



Clinical Study on Safety and Efficacy of Microwave Ablation for Primary Hyperparathyroidism

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Objective: To evaluate the safety, feasibility, and efficacy of microwave ablation (MWA) for the treatment of primary hyperparathyroidism (PHPT).

Materials and Methods: This study enrolled 67 PHPT patients (22 men, 45 women; mean age, 56.0 ± 16.3 years; range, 18–83 years) from January 2015 to December 2018. The laboratory data, including the serum intact parathyroid hormone (iPTH), calcium, phosphorus, and alkaline phosphatase (ALP) levels, were evaluated before MWA and again 2 hours, 1 day, 7 days, 1 month, 3 months, 6 months, 12 months, 18 months, and 24 months after.

Results: Complete ablation was achieved with all 72 hyperplastic parathyroid glands found on the 67 patients enrolled, 64 of whom were treated in one session and 3 were treated over two sessions. The technical success rate was 100%. The median follow-up time was 13.6 months (range, 10.0–31.1 months). The clinical success rate was 89.4%. The volume reduction rate was 79.4% at 6 months. Compared to pre-MWA, the serum iPTH, calcium, phosphorus, and ALP levels had significantly improved 6 months post-MWA (iPTH, 157.3 pg/mL vs. 39.2 pg/mL; calcium, 2.75 ± 0.25 mmol/L vs. 2.34 ± 0.15 mmol/L; phosphorus, 0.86 ± 0.20 mmol/L vs. 1.12 ± 0.22 mmol/L; ALP, 79 U/L vs. 54 U/L, respectively; all, $p < 0.01$). Hoarseness was a major complication in 4 patients (6.0%), but it improved spontaneously within 2–3 months.

Conclusion: MWA is safe, feasible, and effective for the treatment of PHPT.

Keywords: Microwave ablation; Primary hyperparathyroidism; Intact parathyroid hormone

INTRODUCTION

Primary hyperparathyroidism (PHPT) is the third most common endocrine disorder, and its incidence increases with age (1). The prevalence of PHPT in patients over 65 years of age is 1.5%, and the incidence in postmenopausal women is 2.1–3.4% (2). Nephrolithiasis is the most common overt symptom, and although skeletal disease is rare, the incidence

of osteoporosis with related fractures is increasing. Over the past 10 years in China, the percentage of asymptomatic patients with PHPT has increased from 21% to 52.5% due to the development of biochemical detection methods (3).

Surgery is the only definitive treatment for symptomatic PHPT, and it has a high cure rate of 95–98% (1, 4, 5). Early intervention in asymptomatic patients should be considered since regular surveillance and pharmacological therapies are less effective and less cost-effective than surgery (2, 4). Nevertheless, morbidity and mortality increase in advanced-age patients with comorbidities, who are contraindicated to undergo a parathyroidectomy under general anesthesia. Additionally, symptomatic hypocalcemia or hyperparathyroidism may recur during the postoperative period (6–10), and therefore, patients with few or no symptoms may decline to undergo surgery. Thus, patients who have failed surgery, have contraindications for surgery, or who refuse to undergo a parathyroidectomy should be targeted for pharmacological management of PHPT. However, it must be recognized that pharmacological management is not radical and has adverse effects (11).

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Currently, there is considerable interest in identifying therapeutic alternatives to surgery. There have been several reports on minimally invasive treatments of PHPT, such as ethanol ablation (12), laser ablation (13), radiofrequency ablation (RFA) (14), and high-intensity focused ultrasound (US) (15, 16). As another minimally invasive treatment, microwave ablation (MWA) has also been used successfully in recent years (17-19). For PHPT management, the results of MWA and parathyroidectomy have been comparable in terms of the cure rate and the number of treatment complications (20). However, the sample sizes of that study were small, and the follow-up durations were short. Therefore, definitive evidence for the efficacy of MWA in treating PHPT has not been established. In addition, nodule size changes after ablation have not been evaluated. Based on the promising results of MWA in the treatment of secondary hyperparathyroidism first reported by our team (21), the aim of this study was to evaluate further, the safety, feasibility, and efficacy of MWA in treating PHPT using a large sample size.

MATERIALS AND METHODS

Study Design

This prospective study (ChiCTR-OCN-15006163) consecutively enrolled 67 patients (72 parathyroid nodules) with PHPT who received MWA treatment at the Department of Interventional Ultrasound, China-Japan Friendship Hospital, between January 2015 and December 2018. The study protocol was approved by the Human Ethics Review Committee of the China-Japan Friendship Hospital (2015-GZR-77). Written informed consent was obtained from each patient before the ablation procedure.

