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Original Article**High-Intensity Focused Ultrasound in the Treatment of Abdominal Wall****Endometriosis**

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Pris: We conducted a preliminary evaluation of the clinical efficacy and safety of high-intensity focused ultrasound (HIFU) in ablation therapy for abdominal wall endometriosis.

Abstract

Study Objective: To evaluate high-intensity focused ultrasound (HIFU) ablation therapy for abdominal wall endometriosis.

Design: A retrospective study.

Setting: Gynecological department of a teaching hospital in China.

Patients: Thirty patients with abdominal wall endometriosis were treated from May 2013 to December 2015.

Interventions: Thirteen patients were treated with HIFU ablation, and 17 patients were treated with surgical resection.

Measurements and Main Results: Color Doppler ultrasonography and magnetic resonance imaging were used to observe the lesions before and after treatment. In addition, recovery time, complications, and adverse reactions of the two groups were compared. Menstrual pain was relieved after treatment in all 30 patients. After treatment, the lesions in patients who underwent HIFU ablation decreased gradually, and there was no recurrence. Symptoms recurred in 1 patient in the surgery group 12 months after surgery. The posttreatment hospital length of stay of the HIFU ablation group (1.00 ± 0 days) was significantly shorter than that of the surgical group (5.23 ± 1.24 days; $p < .001$). The incidence of fever (0% vs 11.8%; $p = .049$) and complications of the urinary system (7.7% vs 17.6%; $p = .43$) in the HIFU ablation group was significantly lower than that of the surgical group.

Conclusions: High-intensity focused ultrasound ablation therapy is a promising treatment for abdominal wall endometriosis, and further study is warranted.

Keywords: Ablation; AWE; Endometriosis; HIFU; Lesions

Abdominal wall endometriosis (AWE) is a rare extrapelvic endometriosis. Most cases of AWE are related to obstetric or gynecological surgery [1]. The main clinical manifestations of AWE include periodic abdominal incision pain of the mass and progressively intensifying menstrual cramps that impact patient quality of life [2–4]. Surgical resection is the most common treatment for AWE [1–4]. Wide excision with at least 1 cm of a clear margin is advocated to prevent local recurrence [5]. However, the procedure causes further operative trauma and scars. For large lesions, especially those involving both muscle and fascia, synthetic mesh placement may be needed to strengthen the abdominal wall to prevent postoperative hernia that would induce further pain and economic burden.

High-intensity focused ultrasound (HIFU) ablation is a novel, noninvasive treatment of solid tumors that was developed in recent years [6–11]. The mechanism for HIFU ablation is focusing the low-intensity ultrasound emitted from outside the body to target the tissue in the body, amplifying the intensity of the focal point 1,000 times to instantaneously produce a high temperature (range, 60°C to 100°C) and coagulative necrosis of the tissue without damaging adjacent structures [12]. With the expansion of HIFU ablation indications, it has been used to treat placenta accreta, cesarean scar pregnancy, and hypersplenism [13–15]. At present, some reports are available on HIFU ablation of AWE [16,17]. The current study aimed to evaluate HIFU ablation therapy on AWE.

Materials and Methods

The inclusion criteria were (1) previous history of obstetric or gynecological surgery (such as cesarean section, mid-second-trimester cesarean section, excision of uterine fibroids, subtotal hysterectomy); (2) painful hard segments at the abdominal incision scar during the menstrual cycle and masses that are enlarged during menstruation and shrink after menstruation; (3) magnetic resonance imaging (MRI) and color Doppler ultrasound manifestations such as (a) irregularly mixed signal

lesions in the subcutaneous tissue, (b) unsmooth edges and burr shape surrounded by incomplete annular loop that often invades the rectus sheath, (c) color Doppler shows internal blood flow signal; (4) distance between the mass and skin surface >15 mm; (5) ultrasound showing endometriosis.

Exclusion criteria included (1) pregnancy; (2) inflammation or ulceration of the skin in or near the nodule; (3) serious additional health issues such as liver failure, heart failure, severe arrhythmia, and uncontrolled diabetes; (4) suspected or confirmed malignancy.

Patients were divided into treatment groups based on individual preference, and lesions were removed by HIFU ablation (treatment group) and surgical resection via traditional surgery (control group). All patients signed informed consent after admission and before treatment .

