Comparison of ultrasound-guided thermal ablation and conventional thyroidectomy for benign thyroid nodules: a systematic review and meta-analysis

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ABSTRACT
Objective: To compare the safety and efficacy of ultrasound-guided thermal ablation and conventional thyroidectomy for benign thyroid nodules (TNs) by performing a systematic review and meta-analysis.

Methods: We searched PubMed, Embase, Web of Science and Cochrane Library databases for clinical trials from the date of their inception to 1 April 2019. Two investigators independently examined the trials to select qualified studies, extracted relevant information and assessed the risk of bias according to the Cochrane Collaboration checklist (Oxford, UK). The primary study outcomes were safety (hoarseness, hypothyroidism and postoperative pain) and efficacy (symptom improvement, postoperative cosmetic effects and hospitalization time). This study is registered with PROSPERO (CRD42019125643).

Results: Seven studies involving 1289 patients were included. The results demonstrated that the incidences of hoarseness [odds ratio (OR) 0.33, 95% confidence interval (95% CI) (0.14, 0.79)], hypothyroidism [risk difference (RD) –0.31, 95% CI (–0.34, –0.28)] and postoperative pain [OR 0.35, 95% CI (0.25, 0.49)] were lower, and the hospitalization time was shorter [standard mean difference (SMD) –4.01, 95% CI (–4.22, –3.81)] in the thermal ablation group than in the conventional thyroidectomy group, and postoperative cosmetic effects were better [relative risk (RR) ratio 1.12, 95% CI (1.01, 1.24)] (p < 0.05). For symptom improvement, the difference was not statistically significant.

Conclusions: This study shows that for benign TNs, ultrasound-guided thermal ablation may have potential advantages in terms of safety, cosmetic effects and shorter hospitalization time compared with conventional thyroidectomy, while symptom improvement is the same.

Introduction
Thyroid nodules (TNs) are commonly detected, with a prevalence of up to 76% in the general population [1]. According to current research, most TNs are benign [2]. In most cases, TNs are completely asymptomatic and do not need treatment; they are occasionally found by ultrasound during a health check. For benign TNs that become symptomatic, conventional thyroidectomy is the standard therapy [3], but it may lead to complications, such as damage to the recurrent laryngeal nerve and parathyroid gland, or cosmetic concerns, such as permanent scar formation. Some patients who undergo total thyroidectomy may develop hypothyroidism and require lifelong levothyroxine treatment, which can cause economic losses and can potentially lead to adverse effects [4,5]. In addition, thyroidectomy may not be an option for patients with high surgical risks. Levothyroxine and radiiodine have been used as alternative noninvasive treatments for older and high surgical risk patients; however, these treatments cannot avoid iatrogenic hypothyroidism or hyperthyroidism [6,7].

Ultrasound-guided thermal ablation (laser, radiofrequency, microwave and high-intensity focused ultrasound ablation) is an excellent alternative treatment for benign TNs [8–11]. Previous systematic reviews and meta-analyses of thermal ablation have proven its role in improving the outcomes and prognosis of patients with benign TNs [12,13]. However, whether thermal ablation can be equivalent or even superior to conventional thyroidectomy for benign TNs is still unknown. This is a very important issue for patients with benign TNs as it may determine whether a more suitable treatment method is available.

The purpose of this study was to perform a systematic review and meta-analysis to compare the safety and efficacy of ultrasound-guided thermal ablation and conventional thyroidectomy for benign TNs.

Methods
Search strategy
We searched the PubMed, Embase, Web of Science and Cochrane Library databases for clinical trials from the date of
their inception to 1 April 2019. We used the search terms ‘benign’ AND ‘thyroid nodules’ OR ‘thyroid neoplasm’ OR ‘thyroid tumor’ AND ‘surgery’ OR ‘operation’ OR ‘surgical’ OR ‘resection’ OR ‘thyroidectomy’ AND ‘ablation’ OR ‘ablative’. This study is registered with PROSPERO (CRD42019125643).

**Selection criteria**

Inclusion criteria: (1) retrospective or prospective studies on both ultrasound-guided thermal ablation and conventional thyroidectomy for benign TNs; (2) sample size ≥30 patients who had thermal ablation or conventional thyroidectomy for compressive symptoms or cosmetic problems or anxiety about a malignancy; (3) results that included preestablished outcome indicators; and (4) diagnosis of benign TNs confirmed by surgical pathology or cytopathology.

Exclusion criteria: (1) repeated studies; (2) insufficient sample size; (3) research indicators inconsistent with the preestablished indicators; (4) case reports, meeting summaries, comments, letters or reviews.

**Study selection**

Two investigators independently examined titles and abstracts to select qualified studies. They focused on potentially relevant studies and read the full texts to determine which ones met the inclusion criteria.

**Data extraction and data quality assessment**

Two investigators independently extracted relevant information from the included trials, including the author, nation, study type, publication year, patient characteristics and observed indices, including safety and efficacy. Safety was assessed in terms of hoarseness, hypothyroidism and postoperative pain, and efficacy was assessed in terms of symptom improvement, postoperative cosmetic effects and hospitalization time.

