A comparison of reproductive outcomes of patients with adenomyosis and infertility treated with High-Intensity focused ultrasound and laparoscopic excision

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ABSTRACT

Objective: The aim of this study was to compare the treatment effects of high-intensity focused ultrasound (HIFU) and laparoscopic excision (LE) in patients with adenomyosis and infertility.

Materials and methods: A total of 93 patients with adenomyosis and infertility who were treated with HIFU (50 patients) or LE (43 patients) from January 2012 to January 2017 at the Third Xiangya Hospital of Central South University were retrospectively analyzed. Clinical characteristics including dysmenorrhea severity pain score, menorrhagia severity scores, reproductive outcomes, complications during pregnancy and delivery, adverse effects, surgical complications, and other clinical variables were compared between the HIFU and LE groups.

Results: Of the total 93 patients with adenomyosis and infertility, 50 were treated with HIFU and 43 underwent LE. Both HIFU and LE treatments achieved significant relief of dysmenorrhea and menorrhagia. The total hospital stay was shorter in patients treated with HIFU than in those who underwent LE surgery. Neither HIFU nor LE treatment led to severe complications after treatment. Most importantly, patients treated with HIFU showed significantly higher pregnancy rates and natural conception rates than those who underwent LE surgery. Notably, in the HIFU treatment group, those with diffuse adenomyotic lesions had significantly lower postoperative pregnancy rates than those with focal adenomyosis.

Conclusion: HIFU showed a safe and effective profile as a therapeutic management option for patients with adenomyosis. In comparison with LE, HIFU treatment achieved better postoperative reproductive outcomes. HIFU treatment should be encouraged and implemented in clinical practice.

Introduction

Adenomyosis, a common gynecologic condition, occurs when the endometrial glands and stroma that are normally in the inner lining of the uterus grow into the outer muscular walls [1]. It is a relatively common disease among women of childbearing age, with a prevalence ranging from 8% to 27% [2]. The symptoms of adenomyosis include secondary dysmenorrhea, heavy and prolonged menstrual bleeding, metrorrhagia, and an enlarged uterus [1,3,4]. Although the correlation between adenomyosis and infertility is unclear, emerging clinical evidence indicates that adenomyosis has an adverse effect on fertility [5]. Adenomyosis has been reported to disrupt uterine peristalsis and cause implantation failure [6]. Surgical treatments, such as hysterectomy and laparoscopic excision (LE), as well as hormonal treatments, including oral contraceptive pills and progestogens, are widely used to treat adenomyosis [7,8]. However, these treatments have many restrictions and adverse effects [7,8].

High-intensity focused ultrasound (HIFU), a newly introduced medical procedure, is being widely used in the treatment of patients with adenomyosis. It relies on highly focused ultrasound energy to precisely destroy the adenomyotic area in a noninvasive and bloodless manner [9]. Patients treated with HIFU have shown substantial alleviation of adenomyosis symptoms and have regained a relatively high pregnancy rate after therapy [10,11]. However, the clinical outcomes and safety of HIFU have not been assessed in patients diagnosed with adenomyosis and infertility.

In this study, we aimed to evaluate the therapeutic effect of HIFU treatment in patients with adenomyosis and infertility and to compare the reproductive outcomes between patients treated with HIFU and those who underwent LE.

Materials and methods

Ethical considerations

The ethics committee of the Third Xiangya Hospital approved this study. All patients signed an informed consent form.
Study participants and enrollment

In this retrospective study, we analyzed the data of patients diagnosed with adenomyosis and infertility who were treated with HIFU or LE between January 2012 and January 2017 at the Third Xiangya Hospital of Central South University, Changsha, China.

Patient inclusion criteria were as follows: (1) age range from 23 to 45 years; (2) diagnosis of adenomyosis based on the criteria proposed by Gunther and Walker [12]; (3) presence of defined infertility (not being able to get pregnant after 1 year of having regular sexual intercourse without the use of birth control techniques); (4) adenomyosis lesions suitable for HIFU treatment based on ultrasound examination; and (5) confirmed normal function of the liver, kidneys, and heart. Exclusion criteria were as follows: (1) a history of abdominal or pelvic surgery, and (2) infertility due to ovarian disorders, including ovarian insufficiency.

