Review Article

Ultrasound-guided percutaneous microwave ablation of adenomyosis: a narrative review

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Objective: The purpose of the present review is to analyze and summarize the feasibility, effectiveness, and safety of ultrasound-guided percutaneous microwave ablation (MWA) for adenomyosis according to largest studies available in current literature, so as to provide a more robust foundation for its use in the treatment of patients with this condition.

Background: Adenomyosis is a common and frequently occurring gynecological disease. It can lead to clinical symptoms such as dysmenorrhea, menostaxis, menorrhagia, and anemia, and can seriously affect patients' quality of life. Treatments for adenomyosis include drug, minimally invasive, and surgical therapies. Among them, ultrasound-guided percutaneous microwave ablation has become a new hotspot in the minimally invasive treatment of adenomyosis in recent years, with its advantages of small trauma and a good therapeutic effect.

Methods: Relevant studies were retrieved from the CNKI (Chinese National Knowledge Infrastructure), CQVIP, Wanfang, PubMed, Web of Science, Cochrane Library, EMBASE, ClinicalTrials.gov, and Google Scholar databases. The retrieval time range was from January 2000 to June 2021. Chinese search terms included "adenomyosis", "microwave ablation", and "ultrasound". English search terms included "microwave ablation", "ultrasound", "(adenomyosis) OR (endometrioma) OR (adenomyoma)".

Conclusions: Ultrasound-guided percutaneous microwave ablation therapy is a feasible, safe, and effective technique for the treatment of adenomyosis, and is worthy of clinical application and promotion.

Keywords: Adenomyosis; microwave ablation; ultrasound guided; review

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Introduction

Adenomyosis is a benign uterine condition characterized by ectopic invasion of the myometrium by endometrial glands and mesenchyme. It shows periodic bleeding under the influence of hormones, and myofibrous connective tissue hyperplasia located throughout the entire uterus or localized in one spot (1). In recent years, the increase in the number of intrauterine operations, such as cesarean section and induced abortion, has led to a rise in the incidence of adenomyosis. Epidemiological research has shown that the clinical prevalence of adenomyosis ranges from 5% to 70%, with an average prevalence of approximately 20% to 30%, and that the condition most commonly affects women in their 30 s to 50 s (2). Furthermore, with the delay of childbearing in recent years, the incidence of adenomyosis has also increased among non-childbearing women. The main clinical symptoms of adenomyosis include dysmenorrhea, menostaxis, menorrhagia, and anemia, which can seriously affect patients' life and work (3).

Treatments for adenomyosis include drug, minimally invasive, and surgical therapies. However, drug therapy cannot cure the condition completely, and long-term drug use can have significant side effects, meaning patients cannot adhere to long-term medication. Hysterectomy can completely remove the nidus, but entails considerable surgical trauma and slow postoperative recovery; moreover, intraoperative resection and suture of the superior uterine artery can lead to insufficient ovarian blood supply, increase the risk of ovarian function decline, and reduce patients' postoperative quality of life (4). Also, hysterectomy is not suitable for the patients who want to preserve the uterus or have fertility requirements (5). Minimally invasive treatment has therefore become the preferred treatment for patients with adenomyosis.

Minimally invasive therapy mainly includes vascular interventional and in situ thermal ablation therapies, among which ultrasound-guided percutaneous microwave ablation is a novel minimally invasive treatment method that has been applied in clinical practice in recent years. Under real-time guidance and monitoring of ultrasound images, the needle microwave antenna is implanted into the nidus via percutaneous puncture. The heat generated by microwave radiation is used to induce coagulation necrosis of the nidus tissue in the thermal field. The nidus becomes narrower or disappears, resulting in the loss of ectopic endometrial function and the relief or elimination of clinical symptoms such as dysmenorrhea, anemia, and compression, thus improving the patient's quality of life.

Through clinical verification, ultrasound-guided percutaneous microwave ablation has been shown to be convenient to perform, safe, and effective, while being associated with little trauma, a short treatment time, few complications, and quick recovery. It has therefore become an effective method for the clinical treatment of adenomyosis (6-8). The present study sought to further explore the feasibility, effectiveness, and safety of ultrasound-guided percutaneous microwave ablation for adenomyosis by analyzing and summarizing the existing literature, in the hope of providing a basis for its use as a treatment for patients with the condition.