High-intensity focused ultrasound ablation

The JC treatment system (Chongqing Haifu Medical Technology Co., Ltd. Chongqing, China) was used for HIFU ablation that was performed by only professionally trained and qualified surgeons.

Previous studies [16,17] have shown that to minimize gas in the intestinal tract and reduce risk of intestinal damage, a 3-day preoperative bowel preparation is necessary before HIFU ablation. This includes ingesting liquid food and fasting for 3 days before treatment, and an enema being administered the morning of treatment. The anterior abdominal wall from the umbilicus to the level of the pubic symphysis was shaved and disinfected. A urinary catheter was inserted, and the patients were placed in a prone position with the abdominal skin in contact with the degassed water on the treatment bed [16]. The therapeutic transducer was immersed in the water reservoir, the HIFU beam directed upward, focusing on the AWE through the skin. Patients remained under conscious sedation following administration of fentanyl and midazolam via the peripheral vein. Real-time ultrasound was used to determine the extent of the lesion area and to target the nodule by moving the integrated probe. An

output power of 100 watts was used initially; each energy exposure lasted for one second and ceased for two seconds. If after energy exposure, the treated area did not become hyperechoic on ultrasound, the output power was increased in 10 watt increments until the treatment spot was hyperechoic on ultrasound. Ablation was terminated when the hyperechoic area covered the nodules in the entire area including a 1-cm margin. Contrast-enhanced ultrasound was used before and after treatment to check for blood perfusion in the lesion. Respiratory frequency, heart rate, blood pressure, and oxygen saturation were monitored throughout treatment. Patients were asked to report any pain or discomfort during HIFU ablation. Possible complications, such as skin burns, were checked and documented. After treatment, cold saline infusion was injected into the bladder, and the patient remained in the position for 30 minutes to facilitate cooling of the treatment area.

Surgical resection

Patient skin was disinfected and prepared and a catheter was inserted before surgery; 5 patients who had deep lesions and adhesions between the intestine and peritoneum identified by preoperative imaging were also administered bowel preparation. General anesthesia was administered, and the complete lesion and at least 1 cm margin around the lesion was resected to avoid recurrence. Postoperative resection specimens were routinely examined pathologically, and the stitches were removed 7 to 10 days following surgery. The procedure was performed by experienced gynecologists.

Efficacy evaluation and follow-up

Color Doppler ultrasound was used to check the blood flow signals. If residual blood flow was observed after ablation, treatment was considered incomplete, and further HIFU ablation was performed. If the nodule disappeared, no blood flow was present, and the periodic pain ceased in the treatment area, then the treatment was considered successful. To accurately evaluate the results of the treatment, an MRI

was performed one day before and one day after HIFU ablation. If coagulation necrosis occurred in the lesioned area after treatment and the MRI T2-weighted image showed a low signal that was not enhanced on the T1-weighted image, the treatment was also considered successful.

In the surgical group, if the lesion was completely excised without evidence of lesion tissue, periodic pain was relieved, and postoperative pathology confirmed that surgical margins were negative, the surgery was considered successful.

All patients were asked to return to the outpatient department for follow-up examination and color Doppler ultrasound or MRI examination at 1, 3, 6, and 12 months after treatment to evaluate the nodules. Although it has been reported [4] that it is more economical and practical to use Doppler for AWE evaluation, MRI is more advantageous for patients with abundant blood vessel growth and lesions >4 cm [5,18]. Therefore, in the current study, this patient population underwent MRI at postoperative follow-up, and Doppler was used for the other patients.

Clinical safety indicators and adverse reactions evaluation

Following the approved protocol, operative time, hospital length of stay, postoperative activity time, and time to return to work (from day of surgery) were recorded. The pain score was evaluated 6 hours, 12 hours, and 24 hours after treatment by visual analogue scale (VAS), and adverse events were recorded within 24 hours after treatment in accordance with the standards established by the Common Terminology Criteria for Adverse Events v3.0 [19].

Statistical analysis

Statistical Package for the Social Sciences 16.0 software (SPSS Inc., Chicago, IL) was used for statistical processing. The normal distribution data were expressed as mean \pm standard deviation. The skewed distribution data were expressed as median and range. Chi-square test was used for data counting, and independent sample *t* test was used for data measurement. Significance of $p < .05$ was considered statistically significant.

