Research Article

Ultrasound and Gene-Guided Microwave Ablation versus Surgery for Low-Risk Papillary Thyroid Carcinoma: A Prospective Study

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Mini Abstract

This study examines the efficacy of ultrasound-guided, gene-based microwave ablation compared to surgery in managing low-risk papillary thyroid carcinoma. It highlights the critical role of genetic testing in tailoring treatment strategies, thereby improving patient safety and optimizing clinical outcomes.

Abstract

Objective: This study evaluates and compares the efficacy and prognosis of ultrasound and gene-based microwave ablation (MWA) and surgical treatment in patients with low-risk papillary thyroid carcinoma (PTC), emphasizing the influence of genetic mutations on low-risk patients' selection.

Background: MWA, a minimally invasive technique, is increasingly recognized in the management of PTC. While traditional criteria for ablation focus on tumor size, number, and location, the impact of genetic mutations on treatment efficacy remains underexplored.

Methods: A total of 201 patients with low-risk PTC without metastasis were prospectively enrolled. All patients underwent ultrasound and next-generation sequencing to confirm low-risk status. Patients chose either ablation or surgery and were monitored until November 2024. Efficacy and complications were assessed using thyroid ultrasound and contrast-enhanced ultrasound.

Results: The median follow-up of this study is 12 months. There is no significant difference between the ablation group (3.0%) and the surgery group (1.0%), in disease free survival (DFS) (P= 0.360). However, the surgery group exhibited a significantly higher complication rate, particularly for temporary hypoparathyroidism (P < 0.001). Ablation offers notable advantages, including shorter treatment duration, faster recovery, less intraoperative blood loss, and reduced costs (P < 0.001), while maintaining favorable safety and comparable efficiency.

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Conclusion: For patients with low-risk genetic mutations, ablation provides comparable efficacy and DFS to surgery, with with significant benefits in safety, recovery, and overall cost. Guided by ultrasound and next-generation sequencing, precise patient selection enhances the potential of ablation as a promising, minimally invasive alternative to surgery in the management of low-risk PTC.

Keywords: *Papillary thyroid carcinoma, next-generation sequencing, microwave ablation, surgical treatment*

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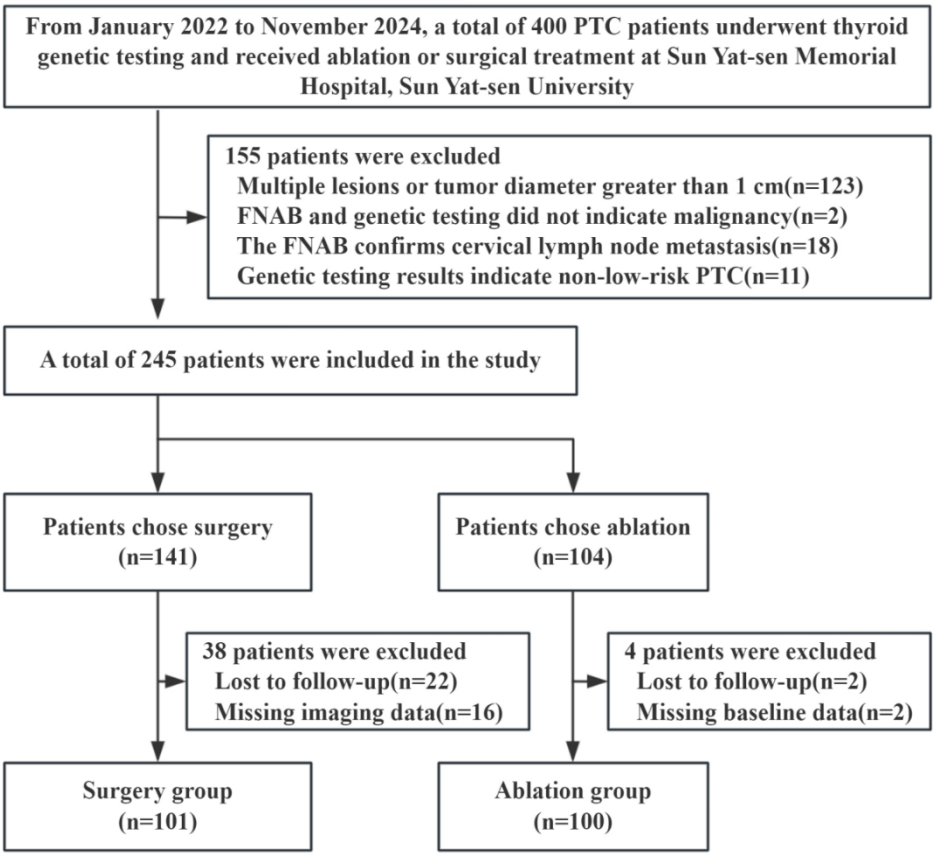

