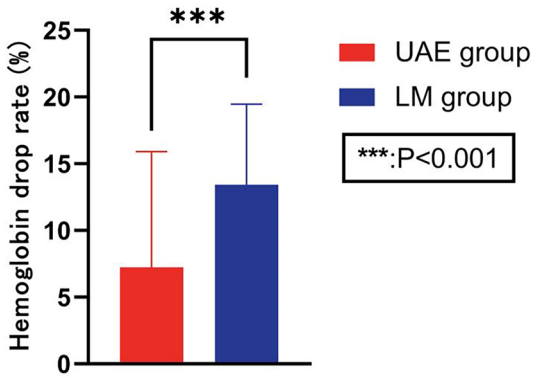

Fig. 2 Comparison of hemoglobin decline rates between the two groups

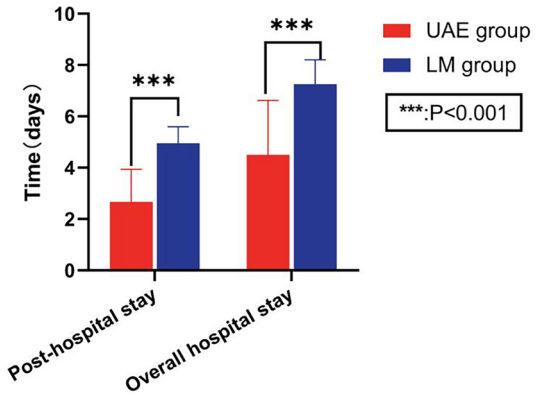

Fig. 3 Comparison of postoperative hospital stay and total hospital stay between the two groups

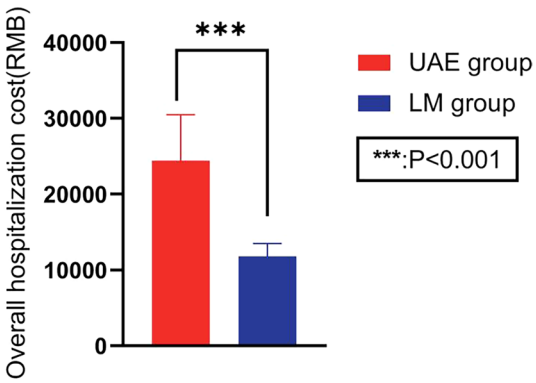

Fig. 4 Comparison of hospitalization costs between the two groups

Table 4 Comparison of postoperative physical recovery indicators between the two groups

Indicator	UAE group	LM group	P value
Time to ambulation after surgery (hours)	14.54 ± 11.04	28.34 ± 22.71	P < 0.001
Time to resume self-care after surgery (days)	7.05 ± 4.33	9.18 ± 4.20	0.015
Time to complete simple household chores after surgery (days)	9.96 ± 5.39	15.34 ± 8.47	P < 0.001
Time to resume work or social activities after surgery (days)	16.42 ± 11.48	27.70 ± 9.22	P < 0.001