Results

From May 2013 to December 2015, 37 patients diagnosed with AWE were admitted to the gynecology department in our hospital. In 2 of the 37 patients, the mass of the abdomen was close to the skin, distance <10 mm; 2 patients refused surgery or HIFU ablation because the lesion was small; 1 patient had ulceration of the skin near the nodule, 1 patient was pregnant, and 1 patient had diabetes (uncontrolled), leading to the exclusion of these 7 patients. Thirty patients satisfied the inclusion criteria, and all had a history of cesarean section; none presented with a history of myomectomy or subtotal hysterectomy. The patients had not been medically treated before the study. Thirteen patients chose HIFU ablation and 17 patients chose treatment with surgical resection owing to medical insurance and reimbursement issues for HIFU ablation versus surgical resection. The two groups presented no significant differences in age ($p = .081$), body mass index ($p = .956$), or lesion size ($p = .728$) (Table 1). In the HIFU ablation group, there were 2 patients with lesions >3 cm, 10 patients with deep lesions involving the fat layer, 1 patient with the anterior sheath of the rectus abdominis, and 2 patients with the rectus abdominis. In the surgical treatment group, there were 2 patients with lesions >3 cm, 12 patients with deep lesions involving the fat layer, 2 lesions involving the rectus sheath, 3 lesions involving the rectus abdominis muscle. The two groups were also not statistically significant regarding the sizes or location of lesions.

HIFU ablation group

All 13 patients successfully underwent HIFU ablation. During the treatment, six patients felt pain in the treatment area, but no patient asked to discontinue HIFU ablation because of pain. The total time of the HIFU ablation averaged 13 minutes (range, 5–48 minutes) from the first energy exposure, and the total energy exposure time was a median 84 seconds (range, 32–650 seconds). The average therapeutic power was 101.5 watts, and the focused ultrasound irradiation time was 315.16 ± 150.35 seconds. Grayscale changes in the ultrasound image during ultrasound

ablation were considered markers of coagulation necrosis of the tissue. These changes were classified as mass-like or overall gray changes (Fig. 1). Of the 13 patients, 12 (92.3%) developed agglomerative grayscale changes (gray-block changes at an irradiation time of 240 ± 127.23 seconds), and 1 patient developed overall gray changes. After HIFU ablation, no blood flow signal was observed in any patient. All patients were slightly swollen in the treatment area. Eight patients reported mild pain in the treatment area that was resolved within 1 to 3 days without pain medication. There were no skin burns. All patients were discharged on postoperative day 1. Abdominal wall pain was relieved in all patients during the next menstrual cycle, all patients were followed for 12 to 24 months after treatment, and the lesion size gradually decreased during the follow-up period. After treatment, coagulation necrosis in the lesion area showed low T2-weighted image signal, no enhancement on T1-weighted image (Fig. 2), and no blood flow signals in the color Doppler ultrasound. All treated nodules gradually shrank over time (Fig. 1). No serious complications, such as abscess formation, were found during follow-up.

Surgical resection group

All 17 surgical patients underwent resection successfully. Fascia and rectus muscle involvement was detected in 5 patients, and additional mesh was used in 1 patient. The surgery of the single patient where mesh was used was performed in cooperation with a surgeon; the rest of the procedures were completed by gynecologists. Median blood loss was 20 mL (range, 10–50 mL; Table 2). Median operative time was 45.0 minutes (range, 30–50 minutes), and average postoperative hospital length of stay was 5.23 ± 1.24 days. Pathology was performed for the resected lesions, and the report identified endometrial glands and stroma inside the hyperplastic connective tissue. All surgical margins were confirmed negative. And in all surgical cases, the periodic pain in the abdomen incision was relieved after lesion resection.

The relief of periodic pain between the two groups was not statistically different during the follow up period (at 1-month posttreatment $p = .541$, at 3-months

posttreatment $p = .446$, at 6-months posttreatment $p = .676$, at 12-months posttreatment $p = .435$; Table 3). At 12 to 24 months follow-up, surgical scars appeared an average of 42 mm (range, 0–50 mm). In the surgical group, 4 patients suffered continuous discomfort at the abdominal incision sites, 4 had sunken defect in the subcutaneous tissue of the surgical incision.

