

cosmetic grading scores and clinical symptoms. The comparison with the group of similar patients who were not treated indicated that the results were not due to spontaneous nodule change.

Microwave ablation is a minimally invasive technique to treat hepatic tumors that has been proven reliable, efficient, and safe [5, 19]. We conducted MWA for the treatment of benign thyroid nodules, and the efficacy is showed with a year of follow-up for these patients after the procedure. The nodule volume gradually reduced after MWA. According to the baseline, it can get nearly 85% of the volume reduction and greatly improve the clinical symptoms and cosmetic grading. Meanwhile, the side effects are mild. The thyroid nodules did not disappear after microwave ablation. However, it seemed to need a period of time for degradation by the immune system in the ablation area. The VRR at 3-, 6-, 9-, and 12-month follow-ups was 55.98%, 69.31%, 76.65%, and 84.67%, respectively. It proved to shrink in nodule volume significantly. Though microwave ablation will not lead to excessive destruction of thyroid, the thyroid hormones will not be affected [20].

The results among patients undergoing MWA in this study were superior to those among patients acting as control. It revealed that MWA significantly decreased TN volume in comparison with untreated patients who did experience TN size increase. The magnitude of volume reduction in this study is similar to studies conducted by RFA and other MWA studies [6, 8, 21], though there is no head-to-head studies which thermal modality is superior. Electromagnetic microwaves agitate water molecules in the surrounding tissue, producing friction and heat, thus inducing cellular death via coagulation necrosis. Microwave ablation of tumor center of the highest temperature can reach 100–120°C, not only can quickly kill tumor cells but also can solidify the surrounding blood vessels, and reduce the blood supply to the tissue [22].

Procedure-related major complications including recur-

This study has some limitations and shortcomings. Firstly, the major complication rate is a little higher than previous studies [20, 24, 27]. It seemed that the hydrodissection technique was not perfect. The injected fluid usually disappeared within some minutes; therefore, repeated fluid injection is necessary during the procedure. Moreover, lateral approach can increase recurrent laryngeal nerve injury when it is close to the nodules in the danger triangle. In addition, MWA has a much larger area of active heating compared with RFA [28]. Secondly, the enrolled nodules, with the largest diameter > 2 cm, have greatly reduced in nodule volume after the procedure; however, the treated nodules were smaller than 10 ml. Therefore, the volume reduction may be overestimated. No nodules showed complete disappearance at 12-month follow-up. It seemed that there is still not enough time for the degradation of the ablated tissues. Longer follow-up should be necessary for observation. Lastly, the study sample size is small and the study was conducted retrospectively.

In conclusion, MWA is an effective modality in decreasing volumes of benign thyroid nodules, as well as improving cosmetic grading and clinical symptoms, compared with the control group. However, prospective study with large-scale and long-term follow-up is necessary to be developed.

Conflicts of Interest

No potential conflict of interests relevant to this article was reported.

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-----from "Ultrasound-Guided Percutaneous Microwave Ablation for Solid Benign Thyroid Nodules: Comparison of MWA versus Control Group"

the mean volume reduction rate(VRR) at 3, 6 and 12 months after ablation was $57.66 \pm 22.95\%$, $70.23 \pm 20.07\%$, $85.97 \pm 14.04\%$, respectively (shown in Fig. 3). At 12-month follow-up, there were 89.4% nodules which volume reduction rate achieved more than 50% [11].

Safety

All the patients received microwave ablation well tolerated to the procedure. Ten patients (10.0%) complained of various degrees of pain at ablated site, or pain radiating to the ear, shoulder or teeth, but can stand. The pain totally relieved when the ablation finished. No one needed analgesics. There were no hematoma formation developed. Ten patient(10%) encountered voice change after procedure, and 2 in 10 recovered within 2 months under the treatment of neurotrophic drugs. The others recovered within 24 hours spontaneously. Slight skin burn happened in two cases(2.0%). One patients (1.0%) suffered from Horner syndrome, mainly for ptosis and pupil shrinks, within 2 months recovered to normal. There were no serious complications such as esophageal perforation and tracheal injury.

Discussion

Thyroid nodules(TNs) have annual increasing trends worldwide, and the prevalence in China is relatively high [12]. For benign TNs, surgery involves some drawback and complications such as nerve injury and scar formation [13]. Levothyroxine(LT4) suppressive therapy is not recommended in euthyroid patients with benign thyroid nodules [14]. Non-surgical treatment options were used to treat benign thyroid nodules. Those modalities have achieved great efficacy and mild complications [3, 5, 6, 15, 16].

Ethanol ablation is more suitable to treat cyst or pre-dominant cyst benign thyroid nodules [11, 17, 18]. In

this study, we conducted microwave ablation for the 121 predominant solid or mixed benign thyroid nodules, one-year follow-up demonstrated the significant reduction in nodule volume. The symptom grading score and cosmetic grading score were also significantly improved. MWA heats tissue to cytotoxic level through which cell death is caused. Afterwards the created coagulative necrosis is degraded by the patients' own immune system [19]. It is comparable to the radiofrequency ablation in light of volume reduction rate [3, 20, 21]. But we needed less ablated time when microwave ablation was chosen. Nodules larger than 4.0ml were enrolled in our study, but the mean ablated time was 6.43 minutes. The time was significant shorter than that of RFA studies [3, 4]. It probably due to the advantages of the microwave technique. When compared with other thermoablative technologies, the main advantages of the microwave ablation includes consistently higher intratumoral temperatures, larger tumor ablation volumes, faster ablation times, and an improved convection profile [22]. Our study showed that MWA not only achieved good effect on VRRs, but also made the procedure more time-effective.