We present the following article in accordance with the Narrative Review reporting checklist (available at https://dx.doi.org/10.21037/apm-21-3133).

Methods

Retrieval strategy

Relevant studies published from January 2000 to June 2021 were comprehensively retrieved from databases including CNKI (Chinese National Knowledge Infrastructure), CQVIP, Wanfang, PubMed, Web of Science, Cochrane Library, EMBASE, ClinicalTrials.gov, and Google Scholar. Chinese search terms included "adenomyosis", "microwave ablation", and "ultrasound". English search terms included "microwave ablation", "ultrasound", and "(adenomyosis) OR (endometrioma) OR (adenomyoma)". Studies describing microwave ablation for adenomyosis were included for analysis. Additional studies were identified through manually searching major research references, review articles, and key journals. Overlapping or duplicate studies, reviews, abstracts, unpublished studies, dissertations, case reports, reviews, secondary analyses, letters, and studies for which the full text was not available were excluded.

Evaluation index

The following indicators were extracted from the included articles: number of patients; related technical parameters including the number of antennas placed and the total ablation time; the rates of ablation, uterine volume reduction, and nidus volume reduction; improvement of clinical symptoms; complications; and recurrence.

The effectiveness of the technique was evaluated based on the post-treatment ablation rate, uterine volume reduction rate, nidus volume reduction rate, disease-related symptoms, and health-related quality of life assessment.

Patients were followed up at 1, 3, 6, and 12 months after treatment. Some studies also reported on the levels of hemoglobin (Hb), CA125, CA199, and hormones such as estradiol (E2), luteinizing hormone (LH), and follicle-stimulating hormone (FSH) to further evaluate the clinical efficacy of microwave ablation.

Ablation rate refers to the ablation range, as evaluated by intravenous contrast-enhanced ultrasound and/or enhanced MRI after ablation. The area without contrast agent perfusion after tissue ablation was the necrotic area, and the percentage of necrotic tissue in the total lesion area was taken as the ablation rate (7).

The uterine volume reduction rate was calculated using the following formula (7,9-11): (uterine volume before treatment – uterine volume after treatment)/uterine volume before treatment ×100%. The following methods were used to measure uterine volume. The distances between the serous layer of the fundus of the uterus and the internal opening of the cervix was measured on the longitudinal section of the uterus. Anteroposterior diameter: The maximum diameter of the section perpendicular to the section of the long diameter (two measuring scales were placed on the serosal surfaces of the anterior and posterior uterus walls. Transverse diameter: in the transverse section of the uterus, the distance between the serous membranes on both sides was measured below the fallopian tube opening at the fundus of the uterus.

The nidus volume reduction rate was calculated using the following formula (12): (nidus volume before treatment – nidus volume after treatment)/nidus volume before treatment ×100%. The calculation method for nidus volume was V (cm^3) = length × width × height ×0.5233.

Pain severity was assessed by visual analogue scale (VAS) score, which measured pain intensity on a scale of 0 to 10 (no pain, 0 points; mild pain, 1–3 points; moderate pain affecting sleep, 4–6 points; and severe pain affecting sleep or appetite, 7–10 points).

Symptoms were assessed by symptom severity score (SSS). The SSS questionnaire includes eight items: menstrual blood loss, menstrual clotting volume, prolonged periods, menstrual disorders, pelvic pressure, urination times during the day and night, and fatigue. The higher the SSS, the more severe the symptoms.

Results

The results of the included studies and their variable characteristics are summarized in *Table 1*.

Treatment parameters

Thirteen studies involving 736 patients who received ultrasound-guided microwave ablation for adenomyosis were retrieved (9-19). An ablation frequency of 2,450 MHz was adopted for all the microwave ablation instruments used in the included studies, and the power range was 40–120 W. The number of ablation needles was selected according to the size of the nidus. For nidi of less than 5 cm in diameter, a single needle was used; for those with a diameter exceeding 5 cm, a double needle was used. The average ablation duration was 700 seconds (9), and not all studies reported the ablation time.