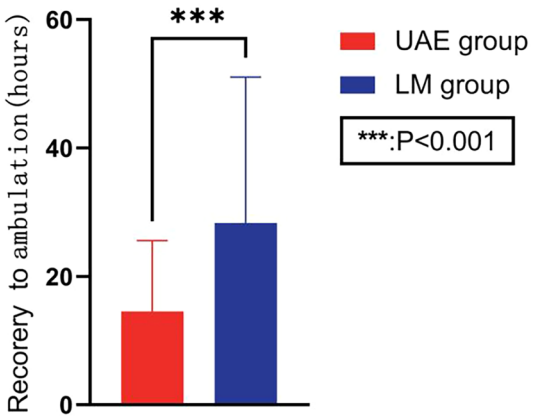

Fig. 5 Comparison of time to ambulation after surgery between the two groups

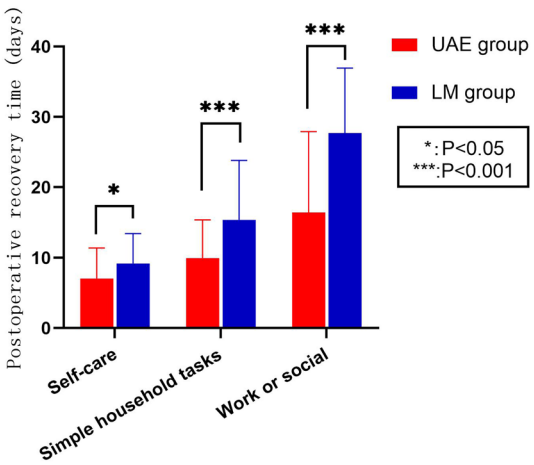

Fig. 6 Comparison of time to resume self-care, simple household tasks, work and social activities after surgery between the two groups

Table 5 Baseline UFS-QOL scores before treatment in the two groups

Before treatment	UAE group	LM group	P value
UFS8 score	37.26 ± 2.56	40.98 ± 1.65	0.224
HRQL score	60.98 ± 1.93	60.52 ± 1.71	0.862
Concern about the disease	49.15 ± 2.82	55.43 ± 1.92	0.080
Activity limitation	61.15 ± 2.51	59.39 ± 1.80	0.571
Energy/mood	63.15 ± 2.45	60.00 ± 2.30	0.356
Loss of control of life	60.61 ± 2.40	60.71 ± 2.24	0.975
Self-concern	73.98 ± 3.12	71.90 ± 2.02	0.578
Sexual function	64.33 ± 2.68	61.43 ± 2.20	0.415

Table 6 Changes in UFS-QOL scores before and after treatment in the UAE and LM groups

	Before treatment	After treatment	Mean difference	P value
UAE group				
UFS8 score	37.26 ± 2.56	8.83 ± 1.12	− 28.43 ± 2.43	< 0.001
HRQL score	60.98 ± 1.93	87.25 ± 1.91	26.28 ± 2.26	< 0.001
Concern about the disease	49.15 ± 2.82	83.41 ± 2.36	34.27 ± 3.69	< 0.001
Activity limitation	61.15 ± 2.51	89.81 ± 1.76	28.66 ± 2.56	< 0.001
Energy/mood	63.15 ± 2.45	87.63 ± 2.46	24.45 ± 3.14	< 0.001
Loss of control of life	60.61 ± 2.40	88.54 ± 2.21	27.93 ± 2.83	< 0.001
Self-concern	73.98 ± 3.12	87.60 ± 2.45	13.61 ± 3.55	0.001
Sexual function	64.33 ± 2.68	84.45 ± 2.34	20.12 ± 2.82	< 0.001
LM group				
UFS8 score	40.98 ± 1.65	10.18 ± 1.18	− 30.80 ± 2.29	< 0.001
HRQL score	60.52 ± 1.71	82.73 ± 1.80	22.21 ± 2.58	< 0.001
Concern about the disease	55.43 ± 1.92	83.00 ± 1.33	27.57 ± 1.96	< 0.001
Activity limitation	59.39 ± 1.80	86.43 ± 1.83	27.04 ± 2.60	< 0.001
Energy/mood	60.00 ± 2.30	79.49 ± 2.20	19.49 ± 3.55	< 0.001
Loss of control of life	60.71 ± 2.24	84.29 ± 2.49	23.57 ± 3.54	< 0.001
Self-concern	71.90 ± 2.02	80.00 ± 2.90	8.10 ± 3.90	0.048
Sexual function	61.43 ± 2.20	80.71 ± 2.91	19.29 ± 3.70	< 0.001