Some complications encountered in this study. Recurrent laryngeal nerve palsy and cervical sympathetic ganglia injury happened in 2 patients and 1 patient, respectively. Clinical manifestations includes hoarseness, ptosis, and corestenoma. The patients recovered within 2 months. The incidence of recurrent laryngeal nerve palsy was a little higher than that of some previous reports [5, 20, 23-25]. However, iatrogenic nerve injury cannot be avoid completely even in surgery. Minor complications was similar to what was reported with RFA and laser ablation [3, 5, 20]. Pain was the most common complaints of the patients during the procedure. It occasionally radiates to ear, shoulder, jaw and upper chest. But it was usually self-limiting and resolved when the power of the microwave device had been switched off.

-----from "US-guided percutaneous microwave ablation for the treatment of benign thyroid nodules"

clinical practice, and new thyroid nodules can develop in almost 10% of patients during their lifetime.^{1,2} Clinically non-palpable nodules are more likely to be detected by ultrasound (US), and the rate of nodule detection with US imaging for screening purposes can reach up to 70%.³ The widespread use of US causes further detection of asymptomatic nodules. Similar data were reported in autopsy studies and the presence of a much higher rate of thyroid nodules was proven.^{3,4}

Despite the fact that the majority of thyroid nodules diagnosed are benign and do not cause significant clinical symptoms, some nodules may lead to compression-related symptoms. In addition, thyrotoxic symptoms may develop due to hyperfunctioning of some nodules.^{3,5} The ideal method to decide the need for treatment is a cytological result obtained with fine-needle aspiration biopsy (FNAB). A new study issue is determining the optimal therapy technique for cases with cytologically verified benign thyroid nodules (BTN), especially as a minimally invasive approach is desired.^{6,7}

Thyroid nodules are frequently small sizes and benign, and needing no treatment. Some of these nodules enlarge with time, giving in local symptoms requiring treatment, especially due to compression.^{8,9} In a few previous studies on thyroid nodules, combinations of thermal ablative methods and radioiodine-treatment (RIT) were used, and positive results were obtained. However, new studies with high case numbers are needed in terms of optimal evaluation of efficacy.⁹⁻¹¹ In the past, levothyroxine has also been used in the medication of multinodular goiter.¹² Because levothyroxine medication involves negative effects such decreased bone density and atrial fibrillation; and RIT complications may develop in different organs secondary to radiation exposure, both methods were discontinued for the treatment of BTN.¹⁰⁻¹²

Due to the inadequacy of medical methods, studies on non-surgical minimally invasive alternative treatments have been initiated in different centers. The efficiency of minimally invasive approaches have been increasingly reported in clinical studies.¹³⁻¹⁵ Minimally

High-intensity focused ultrasound (HIFU) looks to be a noninvasive therapeutic option for BTN. With this method, a volume decreasing of over 50% was obtained at the end of a 24-month follow-up.¹⁸

Local ablation of BTN is a current issue, and radiofrequency ablation is frequently used as an alternative to surgical treatments. Radiofrequency ablation has been recognized as a reliable alternative and both BTN and recurrent thyroid malignancies can be treated with this strategy.^{13,19} In one of the recent studies, a decrease in volume of 30-60% at one month follow-up, and 50-85% at 6 months was detected in benign cold thyroid nodules treated with RFA, as well as a decrease in cosmetic complaints and compression symptoms.²⁰ After the radiofrequency treatment was applied for autonomic thyroid nodules, it was determined that the high thyroid hormone levels before treatment returned to normal, and also there was a reduction in the size of the nodules.^{19,20} Although complications of RFA application such as pain, voice change, hematoma, skin burn, thyrotoxicosis, hypothyroidism, fever can occur, the majority of patients recovered over time without a permanent sequela.^{21,22}

Microwave ablation, which is among the thermal ablative methods, is increasingly used as an another option to surgery in the treatment of thyroid nodules.^{14,15} The liver, kidneys, adrenal glands, spleen, and lungs are all treated with this technique, which involves triggering tissue necrosis using heat.²²⁻²⁵ When compared to RFA, it has been determined that MWA treatment has advantages such as providing a larger ablation volume, more homogeneous distribution of heat, and less heat loss. The most important advantage of MWA application is that it is less painful.²¹⁻²⁵

In this study, the clinical and functional results were examined using RFA and MWA treatment methods cytology-confirmed benign thyroid nodules. The current study's primary aim was to assess the changes of symptoms such as pain, dysphagia, and foreign body sensation 1, 3, and 6 months after RFA and MWA procedures. A secondary objective was to see how RFA and MWA treatments affected thyroid nodule volume, function tests, and complication rates.

-----from "Clinical and functional results of radiofrequency ablation and microwave ablation in patients with benign thyroid nodules"