Inclusion Criteria

The inclusion criteria were as follows: 1) patients with symptomatic PHPT; 2) patients who did not meet the criteria for surgery or refused surgery; 3) patients with asymptomatic PHPT with one of the following conditions: a) inability or unwillingness to comply with observation protocols; b) serum calcium level higher than the normal range; c) T-score < -2.5 at the lumbar spine, total hip, femoral neck, or distal one-third of the radius, significant reduction in bone mineral density and/or increased risk of a fragility fracture; d) reduction in creatinine clearance < 60 mL/min (4); and e) aged < 50 years; 4) at least one hyperplastic parathyroid nodule clearly shown on US; 5) increased

radionuclide concentration in both the early and delayed phases on ^{99m}Tc-sestamibi (MIBI) examination.

Exclusion Criteria

The exclusion criteria were as follows: 1) abnormal coagulation function tests, such as prothrombin time > 18 seconds, prothrombin activity < 60%, or platelet count < 60 × 10⁹/L; 2) underlying disease, such as cardiac insufficiency or hypertension, refractory to management with medication.

Pre-Ablation Examination and Preparation

An Aplio 500 system (Canon Medical Systems, Tokyo, Japan) with a 10.0-MHz linear probe was used for US guidance. Contrast-enhanced US (CEUS) with a contrast agent (SonoVue, Bracco, Milan, Italy) was used to evaluate the effect of the ablation. For diagnosis, an MIBI scan (SymbiaT2, Siemens Healthineers, Munich, Germany) was conducted prior to the ablation procedure. Laryngoscopy was performed to rule out recurrent laryngeal nerve (RLN) impairment in patients with voice changes.

Before MWA, the diagnosis of PHPT on US was based on the following criteria: 1) enlarged hypoechoic parathyroid glands with clearly defined margins; and 2) no suspicion of lymph node metastasis.

Vitamin D supplementation in patients with vitamin D deficiency could safely begin at a dose of 1000–2000 IU/day before MWA (22). Intravenous fluid resuscitation and pharmacological management (calcitonin, bisphosphonate, and furosemide) were used in patients with PHPT who presented with a hypercalcemic crisis (serum calcium > 3.75 mmol/L).

MWA Procedure

MWA was performed by an expert with more than 5 years of experience in MWA for hyperplastic parathyroid nodules. Before MWA, intravenous access was obtained via an antecubital vein. Electrocardiography monitoring and pulse oximetry were routinely applied. Patients were placed in a supine position with the neck extended. After the neck was sterilized, 40–60 mL of normal saline (NS) was first injected into the area around the parathyroid nodule to provide hydrodissection. Then, a lidocaine and NS mixture (1:3) was injected close to the peri-parathyroid capsule for local anesthesia. The cooled MWA antenna (17 G) with a 0.4-cm tip (Intelligent Basic Type Microwave Tumor Ablation System, Nanjing ECO Microwave System, Nanjing, China) was inserted freehand into the parathyroid gland under US guidance. A

multipoint ablation strategy was adopted, where the power was 30 W and the radiation time was 15–25 seconds at each ablation point (23).

The therapy was terminated when the hyperechoic zone covered the entire nodule. A CEUS was performed 3–5 minutes later to assess the efficacy. If the ablated nodule was covered by a nonenhanced zone, complete ablation was achieved, and if there was nodular enhancement inside the nodule, further ablation was performed immediately (Fig. 1). For bilateral nodule ablation, if there were no voice changes and no abnormal vocal cord movements on US after one side was ablated, a MWA would immediately then be performed on the contralateral side. If there were any signs of RLN injury,

the ablation would be stopped, and the second session would be suspended until RLN function recovered. At the end of the procedure, the puncture site was compressed for 30 minutes, and the patient remained under observation for an additional 2 hours to monitor for potential complications. Calcium and vitamin D were administered postoperatively according to the clinical symptoms and laboratory data.

Clinical Data Collection and Follow-Up

Follow-up included US examination and blood biochemistry (e.g., serum intact parathyroid hormone [iPTH], calcium, phosphate, and alkaline phosphatase [ALP]). The follow-up times were 2 hours, 1 day, 7 days, 1 month, 3