Ultrasound-guided HIFU therapy

One day before the HIFU treatment, all patients took polyethylene glycol electrolyte solution to clean their bowels. In the evening before the treatment and the morning of the treatment day, a mandatory enema was performed. A bladder catheter was inserted before the HIFU treatment. Before HIFU ablation, suction curettage was performed under hysteroscopic guidance to eliminate intrauterine lesions. The treatment was conducted under analgesia and sedation. The dose of fentanyl and midazolam was calculated based on patients’ body weight (fentanyl citrate, 7.8–29.4 mL; midazolam hydrochloride, 2.8–8.5 mL), and the drugs were injected intravenously. The degree of sedation was maintained at a Ramsay score of 3–4 (being asleep, actively responding to loud voices, being sensitive to sounds after a soft tap between the brows or responding only to instructions). During the treatment, the heart rate, respiration rate, and blood pressure were monitored. A JC-200 focused ultrasound tumor therapeutic system (Chongqing Haifu Medical Technology, Chongqing, China) was used for the treatment. The distance of the therapeutic equipment from the target endometrium and serosa was longer than 15 mm. The distance between the HIFU focused layers was set to 5 mm. The output power used was 400 W. The site and intensity of the treatment were adjusted according to the patient’s reactions and the grayscale changes. The treatment was stopped according to the grayscale, and intra-operative contrast-enhanced ultrasound was then conducted. After the treatment, ice-cold saline was used to wash the bladder. After recovery from the surgery, the patients were encouraged to consume a large amount of fluid food and rest in a prone position in bed for 2 h. All patients were discharged after a 24-h observation period.

LE of uterine adenomyoma

Under general anesthesia, patients were placed in a dorsal lithotomy position, sterilized, and draped with a towel. An arc-shaped incision was then made at the upper edge of the umbilicus to create a pneumoperitoneum, and the abdominal pressure was set to 12 mmHg. Trocars were used to puncture the abdomen and they were placed under the microscope to prevent the vessel from getting into the lower abdominal wall. Uterine body injection of oxytocin (20 μunits) was administered under a laparoscope, and an electrocoagulation hook was used to make a longitudinal incision into the sarcomuscular layer to reach the tumor. The adenomyoma surface was bluntly separated. The adenomyoma was removed, and the sarcomuscular layer was continuously sutured. Normal saline was used for flushing the pelvic cavity. After cessation of active bleeding was detected, the instrument was pulled out and gas was released.

Management of patients after HIFU or LE

Patients treated with either HIFU or LE were injected subcutaneously with 3.75 mg of leuprolrelin acetate microspheres (Beijing Biote Pharmaceutical Co., Ltd., Beijing, China) every 28 days for 4–6 times. The first injection was administered on the first day of menstrual bleeding after HIFU or LE.

Follow-up observations

Follow-up visits were scheduled at 1, 6, and 12 months after the treatments to monitor for adverse effects and surgical complications. The degree of dysmenorrhea alleviation post-surgery was measured using a visual analog scale (scales 0–10, with higher scores indicating more severe pain) [13]. The degree of menorrhagia reduction was assessed via the Uterine Fibroid Symptom and Quality of Life (UFS-QOL) questionnaire using a 5-point categorical scale (1, not affected; 2, a little increased; 3, somewhat increased; 4, greatly increased; 5, very greatly increased). The uterine size was measured using color Doppler ultrasound. The uterine volume was calculated using the following formula: 0.523 × anteroposterior diameter × transverse diameter × utero-cervical length. To monitor the reproductive outcomes of patients treated with HIFU or LE, the percentage of women who became pregnant after treatment, pregnancy length, delivery methods, and complications during pregnancy were also recorded.

Statistical analysis

Data were analyzed using Statistical Package for the Social Sciences (SPSS) software program, version 23 (IBM, Armonk, NY, USA). The normally distributed data were reported as means ± standard deviation, whereas the skewed distribution data were reported as medians and interquartile range (IQR). The Mann–Whitney U test or Fisher’s exact test was performed to compare the clinical parameters between the HIFU and LE groups. For comparisons of the difference among different time points in each group, the Wilcoxon Rank Sum tests were performed. Univariate and multivariate logistic regression analyses and $\chi^2$ test were used to determine and compare the risk and influencing factors in patients after HIFU and LE treatment. A significant difference was defined as a $p$-value of <0.05.
Table 1. Patients’ baseline characteristics.

