Trends in Oncology Vol 5 Issue 1 2023
DOI: 10.37155/2717–5278–0501–3

Original Research Article

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Analysis of the Therapeutic Effects of Ultrasound-Guided Microwave Ablation at Different Energy Levels on Thyroid Nodules

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How to cite: Elias Abula, Xiangyou Yu. Analysis of the Therapeutic Effects of Ultrasound-Guided Microwave Ablation at Different Energy Levels on Thyroid Nodules. *Trends in Oncology*, 2023; 5(1).
Doi: 10.37155/2717-5278-0501-3

Abstract: Objective: To analyze the application effects of ultrasound-guided microwave ablation at different energy levels in the treatment of thyroid nodules. **Methods**: A total of 72 patients with thyroid nodules from November 2022 to November 2023 were selected for the study. They were randomly divided into a control group of 36 cases, treated with traditional surgery, and an observation group of 36 cases, treated with microwave ablation. The clinical efficacy of the two groups was compared. **Results:** The levels of T4 and T3 in the observation group were significantly higher than those in the control group. The incidence of complications, TSH levels, hospitalization time, intraoperative blood loss, surgical time, and VAS scores were significantly lower in the observation group than in the control group ($P < 0.05$). The average volume reduction rate of nodules in the observation group showed a significant increase trend with the extension of ablation time, with the average volume initially decreasing and then increasing ($P < 0.05$). **Conclusion:** Microwave ablation therapy for thyroid nodules can enhance therapeutic effects, improve thyroid function, prevent complications, and has potential for wider application.
Keywords: Ultrasound-guided; Microwave ablation; Thyroid nodules; Surgery

Thyroid nodules are among the common tumors in the head and neck region, particularly prevalent in young females. This condition can manifest in two forms, with thyroid adenomas being benign and thyroid cancer being malignant. Patients with thyroid nodules may experience symptoms such as difficulty swallowing and hoarseness. Currently, the exact cause of this condition is unclear, but research indicates a close relationship with environmental factors, genetic factors, and others. Among the environmental factors, TSH levels, radiation exposure, and excessive or deficient iodine intake are particularly noteworthy, impacting health and safety[1]. The primary treatment for thyroid nodules is surgery. Although traditional surgery is well-established and widely used, it comes with significant trauma, high blood loss, poor aesthetic outcomes, and hindered recovery. Therefore, exploring effective and safe alternatives is crucial. Microwave ablation is a novel therapeutic approach known for reducing pain, shortening treatment duration, and being cost-effective. It has demonstrated notable advantages in treating liver and kidney tumors but has been less extensively studied in thyroid nodules[2]. This study focuses on patients with thyroid nodules, aiming to analyze the application effects of microwave ablation therapy.

1. Data and Methods

1.1 General Information

Between November 2022 and November 2023, a total of 72 patients with thyroid nodules from our hospital were selected for the study. They were randomly divided into a control group of 36 cases, consisting of 15 males and 21 females, with an age range of 21-66 years and an average age of (45.21±2.45) years. The observation group included 36 cases, with 16 males and 20 females, aged between 22-67 years, and with an average age of (45.33±2.28) years. There were no significant differences in general information between the two groups ($P > 0.05$), indicating comparability.

Inclusion Criteria: Conforming to the diagnostic criteria for thyroid nodules[3]; Confirmation of thyroid nodules through imaging examinations; Availability of complete patient data; Informed consent from patients to participate in the study.

Exclusion Criteria: Presence of other physical illnesses; Psychological disorders or a history of mental illness; Other types of tumors; Immunological disorders.

1.2 Methods

1.2.1 Control Group

The control group underwent traditional surgical treatment. Prior to the surgery, relevant examinations were conducted to ensure the patient's head was lowered and shoulders were elevated, optimizing exposure of the surgical field. General anesthesia was administered through intravenous means, and the surgical area was draped. The surgical site was then sterilized. The incision was made 2cm from the upper border of the thyroid cartilage, horizontally, with a length of 5cm. A ultrasonic scalpel was used to dissect and handle the tumor, as well as nearby blood vessels and tissues. After complete dissection, a full excision was performed to obtain a sample. Pathological examination was promptly conducted, followed by the placement of a drainage tube and suturing of the incision.

1.2.2 Observation Group

The observation group underwent microwave ablation therapy. Prior to the procedure, preoperative examinations were conducted. The patient was positioned with the head lowered and shoulders elevated. With the assistance of color Doppler ultrasound, the tumor location and size were carefully observed. The entry point for the microwave probe was identified, and the area was sterilized. The surgical site was draped, and 2% lidocaine was used for local anesthesia. Local anesthesia was performed by infiltrating a suitable amount of physiological saline near the thyroid, preventing damage to nearby nerves and blood vessels, and protecting healthy thyroid tissue from potential thermal injury. A disposable microwave surgical electrode was selected and placed at the distal end of the thyroid nodule. Wet gauze was applied externally to the electrode's path to prevent thermal injury. Microwave power was set between 60W and 70W, coagulation time was set at 6 seconds, and interval time was set at 2-3 seconds. The moving distance was adjusted to 3-5mm/s. A footswitch was used to control the procedure. The ablation treatment was conducted in a multipoint, multi-surface manner, ensuring comprehensive coverage of the nodule with heat. The thyroid nodule was excised, and the treatment process was monitored using an ultrasound device to achieve complete ablation. After completing the treatment, a cold compress was applied to achieve hemostasis, ensuring that the cold compress time was not less than 30 minutes. A sample was obtained for pathological examination.