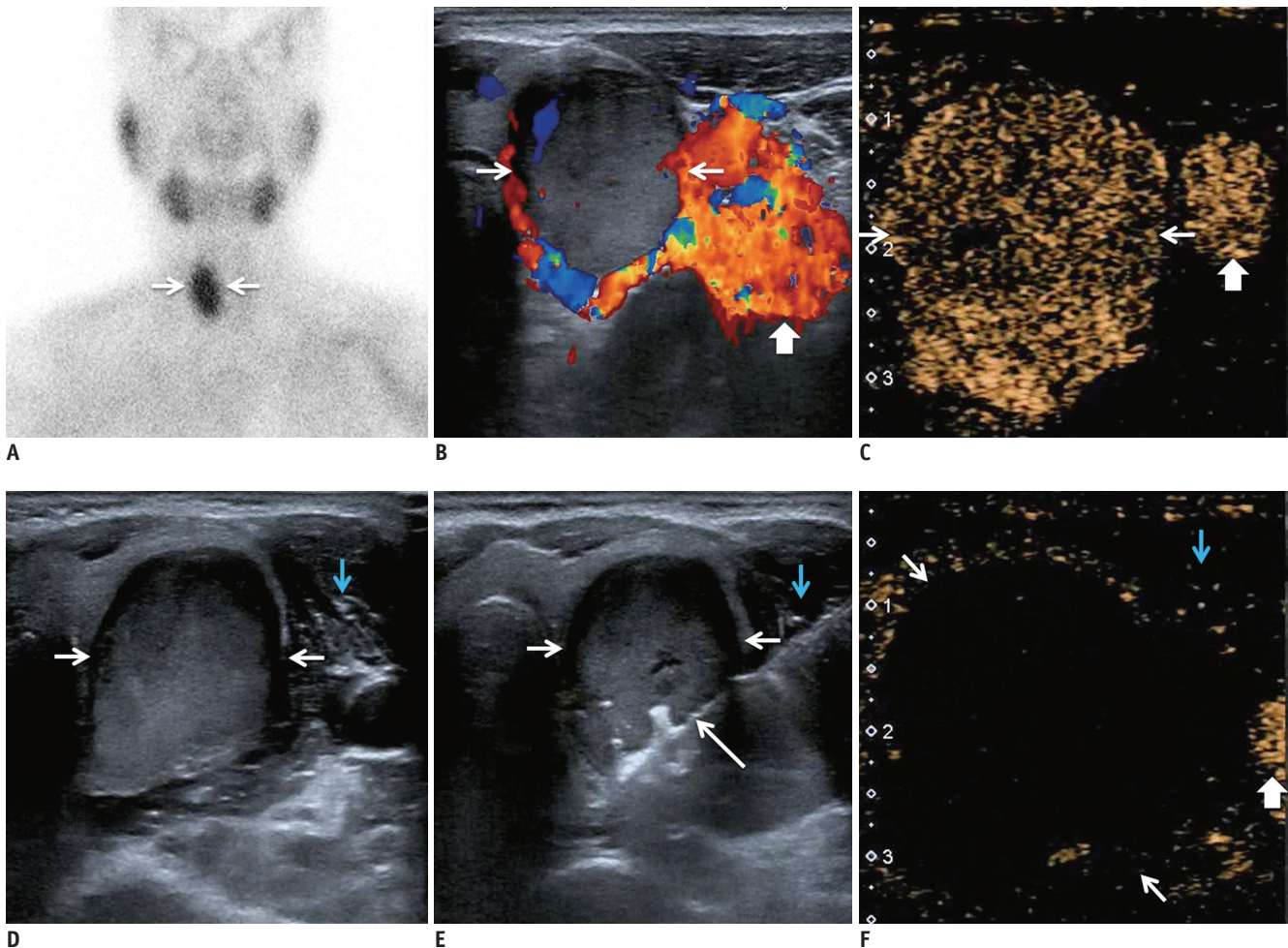


Fig. 1. Images show percutaneous MWA of PHPT nodule.

A. There was radioactive concentration in PHPT nodule (arrows) on MIBI. **B.** Isoechoic PHPT nodule with sharp boundary (arrows) behind superior left lobe of thyroid and on right side of carotid artery (thick arrow) on US. **C.** Uniform hyperenhancement of PHPT nodule (arrows) beside carotid artery (thick arrow) in arterial phase on CEUS. **D.** Injection of hydrodissection (blue arrow) around PHPT nodule (arrows) before MWA. **E.** MWA procedure of PHPT nodule: hyperechoic area emerging inside nodule (short arrows)-which surrounded by hydrodissection (blue arrow), around antenna (long arrow). **F.** After MWA, nonenhancement area covered PHPT nodule (arrows), peripheral hydrodissection (blue arrow) beside carotid artery (thick arrow) on CEUS. CEUS = contrast-enhanced US, MIBI = 99mTc-sestamibi, MWA = microwave ablation, PHPT = primary hyperparathyroidism, US = ultrasound

months, 6 months, 12 months, 18 months, and 24 months after ablation. A CEUS was only performed if the serum iPTH and calcium levels were elevated or if a conventional US showed suspicious nodules in the parathyroid region. The 14-item Chalder Fatigue Scale was used to assess symptoms of fatigue before and after MWA.