FIGURE 1. Study flow diagram.

Study flowchart of patient inclusion for the study on low-risk PTC treatments at Sun Yat-sen Memorial Hospital. A total of 400 patients who underwent ablation or surgical treatment from January 2022 to November 2024 were initially screened for the prospectively observational cohort study. Exclusions included patients with multiple lesions or tumor diameters greater than 1 cm (n=123), those without malignancy indications in fine-needle aspiration biopsy (FNAB) and genetic testing (n=2), and patients with genetic testing indicating intermediate-high risk PTC (n=11). Additionally, patients with cervical lymph node metastasis (n=18) were excluded. Ultimately, 245 patients with low-risk PTC were included, with 141 opting for surgery and 104 choosing ablation. After further exclusions for incomplete data, the final groups included 101 patients in the surgery group and 100 patients in the ablation group.

TABLE 1. Patients characteristics.

	Ablation (N=100)	**Surgery (N=101)**	**P value**
Age (year), mean (SD)	41.89 (11.13)	40.79 (10.89)	0.481
Gender (%)			0.154
Male	25 (25.0)	17 (16.8)	
Female	75 (75.0)	84 (83.2)	
Tumor location (%)			0.295
Left	51 (51.0)	41 (40.6)	
Isthmus	5 (5.0)	8 (7.9)	
Right	44 (44.0)	52 (51.5)	
Tumor morphology (%)			0.912
Sharp margins	51 (51.0)	52 (51.5)	
Fairly clear margins	16 (16.0)	18 (17.8)	
Blurred margins	33 (33.0)	31 (30.7)	
Tumor aspect ratio (%)			0.301
<1	52 (52.0)	49 (48.5)	
=1	4 (4.0)	1 (1.0)	
>1	44 (44.0)	51 (50.5)	
Maximum tumor diameter (mm), mean (SD)	6.14 (2.10)	6.25 (2.11)	0.696
Tumor volume (ml), mean (SD)	0.08 (0.09)	0.08 (0.07)	0.462
UItrasound classification (%)			0.484
TI-RADS 1	0 (0)	0 (0)	
TI-RADS 2	1 (1.0)	0 (0)	
TI-RADS 3	1 (1.0)	2 (2.0)	
TI-RADS 4	28 (28.0)	30 (29.7)	
TI-RADS 5	70 (70.0)	67 (66.3)	
TI-RADS 6	0 (0)	2 (2.0)	
CDFI (%)			0.468
Blood flow signal within the nodule	43(43.0)	51 (50.5)	
Peripheral ring-like blood flow signal	7 (7.0)	4 (4.0)	
Ring-like blood flow signal within and around the nodule	14(14.0)	17 (16.8)	
No ring-like blood flow signal within and around the nodule	36(36.0)	29 (28.7)	
FNAB (%)			0.505
TBS-I	0 (0)	0 (0)	
TBS-II	0 (0)	0 (0)	
TBS-III	5(5.0)	2 (2.0)	
TBS-IV	0 (0)	0 (0)	
TBS-V	4(4.0)	4 (4.0)	
TBS-VI	91(91.0)	95 (94.0)	
Gene mutation type (%)			0.664
Single BRAF gene mutation	58(58.0)	54 (53.4)	
BRAF gene mutation combined with other gene mutations	37(37.0)	38 (37.6)	
Other gene mutations	2(2.0)	5 (5.0)	
No gene mutation detected	3(3.0)	4 (4.0)	
Follow-up time (month), mean (SD)	11.51 (5.45)	11.50 (3.12)	0.434