Posttreatment medication and recurrence

In the HIFU ablation group, 5 patients were at high risk for recurrence of pain and/or lesion (2 patients with lesions >3 cm, 1 patient with anterior sheath of the rectus abdominis, and 2 patients with rectus abdominis). Patients were followed for an average of 19.7 months, with no recurrence of pain and/or lesion.

Seventeen patients underwent surgical resection, 7 were at high risk for recurrence of pain and/or lesion (5 lesions were located deep in the anterior rectus sheath and rectus abdominis; 2 lesions were >3 cm). All patients were followed for an average of 18.1 months, and 1 patient had recurrent local mild pain at the abdominal incision at 12 months after surgery. The patient with pain recurrence had a history of two cesarean sections, and the lesion was 2.5×2.0 cm involving the rectus abdominis anterior sheath and part of the rectus abdominis. Pain recurrence in the HIFU group was lower than that in the surgical resection group ($p < .047$).

Adverse events

Adverse events related to treatment were as follows. In the HIFU ablation group, 8 (61.5%) patients complained of discomfort in the treatment area, and 1 (7.7%) patient had hematuria. In the surgical group, 2 (11.8%) patients experienced fever, 12 (70.6%) patients complained of pain or discomfort, 2 (11.8%) patients had signs of bladder irritation, 1 (5.9%) patient had urinary retention, and 3 (17.6%) patients complained of nausea and emesis. The incidence of fever ($p = .049$), complications of urinary system ($p = .43$), and complications of the digestive system ($p = .032$) in the HIFU ablation group was significantly lower than that in the surgical resection group (Table 4).

Posttreatment recovery

The average hospital length of stay ($p < .001$), postoperative activity time ($p < .001$), and time to return to work (from day of surgery; $p < .001$) in the HIFU ablation group were significantly shorter than those in the surgical group (Table 5). Twelve postoperative patients in the surgery group used anesthetic analgesics. In contrast, no patient required anesthetic analgesics after treatment in the HIFU group. However, no significant difference was observed in the pain scores of the two groups at 6 hours ($p = .063$), 12 hours ($p = .093$), and 24 hours ($p = .674$) after treatment (Table 6).

Discussion

The HIFU ablation technology was noninvasive with minimal trauma and no scarring, does not involve radiation, results in minimal adverse events, and can be duplicated. It has been successfully applied to treat various solid tumors and has achieved noteworthy results [6–11,20–22]. The indications of HIFU ablation for noncancer are gradually expanding. At present, there are several reports [16–17] on the noninvasive characteristics of HIFU ablation of AWE; however, there have been no qualitative correlations and evaluation of the efficacy and safety between traditional invasive treatments and HIFU ablation.

Standard treatment of AWE includes wide local excision and hormonal therapy that often slightly improves symptoms [5]. Upadhyaya et al [23] noted that surgical excision provides both diagnostic and therapeutic intervention, and once the diagnosis of AWE is made, wide surgical excision should be completed. Gonzalez-Fernandez et al [24] reported that the risk factors for recurrence of AWE include the size of the mass and its infiltration, and that typically when the peritoneum and/or abdominal muscles are involved, recurrence is prevalent. It is recommended to appropriately expand the scope of surgery resection for patients with high risk.

In the current study, all HIFU-ablated lesions were gradually reduced during

follow-up, but the reduction of lesion size was less than the surgical group. There were 5 patients with high risk factors in the HIFU group with no recurrence during the follow-up period. In the surgical treatment group, 7 patients had high-risk factors, and there was one instance of recurrence. This result may be owing to the effect of HIFU ablation on the focal ultrasound ablation of the lesion and its surrounding tissues causing an irreversible coagulation necrosis. The HIFU ablation destroys the AWE lesion and causes the ectopic endometrium to lose its function [25]. In particular, large and deep lesions are not easy to cut, and HIFU ablation offers certain advantages for such cases.

The AWE is not in the pelvic cavity and the site is relatively superficial, leading to no significant ultrasound energy reflections and rare side effects. However, inaccurate positioning of the HIFU ablation wand during treatment may result in skin burns [26]. In the current study, the scars were evaluated carefully before treatment (owing to the characteristics of the scars identified on ultrasound that impacted the selection of the intensity of the ultrasonic energy). Because the power started from 100 watts and gradually increased if tolerated and because each exposure was limited to 1 second, no skin burn was observed. Without anesthesia analgesics after treatment, the degree of pain tolerance of patients in the HIFU ablation group was similar to that of patients treated with postoperative analgesia. The incidence of adverse events in the HIFU ablation group was lower than that in the surgical group, and the hospital length of stay and postoperative recovery of normal activities were shorter than in the surgical group.

