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Efficacy and Safety of Radiofrequency Ablation for Papillary Thyroid Cancer: A Systematic Review and Meta-Analysis

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ADMINISTRATIVE INFORMATION

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 23 April 2025 and was last updated on 23 April 2025.

INTRODUCTION

Review question / Objective This systematic review and meta-analysis aimed to evaluate the efficacy and safety of radiofrequency ablation (RFA) in the management of papillary thyroid cancer (PTC).

Condition being studied Papillary thyroid cancer (PTC) is the predominant form of thyroid malignancy, accounting for approximately 80% of all thyroid cancer cases. The global incidence of PTC has shown a significant upward trend over recent decades, attributed in part to improved diagnostic techniques and increased surveillance. Despite this rise in incidence, mortality rates have remained relatively stable, largely due to the generally indolent nature of PTC and continuous advancements in both diagnostic and therapeutic strategies.

The management of PTC has traditionally centered on surgical intervention, with approaches ranging from thyroid lobectomy to total thyroidectomy. While surgery is considered the gold standard, it carries potential complications including recurrent laryngeal nerve injury and hypoparathyroidism. Additionally, patients who undergo total thyroidectomy require lifelong thyroid hormone replacement therapy.

These surgical risks, coupled with the increasing detection of small, low-risk PTCs, have fueled interest in exploring minimally invasive alternatives. Among these, radiofrequency ablation (RFA) has emerged as a promising technique, initially used for benign thyroid nodules and more recently for selected cases of PTC.

RFA uses high-frequency alternating current to induce thermal injury in target tissue, leading to coagulative necrosis and subsequent volume reduction. Performed under ultrasound guidance, RFA allows precise targeting of cancerous tissue while minimizing damage to surrounding structures. Potential advantages include preservation of thyroid function, reduced complication rates, and superior cosmetic outcomes compared to surgery.

Despite growing adoption of RFA for PTC treatment, several questions remain regarding its

long-term efficacy compared to traditional surgical approaches. The optimal patient selection criteria and technical considerations in RFA application also warrant further investigation. Additionally, while major complications are rare, understanding the incidence and management of minor complications is crucial for informed decision-making.

METHODS

Participant or population All 15 included studies were retrospective in design, collectively involving 1,844 patients who underwent radiofrequency ablation for papillary thyroid cancer. The sample sizes ranged from 37 to 414 patients. The mean age of patients across studies varied from 40.7 to 66.0 years, with a predominance of female participants in most studies.

Intervention Radiofrequency ablation for papillary thyroid cancer.

Comparator N/A.

Study designs to be included We systematically searched PubMed, Embase, Cochrane Library, Web of Science, and CNKI databases for relevant studies published up to October 18, 2024. The search strategy employed a combination of Medical Subject Headings (MeSH) terms and free-text words, including "Radiofrequency ablation," "Papillary thyroid cancer," "radiofrequency ablation (RFA)," and "RFA." The complete search string used was: "(Radiofrequency ablation [MeSH Terms]) OR (radiofrequency [Title/Abstract]) OR (radio frequency[Title/Abstract]) OR (radio-frequency[Title/Abstract]) OR (RFA[Title/Abstract])."

Eligibility criteria Studies were included if they met the following criteria: (1) involved patients diagnosed with papillary thyroid cancer; (2) utilized radiofrequency ablation as the primary treatment modality; (3) reported at least one of the following outcomes: volume reduction rate, complete disappearance rate, local recurrence, recurrence-free survival rate, or local tumor progression; (4) had a minimum follow-up period of 6 months; and (5) were published in English or Chinese.

Information sources We systematically searched PubMed, Embase, Cochrane Library, Web of Science, and CNKI databases for relevant studies published up to October 18, 2024. The search strategy employed a combination of Medical Subject Headings (MeSH) terms and free-text words, including "Radiofrequency ablation," "Papillary thyroid cancer," "radiofrequency ablation (RFA)," and "RFA." The complete search string used was: "(Radiofrequency ablation [MeSH Terms]) OR (radiofrequency [Title/Abstract]) OR (radio frequency[Title/Abstract]) OR (radio-frequency[Title/Abstract]) OR (RFA[Title/Abstract])."