To assess hoarseness, patients with voice changes identified by multidimensional voice program (MDVP) testing underwent laryngoscopy to verify vocal cord palsy. Postoperative pain was estimated according to the visual analog scale (VAS), and an increased postoperative score indicated that the pain was positive. For symptom improvement, patients were asked to score the improvement in nodule-related symptoms after treatment (0 = same; 1 = slight improvement; 2 = moderate improvement; 3 = significant improvement), and a score greater than 0 represented a positive result. Postoperative cosmetic effects were graded as poor, acceptable, good and excellent. When the results were excellent, the patient considered that the cosmetic effects of the treatment outweighed the presence of scars.

Two investigators independently assessed the quality of the randomized controlled trials (RCTs) according to the Cochrane Collaboration checklist (Oxford, UK) [14] and assessed the quality of the nonrandomized studies using the Newcastle Ottawa scale (NOS). The results were discussed with a third investigator, and any discrepancies were resolved by consensus.

**Statistical analysis**

We used Review Manager Version 5.3 software (Cochrane Collaboration) to analyze the data. To account for the differences between thermal ablation and conventional thyroidectomy, odds ratios (ORs) with 95% confidence intervals (95% CIs) were used to analyze hoarseness and postoperative pain; risk differences (RDs) with 95% CIs were used to analyze hypothyroidism; standard mean differences (SMDs) with 95% CIs were used to analyze hospitalization time; and relative risk (RR) ratios with 95% CIs were used to analyze symptom improvement and postoperative cosmetic effects. For all analyses, p < 0.05 was considered statistically significant.

Heterogeneity was assessed using the chi-square test and I² statistic. For the chi-square test, p > 0.1 indicates no heterogeneity. When p ≤ 0.1, the I² statistic was performed for further evaluation of heterogeneity (I² ≥ 25%, low heterogeneity; I² ≥ 50%, moderate heterogeneity; I² ≥ 75%, significant heterogeneity). A fixed-effects model was suitable for data with no or low heterogeneity; otherwise, a random-effects model was used [15,16]. When heterogeneity was significant, we performed subgroup and sensitivity analyses to estimate heterogeneity and explore the source of the heterogeneity.

Funnel plots were used to assess publication bias. When a funnel plot is symmetrical, no publication bias exists. Otherwise, publication bias should be considered [17].

**Results**

**Literature retrieval**

Initially, 726 records were identified in the target databases. After deleting duplicate records, we considered 269 articles for inclusion. We narrowed the scope to 26 articles by browsing the titles and abstracts of these articles. Thirty-eight animal studies and 205 unexpected types of articles (case reports, reviews, letters, etc.) were excluded. Then, we analyzed the full texts of the remaining 26 studies, removed studies with incomplete data or inconsistently observed indices, and finally obtained 7 studies (involving 1289 patients) (Figure 1).

**Data extraction and data quality assessment**

The data extracted from the 7 included studies (1 RCT and 6 cohort studies) are shown in Table 1 [5,18–23]. Propensity score matching was performed in the included studies to balance all baseline covariates between the thermal ablation group and the conventional thyroidectomy group. The patients’ baseline characteristics are reported in Table 2. We assessed the quality of the RCTs according to the risk of bias using the Cochrane Collaboration tool. For the cohort studies, we used the NOS, and the assessments are shown in Tables 3 and 4, respectively.
The meta-analysis results showed that the incidences of hoarseness [OR 0.33, 95% CI (0.14, 0.79)], hypothyroidism [RD -0.31, 95% CI (-0.34, -0.28)] and postoperative pain [OR 0.35, 95% CI (0.25, 0.49)] (p < 0.05) were significantly lower in the thermal ablation group than in the conventional thyroidectomy group. The incidence of hoarseness was 1.56% (7/448) in the thermal ablation group and 4.78% (23/481) in the conventional thyroidectomy group. The incidence of hypothyroidism was 0% (0/520) in the thermal ablation group and 31.10% (172/553) in the conventional thyroidectomy group. The incidence of postoperative pain was 32.24% (79/245) in the thermal ablation group and 62.59% (174/278) in the conventional thyroidectomy group.