| Variables                  | HIFU group (n = 50) | LE group (n = 43) | p-value |
|----------------------------|---------------------|-------------------|---------|
| Age (years)                | 36.0 (32.0, 38.0)   | 35.0 (31.0, 38.0) | 0.562   |
| BMI (kg/m²)                | 21.4 (19.7, 23.5)   | 22.7 (21.4, 23.4) | 0.535   |
| Dysmenorrhea pain score    | 5.0 (4.0, 6.0)      | 5.0 (4, 7)        | 0.330   |
| Menorrhagia severity score | 3.0 (3.0, 4.0)      | 3.0 (2.0, 3.0)    | 0.148   |
| Hemoglobin level (g/L)     | 111.5 (87.0, 124.0) | 118.0 (109.0, 127.0) | 0.088 |
| Uterine volume (cm³)       | 179.9 (114.3, 240.7)| 148.3 (73.5, 202.1)| 0.073   |
| Length of infertility (years) | 5.0 (3.0, 10.0) | 4.0 (2.0, 8.0) | 0.283   |

Data are presented as medians and interquartile ranges.
BMI: body mass index; HIFU: high-intensity focused ultrasound; LE: laparoscopic excision.

Results

Patients’ characteristics

Of the 93 patients studied in this research, 50 were treated with HIFU, and 43 underwent LE. In the HIFU group the average age of patients was 36 years (IQR 32–38) and their average uterine volume before HIFU treatment was 179.9 cm³ (IQR 114.3–240.7). Of the 50 patients, 8 (16%) were diagnosed with primary infertility, and 42 (84%) were diagnosed with secondary infertility. In the LE group, the average age of patients was 35 years (IQR 31–38). Before LE treatment, their average uterine volume was 148.3 cm³ (IQR 73.5–202.1). Of these 43 patients, 14 (32.6%) were diagnosed with primary infertility, and 29 (67.4%) were diagnosed with secondary infertility. No statistically significant differences were observed between the HIFU and LE groups before treatment in terms of age, body mass index, dysmenorrhea and, menorrhagia severity scores, hemoglobin level, uterine volume, and infertility length (Table 1).

HIFU treatment and adverse effects

All patients in the HIFU group were treated with a single session. The median treatment time was 53 min (IQR 35–92.5). The median of the average ultrasound power was 400 W (IQR 350–400), and the median energy of the ultrasound was 131.6 kJ (IQR 72.1–240.5). The median length of hospital stay was 5 days (IQR 4–6). After the procedure 9 patients had abdominal pain that subsided within 24 h after taking oral indomethacin. Two patients had lumbar backache, which alleviated within 3 days after intravenous injection of dexamethasone (10 mg). No severe complications, including skin burns or nerve injuries, were observed.

LE treatment and adverse effects

In the LE group, no complications, including injuries of the intestinal tract, were observed. The median bleeding volume was 50 mL (IQR 20–150). The median length of hospital stay was 7 days (IQR 6–8).

Follow-up observation

Of the 50 patients treated with HIFU, 47 had varying degrees of dysmenorrhea. Of the 43 patients who were treated with LE, 21 had dysmenorrhea. Follow-up data showed a significant decrease in dysmenorrhea pain in both HIFU and LE treatment groups beginning from 1-month post-surgery (Table 2). In addition, in all three follow-up visits, patients who received HIFU treatment had slightly lower pain scores than did those who underwent LE. However, no statistically significant differences were found between the HIFU and LE groups (Table 2).

Before the procedure, 33 patients in the HIFU group and 6 patients in the LE group had heavy menstrual bleeding. After the treatment, the menorrhagia severity scores of the patients in both groups decreased significantly over time (Table 3).

Reproductive outcomes after HIFU or LE treatment

After HIFU therapy, 26 patients became pregnant, and the total pregnancy rate was 52% (Table 4). The average time from surgery to pregnancy was 10 months (range 7–31 months). Of those 26 patients, there were 6 cases of vaginal delivery, 12 cesarean sections, 3 missed abortions, 3 spontaneous abortions, and 2 induced abortion (in which one patient had heart disease, and the other patient had radiation exposure) (Table 4). Notably, two patients with a history of spontaneous abortion became pregnant and delivered successfully after HIFU treatment.

In the LE group, 13 patients became pregnant, and the total pregnancy rate was 30.2%. There were seven cases of...
vaginal delivery, five cesarean sections, and one spontaneous abortion (Table 4).

**Complications during pregnancy and delivery**

In the HIFU group, a total of five patients (10%) experienced complications during pregnancy and delivery. Of these two (4%) cases had placenta accreta, two (4%) cases had postpartum hemorrhage, with blood loss volumes of 1300 and 1000 mL, respectively, and 1 patient (2%) had a premature rupture of membranes, which resulted in delivery at week 34 of gestation (Table 5).

