A comparison of the pregnancy outcomes between ultrasound-guided high-intensity focused ultrasound ablation and laparoscopic myomectomy for uterine fibroids: a comparative study

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Objective: To compare the pregnancy outcomes between ultrasound-guided high-intensity focused ultrasound (USgHIFU) ablation and laparoscopic myomectomy (LM).

Materials and methods: This study included 676 women with symptomatic uterine fibroids who wished to become pregnant underwent USgHIFU or LM at three hospitals in China from 1 May 2009 to 31 May 2018. The related information of pregnancy and delivery were followed up and analyzed using the chi-square test and two-sided Student t-test.

Results: The median follow-up duration was 5 (1–8) years; 20 patients (2.9%) were lost to follow-up. 320 patients were treated with USgHIFU, and 336 were treated with LM. Two hundred nineteen (68.4%) women became pregnant after USgHIFU ablation, and 224 (66.7%) became pregnant after LM. Four hundred forty-three patients had 501 pregnancies (natural pregnancies, 405; in vitro fertilisation-embryo transfer pregnancies, 38). Average times to pregnancy were 13.6 ± 9.5 months after USgHIFU and 18.9 ± 7.3 months after LM (p < 0.05). The rate of cesarean delivery was lower in the USgHIFU group (41.6%) than in the LM group (54.9%) (p < 0.05). Incidences of placenta increta, placenta previa, and postpartum hemorrhage were low after USgHIFU compared with after LM. Incidences of preterm birth, fetal distress, fetal growth restriction, and puerperal infection were higher after USgHIFU than after LM. There was a risk of uterine rupture after both procedures.

Conclusions: Compared with LM, USgHIFU ablation can significantly shorten the time to pregnancy, although pregnancy rates of the two procedures are similar. Some risks in pregnancy and delivery after HIFU should be evaluated and monitored.

Introduction

Uterine fibroids are one of the most common benign tumors in women of reproductive age, with an incidence rate ranging from 5.4% to 77% in women of different races [1]. Uterine fibroids are independently related with women’s fertility, resulting in 1–2.4% cases of infertility and 7% cases of recurrent miscarriage [2]. It has been reported that 20–30% of women with uterine fibroids may have a miscarriage, which is two to three times higher than that of women without fibroids [3]. Additionally, common factors resulting in infertility or miscarriage include fibroid-associated anatomical changes in the uterus, high level of estrogen [4,5], uterine contraction, dysmotility, decreased endometrial receptivity, and dysfunction of ovulation. Uterine fibroids may also lead to a higher incidence of pregnancy complications during pregnancy and labor. With the change in women’s minds about marriage and childbearing practices, the number of uterine-fibroid-bearing women older than 35 years of age with the desire for children has increased significantly. In order to improve the fibroid-associated symptoms and facilitate fertility, effective treatment modalities for uterine fibroids are still needed. Common approaches for the treatment of uterine fibroids that preserve the reproductive function include drug therapy, myomectomy, ultrasound-guided high-intensity focused ultrasound (USgHIFU) ablation or magnetic resonance-guided focused ultrasound surgery, and uterine artery embolization (UAE), but they may have different effects and influences on pregnancy. Drug therapy involving the adjustment of endocrine may improve fibroid-associated symptoms and reduce the fibroid size, but it is not appropriate for women with a pregnancy plan. Removing the uterine fibroids is still needed. Common approaches for the treatment of uterine fibroids that preserve the reproductive function include drug therapy, myomectomy, ultrasound-guided high-intensity focused ultrasound (USgHIFU) ablation or magnetic resonance-guided focused ultrasound surgery, and uterine artery embolization (UAE), but they may have different effects and influences on pregnancy. Drug therapy involving the adjustment of endocrine may improve fibroid-associated symptoms and reduce the fibroid size, but it is not appropriate for women with a pregnancy plan. Removing the uterine fibroids is still needed.
fibroids via surgical operations can effectively reduce miscarriage while improving the live birth rate [6–9]. The average time interval between pregnancy and previous myomectomy is 11.3 (5–19) months [10]. However, invasive surgical operations can cause a change in the physiological environment and induce pelvic adhesion, which may accordingly reduce the pregnancy rate of these patients. Furthermore, approximately 0.4–1.2% of patients after myomectomy had uterine rupture in the mid and late phase of pregnancy, with a high risk of life danger [8,11]. UAE, an emerging treatment modality, is a minimally invasive therapy that can reduce the fibroid volume and improve patients’ symptoms; but, it may also impair the ovary blood supply and function of the endometrium, leading to permanent infertility. UAE is associated with an increased incidence of miscarriage and abnormal placenta. Therefore, the American Association of Obstetricians and Gynecologists does not recommend UAE for patients with fibroid who desire fertility [11]. In the last decade, another emerging noninvasive therapeutic technology, USgHIFU ablation, has been widely used, affording a safe and effective management for uterine fibroids [12–18]. However, its effect on fertility requires further study. Therefore, this study aimed to investigate pregnancy outcomes USgHIFU ablation and laparoscopic myomectomy (LM).

