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Effectiveness and Safety of Microwave Ablation Therapy in Parathyroid Adenomas

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Abstract

Objective We report the effectiveness and safety of ultrasound (US) guided microwave ablation (MWA) treatment of parathyroid adenomas.

Materials and Methods A total of 35 patients underwent US-guided MWA therapy of parathyroid adenomas. Before the procedure, blood parathyroid hormone (PTH; mean: 202.32 ± 158.46 ng/L) level, calcium (mean: 11.65 ± 0.53 mg/dL) level, and parathyroid adenoma volume (mean: 1.76 ± 0.73 cm^3) were recorded. Blood parameters and US-guided follow-up evaluations were performed at 1 and 3 months after the procedure.

Results Technical success was 91% for the first session. There was a statistically significant decrease in parathyroid adenoma size and calcium and PTH levels at 3 months of follow-up ($p < 0.001$). A perfect positive correlation (r: 0.927; $p < 0.001$) was found between the ablation time and the adenoma size. Transient vocal cord paralysis occurred in two (5.7%) patients and short-term (<2 hours) local pain occurred in four (11.4%) patients after the procedure.

Conclusion US-guided MWA is effective in the treatment of parathyroid adenomas with low complication risk. Our preliminary results showed that MWA treatment resulted in an effective improvement in blood tests and adenoma size.

Keywords
- ablation
- parathyroid
- ultrasound

Introduction

Parathyroid adenomas are benign tumors that can cause hypercalcemia by secreting parathyroid hormone (PTH). The most common cause of primary hyperparathyroidism is parathyroid adenoma (~80% of patients) and may be symptomatic with osteoporosis, nephrolithiasis, and neuromuscular changes.[1,2] Parathyroidectomy operations have been used as an effective treatment until today. The need for less invasive treatments has emerged due to the high prevalence in elderly patients and the increased morbidity and mortality associated with parathyroid surgery in this patient group.[3] In recent years, treatments such as microwave ablation (MWA) and radiofrequency ablation have become a safe and effective treatment for parathyroid adenoma. Ultrasound (US) guided MWA continues to be applied as an effective and safe treatment for patients who cannot receive general anesthesia, who are not suitable for parathyroidectomy, and who do not want surgical operation. This study aims to report our results in the effectiveness and

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safety of US-guided MWA treatment of parathyroid adenomas.

Materials and Methods

Patient Selection

This retrospective study was approved by the institutional ethics review board (Decision No: 2022/09–18; Date: September 14, 2022). A total of 35 patients underwent US-guided MWA therapy. All parathyroid adenomas were evaluated with parathyroid wash test, fine-needle aspiration biopsy, and ^{99m}Tc sestamibi (MIBI) before the ablation procedure. Baseline blood values (mean PTH: 202.32 ± 158.46 ng/L; mean calcium: 11.65 ± 0.53 mg/dL) and US findings (mean parathyroid adenoma volume: 1.76 ± 0.73 cm^3) were evaluated. In all patients, before MWA, vocal cords were evaluated with US to evaluate recurrent laryngeal nerve (RLN) function. Laryngoscopy was performed in 11 (31%) cases, which could not be evaluated adequately by US due to anatomical limitations. Patients were included in the study according to the 4th International Workshop guidelines.[4,5] The inclusion and exclusion criteria are given in ►**Table 1**.

Microwave Ablation Procedure

At the beginning of the procedure, a US (Acuson S3000; Siemens Medical Solutions, Mountain View, CA, United States) examination was performed with a 4- to 9-MHz frequency linear transducer for parathyroid adenoma location and intervention approach strategy.