Disease progression (%)			0.308
Yes	3 (3.0)	1 (1.0)	
No	97(97.0)	100 (99.0)	

CDFI: Color Doppler Flow Imaging; FNAB: Fine Needle Aspiration Biopsy; SD: Standard Deviation; TBS: The Bethesda System for Reporting Thyroid Cytopathology; TI-RADS: American College of Radiology Thyroid Imaging, Reporting and Data System.

TABLE 2. Patients baseline between different gene mutations.

	Single BRAF gene mutation（N=112）	**BRAF accompanied with other gene mutations（N=75）**	**Non-BRAF gene mutations（N=7）**	**No gene mutation（N=7）**	***P*-value**
Age (years), mean (SD)	40.93 (11.13)	42.16 (11.00)	38.57 (12.43)	41.86 (8.53)	0.796
Gender (%)					0.479
Female	89 (79.5)	57 (76.0)	7 (100.0)	6 (85.7)	
Male	23 (20.5)	18 (24.0)	0 (0.0)	1 (14.3)	
Tumor location (%)					0.631
Left	54 (48.2)	31 (41.3)	4 (57.1)	3 (42.9)	
Right	50 (44.6)	41 (54.7)	2 (28.6)	3 (42.9)	
Isthmus	8(7.2)	3(4.0)	1(14.3)	1(14.3)	
Tumor morphology (%)					0.410
Sharp margins	52 (46.4)	43 (57.3)	4 (57.1)	4 (57.1)	
Fairly clear margins	24 (21.4)	10 (13.3)	0 (0.0)	0 (0.0)	
Blurred margins	36 (32.1)	22 (33.4)	3 (42.9)	3 (42.9)	
Tumor aspect ratio (%)					0.397
<1	57 (50.9)	36 (48.0)	6 (85.7)	2 (28.6)	
=1	2 (1.8)	3 (4.0)	0 (0.0)	0 (0.0)	
>1	53 (47.3)	36 (48.0)	1 (14.3)	5 (71.4)	
Tumor diameter (mm), mean (SD)	6.12 (2.06)	6.28 (2.13)	7.03 (2.61)	5.71 (2.21)	0.636
Tumor volume (ml), mean (SD)	0.07 (0.07)	0.09 (0.09)	0.08 (0.07)	0.07 (0.05)	0.732
TI-RADS (%)					0.213
1	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
2	0 (0.0)	1 (1.3)	0 (0.0)	0 (0.0)	
3	1 (0.9)	1 (1.3)	1 (14.3)	0 (0.0)	
4	30 (26.8)	25 (33.3)	2 (28.6)	1 (14.3)	
5	81 (72.3)	46 (61.3)	4 (57.1)	6 (85.7)	
6	0 (0.0)	2 (2.7)	0 (0.0)	0 (0.0)	

SD: Standard Deviation; TBS: The Bethesda System for Reporting Thyroid Cytopathology; TI-RADS: American College of Radiology Thyroid Imaging, Reporting and Data System.