Therapeutic Effect Evaluation

A technical success was defined as achievement of a complete ablation after undergoing appropriate treatment according to the protocol. For the surgical resection criteria, clinical success was defined as serum iPTH and calcium levels within the normal range 6 months after the MWA (24-26). The nodule volume was calculated according to the sphere formula ($V = \text{length} \times \text{width} \times \text{depth} \times 0.524$), and the volume reduction rate was defined as $(V_{\text{before}} - V_{\text{after}}) / V_{\text{before}}$.

Complications

Major complications were defined as events leading to substantial morbidity and disability that increased the level of care, resulted in hospital admission, or substantially lengthened the hospital stay. Permanent nerve injuries (e.g., to the RLN, cervical sympathetic ganglion, or spinal accessory nerve) and permanent hypoparathyroidism were defined as major complications. All other complications were considered minor. Therefore, hematoma, numbness, hypocalcemia, vomiting, skin burn, lidocaine toxicity, hypertension, cough, and pain were defined as minor complications (26, 27).

Statistical Analysis

All statistical analyses were performed using SPSS software (version 20.0 for Windows, IBM Corp., Armonk, NY, USA). The serum calcium, phosphate, iPTH, and ALP levels were compared at baseline and at each follow-up using paired-sample *t* tests and paired-sample Wilcoxon signed-rank tests. The relationship between the laboratory values before and after MWA was calculated using the Pearson test and Spearman rank correlation analysis. Continuous data were presented as the mean \pm standard deviation or median and interquartile range. All statistical tests were two-sided, and $p < 0.05$ was considered statistically significant.

RESULTS

The baseline clinical characteristics, laboratory test

Table 1. Baseline Clinical Characteristic of Patients with PHPT (n = 67)

Characteristic	Data
Sex	
Male	22
Female	45
Mean age (years)	56.0 \pm 16.3
< 50	22
> 50	45
Clinical and laboratory data	
Symptomatic	32
Nephrolithiasis	14
Ostealgia	11
Fatigue	8
Pruritus	1
Asymptomatic	35
25-hydroxyvitamin D (nmol/L)	28.7 (7.0–102.1)
Frankly deficiency	23
Insufficiency	40
Normal	4
Normocalcemic PHPT	24 (2.51 \pm 0.16)
Hypercalcemic	43 (2.88 \pm 0.21)
Creatinine clearance (mL/min/1.73 m ²)	91.8 (22.0–131.4)
Urinary calcium (mmol/24 h)	6.9 \pm 3.1
Nodules	72
Normal location	71
Superior left	12
Inferior left	29
Superior right	11
Inferior right	19
Ectopic location	1
Within thyroid	1
Volume (mL)	0.6 (0.03–37.4)
Enhancement pattern on CEUS	
Uniform hyperenhancement	59
Nonuniform hyperenhancement	8

CEUS = contrast-enhanced ultrasound, PHPT = primary hyperparathyroidism

results, and nodule parameters before MWA are shown in Table 1. Altogether, 72 nodules on 67 patients were studied (63 patients with 1 nodule, 3 with 2 nodules, and 1 patient with 3 nodules). Of the 67 patients, 65 had initial PHPT, and 2 had recurrent PHPT (1 patient underwent a parathyroidectomy 6 years prior, and 1 received an ablation 2 years prior). Correlation analysis showed that the iPTH level was negatively correlated with the 25-hydroxyvitamin D level ($r = -0.317$, $p = 0.012$) at baseline and positively correlated with the hyperplastic parathyroid gland volume ($r = 0.546$, $p < 0.001$). After MWA, no newly developed

nephroliths were observed in the 14 patients who had urolithiasis before MWA. Ostealgia disappeared in 7 patients (63.6%) and considerably reduced in 3 patients (27.2%). Fatigue and pruritus disappeared within 7–30 days in all nine of the patients affected.

MWA

Complete ablation was achieved in all 67 patients, 64 in one session and 3 in two sessions. The technical success rate was 100%. The median ablation time was 170 seconds (range, 89–950 seconds). The median follow-up duration

was 13.6 months (range, 10.0–31.1 months). The two patients who had elevated levels of iPTH in three months after the MWA showed hyperenhancement of residual lesions on CEUS and underwent an additional ablation (Fig. 2). One 76-year-old woman who had a large hyperplastic parathyroid gland (volume, 37.4 cm³) presented with a hypercalcemic crisis before the ablation. After the first ablation, the serum iPTH decreased from 572 pg/mL to 188 pg/mL. Four months later, the patient received the second ablation and the serum iPTH decreased from 110 pg/mL to 54 pg/mL.