After the patient was placed in the supine position with the neck slightly hyperextended, the appropriate entry tracing was determined and prilocaine hydrochloride was applied from the skin to the thyroid capsule. Afterward, hydrodissection was performed around the adenoma, with ~50 to 60 mL 5% cold dextrose to protect important anatomical structures such as the carotid artery, trachea, esophagus, and RLN from thermal damage (►**Fig. 1**). The thyroid MWA antenna was positioned to the parathyroid adenoma location via a trans-isthmic or lateral cervical approach under US guidance. The moving shot technique was used throughout the ablation process. In the moving shot technique, which we used in our study, the ablation areas are created by starting from the medial posterior part of the parathyroid adenoma and directing the microwave probe toward the lateral and anterior parts.

Table 1 Inclusion and exclusion criteria of the study

Inclusion criteria for the study: • Symptomatic primary hyperparathyroidism (PHPT) • Asymptomatic PHPT combined with the following: → Hypercalcemia (serum calcium >0.25 mmol/L above normal reference range) → Renal involvement (glomerular filtration rate of less than 60 ml per minute, renal stones) → Skeletal involvement (reduced bone mineral density as a T score of less than –2.5 at any site, vertebral fracture)
Exclusion criteria for the study: • Secondary or tertiary hyperparathyroidism • Severe hypertension or cardiac failure resistant to medication • Suspected parathyroid malignancy • Inappropriate coagulation parameters

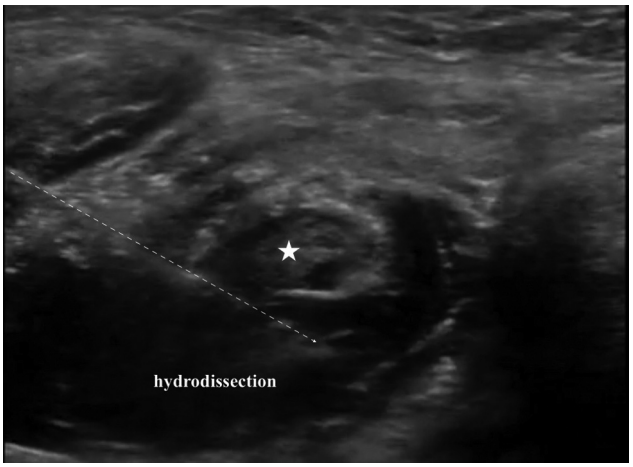

Fig. 1 Parathyroid adenoma (*white asterisk*), 22-gauge spinal needle (*white line*), and hydrodissection around the adenoma are observed.

A microwave generator (ECO-100E, Nanjing ECO Microwave System Co, Nanjing, China) producing 20- to 40-W power continuously or pulsed at 2,450 MHz and a 16-gauge internally cooled 10-cm shaft with a flexible cable and 3-mm active tip length thyroid antenna was used.

Vital signs were monitored during the procedure. Ablation was terminated when the entire adenoma was covered with hyperechoic microbubbles as an indication of full ablation (►**Fig. 2**). Before the ablation was completed, the

Fig. 2 Microbubbles (*black asterisk*) formed during the microwave ablation (MWA) process are observed.

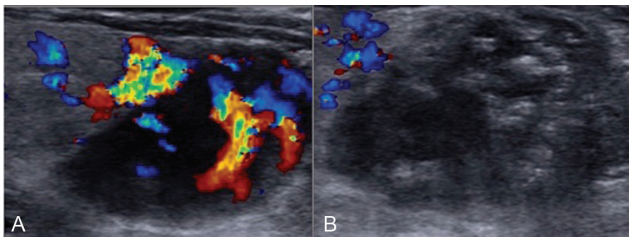

Fig. 3 (**A**) Vascularization in parathyroid adenoma is observed on Doppler ultrasound (US) before the procedure and (**B**) avascularization is observed after the procedure.

blood supply of the parathyroid adenoma was controlled with Doppler US to make sure that there was no residual area showing blood supply (►**Fig. 3**). Cold compression was applied at the procedure site, and patients were discharged after few hours of observation.

Control PTH was studied from blood samples taken 2 hours after the procedure. Blood parameters and US evaluations were performed at 1 and 3 months after the procedure (►**Fig. 4**).