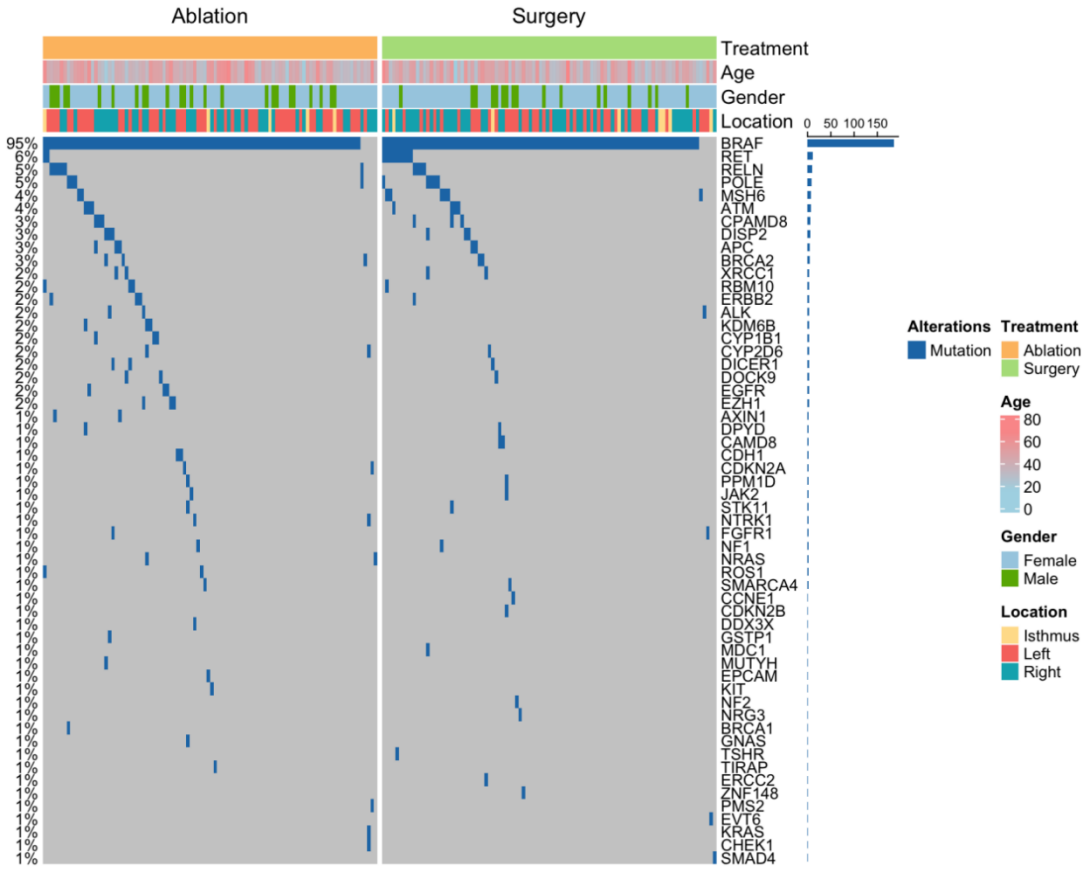

FIGURE 2. Distribution of genetic mutations, demographic characteristics, and treatment types among patients with low-risk papillary thyroid carcinoma.

The figure shows the frequency of genetic mutations in patients undergoing ablation and surgery, with B-Raf proto-oncogene, serine/threonine kinase V600E (BRAF V600E) mutations being the most common.