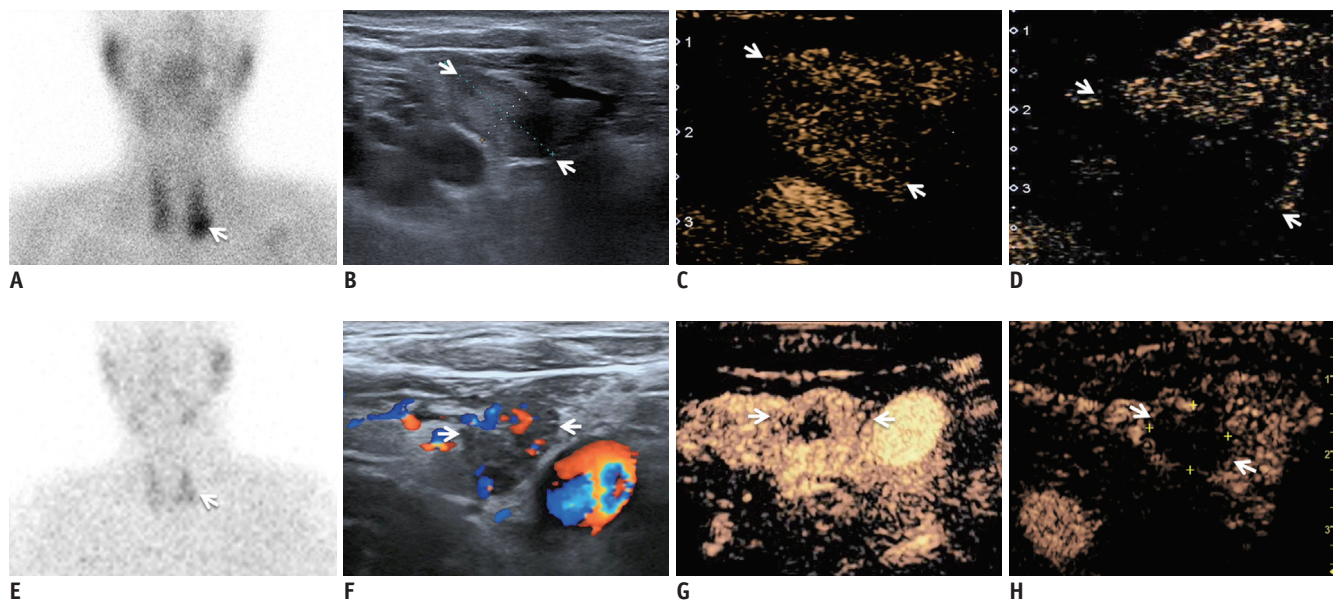


Fig. 2. Images show additional ablation of residual PHPT lesion.

A. There was radioactive concentration in PHPT nodule (arrow). **B.** Before MWA, inhomogeneous isoechoic PHPT nodule on US (arrows). **C.** There was nonuniform hyperenhancement PHPT nodule (arrows) on CEUS. **D.** After MWA, nonenhancement area (arrows) covered PHPT nodule on CEUS. **E.** Three months after MWA, there was radioactive concentration in PHPT nodule (arrow). **F.** Hypoechoic PHPT nodule with abundant blood flow signals (arrows) around ablation zone was shown on US. **G.** There was active area-hyperenhancement (arrows) around ablation zone on CEUS. **H.** After additional ablation, non-enhancement (arrows) was shown on CEUS.

Table 2. Rates of Achieving Normal Level or for Serum iPTH, Calcium and Phosphorus after MWA

Follow-Up Time	iPTH (pg/mL)	Calcium (mmol/L)	Phosphorus (mmol/L)
	Rate (Normal Number/Total Number)	Rate (Normal Number/Total Number)	Rate (Normal Number/Total Number)
Post-MWA (2 H)	64.2 (43/67)	71.6 (48/67)	67.2 (45/67)
Post-MWA (1 D)	74.6 (47/63)	84.1 (53/63)	79.4 (50/63)
Post-MWA (7 D)	77.5 (31/40)	90.0 (36/40)	85.0 (34/40)
Post-MWA (1 M)	84.9 (45/53)	92.5 (49/53)	90.6 (48/53)
Post-MWA (3 M)	86.7 (39/45)	91.1 (41/45)	93.3 (42/45)
Post-MWA (6 M)	89.4 (42/47)	93.6 (44/47)	95.7 (45/47)
Post-MWA (12 M)	89.5 (34/38)	92.1 (35/38)	94.7 (36/38)
Post-MWA (18 M)	89.3 (25/28)	92.9 (26/28)	96.4 (26/28)
Post-MWA (24 M)	86.4 (19/22)	90.9 (20/22)	95.5 (21/22)

There are 42, 34, and 28 patients who received MWA more than 12 M, 18 M, and 24 M, respectively. D = day, H = hour, iPTH = intact parathyroid hormone, M = month, MWA = microwave ablation