In the LE group, three cases of complications were observed; two cases of fetal distress (4.6%) and one case (2.3%) of placenta accreta. In all three cases, cesarean-section was performed for delivery hence no postpartum hemorrhage occurred in the LE group (Table 5).

**Logistic regression analysis of factors influencing reproductive outcomes after HIFU treatment**

To investigate the factors affecting reproductive outcomes, univariate logistic regression analysis was performed. The resulting $\chi^2$ and $p$-values are shown in Table 6. We found that patient age, uterine volume, uterus location, grayscale change, ablation rate, and ultrasound power were not significantly associated with reproductive outcomes. However, the location of adenomyosis and types of adenomyosis (diffuse versus focal) had a significant impact on the reproductive outcomes. Patients with adenomyosis in the posterior uterine wall had better postoperative reproductive outcomes than did those with adenomyosis in the anterior or lateral uterine wall. Furthermore, patients with diffused adenomyosis were associated with less improvement in reproductive outcomes than those with focal adenomyosis (Table 6).

To confirm the results of the univariate logistic regression analysis, we investigated the correlation between the type or location of adenomyosis and reproductive outcomes. We found that the pregnancy rate was significantly higher in patients with focal adenomyosis than in those with diffuse adenomyosis (Table 7).

**Discussion**

HIFU uses guided ultrasound energy to ablate tumor tissues, without damaging the surrounding tissues. Therefore, it is considered a safe and noninvasive treatment for solid tumors, including prostate tumors [14] and uterine fibroids [15]. Adenomyosis is a gynecologic disorder characterized by misplaced endometrial tissue in the myometrium of the uterus [1]. Its symptoms include dysmenorrhea and menorrhagia [16,17]. In addition, recent studies have suggested an adverse impact of adenomyosis on the fertility of women [3]. In this study, we sought to compare the efficacy and pregnancy outcomes of HIFU and LE interventions in patients with adenomyosis and infertility. Our results revealed that the major symptoms, including dysmenorrhea and menorrhagia, were alleviated after HIFU treatment (Tables 2 and 3). Most importantly, a significantly higher pregnancy rate was observed in HIFU treated patients than in those who underwent LE (Table 4). Furthermore, compared to diffuse adenomyosis, the patient with focal adenomyosis showed significantly better clinical outcomes after HIFU treatment (Tables 6 and 7). In summary, our study showed that HIFU is a promising therapeutic approach for patients with adenomyosis and infertility to achieve pregnancy and have live-birth deliveries.

Adenomyosis has been associated with an increased risk of abortion and a decreased chance of natural conception, and was regarded as one of the major contributors to infertility [3]. A study of 171 women showed that patients with adenomyosis have a significantly higher rate of miscarriage than those without it [18]. A meta-analysis that included 11 comparative studies found that women with adenomyosis have lower rates of implantation, clinical pregnancy, and live birth [19]. The mechanisms studies revealed several potential mechanisms by which adenomyosis might adversely impact the reproductive outcomes. First, Kido et al. found that uterine peristalsis is suppressed in patients with adenomyosis, thus sperm transport was impeded, leading to infertility [20]. Second, patients with adenomyosis had higher levels of IL-6, IL-8, TNF-α, and reactive oxygen species in the peritoneal fluid. These high levels of immune-inflammatory cytokines might result in ovarian dysfunction and impaired sperm quality, causing infertility [21–24]. Furthermore, women with adenomyosis have a low expression of progesterone receptors, which are required for uterine receptivity [3].

Medical treatment and excisional surgery are the most common therapies for adenomyosis [7,8]. Gonadotropin-releasing hormone agonist (GnRHa), which has been proven to increase pregnancy rates in patients with adenomyosis, has been widely used [25]. However, the high recurrence rate and the adverse effects of GnRHa renders limit its applicability [26]. Classical surgical management of adenomyosis, including laparoscopic adenomyosis lesion excision, is associated with a high uterine rupture risk and relatively long recovery time [27]. Although hysterectomy is considered the most effective approach to cure adenomyosis, it is not suitable for patients who have the desire to give birth [28].

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**Table 5. Comparison of complications during pregnancy and delivery between the groups.**

| Complications                        | HIFU group ($n = 50$) | LE group ($n = 43$) | $p$-value |
|--------------------------------------|-----------------------|---------------------|-----------|
| Total cases with complications (%)   | 10 (5/50)             | 6.9 (3/43)          | 0.721     |
| Placenta accreta (%)                 | 4 (2/50)              | 2.3 (1/43)          | 1.000     |
| Postpartum hemorrhage (%)            | 4 (2/50)              | 0 (0/43)            | 0.497     |
| Premature rupture of membranes (%)   | 2 (1/50)              | 0 (0/43)            | 1.000     |
| Fetal distress (%)                   | 0 (0/50)              | 4.6 (2/43)          | 0.211     |

Data were presented as number (%).