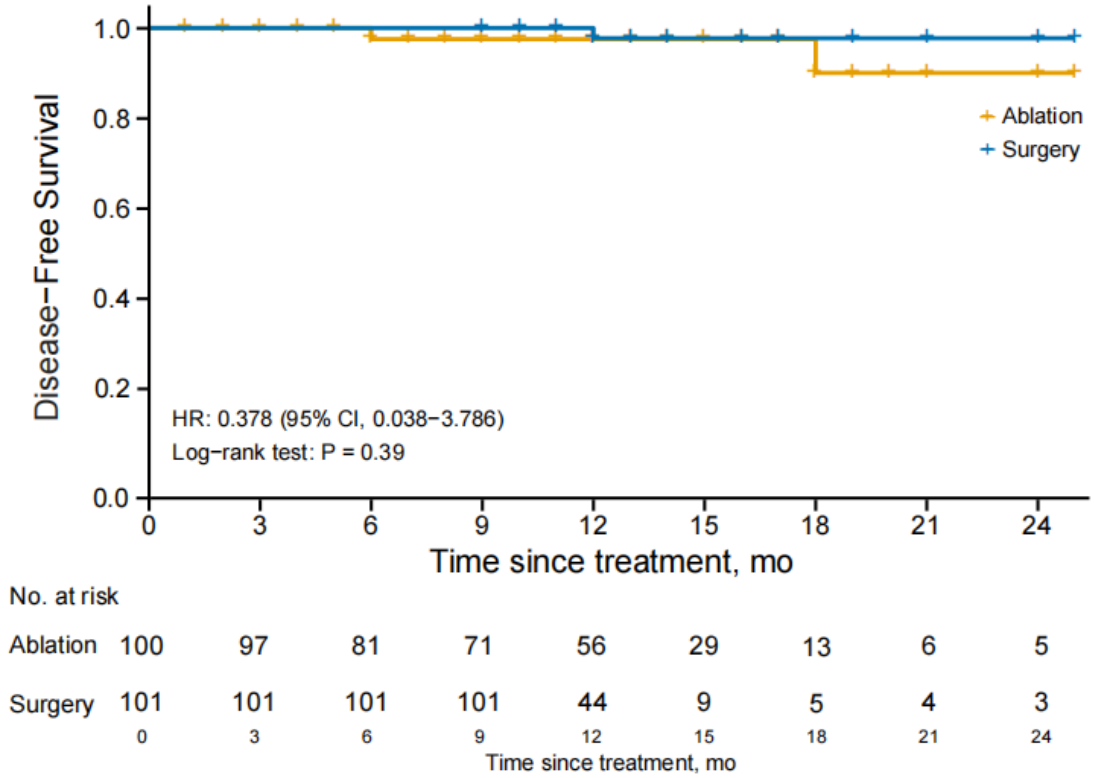

FIGURE 3. Disease-free survival curves of ablation versus surgery.
Kaplan-Meier curve illustrating disease free survival (DFS) for patients with low-risk PTC who underwent either ablation or surgery.

TABLE 3. Disease progression between ablation and surgery groups.

	Ablation (N=100)	**Surgery (N=101)**	***P*-value**
Disease progression (%)			0.360
Cervical lymph node metastasis	0 (0.0)	0 (0.0)	
Local tumor progression	2 (2.00)	0 (0.0)	
Tumor recurrence	1 (1.0)	1 (1.0)	
Distant metastasis	0 (0.0)	0 (0.0)	
Recurrence location (%)			0.368
PTC-RT	1 (1.0)	0 (0.0)	
PTC-LT	0 (0.0)	1 (1.0)	

Local tumor progression, the tumor continues to grow within the ablation zone.
PCT: Papillary Thyroid Carcinoma; PTC-RT: PTC of the Right Lobe; PTC-LT, PTC of the Left Lobe.

TABLE 4. Complications and hospitalizations in ablation and surgery groups.

	Ablation (N=100)	**Surgery (N=101)**	***P*-value**
Complication (%)			<0.001
Postoperative fever	0 (0.0)	1 (1.0)	
Postoperative cervical pain	0 (0.0)	5 (5.0)	
Postoperative nausea	0 (0.0)	2 (2.0)	
Temporary hypoparathyroidism	0 (0.0)	19 (18.8)	
Postoperative hypertension	0 (0.0)	0 (0.0)	
Hemorrhage (ml), mean (SD)	0.00 (0.00)	8.72 (3.74)	<0.001
hospitalization time (d), mean (SD)	1.00 (0.00)	2.88 (0.41)	<0.001
Treatment time (h), mean (SD)	0.29 (0.04)	1.31 (0.58)	<0.001
Cost (CNY), mean (SD)	17669.73 (175.14)	35757.29 (2781.39)	<0.001

SD: Standard Deviation.