1.3 Observation Items and Indicators

Evaluation of Thyroid Hormone Levels[4]: Examine the levels of T4, T3, and TSH before and after treatment. Evaluation of Surgical Outcomes[5]: Observe the hospitalization time, intraoperative blood loss, and surgical time for both groups. Complications include seizures, hoarseness, and coughing. Evaluation of

Nodule Reduction[6]: Examine the number and average volume of nodules in the observation group before ablation, and at 1, 3, 6, and 12 months post-ablation, and calculate the average volume reduction rate.

1.4 Statistical Methods

Data were processed using SPSS 27.0. ($\bar{x}\pm s$)and (%) were used for measurement and counting data, and t and χ^2 were conducted for comparisons respectively, and a significance level of $P < 0.05$ was considered statistically significant.

2. Results

2.1 Comparison of Thyroid Hormone Levels in Two Groups

After treatment, the levels of T4 and T3 in both groups were significantly higher than before treatment, while TSH was significantly lower than before treatment. The observed changes were more pronounced in the observation group ($P < 0.05$). See (**Table 1**) for details.

2.2 Comparison of Surgical Outcomes between the Two Groups

The observation group exhibited significantly lower rates of complications, shorter hospital stays, reduced intraoperative blood loss, shorter surgical duration, and lower VAS scores compared to the control group. These differences were statistically significant ($P < 0.05$). For details, please refer to (**Table 2**).

2.3 Comparison of Nodule Size Reduction between the Two Groups

In the observation group, as the ablation time extended, there was a noticeable increasing trend in the average volume reduction rate of nodules. The average volume initially decreased and then increased ($P < 0.05$). For details, please refer to (**Table 3**).

Table 1: Comparison of Thyroid Hormone Levels in Two Groups [n($\bar{x}\pm s$)]

group	instances	T4 (pmol/L)		T3 (pmol/L)		TSH (mIU/L)	
		before treatment	after treatment	before treatment	after treatment	before treatment	after treatment
Observation	36	12.84±1.44	13.65±1.12^a	4.34±0.41	4.13±0.34^a	2.11±0.25	1.47±0.11^a
Control	36	12.86±1.39	11.25±1.24^a	4.36±0.38	3.63±0.42^a	2.13±0.21	12.52±1.55^a
t	/	0.060	8.618	0.215	5.552	0.368	42.667
P	/	0.952	0.000	0.831	0.000	0.714	0.000

Note: With reference to this group, $^aP < 0.05$ when compared before treatment.

Table 2: Comparison of Surgical Outcomes between the Two Groups [n($\bar{x}\pm s$)/(%)]

group	instances	Hospital Stay Duration (days)	Intraoperative Blood Loss (ml)	Surgical Duration (min)	VAS (points)	Complication Rate (%)
Observation	36	1.51±0.21	4.21±1.00	21.25±1.25	1.24±0.12	2(5.56)
Control	36	4.13±0.23	13.37±1.15	41.23±1.34	5.13±0.14	10(27.78)
t/x^2	/	50.474	36.064	65.418	126.579	6.400
P	/	0.000	0.000	0.000	0.000	0.011

Table 3: Comparison of Nodule Size Reduction between the Two Groups [($\bar{x}\pm s$)]

Ablation Time	Nodule Count (n)	Average Volume (ml)	Average Volume Reduction Rate (%)
Before Ablation	50	4.11±1.21	
After 1 month of Ablation	49	3.11±0.23^a	22.28±1.18
After 3 month of Ablation	43	1.81±0.22^{ab}	44.17±1.78^{ab}
After 6 month of Ablation	43	0.39±0.02^{abc}	81.88±2.35^{abc}
After 12 month of Ablation	26	0.33±0.01^{abcd}	85.48±2.31^{abcd}

Note: Compared to before ablation, $^aP < 0.05$; compared to 1 month after ablation, $^bP < 0.05$; compared to 3 months after ablation, $^cP < 0.05$; compared to 6 months after ablation, $^dP < 0.05$.

3. Discussion

The incidence of thyroid tumors is high, reaching 3.2 per 100,000 person-years globally. Based on pathological characteristics, this disease is classified into two types: benign tumors, including thyroid cysts and adenomas; and malignant tumors, with the majority being primary thyroid cancer, accounting for approximately 95%[7]. There are various treatment options for this condition, commonly including surgical intervention, minimally invasive therapies, and pharmacological treatments.