In summary, compared with traditional surgical resection, HIFU ablation therapy of AWE offers certain advantages. First, it is minimally invasive, leaves no scars, and preserves the integrity of the abdominal wall. Second, ultrasound-guided HIFU is relatively simple and quick and could be more acceptable to patients. Third, it can be repeated, and the original residue or recurrent nodules can be repeatedly treated if the skin has no damage.

This study has certain limitations. First, it is not a randomized, controlled trial and

has a small number of patients. Further, though demographic characteristics did not differ between groups, selection bias of the patient groups may still exist. Also, the patients in the study group were only clinically diagnosed and not pathologically diagnosed. In addition, the local standard of care differs from worldwide standard of care and may impact the lack of generalizability. Finally, this study is also limited by the relatively short follow-up period.

Conclusion

It appears that HIFU ablation is a favorable method in the treatment of AWE in the short-term. Compared with traditional surgical treatment, HIFU ablation seems simple, does not seem to leave additional scarring, presents with rapid recovery, and has a lower incidence of adverse reactions. High-intensity focused ultrasound ablation may be an alternative to traditional AWE surgery in the future; however, multicenter studies with longer follow-up and a larger number of patients are warranted.

References

1. Grigore M, Socolov D, Pavaleanu I, et al. Abdominal wall endometriosis: an update in clinical, imagistic features, and management options. *Med Ultrason*. 2017;19:430–437.
2. Ecker AM, Donnellan NM, Shepherd JP, et al. Abdominal wall endometriosis: 12 years of experience at a large academic institution. *Am J Obstet Gynecol*. 2014;211:363.e1–5.
3. Heller DS, Fitzhugh VA. Abdominal wall endometriosis: a rarely anticipated diagnosis: a 16-year experience and brief literature review. *J Reprod Med*. 2014;59:110–112.
4. Rindos NB, Mansuria S. Diagnosis and management of abdominal wall endometriosis: a systematic review and clinical recommendations. *Obstet Gynecol Surv*. 2017;72:116–122.
5. Min K, Han HH. Treatment of abdominal wall endometriosis using a mini-abdominoplasty design. *Arch Aesthetic Plast Surg*. 2018;24:134–137.
6. Chen W, Zhu H, Zhang L, et al. Primary bone malignancy: effective treatment with high-intensity focused ultrasound ablation. *Radiology*. 2010;255:967–978.
7. Van Velthoven R, Aoun F, Marcelis Q, et al. A prospective clinical trial of HIFU hemiablation for clinically localized prostate cancer. *Prostate Cancer Prostatic Dis*. 2016;19:79–83.
8. Marinova M, Rauch M, Mücke M, et al. High-intensity focused ultrasound (HIFU) for pancreatic carcinoma: evaluation of feasibility, reduction of tumour volume and pain intensity. *Eur Radiol*. 2016;26:4047–4056.
9. Merckel LG, Bartels LW, Köhler MO, et al. MR-guided high-intensity focused ultrasound ablation of breast cancer with a dedicated breast platform. *Cardiovasc Intervent Radiol*. 2013;36:292–301.
10. de Senneville BD, Moonen C, Ries M. MRI-guided HIFU methods for the ablation

of liver and renal cancers. *Adv Exp Med Biol.* 2016;880:43–63.

11. Zhang X, Li K, Xie B, et al. Effective ablation therapy of adenomyosis with ultrasound-guided high-intensity focused ultrasound. *Int J Gynaecol Obstet.* 2014;124:207–211.

12. Xiong Y, Yue Y, Shui L, et al. Ultrasound-guided high intensity focused ultrasound (USgHIFU) ablation for the treatment of patients with adenomyosis and prior abdominal surgical scars: a retrospective study. *Int J Hyperthermia.* 2015;31:777–783.

13. Zhu X, Deng X, Xiao S, et al. A comparison of high-intensity focused ultrasound and uterine artery embolisation for the management of caesarean scar pregnancy. *Int J Hyperthermia.* 2016;32:144–150.