Therapeutic evaluation

The ablation rate was 79.7–91.34%, the uterine volume reduction rate was 55.2–64.9%, and the nidus volume reduction rate was 64.9–93.1% after 12 months of follow-up. After treatment, patients' clinical symptoms significantly improved: the improvement rates of dysmenorrhea, SSS, menstrual disorder, and anemia were 50–81.7%, 20.9–60.2%, 40–80.2%, and 55.6–78.5%, respectively.

Only minor complications were observed among the patients. The incidence rates of pain in the lower abdomen, at the puncture site, and at the ablation site ranged from 43.9% to 100%, and the incidence rate of vaginal discharge ranged from 7.1% to 88.2%.

Discussion

In recent years, some progress has been made in the treatment of adenomyosis with microwave ablation therapy. This treatment is clinically verified to have the characteristics of being convenient to perform, safe, and effective, while being associated with little trauma, a short treatment time, a low level of pain, and few adverse reactions. Consequently, it has become an effective method for the clinical treatment of symptomatic adenomyosis, and has increasingly been recognized by clinicians and patients.

The ablation rate is one of the main indicators for evaluating the effect of microwave ablation. In principle, the ablation rate for adenomyosis should exceed 70% (7). Most reported ablation rates of microwave ablation surpass 90% (18,19,21), and thus meet the ablation standard. For patients with incomplete ablation, contrast-enhanced ultrasound or enhanced MRI can be used to timely detect and supplement the ablation. Zhu *et al.* (18) performed

Table 1 Summary of indicators in the included literatures

Study	Number	Age, years	Ablation parameters	Ablation rate	Uterine volume reduction rate	Nidus reduction rate	Symptom improvement	Complications	Total effective rate	Follow-up time	Recurrence rate
Zhang, 2011 (9)	22	39.2	KY2000, 2,450 MHz, microwave antenna 15G	N/A	N/A	N/A	Dysmenorrhea improvement rate, 57.1%; hemoglobin improvement rate, 40.6%	Local pain or discomfort (72.7%); vaginal discharge (31.8%)	N/A	6	N/A
Yang, 2014 (10)	87	37.9±4.2	KY2000, 2,450 MHz, microwave antenna 15G	N/A	N/A	N/A	No differences in serum estradiol E2 or follicle-stimulating hormone (FSH) levels. One patient had uterine amenorrhea, but the rest had normal menstrual cycles and menstrual duration	N/A	N/A	12	N/A
Li, 2016 (11)	21	36	50 W	N/A	N/A	N/A	No changes in dysmenorrhea, or menstrual cycle or duration. No differences in E2, LH, or FSH levels	No significant complications	N/A	12	N/A
Xu, 2016 (12)	13	36	KY2000, 50–70 W	N/A	N/A	77.1%	Dysmenorrhea improvement rate, 77.8%; menstrual disorder improvement rate, 40%	Abdominal pain to varying degrees (100%)	N/A	12	N/A
Hai, 2017 (13)	75	41.4±4.2	2,450 MHz, 40–60 W, microwave antenna 15G	N/A	N/A	N/A	VAS pain improvement rate, 56.5%; SSS improvement rate, 24.8%	N/A	N/A	3	N/A
Zhao, 2017 (14)	31	43.7±5.2	KY2000, 2,450 MHz, 40–120 W microwave antenna 15G	N/A	N/A	N/A	Dysmenorrhea VAS improvement rate, 50%	Pain at puncture site or ablation area (70.9%); vaginal discharge (32.2%)	87.1%	3	N/A
Liu, 2019 (15)	70	42±6	2,450 MHz, 60 W, microwave antenna 15G	N/A	1 month: 28.2%; 6 months: 50.6%; 12 months: 55.2%	1 months: 34.7%; 6 months: 61.0%; 12 months: 77.6%	VAS pain improvement rate, 81.7%; SSS improvement rate, 60.2%	Vaginal discharge (16%); abdominal pain (13%)	N/A	12	N/A

Table 1 (*continued*)

Table 1 (*continued*)