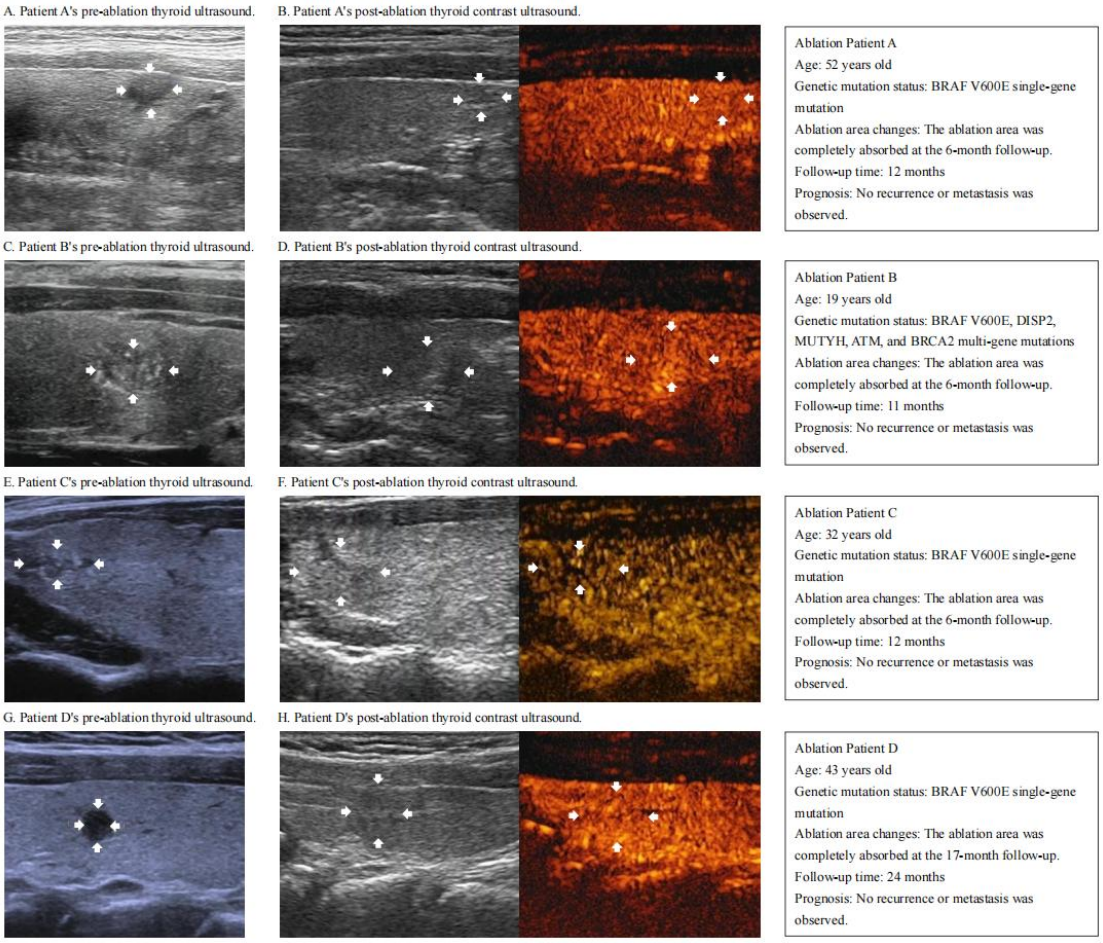

FIGURE 4. Ultrasound images for patients with thyroid carcinoma before and after Microwave ablation. **A)** Pre-ablation thyroid ultrasound of patient A. **B)** Post-ablation thyroid contrast-enhanced ultrasound of patient A. **C)** Pre-ablation thyroid ultrasound of patient B. **D)** Post-ablation thyroid contrast-enhanced ultrasound of patient B.

E) Pre-ablation thyroid ultrasound of patient C. **F)** Post-ablation thyroid contrast-enhanced ultrasound of patient C. **G)** Pre-ablation thyroid ultrasound of patient D. **H)** Post-ablation thyroid contrast-enhanced ultrasound of Patient D.

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