14. Hong Y, Guo Q, Pu Y, et al. Outcome of high-intensity focused ultrasound and uterine artery embolization in the treatment and management of cesarean scar pregnancy: a retrospective study. *Medicine (Baltimore).* 2017;96:e7687.

15. Zhu J, Chen X, Hu X, et al. A comparative study of surgical splenectomy, partial splenic embolization, and high-intensity focused ultrasound for hypersplenism. *J Ultrasound Med.* 2016;35:467–474.

16. Wang Y, Wang W, Wang L, et al. Ultrasound-guided high-intensity focused ultrasound treatment for abdominal wall endometriosis: preliminary results. *Eur J Radiol.* 2011;79:56–59.

17. Luo S, Zhang C, Huang JP, et al. Ultrasound guided high intensity focused ultrasound treatment for abdominal wall endometriosis: a retrospective study. *BJOG.* 2017;124:59–63.

18. Stein L, Elsayes KM, Wagner-Bartak N. Subcutaneous abdominal wall masses: Radiological reasoning. *AJR Am J Roentgenol.* 2012;198:W146–W151.

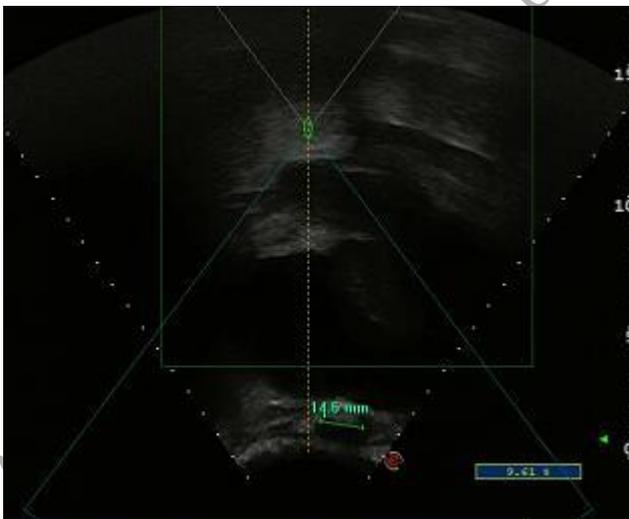
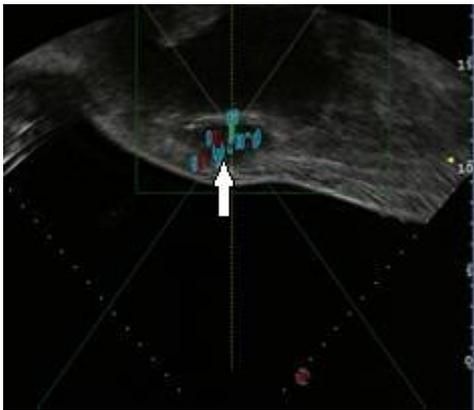
19. Zhang S, Chen Q, Wang Q. The use of and adherence to CTCAE v3.0 in cancer clinical trial publications. *Oncotarget.* 2016;7:65577–65588.

20. Orsi F, Arnone P, Chen W, et al. High intensity focused ultrasound ablation: a new therapeutic option for solid tumors. *J Cancer Res Ther.* 2010;6:414–420.
21. Jones TA, Chin J, Mcleod D, et al. High intensity focused ultrasound for radiorecurrent prostate cancer: A North American clinical trial. *J Urol.* 2018;199:133–139.
22. Crouzet S, Blana A, Murat FJ, et al. Salvage high-intensity focused ultrasound (HIFU) for locally recurrent prostate cancer after failed radiation therapy: multi-institutional analysis of 418 patients. *BJU Int.* 2017;119:896–904.
23. Upadhyaya P, Karak AK, Sinha AK, Kumar B, Karki S, Agarwal CS. Abdominal wall endometriosis. *JNMA J Nepal Med Assoc.* 2010;49:158–160.
24. Gonzalez-Fernandez S, Sabra S, Oltra M, et al. Case report of recurrent abdominal wall endometrioma at the same location after nine years of its first excision. *JFIV Reprod Med Genet.* 2017;5:1–3.
25. Guan L, Xu G. Damage effect of high-intensity focused ultrasound on breast cancer tissues and their vascularities. *World J Surg Oncol.* 2016;14:153.
26. Zhang L, Zhang W, Orsi F, et al. Ultrasound-guided high intensity focused ultrasound for the treatment of gynaecological diseases: a review of safety and efficacy. *Int J Hypertherm.* 2015;31:280–284.