Study	Number	Age, years	Ablation parameters	Ablation rate	Uterine volume reduction rate	Nidus reduction rate	Symptom improvement	Complications	Total effective rate	Follow-up time	Recurrence rate
Lin, 2020 (16)	68	39.4±4.2	2,450 MHz, 50 W, microwave antenna 15G	79.7%	3 months: 44.8%; 12 months: 71.7%	3 months: 54.4%; 12 months: 64.9%	Pain VRS improvement rate, 56%; SSS improvement rate, 20.9%	N/A	N/A	12	N/A
Liu, 2020 (17)	28	38.9±6.1	50 W/60 W	N/A	N/A	3 months: 48.67%; 6 months: 68.52%; 12 months: 81.41%	Dysmenorrhea improvement rate, 61.1%; menstrual disorder improvement rate, 39.1%; anemia improvement rate, 73.3%	Lower abdominal pain (100%); low thermal (21.4%); vaginal discharge (7.1%)	91.43%	12	N/A
Zhu, 2020 (18)	37	43.3±7.4	N/A	90%	N/A	3 months: 60.8%; 6 months: 78.1%; 12 months: 93.1%	Dysmenorrhea improvement rate, 78.9%; menstrual disorder improvement rate, 42.9%; anemia improvement rate, 55.6%	N/A	91.9%	12	N/A
Xu, 2020 (19)	66	44.44±6.43	2,450 MHz, 50–60 W microwave antenna 15G	90.90%	N/A	N/A	Average amenorrhea score at 3 months, 49.3%; at 3 months and 6 months, hemoglobin concentration had increased by 15.7% and 34.8%, respectively	Pain at the puncture site or ablation site (43.9%); vaginal discharge (25.7%)	N/A	6	N/A
Li, 2017 (20)	40	42.2±5.8	450 MHz, 60 W	N/A	1 month: 34.8%; 3 months: 47.8%; 6 months: 55.9%; 12 months: 59.1%	1 month: 37.7%; 3 months: 54.9%; 6 months: 63.6%; 12 months: 66.1%	At the 12-month follow-up, decreased menstrual volume, dysmenorrhea in remission, and decreased CA125 and CA199	No damage to surrounding organs	N/A	12	No recurrence
Lu, 2021 (21)	178	39.3±5.6	N/A	91.34%	N/A	1 month: 20.47%; 3 months: 61.16%; 6 months: 63.39%; 12 months: 76.93%	Dysmenorrhea improvement rate, 73.8%; VAS pain improvement rate, 70.8%; SSS improvement rate, 32.1%; menstrual disorder improvement rate, 80.2%; anemia improvement rate, 78.5%. At the 12-month follow-up, no differences in hemoglobin or CA125	Varying degrees of pain (100%); mild pain (79.2%); vaginal discharge (88.2%); and postoperative amenorrhea (6.7%)	N/A	12	Within 1–2 years, localized (18%) and diffuse (38%)

E2, estradiol; LH, luteinizing hormone; FSH, follicle-stimulating hormone; VAS, visual analog scale; SSS, symptom severity score; VRS, Verbal Rating Scale; N/A, not applicable.

contrast-enhanced ultrasound examination on 37 patients after ultrasound-guided microwave ablation, and found that only 3 patients had incomplete ablation, with ablation rates of 57.3%, 54.7%, and 48.3%. Subsequently, according to accurately positioned contrast-enhanced ultrasound, the ablation was supplemented immediately, and contrast-enhanced ultrasound was performed again 1 to 2 days after the procedure; the ablation rates rose to 92%, 93%, and 95%, respectively. In their study, Xu *et al.* (19-23) compared the difference in the microwave ablation effect between contrast-enhanced ultrasound and enhanced MRI, and found that contrast-enhanced ultrasound could be used to accurately evaluate the ablation rate of local adenomyosis following microwave ablation, with the consequence being consistent with that of enhanced MRI. Contrast-enhanced ultrasound is a simple, real-time, dynamic, and cost-effective method, which is more suitable for timely evaluation after microwave ablation. It can locate the residual area of the nidus after ablation in time, to determine the damage to the microcirculation of the adenomyoma and whether adenomyoma completely ablated, as well as timely supplementation of the ablation to improve the therapeutic effect (21-24).