Laboratory Analysis

The rates of achievement of normal laboratory values are shown in Table 2. The clinical success rate was 89.4% (42/47). The serum iPTH, calcium, phosphorus, and ALP levels significantly improved 6 months after MWA (iPTH, 157.3 pg/mL vs. 39.2 pg/mL; calcium, 2.75 ± 0.26 mmol/L vs. 2.34 ± 0.15 mmol/L; phosphorus, 0.86 ± 0.20 mmol/L vs. 1.12 ± 0.22 mmol/L; ALP, 79 U/L vs. 54 U/L, respectively; all

p < 0.01). The volume reduction rate was 79.4% and 96.4% at 6 months and 12 months, respectively (Table 3). Figure 3 shows the tendency for variation in the serum biochemical data before and after MWA. There were 16 (25.4%), 15 (23.8%), and 3 (7.5%) cases of hypoparathyroidism at 2 hours, 1 day, and 7 days, respectively. One month later, the iPTH level in all 16 patients had normalized.

Of the 5 patients who did not reach clinical success

Table 3. Changes of Serum iPTH, Calcium, Phosphorus, ALP and Volume of Nodule before MWA and at Each Follow-Up

Follow-Up Time (Number)	iPTH (pg/mL)	Calcium (mmol/L)	Phosphorus (mmol/L)	ALP (U/L)	Volume (cm ³)	VRR (%)
Before MWA (n = 67)	157.3 (66.1–1577.2)	2.75 ± 0.26	0.86 ± 0.20	79 (45–1426)	0.56 (0.03–37.41)	-
2 H post-MWA (n = 63)	20.1 (1.7–348.8)*	2.63 ± 0.26*	0.85 ± 0.20	88 (41–1475)	-	-
1 D post-MWA (n = 63)	17.1 (1.7–188.2)*	2.39 ± 0.21*†	0.99 ± 0.22*†	75 (40–1360)	-	-
7 D post-MWA (n = 40)	50.5 (9.4–355.9)*††	2.34 ± 0.26*†	1.03 ± 0.24*†	113 (55–1246)	-	-
1 M post-MWA (n = 53)	61.4 (20.6–498.0)*††	2.35 ± 0.17*†	1.12 ± 0.18*†	87 (46–296)	0.51 (0.03–4.84)*	34.8 (-130.51–84.98)
3 M post-MWA (n = 45)	56.6 (16.1–4166.5)*††	2.39 ± 0.13*†	1.05 ± 0.18*†	60 (36–83)	0.19 (0.02–3.48)*	35.0 (-104.38–81.83)
6 M post-MWA (n = 47)	39.2 (15.1–85.6)*††	2.34 ± 0.15*†	1.12 ± 0.22*†	54 (37–69)*††	0.11 (0–2.10)*	79.4 (75.07–100)
12 M post-MWA (n = 38)	47.0 (27.7–117.4)*††	2.36 ± 0.13*†	1.10 ± 0.18*††	54 (27–104)*††	0 (0–1.76)*	96.4 (79.10–100)
18 M post-MWA (n = 28)	36 (22.8–96.7)*††	2.42 ± 0.09*†	1.13 ± 0.15*††	51 (27–109)*††	0 (0–1.62)*	100 (79.8–100)
24 M post-MWA (n = 22)	45.1 (22.8–120.4)*††	2.38 ± 0.17*†	1.14 ± 0.27*††	46 (28–94)*††	0 (0–0.44)*	100 (80.7–100)

Serum calcium and phosphorus were presented as mean ± standard deviation; iPTH and ALP values were medians and interquartile ranges. Normal range: iPTH, 12–88 pg/mL; calcium, 2.00–2.75 mmol/L; phosphorus, 0.81–1.78 mmol/L; ALP, 40–150 IU/L. There are 42, 34, and 28 patients who received MWA more than 12 M, 18 M, and 24 M. **p* < 0.01 (compared with values before MWA), †*p* < 0.05 (compared with values 2 H after MWA), ‡*p* < 0.05 (compared with values 1 D after MWA). ALP = alkaline phosphatase, VRR = volume reduction rate