Table 7 Postoperative UFS-QOL scores in the two groups

After treatment	UAE group	LM group	P value
UFS8 score	8.83 ± 1.12	10.18 ± 1.18	0.410
HRQL score	87.25 ± 1.91	82.73 ± 1.80	0.093
Concern about the disease	83.41 ± 2.36	83.00 ± 1.33	0.879
Activity limitation	89.81 ± 1.76	86.43 ± 1.83	0.189
Energy/mood	87.63 ± 2.46	79.49 ± 2.20	0.017
Loss of control of life	88.54 ± 2.21	84.29 ± 2.49	0.205
Self-concern	87.60 ± 2.45	80.00 ± 2.90	0.049
Sexual function	84.45 ± 2.34	80.71 ± 2.91	0.315

Table 8 Distribution of complications in the UAE and LM groups

UAE group (5 cases, 7.6%)	LM group (6 cases, 9.1%)
Surgical intervention for fibroid expulsion (2 cases)	Intraoperative massive bleeding (4 cases, > 500 ml)
Amenorrhea (2 cases, 1 case resumed after 3 months)	Surgical intervention for pelvic adhesion (1 case)
Right lower limb pain for 3 weeks (1 case)	Lower abdominal pain for half a year (1 case)

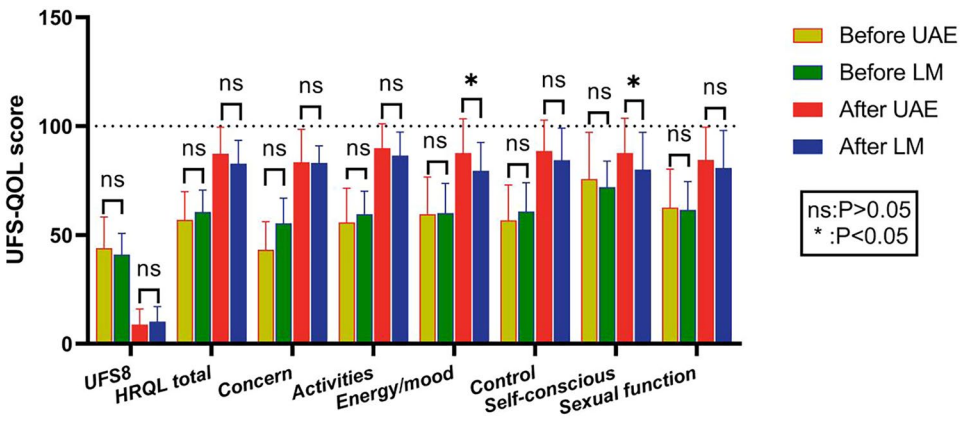

Fig. 7 Comparison of UFS-QOL scores before and after surgery between the two groups

Table 9 Comparison of recurrence rates between the UAE and LM groups

	UAE group (n = 66)	LM group (n = 66)	P value
≤ 1 year	2 (3.0%)	3 (4.5%)	1.000
> 1, ≤ 2 years	5 (7.6%)	8 (12.1%)	0.381
> 2 years	4 (6.1%)	10 (15.2%)	0.156
Total	11 (16.7%)	21 (31.8%)	0.042

Table 10 Number of patients experiencing fibroid recurrence requiring reintervention in the UAE and LM groups

UAE group (5 cases, 7.6%)	LM group (5 cases, 7.6%)
1 patient underwent subtotal hysterectomy 1 year after surgery	1 patient underwent subtotal hysterectomy 1 year after surgery
1 patient underwent total hysterectomy + bilateral adnexectomy 3 years after surgery	1 patient underwent subtotal hysterectomy 4 years after surgery
1 patient underwent abdominal myomectomy 4 years after surgery	1 patient underwent subtotal hysterectomy 4 years after surgery
1 patient underwent abdominal myomectomy 5 years after surgery	1 patient underwent subtotal hysterectomy 5 years after surgery
1 patient underwent hysteroscopic myomectomy 5 years after surgery	1 patient underwent subtotal hysterectomy 6 years after surgery

3.4 Postoperative complications

Table 8 lists the occurrence of surgical complications in both groups. There were 5 cases (7.1%) in the UAE group and 6 cases (9.1%) in the LM group, with no significant difference between the groups (P > 0.05).