Main outcome(s) Volume Reduction Rate

Three studies reported volume reduction rates at the 12-month follow-up. The meta-analysis revealed a pooled risk ratio of 1.11 (95% CI: 0.97-1.27). Heterogeneity among these studies was moderate (I^2 = 55.4%, p = 0.106). To assess publication bias, we conducted an Egger's test, which yielded a p-value of 0.639, suggesting no significant publication bias for this outcome.

Complete Disappearance Rate

Five studies reported on complete disappearance rates. The meta-analysis revealed a pooled risk ratio of 1.08 (95% CI: 0.99-1.18). However, there was significant heterogeneity among the studies (I^2 = 71.4%, p = 0.007). The Egger's test (p = 0.896) indicated no significant publication bias.

Local Recurrence

Eight studies provided data on local recurrence. The pooled analysis yielded a local recurrence rate of 0.62% (95% CI: 0.32%-1.21%). Notably, there was no significant heterogeneity among these studies (I^2 = 0.0%, p = 0.748). The Egger's test resulted in a p-value of 0.055, suggesting a borderline risk of publication bias for this outcome.

Recurrence-Free Survival (RFS) Rate

Three studies reported on recurrence-free survival rates. The meta-analysis revealed a pooled risk ratio of 1.00 (95% CI: 0.93-1.08). There was no significant heterogeneity among these studies (I^2 = 0.0%, p = 0.973). The Egger's test (p = 0.676) indicated no significant publication bias for this outcome.

Local Tumor Progression

Four studies provided data on local tumor progression. The pooled analysis showed a local tumor progression rate of 1.42% (95% CI: 0.81%-2.48%). There was no significant heterogeneity among these studies (I^2 = 0.0%, p = 0.862). The Egger's test yielded a p-value of 0.676, suggesting no significant publication bias for this outcome.

Quality assessment / Risk of bias analysis Publication bias was evaluated using funnel plots and Egger's test when a sufficient number of studies (≥10) were available for a given outcome. A p-value <0.05 was considered statistically significant for all analyses.

Strategy of data synthesis Data extraction was performed independently by two reviewers using a standardized form. The extracted information

included: first author, year of publication, study design, sample size, patient demographics (age, gender), follow-up duration, and outcome measures. In cases where multiple publications reported on the same patient cohort, we included the most recent or most comprehensive study to avoid duplication.
The quality of the included studies was assessed using the Newcastle-Ottawa Scale (NOS) for non-randomized studies. This scale evaluates studies based on three domains: selection of study groups, comparability of groups, and ascertainment of exposure or outcome. Studies with NOS scores of 7 or higher were considered high quality.

Subgroup analysis All statistical analyses were performed using Review Manager (RevMan) version 5.3 (Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2014). For dichotomous outcomes, we calculated risk ratios (RRs) with 95% confidence intervals (CIs). For continuous outcomes, mean differences (MDs) or standardized mean differences (SMDs) with 95% CIs were computed, depending on the consistency of measurement scales across studies.

Sensitivity analysis Heterogeneity among studies was assessed using the I^2 statistic, with I^2 values of 25%, 50%, and 75% considered as low, moderate, and high heterogeneity, respectively. Given the expected clinical and methodological diversity among studies, we employed a random-effects model for all meta-analyses, regardless of the observed heterogeneity.

Country(ies) involved China - Beijing Sixth Hospital.

Keywords Radiofrequency ablation; Papillary thyroid cancer; Meta-analysis; Volume reduction; Local recurrence.

Contributions of each author
Author 1 - Jiuxi Wu.
Author 2 - Jian Wang.
Author 3 - Jun Gao.