Materials and methods

Patients

From 1 May 2009 to 31 May 2018, 676 patients with symptomatic uterine fibroids who wished to become pregnant underwent USgHIFU or LM at three hospitals (the First Affiliated Hospital of Chongqing Medical University, 226; Chongqing Nanchuan People’s Hospital, 303; Chongqing Yubei District Maternal and Children Health Care Hospital, 147). All patients in the study were well notified of the benefits, effects, and potential risks related to USgHIFU or LM, including the possible effects on fertility and the possibility of symptom recurrence. Patients made the choice of treatment after being informed about both options.

Inclusion criteria were as follows: (1) women who desire fertility or a pregnancy plan; (2) women who have a regular sexual life and do not use contraception postoperatively; (3) women with symptomatic fibroids confirmed by an imaging examination and with any of the following indications for intervention: (a) enlarged uterus (uterine volume equal to or larger than that at 10 week’s gestation); (b) menorrhagia and/or secondary anemia; (c) pelvic pain, frequent urination, or constipation; (4) women who had fewer than three fibroids with an individual diameter larger than 2 cm, as visualized by pelvic ultrasonography; and (5) women who chose to be treated with USgHIFU ablation and had fibroids clearly detected by ultrasonography. For patients with abdominal surgical scars, the range of the blurred image caused by acoustic attenuation should be <10 mm.

Exclusion criteria were as follows: (1) women with uterine adenomyosis; (2) women with previous myomectomy; (3) women with concurrent pregnancy; (4) women with pedunculated subserous or submucosal fibroids; (5) women with any single fibroid whose maximum diameter was >10 cm; (6) women with acute pelvic inflammation or uncontrolled systemic disease; (7) women who were unable to communicate adequately with surgeons; (8) women with spouse’s whose infertility could not be confirmed through diagnosis; (9) women with infertility due to hysterecomy or bilateral salpingectomy; and (10) women who refused to accept follow-up.

Ethical statements

All patients provided informed consent. The study protocol was approved by the ethics committees of the First Affiliated Hospital of Chongqing Medical University, Chongqing Yubei District Maternity and Child Health Care Hospital, and Chongqing Nanchuan People’s Hospital. All centers were able to perform USgHIFU ablation and LM according to the standard operating procedures.

Eligibility criteria for doctors

According to the standard operating procedure of routine clinical practice, prior training, and quality control, (1) surgeons were required to have a board certification for more than 3 years, with a speciality in gynecology; and (2) specialists in USgHIFU treatment received training and obtained the certification authorized by the Ministry of Health of China.