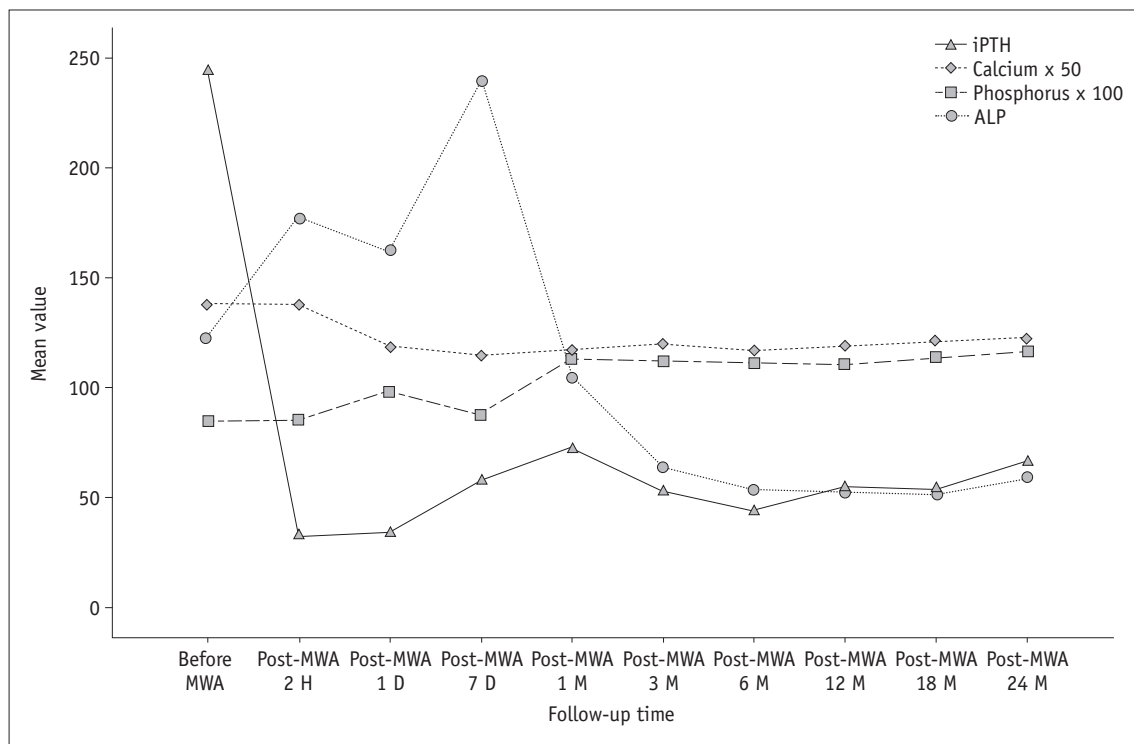


Fig. 3. Multiple comparisons among serum iPTH, calcium, phosphorus and ALP before and after ablation. ALP = alkaline phosphatase, D = day, H = hour, iPTH = intact parathyroid hormone, M = month, MWA = microwave ablation

Table 4. Complications and Side Effects of MWA in PHPT Patients

Complication or Side Effect	Number (%)	Time of Detection (Days)	Time to Recovery (Days)
Major			
Hoarseness	4 (6.0)	1–3	30–90
Minor			
Cough	2 (3.0)	1	1–3
Side effect			
Pain	11 (16.4)	1	1–3
Numbness	12 (17.9)	1–3	1–30
Hypoparathyroidism	16 (25.4)	1–7	3–14
Hypocalcaemia	2 (3.0)	1–3	3–30

at 6 months, 2 showed increased levels of serum iPTH and calcium, and the other 3 only showed an increase in the serum iPTH level, while the serum calcium level was normal. Follow-up imaging showed a local residual abnormal parathyroid nodule in one case. In the other 4 patients, no new abnormal parathyroid tissues were found via follow-up imaging after MWA.

Complications and Side Effects

As a major complication, hoarseness occurred in 4 patients (6.0%), but it improved within 2–3 months. Minor complications and side effects included intraoperative pain (11/67, 16.4%), which spontaneously resolved when ablation was suspended; cough (2/67, 3.0%), which resolved 1–3 days after MWA; hand numbness (12/67, 17.9%); and hypocalcemia (2/67, 3.0%) 1 day after MWA, which rapidly resolved with calcium supplementation (Table 4).

DISCUSSION

A parathyroidectomy is better equipped to manage iPTH hypersecretion in patients with PHPT than pharmacological treatment (11). Therefore, a parathyroidectomy would ideally be used as a first-line therapy in symptomatic patients with PHPT (4, 24, 28, 29). However, nearly 27–33% of asymptomatic patients are at a high risk of disease progression, hypercalcemia, and other related symptoms (30, 31). Furthermore, on the spectrum of asymptomatic PHPT patients, those with normocalcemic PHPT can develop kidney and bone involvement (32). Therefore, a parathyroidectomy is also considered appropriate for patients with asymptomatic PHPT (24). However, some patients with PHPT either refuse surgery or are not candidates for surgery. It is

difficult to identify all lesions, especially ectopic (44.3%) and small lesions during surgery (33). Patients with these types of lesions are more likely to require bilateral neck exploration or reoperation, which increases the risks of surgery (34).