Figure Legends

Fig. 1 Ultrasonography of a 31-year-old abdominal wall endometriosis patient treated with high-intensity focused ultrasound (HIFU) ablation. (A) Ultrasonic image found mass-like grayscale change in lesion during HIFU ablation. (B) Right after HIFU ablation, no blood flow signal was detected in color Doppler ultrasound. (C) The lesion was significantly reduced at six months after HIFU ablation. (D) No blood flow signal was observed in color Doppler ultrasound at six months after HIFU ablation.

Fig. 2 Magnetic resonance imaging (MRI) of another 31-year-old abdominal wall endometriosis patient treated with high-intensity focused ultrasound (HIFU) ablation. (A) Before HIFU ablation, MRI examination showed slightly mixed signal with small cystic hyperintensity within the lesion on T2-weighted image. (B) Before HIFU ablation, remarkable enhancement was observed on contrast-enhanced T1-weighted image. (C) One day after HIFU ablation, the treated lesion showed hypointensity on T2-weighted image. (D) One day after HIFU ablation, no enhancement was seen in the treated lesion on contrast-enhanced T1-weighted image. (E) Six months after HIFU ablation, the treated lesion decreased obviously on T2-weighted image. (F) Six months after HIFU ablation, the treated lesion decreased on contrast-enhanced T1-weighted image.