Ultrasound-guided high-intensity focused ultrasound ablation

USgHIFU ablation was performed using the Model-JC (JC200) Focused Ultrasound Tumor Therapeutic Systems (Chongqing Haifu Medical Technology Co., Ltd, Chongqing, China) whose focal region of the ultrasound transducer is 1.5 × 1.5 × 10 mm. The transducer’s diameter is 20 cm, focal length is 15 cm, and working frequency is 0.8–1 MHz. Real-time monitoring was realized using My-Lab70 Ultrasound device (Bisound Esaote Group, Italy). Details of the procedure of USgHIFU ablation have been described previously [19]. The procedure was performed with the woman under conscious sedation using fentanyl and midazolam, which were intravenously administered repeatedly based on the woman’s weight. The degree of sedation was maintained at the level of 3 or 4 according to the Ramsay Sedation Scale (the patient responded to commands or exhibited quick responses to a light tap or loud noise). Women lay in prone position with their stomachs soaked in the degassed water as an ultrasound medium. The ultrasound power used was 400 W. The site and intensity of the dose delivery were adjusted according to the response of the target region and women’s tolerance. The treatment was terminated according to the grayscale change, and contrast-enhanced ultrasonography was used to assess the non-perfused volume at the end of the procedure. Women lay in prone position for 2 h after termination of the procedure, and they were advised to avoid conception for 1 year postoperatively.
**Laparoscopic myomectomy**

The surgical approach of LM was left to the attending gynecologist’s discretion. Preoperative assessments including a detailed review of the woman’s medical history, pelvic examination findings, and ultrasound examination findings. Prior to the laparoscopic procedure, prophylactic antibiotics were administered to the woman. During the procedure, the woman laid in lithotomy position with both legs protected by elastic bandages; a Foley catheter was inserted for urinary drainage. A uterine manipulator was placed into the uterus. The procedure was performed under the guidance of a video camera at the tip of a 10-mm laparoscope that was inserted through the umbilicus. Two ancillary cannulas were placed under laparoscopic visualization: one 5-mm cannula in the right lower quadrant lateral to the inferior epigastric arteries and one 5-mm cannula in the left lower quadrant. After the location of all fibroids was identified, a transverse incision was first made with a unipolar electrode on the serosa overlying the largest fibroid and extended into the pseudocapsule down to the characteristically pearly white substance of the fibroid. Other fibroids located in the same area were removed through the same incision. However, for non-adjacent fibroids, a new incision was needed. The fibroid was bluntly dissected and leveraged against the uterine wall with a probe, and it was pried from the uterus with a laparoscopic myoma screw. The pseudocapsule attachments were further dissected with a unipolar electrode. Before being cut, vessels were electrocoagulated by Kleppinger forceps. Bleeding sites were identified and controlled with electrocoagulation. After fibroid removal, the uterine defect was irrigated, and the uterine surgical defect was sutured in layers, with each suture penetrating the full thickness of the myometrium in a way similar to that applied during laparotomy. The specimen was shattered with a 12-mm electromechanical morcellator (Storz, Tuttlingen, Germany) and removed from the abdominal wall. Then the peritoneal cavity was irrigated and cleaned. Suction drainage was performed until the fluid was clear. A uterine manipulator was placed into the uterus. The procedure was performed under the guidance of a video camera at the tip of a 10-mm laparoscope that was inserted through the umbilicus. Two ancillary cannulas were placed under laparoscopic visualization: one 5-mm cannula in the right lower quadrant lateral to the inferior epigastric arteries and one 5-mm cannula in the left lower quadrant. After the location of all fibroids was identified, a transverse incision was first made with a unipolar electrode on the serosa overlying the largest fibroid and extended into the pseudocapsule down to the characteristically pearly white substance of the fibroid. Other fibroids located in the same area were removed through the same incision. However, for non-adjacent fibroids, a new incision was needed. The fibroid was bluntly dissected and leveraged against the uterine wall with a probe, and it was pried from the uterus with a laparoscopic myoma screw. The pseudocapsule attachments were further dissected with a unipolar electrode. Before being cut, vessels were electrocoagulated by Kleppinger forceps. Bleeding sites were identified and controlled with electrocoagulation. After fibroid removal, the uterine defect was irrigated, and the uterine surgical defect was sutured in layers, with each suture penetrating the full thickness of the myometrium in a way similar to that applied during laparotomy. The specimen was shattered with a 12-mm electromechanical morcellator (Storz, Tuttlingen, Germany) and removed from the abdominal wall. Then the peritoneal cavity was irrigated and cleaned until the fluid was clear. Suction drainage was performed through a 5-mm access if indicated. All port sites were sutured with a 3–0 polyglycolic acid suture at the level of the fascia. The skin was protected with sterile adhesive tape. The women were advised to avoid conception for 1 year postoperatively.