3.5 Fibroid recurrence and reintervention

The postoperative recurrence rates for both groups are shown in Table 9: the total recurrence rates for UAE and LM were 16.7% and 31.8% (P < 0.05), respectively, with no significant differences in subgroups (P > 0.05).

The number of surgical reintervention due to uterine fibroid recurrence in both groups are shown in Table 10. Five reinterventions (7.6%) were performed in the UAE group and 5 were performed (7.6%) in the LM group, with no difference between the groups.

3.6 Fertility outcomes and other

Three patients in the UAE group successfully conceived after surgery, including one infertile patient before surgery; two patients in the LM group successfully conceived after surgery. In addition, this study also investigated the educational background, occupation, source of medical information, and willingness to recommend the surgical method to other patients in both groups. The results showed that the educational background of both groups was comparable, with secondary school and university being the main levels. Most patients were company employees, but the UAE group had a higher proportion of freelancers. Regarding the source of medical information, patients in the UAE group mainly relied on recommendations from friends, colleagues, and other patients, and those in the LM group were outpatients or referrals from primary care doctors. Regarding the willingness to recommend the surgical method to other patients (1–10), the average score for the UAE group was 8.8, and for the LM group, it was 8.5.

4 Discussion

The working principle of PSM is to match experimental subjects with control subjects based on similarities in preexisting characteristics that may influence treatment choice [10, 11]. To ensure the effectiveness of this method, the experiment and control subjects' characteristics must be provided to determine the influence of such characteristics on treatment choice (predictor variables). Researchers use characteristic data for logistic regression analysis to estimate the association

between each variable and the selected treatment. In this regression analysis, the characteristics influencing treatment choice are the independent variables, and the treatment itself is a binary dependent variable. Then, using the coefficient estimates of the regression, the predicted probability of treatment for each subject is calculated retrospectively based on the individual's specific characteristics, ranging from 0 to 1. Finally, each patient in the treatment group is matched with one or more patients in the control group based on the closest treatment probabilities and the size of the control group. There are no systemic differences between the matched groups, so these predictor variables can no longer confound group comparisons. This study is a retrospective study, and to reduce the impact of intergroup confounding effects, PSM was applied when selecting study subjects. However, PSM also has limitations. First, random controls can balance both observed and unobserved confounders, while PSM can only balance observed confounders. Therefore, residual bias is still possible. Second, an important limitation to consider is that PSM involves removing data, such as that of unmatched controls, so the sample size must be large enough to use PSM for relevant research.

Several studies have shown that compared with myomectomy, UAE results in shorter hospital stays, faster return to work, and fewer severe adverse events related to bleeding [12, 13]. This study also obtained similar results: UAE resulted in less bleeding, a shorter surgery time, a shorter hospital stay, and faster physical recovery than LM. This study used four aspects of daily life as reference indicators when comparing the speed of postoperative patient recovery: time to get out of bed, time for self-care, time to complete simple household chores, and time to resume work or social activities. The results showed that UAE patients performed better in terms of all indicators ($P < 0.05$), directly reflecting that patients undergoing UAE surgery reported that they recovered faster and quickly returned to daily activities, housework, and work.