Adopting microwave ablation, there are clear indications for its use in the treatment of this condition. These indications include nodular lesions caused by corresponding thyroid diseases, such as adenomas and hyperthyroidism; solitary solid nodules, where, if the patient shows a favorable trend toward improvement, thorough elimination can be achieved through ablation; those who have undergone traditional surgical treatment but remain unhealed, further surgery may impair thyroid function, and applying this technology can completely eliminate lesions while protecting normal thyroid tissue; individuals with thyroid nodules confirmed to be papillary carcinoma, without lymph node metastasis, and who decline traditional surgery; and post-thyroidectomy patients with recurrent disease due to lymph node metastasis, or those resistant to surgery, among others[8]. Guided by ultrasound, microwave needles generate a microwave magnetic field at the tumor site, causing nearby molecules to rotate rapidly, generating heat through friction. This results in coagulation necrosis and subsequent elimination of the tumor. Microwave ablation not only directly produces a thermal effect on tumor tissue, causing it to coagulate and necrose, but also induces an immune response against the tumor, damaging the tumor tissue. This technology promotes cell apoptosis and inhibits tumor progression[9]. Cell apoptosis, controlled by genes, involves the ordered and autonomous death of cells. Chromatin condenses further, DNA breaks, and apoptotic bodies are formed. During this process, the cell membrane structure remains intact, with no spillover of contents, and there is no inflammation reaction in nearby tissues. After cellular structural apoptosis, corresponding functional changes occur, inhibiting tumor growth. Scholars like Wu Hao propose that, with the premise of thoroughly killing tumor cells, compared to high temperatures, low temperatures are more conducive to activating T cell immune responses. SEIKO and others suggest that for tumor tissue, when adopting thermal ablation therapy, low temperatures can enhance the body's anti-tumor capabilities and strengthen immune responses[10]. When selecting this therapy, pain management should be prioritized. Local anesthesia is used during treatment, with 2% lidocaine selected for injection points, including adjacent tissues, the thyroid anterior capsule, and skin puncture points. The focus is on the capsule around the lesion. Active communication with the patient is essential, and if pain occurs, anesthesia should be administered promptly. Additional medication is generally not necessary, and postoperatively, pain relievers are not required. Hemostasis measures should be implemented, and anticoagulants should not be provided 1 day before the procedure. Coagulation function should be assessed, and precision should be ensured during positioning and puncture to prevent vascular damage. If the lesion is in a region with abundant blood flow, vascular occlusion should be performed before puncture. Post-treatment compression should be applied, and hemostatic agents may be used if necessary. Protecting nearby structures is crucial. The nodular lesion should be carefully observed, its location confirmed, and an appropriate amount of lidocaine and saline solution injected into the anterior and posterior gaps of the thyroid. Neck structures should be examined, and attention should be paid to the patient's recurrent laryngeal nerve and vocal function. The entire treatment process should be monitored using ultrasound, and the nature of the disease should be clarified. The ablation situation should be observed, ensuring that ablation is terminated after complete tumor elimination. Pre and post-treatment biopsy should be performed to diagnose tissue pathology before the procedure and evaluate tissue carbonization and dehydration after treatment, determining the end of the ablation[11]. Compared to traditional surgery, the use of ultrasound-guided microwave ablation reduces trauma, alleviates pain, enhances therapeutic efficacy, and promotes disease recovery. The results of this study indicate that, compared to the control group, the observation group showed higher levels of T4 and T3 and lower levels of TSH ($P < 0.05$). This suggests that microwave ablation can preserve thyroid function. The main reason for this is that traditional surgery can damage thyroid tissue, leading to a decrease in T4 and T3 levels, a reduction in feedback function, and an increase in TSH levels. In such cases, patients may exhibit symptoms of hypothyroidism, such as slow heart rate and lethargy. Additionally, some studies suggest that hypothyroidism can affect lipid levels, increasing the risk of cardiovascular diseases. The observation group also demonstrated lower rates of complications, shorter hospital stays, reduced intraoperative blood loss, shorter surgical durations, and lower VAS scores ($P < 0.05$). This indicates that microwave ablation, performed under local anesthesia, is safer, reduces blood loss, and promotes patient recovery. In the observation group, as the ablation time extended, there was a noticeable increasing trend in the average volume reduction rate of nodules, with the average volume initially decreasing and then increasing ($P < 0.05$). This suggests that after adopting this therapy, the tumor volume significantly decreases, indicating a more precise therapeutic effect. The results indicate that the use of microwave ablation can strengthen the efficacy of thyroid tumor treatment, with high safety and reliability.

In conclusion, applying microwave ablation to thyroid tumor patients can enhance therapeutic efficacy, improve thyroid function, prevent complications, and has potential value for wider application.

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