**Follow-up method**

All women were advised to return to the hospital for follow-up at 3 months, 6 months, and 12 months, and then once a year thereafter. For some women who lived far from the hospital and were unable to return for the follow-up examination, telephone interviews were performed. The following information was recorded: menstruation information, sexual life, time of pregnancy, number and outcomes of pregnancy, pregnancy process, and delivery information. Complications during pregnancy and delivery were acquired from the medical examination report and medical discharge records.

**Statistical analysis**

Statistical analyses were performed using SPSS 22.0 (IBM Corp., Armonk, NY, USA). All data with a normal distribution are expressed as mean ± standard deviation. Non-normally distributed data are expressed as median and range. Categorical data are reported as proportions and percentages. The statistical data are described generally, and intergroup comparisons were conducted with the following method. The chi-square test was used to compare proportions, and the two-sided Student t-test was used to compare continuous parametric variables. Statistical significance was determined at p < 0.05.

**Results**

**Population**

Six hundred seventy-six patients were enrolled; the median follow-up duration was 5 (1–8) years, and 20 patients (2.9%) were lost to follow-up. 320 patients with uterine fibroids were treated with USgHIFU ablation, and 336 were treated with LM; 219 (68.4%) patients became pregnant after USgHIFU ablation, and 224 (66.7%) became pregnant after LM. Average treatment times (from the first sonication to the last one) were 60 ± 30 (18–150) minutes and 60 ± 30 (35–165) minutes for USgHIFU ablation and LM, respectively. Characteristics of the 443 pregnant patients before treatment are shown in Table 1. There were no significant differences in age, BMI, pregnancy history, and uterine fibroids (size, location, and number) between the USgHIFU and LM groups.

**Pregnancy outcomes**

Pregnancy outcomes of the 443 pregnant patients after USgHIFU ablation or LM are shown in Table 2. In total, 443 patients had 501 pregnancies (natural pregnancies, 405; in vitro fertilisation-embryo transfer pregnancies, 38). There were no significant differences in singleton pregnancy, multiple pregnancies, spontaneous abortion, legally induced abortion, ectopic pregnancy, delivery, and pregnancies in progress between the groups. There was a significant difference in the average time to pregnancy between the USgHIFU and LM groups (13.6 ± 9.5 months versus 18.9 ± 7.3 months, p < 0.05).

The child delivery approaches of the 351 pregnancies after USgHIFU ablation and LM are shown in Table 3. The rate of spontaneous vaginal delivery was higher in the USgHIFU group than in the LM group, and the cesarean delivery rate was lower in the USgHIFU group than in the LM group (p < 0.05). The incidence of preterm labor was significantly higher in the USgHIFU group than in the LM group (p < 0.05).

**Complications during pregnancy and delivery**

Complications during pregnancy occurred in 351 pregnancies after USgHIFU ablation or LM (Table 4). There was no significant difference in complications between the groups. Fetal
abnormalities were not significantly different between the groups (p > 0.05). The incidence of macrosomia was lower in the LM group than in the HIFU group, but this was not statistically significant. Incidences of placenta previa and placenta increta were significantly different between the groups (both, p < 0.05). The incidence of postpartum hemorrhage was higher in the LM group than in the USgHIFU group, and the incidence of postpartum infection was higher in the USgHIFU group than in the LM group; however, these differences were not statistically significant.