Our study included 67 PHPT patients treated with MWA, with technical and clinic success rates of 100% and 89.4%, respectively. The primary finding of this study was that MWA could significantly decrease the iPTH and calcium levels with sustained efficacy ($p < 0.05$). These results suggest that MWA could completely inactivate hyper-functional parathyroid glands with definite efficiency in most cases. After a 12-month follow-up, the ablated area was essentially absorbed in most cases. These results are comparable to those of another study, which reported a cure rate of 86.4% (19/22) and iPTH levels that remained normal for 12 months after the ablation (35). As a classical treatment method, the cure rate of a parathyroidectomy is 95–98%, which is higher than that found in the present study (4, 36). However, a comparative study demonstrated that MWA and surgical resection provided comparable short-term cure rates for PHPT (82.1% vs. 89.3%, respectively, $p = 0.705$) (20). A future study with a longer follow-up period needs to be undertaken that compares MWA to parathyroidectomy for PHPT.

Other minimally invasive techniques, such as ethanol ablation, laser ablation, and RFA have also been used to treat PHPT. Ethanol ablation is not considered a first-line therapy for PHPT because of the uneven distribution of ethanol in the parathyroid tissue and the seepage of ethanol outside of the parathyroid gland (12). In a study that retrospectively reviewed six cases of PHPT treated with laser ablation, only a transient reduction in the serum parathyroid hormone (PTH) and calcium levels was observed (13); thus, the technique needs to be verified further. Additionally, RFA for PHPT has been discussed in case reports. The serum PTH and calcium levels in a postmenopausal woman returned to normal following RFA treatment in one study (18). In another study of two symptomatic patients, normocalcemia and symptom improvement were achieved 4 days following RFA, but the serum PTH level remained above the normal range (14). Additional studies are needed to evaluate the therapeutic effect of RFA. High-intensity focused US was used in another study of 13 cases, and demonstrated that it had the potential to treat PHPT (16). Notably, complete remission was reported in three patients (23%) after one year, whereas ten patients (76.9%) continued to have a PTH level above the normal range. It is therefore difficult to acquire definitive results in the minimally invasive treatment

of PHPT from previous studies.

MWA devices create a uniform electromagnetic field surrounding an antenna, which causes rapid tissue heating, and the volume increases through the oscillation of polar water molecules. Tissue temperatures can increase markedly under MWA at high frequencies. In our study, MWA was successfully used to treat PHPT, and its efficacy was confirmed. The iPTH and calcium levels were maintained during the follow-up period in most cases. Five patients did not achieve curative treatment at 6 months, 4 of whom had no new abnormal lesions during the follow-up period. One possible reason could be the presence of some mildly hyperplastic glands that were not shown on US or MIBI examination.

Promising results in terms of improved serum iPTH and ALP levels and normalized serum calcium and phosphate levels have been obtained when treating secondary hyperparathyroidism using MWA (21, 35, 37, 38). For PHPT, complete ablation was often achieved after one session because in most cases, the adenoma or hyperplasia affected only a single gland. Patients with secondary hyperparathyroidism require more sessions to achieve complete ablation because of the multiple hyperplastic parathyroid glands underlying the long-term stimulation of high serum phosphorus and low serum calcium levels.

As a major complication, hoarseness occurred in 4 patients (6.0%), which was a higher rate than that found in the thermal treatment of thyroid nodules (1.5%) and in parathyroidectomies (3.6%) (27). The parathyroid glands are located dorsal to the thyroid gland and are much closer to the tracheoesophageal groove, i.e., the region where the RLN is located. Therefore, minimizing heat exposure to the RLN is crucial in preventing nerve injury. Nerves are sensitive to thermal stimulation, but effective hydrodissection can prevent thermal damage to the RLN. However, in rare cases heat shock may occur because of the temperature rise around the RLN due to inadequate separation or prolonged ablation. Unlike the persistent hoarseness caused by nerve necrosis, all patients in this study recovered. RLN thermal damage can be avoided through improved hydrodissection techniques. In addition, the hydrodissection in this study used NS instead of 5% distilled water, since NS is an ionic fluid that can conduct electricity (39). In MWA, tissue heating is mainly caused by the oscillation of polar water molecules, so whether the injury of RLN was caused by NS is unknown. Further studies using 5% distilled water for hydrodissection should be undertaken.

In this study, minor complications and side effects resolved spontaneously in a short time without special treatment. Even while rates of persistent hypoparathyroidism, neck hematoma, and pneumothorax have been reported in parathyroidectomies at 0.1%, 0.2%, and 0.05%, respectively, there were no cases of any during the follow-up period in this study (36).

There are still a few limitations. First, no pathological results were obtained because a biopsy was not recommended (40). Second, the follow-up period after MWA was relatively short.

In conclusion, we provide evidence that MWA can effectively reduce the serum iPTH and ALP levels and normalize the serum calcium and phosphorous levels for patients with PHPT. Therefore, for some cases, MWA could be an alternative to surgery and medication for patients with PHPT.

Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

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