Statistical Analysis

Statistical analysis was performed with the SPSS software (version 21.0; IBM Corporation, Armonk, NY, United States). Descriptive statistical data were presented as a mean and standard deviation. Mann–Whitney *U* test was used for comparing non-normal continuous data among two groups. Pearson's correlation factor analysis was used to evaluate the relationship between the procedure time and the adenoma US findings. The correlation coefficients were evaluated as follows: $r \geq 0.8$, perfect; $0.8 \geq r \geq 0.6$, good; $0.6 \geq r \geq 0.4$, medium; $0.4 \geq r \geq 0.2$, poor; and $r \leq 0.2$, no correlation. A p value of <0.05 was considered statistically significant.

Results

The mean age of the patients was 56.2 ± 8.7 (range: 26–73) years. Six patients (17.1%) were males and 29 (82.9%) were females. Sixteen (45.7%) parathyroid adenomas were on the right and 19 (54.3%) were on the left. MWA was performed in one patient because of residual adenoma after the surgical procedure. The parathyroid adenoma volume and blood calcium and PTH parameters showed statistically significant differences at baseline and postprocedure ($p < 0.001$; ►**Table 2**). The ablation time ranged from 16 to 67 seconds. Although the MWA ablation time showed a significant relationship with the adenoma volume, no statistically significant relationship was found with the baseline calcium or PTH (►**Table 3**). In the first session, the success rate of our procedure was 91%. The PTH and calcium levels remained high at 1 month in three of our patients. The baseline PTH (mean: 213.46 ± 161.39 ng/L), calcium (mean: 11.87 ± 0.62 mg/dL) values, and adenoma sizes (1.82 ± 0.76 cm^3) of patients whose PTH and calcium values could not be con-

Table 3 Evaluation of the relationship between ablation time and other parameters

Parathyroid adenoma volume	*r*: 0.927	$p < 0.001$
Parathyroid hormone	*r*: 0.168	$p > 0.05$
Calcium	*r*: 0.097	$p > 0.05$

Note: $p < 0.05$ was considered statistically significant.

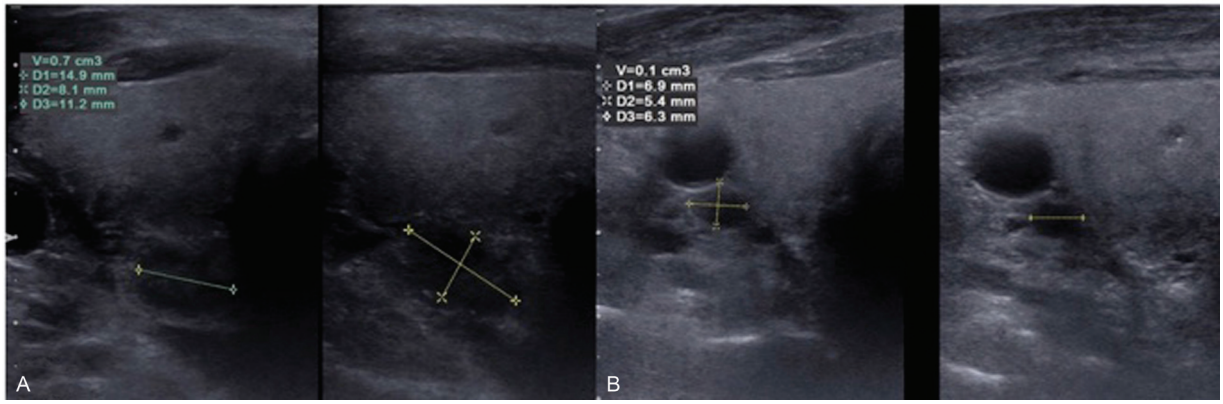

Fig. 4 (**A, B**) It is observed that the volume of parathyroid adenoma decreased significantly compared with the preprocedure at the first month follow-up.