HIFU: high-intensity focused ultrasound; LE: laparoscopic excision.
HIFU as a noninvasive treatment has been shown to improve the pregnancy outcomes of patients with adenomyosis [29]. However, its effect on the pregnancy outcomes of patients with adenomyosis and infertility is largely unknown. Our results indicated that HIFU is a safe and effective treatment option for patients with adenomyosis. Moreover, HIFU treatment led to significantly better pregnancy outcomes compared to LE treatment. Usually, classical surgical treatments have a high risk of uterine rupture. In this study, there was no case of uterine rupture among the patients who underwent HIFU treatment. In addition, there were no cases of uterine rupture during childbirth among these (Table 5). Hence, HIFU would be a reliable treatment option for patients with adenomyosis.

Lynn and Putnam first reported the use of HIFU in 1942 (30). In their study, they used the high frequency and short wavelength ultrasound waves to precisely ablate specific areas of the brain with very low non-targeted disruption [30]. Subsequently, HIFU has been used to treat patients with uterine fibroids [31]. A study that assessed the clinical outcomes of HIFU in patients with uterine fibroids using the UFS-QOL questionnaire indicated that HIFU is a cost-saving and effective treatment option for uterine fibroids [32]. Zou et al. noted that 19.2% of patients (78/406) who had uterine fibroids and had a history of abnormal pregnancies became pregnant after HIFU treatment [33], suggesting that HIFU could be a treatment option for infertility. More recently, the use of HIFU has extended to treatment of patients with

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**Table 6. Univariate logistic regression analysis of factors influencing pregnancy outcomes after HIFU treatment.**

| Variables                        | Pregnant group (n = 26) | Non-pregnant group (n = 24) | χ² value | p-value |
|----------------------------------|-------------------------|-----------------------------|----------|---------|
| Age (years)                      |                         |                             | 0.002    | 0.963   |
| <35                              | 11                      | 10                          |          |         |
| ≥35                              | 15                      | 14                          |          |         |
| Uterine volume                  |                         |                             | 1.974    | 0.160   |
| Smaller than average            | 16                      | 10                          |          |         |
| Larger than average             | 10                      | 14                          |          |         |
| Numbers of abortion before operation |             |                             | 0.033    | 0.856   |
| Below average                   | 14                      | 10                          |          |         |
| Above average                   | 11                      | 7                           |          |         |
| Location of the uterus          |                         |                             | 2.457    | 0.293   |
| Front                            | 16                      | 14                          |          |         |
| Middle                           | 1                       | 4                           |          |         |
| Back                             | 9                       | 6                           |          |         |
| Location of adenomyosis         |                         |                             | 6.425    | 0.040   |
| Anterior uterine wall           | 4                       | 9                           |          |         |
| Posterior uterine wall          | 19                      | 9                           |          |         |
| Lateral uterine wall            | 3                       | 6                           |          |         |
| Type of adenomyosis             |                         |                             | 4.327    | 0.038   |
| Diffuse adenomyosis             | 12                      | 18                          |          |         |
| Focal adenomyosis               | 14                      | 6                           |          |         |
| Gray-scale change               |                         |                             | 0.480    | 0.488   |
| Nodular gray change             | 16                      | 17                          |          |         |
| Integrate gray change           | 10                      | 7                           |          |         |
| Ablation rate                   |                         |                             | 0.244    | 0.621   |
| <80%                            | 19                      | 16                          |          |         |
| ≥80%                            | 7                       | 8                           |          |         |
| Ultrasound power                |                         |                             | 0.263    | 0.608   |
| Lower                           | 9                       | 10                          |          |         |
| Higher                          | 17                      | 14                          |          |         |
| Ultrasound energy               |                         |                             | 0.321    | 0.571   |
| Lower                           | 14                      | 11                          |          |         |
| Higher                          | 12                      | 13                          |          |         |

*a* Patients with uterine volumes smaller than the average size (189.3 cm³) were designated as smaller than the average. Other patients were counted as larger than the average.

*b* The median number of abortions was 2 times.

*c* Nodular gray change: local, immediate, and instantaneous obvious grayscale changes; integrate gray change: the gray level increased gradually in the entire lesion.