The uterine volume and nidus reduction rates are also important evaluation indexes for the effect of microwave ablation of adenomyosis. Liu *et al.* (15) observed the uterine volume reduction rate after microwave ablation in 70 patients with adenomyosis; after 1, 6, and 12 months, the reduction rate was 28.2%, 50.6%, and 55.2%, respectively. In patients with adenomyosis, Lin *et al.* (16) reported uterine volume reduction rates of 44.8% and 64.9% at 3 and 12 months after microwave therapy, respectively, which were better than those after radiofrequency ablation. They described that after microwave ablation, the necrotic area of the nidus gradually absorbed and decreased in volume. In Liu *et al.*'s study (17), microwave ablation was performed on 28 patients, and the reduction rates of the nidus volume were 48.67%±10.87%, 68.52%±9.63%, and 81.41%±11.21% at 3, 6, and 12 months after treatment, respectively, which translated to a statistically significant difference ($P<0.05$).

Common clinical symptoms of adenomyosis include menorrhagia and dysmenorrhea. Approximately 70% of patients with adenomyosis experience obvious clinical symptoms, with abnormal uterine bleeding and progressive dysmenorrhea reported by 40–50% and 25% of patients, respectively (22). The primary goals of treatment for adenomyosis are to relieve clinical symptoms and improve patients' quality of life. Ultrasound-guided percutaneous microwave ablation is an effective technique for the treatment of symptomatic adenomyosis, which can effectively relieve patients' symptoms of menorrhagia and dysmenorrhea, and improve their quality of life. Studies (13,16) have shown that the remission rate of dysmenorrhea symptoms in patients after ultrasound-guided percutaneous microwave ablation is above 80%, with dysmenorrhea symptom alleviated obviously within the 3 months after microwave ablation (19), and these improvements last to 12 months after treatment (23). Liu *et al.* (15) conducted a 12-month follow-up of 70 patients with adenomyosis after microwave ablation. They observed that 84% patients had a significant improvement in dysmenorrhea symptoms, with VAS score decreased from 7.1±0.8 to 1.3±0.4, and SSS score decreased from 21.6±6.3 to 8.6±3.7. Lin *et al.* (16) found that microwave therapy for adenomyosis had a better pain-relieving effect than radiofrequency ablation. In addition to relieving the symptoms of dysmenorrhea, microwave ablation was found to significantly improve the menstrual duration and menstrual volume in patients. Studies (15,17,18,21) have reported varying degrees of improvement of menstrual disorders in patients after microwave ablation. In all 22 patients with adenomyosis in Zhang *et al.*'s study (9), the menstrual volume was lower after than before microwave ablation. Furthermore, microwave ablation had no significant effect on patients' menstrual cycles. Of the 22 patients, 21 had menstruation during the month of treatment and only 1 had menstruation 30 days after treatment. Microwave ablation can also significantly improve anemia symptoms in patients with adenomyosis (17,18,21). No evidence of decreased ovarian function after ultrasound-guided microwave ablation has been reported. Quantitative comparisons of E2, LH, and FSH levels before and after ablation have shown no abnormalities (10,11,25).

Complications of microwave ablation for adenomyosis include pain, bleeding, pelvic effusion, vaginal discharge, vaginal mucosal scalding, nausea, pelvic infection, intestinal and bladder injury, uterine rupture, large area thermal damage of endometrium, and skin burns (7). Microwave ablation has a low incidence of complications, and no serious complications such as intestinal injury, bladder injury, and acute abdominal disease were observed in the included studies during or after surgery (9-15). Postoperative pain is the most common complication after microwave ablation, with some studies reporting that almost all patients experience lower abdominal pain to varying degrees on the day after surgery (12,17,21). For most