Incomplete uterine rupture was found in 2 patients. One was treated with USgHIFU ablation, and the other underwent LM. The patient in USgHIFU group was a 38-year-old primary parturient woman who became pregnant at 4 months after undergoing USgHIFU ablation for a 56-mm single intramuscular myoma located in the right anterior wall. The ablation rate of the fibroid on the day after treatment was 89.7%, according to the magnetic resonance imaging evaluation. An emergency cesarean delivery was performed because of acute abdominal pain and fetal distress at 36 + 5 weeks’ gestation. No muscular layer covered the length of the serosa located about 2–4 cm above the retroperitoneal fold of the bladder, and the closest distance to the right uterine myoma was about 1.5 cm. Only the serous layer was seen, and the amniotic cavity was complete. After delivery of the fetus, uterine contraction was good, and the incision was closed in a routine manner. Myomectomy was performed at the mother’s request. The volume of intraoperative hemorrhage was about 1260 ml. The baby weighed 3.36 kg with an Apgar score of 8. The mother and baby had favorable outcomes.

Table 1. Characteristics of the 443 patients before USgHIFU or LM.

| Characteristic                                      | USgHIFU group (n = 219) | LM group (n = 224) | χ² (Z) | p-Value |
|-----------------------------------------------------|-------------------------|--------------------|--------|---------|
| Age, years                                          | 31.6 (22–42)            | 32.4 (25–41)       | 0.085  | 0.932   |
| BMI, kg/m²                                          | 23.75 (18.1–27.8)       | 22.63 (18.0–27.3)  | 0.109  | 0.913   |
| Primipara (n, %)                                    | 31 (14.2%)              | 29 (12.9%)         | 0.119  | 0.730   |
| Adverse pregnancy history (n, %)                    |                         |                    |        |         |
| Miscarriage                                         | 36 (16.4%)              | 41 (18.3%)         | 0.242  | 0.623   |
| Stillbirth                                          | 2 (0.9%)                | 3 (1.3%)           | 0.001  | 0.982   |
| Failed assisted reproduction                        | 9 (4.1%)                | 11 (4.9%)          | 0.163  | 0.686   |
| Average number of fibroids (n, %)                   | 4.3 (2–15)              | 3.9 (2–8)          | 0.329  | 0.742   |
| Classification of fibroids (n, %)                    |                         |                    |        |         |
| Single                                              | 126 (57.53%)            | 132 (58.92%)       | 0.089  | 0.766   |
| Multiple                                            | 93 (42.46%)             | 92 (41.07%)        |        |         |
| Diameter of the main fibroids, cm                   | 5.6 (3–10)              | 5.8 (3–10)         | 0.650  | 0.516   |
| Location of the main fibroids (n, %)                 |                         | 1.411              |        | 0.703   |
| Subserosal                                          | 27 (12.3%)              | 31 (13.8%)         |        |         |
| Intramural                                          | 167 (76.3%)             | 169 (75.4%)        |        |         |
| Submucosal                                          | 11 (5.0%)               | 7 (3.1%)           |        |         |
| Intramural and submucosal                           | 14 (6.4%)               | 17 (7.6%)          |        |         |

BMI: body mass index; USgHIFU: ultrasound-guided high-intensity focused ultrasound; LM: laparoscopic myomectomy.

Table 2. Pregnancy outcomes of the 443 pregnancies after USgHIFU or LM.