Table 2 Comparison of parathyroid adenoma volume and blood parameters baseline and post-procedure

Parathyroid adenoma volume	1.76 ± 0.73 (0.38–2.95) cm^3	1.14 ± 0.57 (0.14–1.87) cm^3	$p < 0.001$[a]
Parathyroid hormone	202.32 ± 158.46 (125–713) ng/L	37.65 ± 9.5 (11–146) ng/L	$p < 0.001$[a]
Calcium	11.65 ± 0.53 (11.2–13.2) mg/dL	9.87 ± 0.53 (9.3–11.2) mg/dL	$p < 0.001$[a]

[a]$p < 0.05$ was considered statistically significant.

trolled after the first session of MWA were not different from other patients. Our success rate for the second session was 97% and the PTH and calcium levels could not be controlled in only one patient. Transient vocal cord paralysis of less than 3 months was seen in two patients. With medical treatment and voice therapy, normal vocal cord movements were observed again in laryngoscopy within 3 months. Four (11%) patients described short-term local pain after the procedure.

Discussion

Few studies report on the treatment efficacy of MWA in parathyroid adenomas and secondary hyperparathyroidism.[6–8] In our study, the success rate of the first session was 91%. In the limited number of studies on MWA in the literature, the success rate has been reported in the range of 86 to 87%, similar to our study.[9,10] Liu et al reported that MWA and surgical resection showed similar clinical efficacy.[1] Vitamin D deficiency is an important factor affecting the success of MWA or surgical treatment, and it has been reported that PTH rebound may occur in these patients and that vitamin D supplementation causes an increase in the cure rate in patients undergoing parathyroid surgery.[11,12] In our study, vitamin D deficiency was corrected before MWA by supplementation, and rebound PTH elevation was not observed. Liu et al reported that the nodule volume is an independent risk factor for the success of MWA and the probability of success decreases in large lesions.[5] On the contrary, Ying et al reported that the small size of the parathyroid adenoma in patients who underwent MWA was the factor leading to procedural failure.[13] In our study, only ablation time showed a statistically significant correlation with adenoma size. We think that the insufficient overlap of the ablation areas in the "moving shot" technique in large-sized adenomas and the difficulty in determining the adenoma location in small-sized adenomas may be related to the failure. Patients should be evaluated with MIBI scintigraphy and US by an experienced specialist before the procedure to determine the location of the small-sized adenoma and to exclude the presence of parathyroid hyperplasia and multiple parathyroid adenomas (5–7%).[4,14] In our study, all patients underwent MIBI scintigraphy, US, and parathyroid fine-needle aspiration (for PTH level and cytological evaluation) before the procedure. Insogna reported that MIBI, contrast-enhanced CT, MRI, and, if necessary, multimodal image fusion should be used to determine the localization of the parathyroid gland before surgery.[15]

In our three patients, recurrent hyperparathyroidism and increased calcium levels were observed at the 1-month follow-up secondary to inadequate ablation. Our success rate in the second ablation session was 97%. Carsello et al reported that a high preoperative PTH level before the procedure is a risk factor associated with cure rate in patients undergoing surgical resection.[16] Although the efficacy of MWA in secondary hyperparathyroidism has been found to be related to the basal PTH level in previous studies, a factor that may be directly related to the success of treatment in primary hyperparathyroidism has not been definitively revealed.[17] In our study, no significant relationship was found between procedural success with adenoma size and preoperative PTH. In their study, Fan et al observed that treatment efficacy was not significantly associated with lesion size and preprocedural PTH and calcium levels.[9] The limitations of our study include its retrospective nature and small number of patients. Another limitation is that the long-term effectiveness of MWA was not documented. In conclusion, MWA is a safe and effective treatment option in the treatment of parathyroid adenoma and can be applied as a minimally invasive method under local anesthesia.

Conflict of Interest
None declared.

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