*d* Ablation rate $= \frac{\text{ablated volume}}{\text{focus volume}}$.

*e* The average ultrasound power was 374 W. Patients treated with an ultrasound power lower than or equal to 374 W were designated as low. Other patients were counted as high.

*f* The average ultrasound energy was 1,31,575 J. Patients treated with an ultrasound energy lower than or equal to 1,31,575 J were designated as low. Other patients were counted as high.

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**Table 7. Multivariate logistic regression analysis of factors influencing pregnancy outcomes after HIFU treatment.**

| Variables                        | Regression coefficient | Std. error | Wald value | df | P-value | OR value |
|----------------------------------|------------------------|------------|------------|----|---------|----------|
| Location of adenomyosis          | 0.181                  | 0.449      | 0.162      | 1  | 0.687   | 1.198    |
| Degree of adenomyosis diffusion  | −1.248                 | 0.615      | 4.116      | 1  | 0.042   | 0.287    |
| Constant                         | 0.497                  | 0.993      | 0.251      | 1  | 0.617   | 1.644    |

Dependent variable: pregnant = 1, non-pregnant = 0. Covariate: lesion location $= X_1$ (anterior wall = 1, posterior wall = 2, lateral wall = 3), type of adenomyosis $= X_2$ (diffuse adenomyosis = 1; focal adenomyosis = 0). Logit $P_1 = 0.497 - 1.248 \times X_2$ ($P_1$: incidence of pregnancy after HIFU).
adeno- myosis. Zhang et al. found that HIFU effectively reduced the symptoms of dysmenorrhea and menorrhagia in patients with focal or diffuse adenomyosis [34]. Yang et al. observed that combined treatment with HIFU, GnRHα and the levonorgestrel-containing intrauterine system, a form of long-acting reversible contraception, significantly reduced dysmenorrhea and menorrhagia in patients with severe adenomyosis. They also reported that 3 months after this combined treatment, the average uterine volume of patients treated with HIFU decreased to normal size [35]. Ye et al. reported that 83.7% (170/203) of the patients with adenomyosis were completely relieved from dysmenorrhea after HIFU treatment [36]. In the present study, we also found that HIFU treatment significantly reduced the severity scores of dysmenorrhea and menorrhagia in patients with adenomyosis. In comparison with LE, HIFU treatment achieved slightly better alleviation of dysmenorrhea and menorrhagia (Tables 2 and 3).

Since HIFU can precisely ablate adenomyosis lesions under ultrasound guidance, and minimize damage to the surrounding myometrium, it is proposed as a fertility-sparing treatment for patients with adenomyosis [37]. To date, many studies have reported that HIFU treatment does not impair pregnancy outcomes, rather it correlates with an increase in pregnancy and live birth rates. Zhou et al. conducted HIFU in 68 patients who desired to have children but had adenomyosis. They found that 79.4% (54/68) of the patients became pregnant with a live birth rate of 38.9% (21/56) [29]. In our research, 52% (26/50) of the patients with adenomyosis who had a history of infertility became pregnant following HIFU treatment with a 36% live birth rate (Table 4). Notably, two patients who had a history of spontaneous abortion also became pregnant and delivered successfully after HIFU therapy. Compared to patients who underwent LE, those treated with HIFU had higher pregnancy rates and shorter time to pregnancy after the procedure (Table 4).

Interestingly the univariate logistic regression analysis showed that the location of adenomyosis lesions and the degree of diffusion affected the pregnancy rates after HIFU treatment. Patients with adenomyosis lesions in the posterior uterine wall (67.9%) had higher pregnancy rates than did those with lesions in the anterior (30.8%) or lateral uterine wall (33.3%). Patients with focal adenomyosis also had a higher pregnancy rates (70%) than did those with diffuse adenomyosis (40%) (Table 6). Multivariate logistic regression analysis also confirmed that patients with diffuse adenomyosis had lower pregnancy rates after HIFU treatment (Table 7). This result is consistent with that of a previous study, which showed that diffused lesions required larger ablation areas, leading to more severe burning of the uterine endometrium, and a reduced non-perfused volume [38].

In summary, HIFU is a safe and effective treatment option to reduce symptoms of adenomyosis, including dysmenorrhea and menorrhagia. Moreover, HIFU is a better therapeutic option than LE for patients with adenomyosis and infertility, as it achieves higher conception rates and live birth rates. HIFU treatment should be encouraged and implemented in clinical practice.

Disclosure statement
No potential conflict of interest was reported by the author(s).

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