| Variable                                      | USgHIFU group (n = 219) | LM group (n = 224) | χ² (Z) | p-Value |
|----------------------------------------------|-------------------------|--------------------|--------|---------|
| Number of pregnancies                        | 248                     | 253                | 0.055  | 0.814   |
| Number of fetuses                            |                         |                    |        |         |
| Singleton pregnancy                          | 200                     | 204                |        |         |
| Twins pregnancy                              | 24                      | 23                 |        |         |
| Triplet pregnancy                            | 0                       | 1                  |        |         |
| Average time to pregnancy (months)           | 13.6 ± 9.5 (1–96)       | 18.9 ± 7.3 (1–96)  | 2.024  | 0.043   |
| Conception approach (n, %)                   |                         |                    |        |         |
| Natural                                      | 198 (83.2%)             | 207 (87.7%)        | 0.565  | 0.452   |
| Assisted (IVF-ET)                            | 21 (8.8%)               | 17 (7.2%)          |        |         |
| Outcomes of pregnancy (n, %)                 |                         |                    |        |         |
| Spontaneous abortion                         | 12 (5.0%)               | 14 (5.9%)          | 0.119  | 0.730   |
| Legally induced abortion                     | 21 (8.8%)               | 27 (11.4%)         | 0.696  | 0.404   |
| Ectopic pregnancy                            | 2 (0.8%)                | 6 (2.5%)           | 1.078  | 0.299   |
| Delivery                                     | 178 (74.8%)             | 173 (73.3%)        | 1.102  | 0.294   |
| Pregnancies in progress                      | 6 (2.5%)                | 4 (1.6%)           | 0.127  | 0.722   |

USgHIFU: ultrasound-guided high-intensity focused ultrasound; LM: laparoscopic myomectomy; IVF-ET: in vitro fertilisation-embryo transfer.

Table 3. Delivery outcomes of the 351 pregnancies after USgHIFU or LM (n, %).

| Delivery outcome                           | USgHIFU group (n = 178) | LM group (n = 173) | χ² (Z) | p-Value |
|--------------------------------------------|-------------------------|--------------------|--------|---------|
| Delivery approaches                        |                         |                    |        |         |
| Spontaneous vaginal delivery               | 91 (51.1%)              | 63 (36.4%)         |        |         |
| Forceps delivery                           | 13 (7.3%)               | 15 (8.6%)          |        |         |
| Cesarean delivery                          | 74 (41.6%)              | 95 (54.9%)         |        |         |
| Gestational age (week)                     |                         |                    | 1.901  | 0.168   |
| Ended delivery ≥ 37 weeks                  | 162 (91.0%)             | 164 (94.8%)        |        |         |
| Premature delivery < 37 weeks              | 16 (8.9%)               | 9 (5.2%)           |        |         |

USgHIFU: ultrasound-guided high-intensity focused ultrasound; LM: laparoscopic myomectomy.
In the LM group, a 27-year-old multipara had a singleton pregnancy at 18 months after undergoing LM for a 76-mm single intramural myoma located in the left anterior wall. During LM, the uterine cavity was not cut open and the incision was sutured in two layers via laparoscopy with four 3-0 polyglycolic acid sutures at the level of the fascia. An emergency cesarean delivery was performed because of maternal acute abdominal pain and fetal distress at 34 weeks gestation. No muscular layer covered the scar of the original operation at 4.0 cm above the retroperitoneal fold of the left bladder. Only the serous layer was seen (length, about 3 cm), and no active bleeding was found. The amniotic sac was punctured, and light red amniotic fluid was released (400 ml). After delivery of the fetus, uterine contraction was good, and the incision was closed in a routine manner. The mother had intraoperative bleeding (1760 ml) and received a blood transfusion (1400 ml). The baby weighed 2.41 kg with an Apgar score of 7. The mother and baby had favorable outcomes.