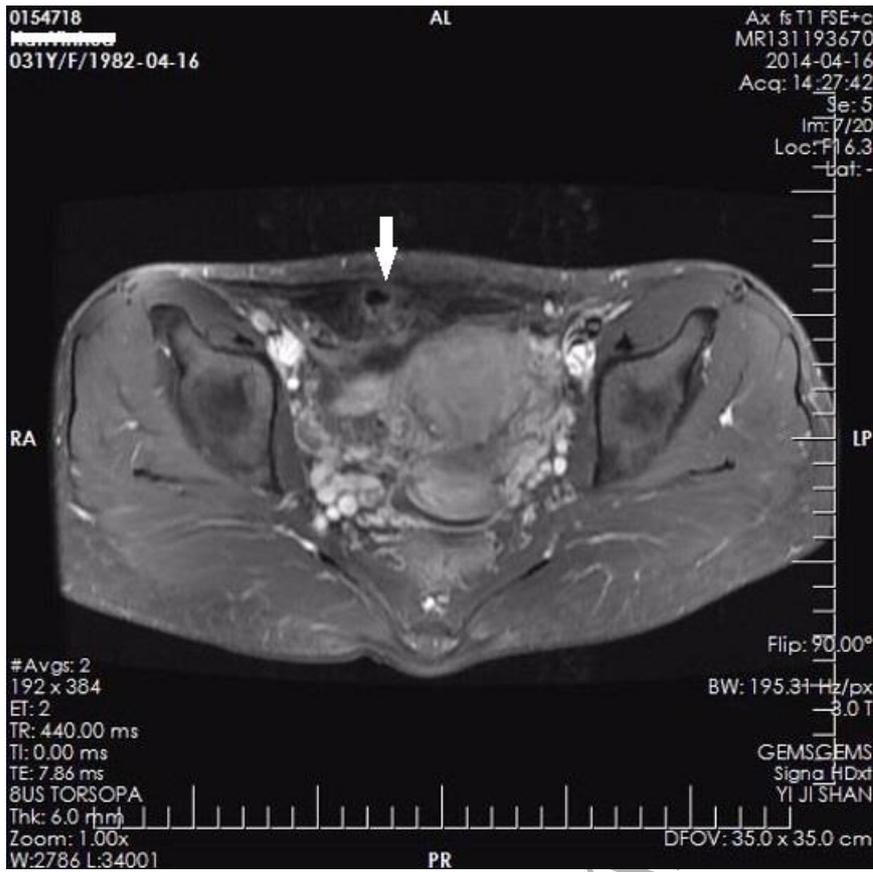


Table 1

Patient characteristics

	HIFU treatment group (n = 13)	Surgical resection group (n = 17)	p value
Age, years*	31.20 ± 4.21	30.08 ± 4.03	.081
BMI, kg/m ² *	21.78 ± 3.52	22.15 ± 2.88	.956
Number of Caesarean deliveries, no*	1.08 ± 0.28	1.06 ± 0.24	.45
IUD, n (%)	2 (15.38%)	2 (11.76%)	.776
Pretreatment pain score*	5.8 ± 1.68	6.0 ± 1.96	.501
Lesion volume, cm ³ *	2.32 ± 2.128	2.41 ± 1.912	.728
Lesion >3 cm ³ , n (%)	2 (15.38%)	2 (11.76%)	.776
Lesions involving the rectus abdominis/rectus sheath, n (%)	3 (23.07%)	5 (29.41%)	.702

BMI, body mass index; HIFU, high-intensity focused ultrasound; IUD, intrauterine device.

*Mean ± standard deviation.

Table 2

Comparison of abdominal wall repairs

Variables	HIFU group n = 13	Surgical resection group n = 17	p value
Treatment time, minutes*	13 (5–48)	45.0 (30–50)	<.001
Amount of bleeding, mL*	0	20 (10–50)	<.001
Excision interrupted the fascia and rectus muscles, n (%)	0	5/17 (29.4%)	<.001
Excision with mesh, n (%)	0	1/17 (5.8%)	.0567

*Median (range).

HIFU, high-intensity focused ultrasound.

Table 3
Clinical outcomes

Variables*	HIFU group (n = 13)	Surgical group (n = 17)	p value
Lesion volume at 1-month posttreatment, cm ³	1.21 ± 1.01	0	<.001
Lesion volume at 3-months posttreatment, cm ³	1.02 ± 0.85	0	<.001
Lesion volume at 6-months posttreatment, cm ³	0.91 ± 0.51	0	<.001
Lesion volume at 12-months posttreatment, cm ³	0.69 ± 0.48	0	<.001
Pain score at 1-month posttreatment	1.23 ± 0.56	1.17 ± 0.61	.541
Pain score at 3-months posttreatment	1.0 ± 0.46	1 ± 0.32	.446
Pain score at 6-months posttreatment	0.62 ± 0.35	0.58 ± 0.27	.676
Pain score at 12-months posttreatment	0.62 ± 0.35	0.71 ± 0.42	.435

*Mean ± standard deviation.

HIFU, high-intensity focused ultrasound.

Table 4
Adverse effects within 24 hours postprocedure

	HIFU group, n (%) n = 13	Surgical resection group, n (%) n = 17	p value
Fever ($\geq 38^{\circ}\text{C}$)	0	2 (11.8%)	.049
Pain/discomfort	8 (61.5%)	12 (70.6%)	.603
Lower abdominal pain	0	2 (11.8%)	
Pain at the incision/discomfort in the treatment area	8 (61.5%)	10 (58.82%)	
Skin burns	0	0	
Urinary system	1 (7.7%)	3 (17.6%)	.043
Hematuria	1 (7.7%)	0	
Signs of bladder irritation	0	2 (11.8%)	
Urinary retention	0	1 (5.9%)	
Digestive system	0	3 (17.6%)	.032
Nausea and emesis	0	0	
Diarrhea/constipation	0	0	

HIFU, high-intensity focused ultrasound.

Table 5
Comparison of posttreatment recovery

	HIFU group	Surgical resection group	t	p value
Posttreatment hospital length of stay, days*	1.00 ± 0.00	5.23 ± 1.24	-18.408	<.001
Postoperative activity time, hours*	1.36 ± 0.76	28.49 ± 5.49	-42.729	<.001
Time to return to work (from day of surgery), days*	4.71 ± 5.61	21.49 ± 10.73	-14.036	<.001

*Mean ± standard deviation.

HIFU, high-intensity focused ultrasound.

Table 6

Posttreatment visual analogue scale (VAS) scores

Item	HIFU group, n = 13	Surgical resection group, n = 17	t	p value
Pain score at 6h posttreatment*	3.68 ± 1.56	4.15 ± 2.01	-1.876	.063
Pain score at 12h posttreatment*	4.02 ± 1.48	4.37 ± 1.92	-1.673	.093
Pain score at 24h posttreatment*	2.80 ± 1.58	2.94 ± 1.80	0.406	.674

visual analogue scale(VAS)scores:0-10

*Mean ±SD