The Uterine Fibroid Symptom and Quality of Life (UFS-QOL) is an important tool widely used internationally to evaluate symptoms and quality of life in patients with uterine fibroids [13, 14]. Studies by Yeung S Y et al. [15], Wei Xu et al. [16] and Zhou Xiaomei et al. [17] have confirmed that the UFS-QOL has high reliability and validity in China and is highly reflective of changes before and after treatment. Therefore, this study used the UFS-QOL to compare the symptoms and quality of life of patients with uterine fibroids treated with UAE and LM. The UFS-QOL involves 37 questions divided into two parts: the Uterine Fibroid Symptom Severity Questionnaire (UFS8, consisting of 8 questions) and the Health-Related Quality of Life Questionnaire for Uterine Fibroids (HRQL, consisting of 29 questions). The questions cover severe bleeding, menstrual conditions, urinary symptoms, psychological symptoms, sexual function, and general fatigue. Each question is divided into five levels, scored from 1 to 5 points. The raw scores are converted into a range of 0 to 100 using a dedicated UFS-QOL calculation formula [18]. A higher score in the UFS8 section indicates more severe symptoms, while a higher score in the HRQL section indicates better quality of life. The results of this study based on PSM are similar to those of Manyonda et al. [13] and Daniels et al. [14], indicating that both UAE and LM can significantly improve patients' uterine fibroid-related symptoms and significantly enhance their quality of life. However, in this study, the overall improvement in symptoms and quality of life between the two groups was similar ($P > 0.05$).

Studies by Zanolli et al. [19] suggest that fertility may not be affected for women who choose UAE, and for women who are not suitable for surgery, UAE can be offered. Serres-Cousine et al. [20] conducted a study on 398 patients who underwent UAE, with 148 pregnancies and 109 live births. Ludwig et al. confirmed that women can become pregnant after UAE, with many pregnancies resulting in successful deliveries. Although the actual fertility rate after UAE is still uncertain, it is close to 38.3% based on currently available results [21]. In this study, three postoperative pregnancies occurred among the 66 patients in the UAE group, also confirming the fact that women can become pregnant and successfully give birth after UAE. Among these cases, one patient had infertility before surgery, suggesting that UAE may become a means for patients with fibroid-induced infertility to restore their fertility. In this study, the willingness to recommend the surgical method to other patients (1–10) was 8.8 for the UAE group and 8.5 for the LM group. This result indicates that patients who underwent either UAE or LM treatment highly approve of their surgical method and have a strong desire to recommend it to friends and family.

The strength of this study lies in the application of PSM to balance confounding factors between groups when selecting study subjects. It mimics certain features of randomized controlled trials (RCTs) and enhances the internal validity and reliability of this study. However, there are also several limitations. First, the sample size of this study is relatively small, especially after PSM. This may hinder the evaluation of differences between comparison groups, particularly potential perioperative and long-term serious complications, which are quite rare. Second, PSM effectively balances confounding factors between groups by excluding a significant number of patients with specific treatment preferences during the matching process. However, this exclusion limits the study's applicability to certain populations, such as those pursuing pregnancy. Third, the study period was long, and there is a potential for recall bias in the long-term follow-up. In addition, some patients did not complete the questionnaire survey during the long-term follow-up. We assume that the data are missing at random, and any deviation from this assumption could lead to biased results.

5 Conclusion

The application of PSM effectively balanced the confounding factors between the two groups in this study, helping to accurately evaluate the intervention effects of UAE and LM on uterine fibroids. The study participants were symptomatic uterine fibroid patients without fertility preservation needs and without other significant comorbidities. In this specific research population, UAE treatment for uterine fibroids results in less surgical trauma, faster physical recovery, and a lower postoperative fibroid recurrence rate compared to LM, but it comes with higher treatment costs. Both UAE and LM can significantly improve fibroid symptoms and enhance health-related quality of life, and both have low rates of adverse events and reinterventions.

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Author contributions Cunbao Wei, Xingwei Sun, contributed equally to this work. Cunbao Wei, Xingwei Sun, and Jin Yong designed the project. Cunbao Wei, Shenzhi Li contributed to the collection, organization, and analysis of data. Cunbao Wei, Xingwei Sun, Shenzhi Li, Yong Jin and Xuming Bai contributed to the writing, review, and editing of the manuscript. Yong Jin and Xuming Bai contributed to the supervision and project development.

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Data availability The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate This study was approved by the Institutional Review Board (IRB)of the Second Affiliated Hospital of Soochow University(IRB number JD-HG-2021-39) and all methods were carried out in accordance with relevant guidelines and regulations. The requirement for informed consent was waived.

Competing interests The authors declare no competing interests.

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