patients in these studies, mild pain was relieved at about 2–8 hours after surgery. A small number of patients with moderate or severe pain were treated with oral painkillers symptomatically, and all pain was relieved at 4 hours to 3 days after surgery. The cause of pain is considered to be related to thermal damage of surrounding tissues and the pain tolerance of some patients, and it may also be related to uterine pain caused by endometrial stimulation (21). The incidence rate of vaginal discharge is second only to that of postoperative pain. Vaginal discharge generally does not require special treatment and often disappears spontaneously in 2–11 days after surgery (15,19). In one study (26), of 117 patients with adenomyosis who were followed up for 1 year after microwave ablation, 22.2% had vaginal discharge, 34.2% had vaginal discharge lasting 1–19 days, and 43.6% had vaginal discharge lasting ≥20 days; the mean duration of vaginal discharge was 20.0±26.4 days. The vaginal discharge can be characterized by colour and the main colours are pink, light red, yellow, and brown. The vaginal discharge is mainly pink/light yellow within the first 20 days after ablation and changes to yellow/brown after 20 days. Some scholars believe that vaginal discharge can be regarded as a normal adverse reaction, which is mainly caused by liquefaction necrosis due to endometrial inflammation and stimulation after microwave ablation (14). Other complications observed in the literature include low fever and postoperative amenorrhea (17,21). Low fever can be significantly alleviated by symptomatic and supportive treatment.

Microwave ablation for adenomyosis is a safe treatment with a low incidence of major complications. By mastering the influence of different power settings and treatment times of the microwave ablation instrument on the scope and extent of tissue ablation, damage to surrounding tissues caused by heat overflow can be avoided. With the help of ultrasound guidance, the relationship between the needle passage and the nidus and surrounding adjacent sites can be monitored throughout the whole process, and the depth and positioning of the ablation needle in the nidus can be monitored in real time to ensure a safe distance and avoid damage to the surrounding vital organs, endometrium, and serosal layer. Appropriate patient selection and effective preoperative planning can further reduce the incidence of complications.

For some specific cases of adenomyosis, such as those with the nidus edge close to pelvic organs or an abdominal surgery history, and other cases of pelvic and abdominal adhesion, which make microwave ablation difficult. Artificial ascites can be established to separate the nidus from the nearby organs, increase the distance between the nidus and organs, form a water isolation zone, and limit heat conduction. Thus, the damage caused by the ablation antenna to pelvic organs, such as bowel and bladder, during the ablation process and the occurrence of postoperative complications can be reduced (13). For subserous adenomyoma adjacent to the rectum and adenomyosis of the posterior uterine wall, an auxiliary guide can be combined with transvaginal ultrasound to reduce the influence of the gas generated during abdominal ultrasound-guided percutaneous puncture. At the same time, it can also avoid unclear ultrasound display of the tissue behind the ablation area, which makes it impossible to accurately determine the situation of the distal field ablation area during surgery, and can reduce the incidence of incomplete ablation and complications (27).

Adenomyosis has always been challenging to treat due to its characteristics of easy recurrence. Because of unclear boundaries and irregular shapes of adenomyosis lesions, and unablated nidus tissue around the solidified necrotic tissue after microwave ablation, all these can result in symptoms repeatedly. In most of the studies included herein, the follow-up time lasted 12 months, and no obvious cases of symptom recurrence were reported (28). The short-term efficacy was satisfactory, which may be related to the high ablation rate with microwave ablation. Under the condition of safety, the maximum ablation can achieve a long clinical effect, but whether recurrence or new lesions occur after a longer period of time remains to be further studied. Lu *et al*. (21) reported that the recurrence rate of localized adenomyosis was 18% at 1–2 years after surgery, while that of diffuse adenomyosis was 38%. The mid- and long-term efficacy in patients with diffuse adenomyosis was worse than that in patients with localized adenomyosis.

Conclusions

To our knowledge, this is the first comprehensive review of studies on microwave ablation for adenomyosis in the past 20 years. We summarized the common parameters, efficacy, complications, and prognosis of ultrasound-guided microwave ablation in the treatment of adenomyosis, providing a more powerful foundation for ultrasound-guided percutaneous microwave ablation of Adenomyosis. Existing studies have confirmed that ultrasound-guided percutaneous microwave therapy is a feasible, safe, and effective technique for adenomyosis. However, currently,

high-quality randomized controlled studies are lacking. Most of the studies included herein were single-arm and retrospective studies without controlled experiments, which may have affected the accuracy of the results. In the future, multi-center, randomized, and prospective trial studies are needed to provide more robust evidence to further support the clinical application and promotion of microwave ablation in the treatment of adenomyosis.

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Footnote

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://dx.doi.org/10.21037/apm-21-3133). The authors have no conflicts of interest to declare.

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