### Discussion

Myomectomy remains the standard of care for treating symptomatic fibroids in women who wish to preserve their fertility. LM and hysteroscopic myomectomy have become the main surgical modalities; the choice of techniques is not only based on sound evidence but also on clinical concerns and the skill of surgeons at each center. USgHIFU ablation, which is widely used in the treatment of uterine fibroids, has been proven to be safe and effective [12]. USgHIFU provides rapid heating of a target tumor tissue, leaving the surrounding tissue relatively unaffected. Coagulation necrosis of more than 70% of the target fibroid volume is usually achieved during a single session. Qin [16] reported 7 patients who were pregnant within 1 year after USgHIFU ablation for uterine fibroids and delivered successfully. Zou et al. [14] reported that 78 patients with uterine fibroids had a better pregnancy rate after USgHIFU ablation. Li et al. [15] reported 133 cases of pregnancy after USgHIFU ablation, with a pregnancy rate of 69.3%, 93 deliveries, and no uterine rupture and other serious adverse event. Hanstede et al. [18] believed that USgHIFU ablation may promote the reproductive function of patients with uterine leiomyoma. In our study, the pregnancy rate was comparable between the groups. According to the literature, the pregnancy rate decreases with increasing age [20,21]. Early conception after treatment of uterine fibroids is beneficial to improving the pregnancy rate. Li et al. [15] reported that 87.7% of pregnancies occurred within 2 years of USgHIFU ablation. The results of Qin et al. and Zou et al.’s studies [14,16] showed that pregnancy within 1 year after USgHIFU ablation had no adverse effects on pregnancy and delivery. Therefore, it is reasonable to suggest shortening the contraceptive time after USgHIFU ablation. Here, the same recommended duration of contraception was 1 year, and the average time to pregnancy was shorter after USgHIFU ablation than after LM. This finding indicates that becoming pregnant is easier after USgHIFU, and it suggests that if the recommended contraception time after USgHIFU ablation is shortened, the pregnancy rate may be higher. The time to conception after USgHIFU ablation is more conducive to the fertility desire of the women with uterine fibroids.

Compared with the LM group, the USgHIFU group had a higher rate of spontaneous vaginal delivery and lower cesarean section rate. In this sense, USgHIFU ablation is conducive to reducing the cesarean delivery rate. However, the incidence of preterm labor was higher in the USgHIFU group than in the LM group, and this result may be associated with the existence of ablated fibroids in pregnant women. The effect of the ablated fibroid on pregnancy is still unclear and needs further clinical evaluation. No amniotic fluid embolism occurred during pregnancy, and labor proceeded safely in all cases. The causes of fetal growth restriction (FGR) and fetal distress in the USgHIFU group may have been related to the volume reduction of the target fibroid, which was not smaller than 5 cm in diameter, and the type of target fibroid; this topic requires further clinical study. The incidence of a large infant was lower in the LM group than in the USgHIFU group, indicating that mothers require further health guidance during the gestational period. Incidences of placenta previa and placenta increta were higher in the LM group.
than in the USgHIFU group; these placental abnormalities may be related to uterine injury and may lead to serious adverse events. We noted that myomectomy during cesarean section increased postpartum hemorrhage, which requires further analysis so the obstetrical procedures can be improved.

The rate of uterine rupture that can be attributed to LM was 1.0%; thus, spontaneous uterine rupture seems to be rare after LM [19,22–26]. Previous literature has not reported the incidence of uterine rupture after USgHIFU ablation. Here, the rate of incomplete uterine rupture was 0.6% in both groups. There were no reports of uterine rupture in the third trimester of pregnancy after USgHIFU ablation of uterine fibroids [12–18]. In cesarean delivery, the uterus contracted well after delivery; thus, it seemed to not be affected by USgHIFU ablation of uterine fibroids. Therefore, for rare uterine rupture in the third trimester of pregnancy, it is difficult to determine whether it is related to the presence of uterine fibroids or USgHIFU ablation of uterine fibroids. For pregnant women with uterine fibroids, high-risk pregnancy monitoring should be carried out more carefully to avoid life-threatening serious adverse events.

**Conclusions**

In this study, the number of cases was limited, and the stratification needed to be further refined. Thus, further multicentre randomized controlled trial studies are needed to confirm our findings. Despite these limitations, the results of this research show that noninvasive USgHIFU ablation has unique advantages for women who wish to become pregnant. This treatment can remarkably shorten the preparation time for conception. Incidences of placenta increta, placenta previa, cesarean delivery, and postpartum hemorrhage are relatively lower after USgHIFU than after LM. However, incidences of preterm birth, fetal distress, FGR, and puerperal infection appear to be relatively higher after USgHIFU ablation than after LM. There is also a risk of uterine rupture after both treatments. Therefore, pregnancy after either treatment should be evaluated and monitored given its potential risk. USgHIFU ablation provides a new choice for women with uterine fibroid, especially those who desire fertility.

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**Disclosure statement**

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