Table 1. Characteristics of the included studies.

| Study          | Nation | N (ablation/thyroidectomy) | Study type | Ablation | Hoarseness | Hypothyroidism | Postoperative pain | Symptom improvement | Cosmetic effect | Hospitalization time |
|----------------|--------|----------------------------|------------|----------|------------|----------------|--------------------|---------------------|-----------------|---------------------|
| Jin et al. [5] | China  | 212 (106/106)              | Cohort study | MWA      | +          | +              | -                  | -                   | -                | +                   |
| Yue et al. [18] | China  | 216 (108/108)              | Cohort study | RFA      | -          | +              | +                  | +                   | +                | +                   |
| Che et al. [19] | China  | 400 (200/200)              | Cohort study | RFA      | +          | -              | -                  | -                   | +                | +                   |
| Bernardi et al. [20] | Italy  | 111 (37/74)               | RCT        | MWA      | +          | +              | +                  | +                   | +                | +                   |
| Zhi et al. [21] | China  | 52 (28/24)                 | Cohort study | RFA      | +          | +              | +                  | +                   | +                | +                   |
| Lang et al. [22] | China  | 154 (77/77)               | Cohort study | HIFU     | +          | +              | +                  | +                   | +                | +                   |
| Liu et al. [23] | China  | 144 (72/72)                | Cohort study | MWA      | -          | +              | +                  | +                   | +                | +                   |

RCT: randomized controlled trial; MWA: microwave ablation; RFA: radiofrequency ablation; HIFU: high-intensity focused ablation; -: data with this indicator have been excluded, +: data with this indicator have been included.

Safety

The meta-analysis results showed that the incidences of hoarseness [OR 0.33, 95% CI (0.14, 0.79)], hypothyroidism [RD -0.31, 95% CI (-0.34, -0.28)] and postoperative pain [OR 0.35, 95% CI (0.25, 0.49)] (p < 0.05) were significantly lower in the thermal ablation group than in the conventional thyroidectomy group. The incidence of hoarseness was 1.56% (7/448) in the thermal ablation group and 4.78% (23/481) in the conventional thyroidectomy group. The incidence of hypothyroidism was 0% (0/520) in the thermal ablation group and 31.10% (172/553) in the conventional thyroidectomy group. The incidence of postoperative pain was 32.24% (79/245) in the thermal ablation group and 62.59% (174/278) in the conventional thyroidectomy group.

Table 2. Patients’ characteristics at baseline.

|                  | Thermal ablation (n = 628) | Conventional thyroidectomy (n = 661) | p Value |
|------------------|-----------------------------|--------------------------------------|---------|
| Age (years)      | 46.3 ± 12.3                 | 50.0 ± 12.6                          | 0.000   |
| Sex (M/F)        | 172/456                     | 185/476                              | 0.322   |
| Nodule diameter (cm) | 3.5 ± 2.2             | 3.7 ± 1.9                            | 0.081   |
| Nodule volume (ml)  | 8.6 ± 9.8             | 8.9 ± 9.8                            | 0.538   |

M: male; F: female. Except for sex (M/F) and p-values, data are reported as mean ± standard deviations.
Table 3. Risk of bias of randomized controlled trial.

| Study          | Random sequence generation (selection bias) | Allocation concealment (selection bias) | Blinding of participants and personnel (performance bias) | Blinding of outcome assessment (detection bias) | Incomplete outcome data (attrition bias) | Selective reporting (reporting bias) | Other bias |
|----------------|---------------------------------------------|------------------------------------------|----------------------------------------------------------|-----------------------------------------------|----------------------------------------|------------------------------------|------------|
| Zhi et al. [21] | Low risk                                    | Low risk                                 | High risk                                                | Low risk                                      | Low risk                               | Low risk                           | Unclear    |

Table 4. Quality assessment of cohort studies.

| Study            | Selection | Comparability | Outcome | Score |
|------------------|-----------|---------------|---------|-------|
| Jin et al. [5]    | ★★★★☆☆☆☆ | ★            | ★★★★☆☆☆☆ | 8     |
| Yue et al. [18]   | ★★★☆★★★★ | ★            | ★★★★☆☆☆☆ | 7     |
| Che et al. [19]   | ★★★★☆☆☆☆ | ★            | ★★★★☆☆☆☆ | 8     |
| Bernardi et al. [20] | ★★★☆★★★★ | ★            | ★★★★☆☆☆☆ | 8     |
| Lang et al. [22]  | ★★★★☆☆☆☆ | ★            | ★★★★☆☆☆☆ | 7     |
| Liu et al. [23]   | ★★★★☆☆☆☆ | ★            | ★★★★☆☆☆☆ | 7     |

(i² = 0%, p = 0.61), while significant heterogeneity was observed in terms of hypothyroidism (i² = 100%, p < 0.000001) and postoperative pain (i² = 95%, p < 0.000001). Therefore, we summarized the data for hoarseness with a fixed-effects model, while hypothyroidism and postoperative pain were summarized with a random-effects model (Figure 2). Subgroup analyses and a sensitivity analysis for hypothyroidism and postoperative pain showed that the sources of heterogeneity were the study by CHE [19] and the study by YUE [18], respectively. Removing the studies had no effect on the results.

Efficacy

In terms of symptom improvement, the difference between thermal ablation and conventional thyroidectomy was not statistically significant [RR 1.02, 95% CI (0.94, 1.12)] (p = 0.58). The chi-square test and i² statistic indicated moderate heterogeneity (i² = 53%, p = 0.12) (Figure 3(A)). However, thermal ablation yielded significantly better postoperative cosmetic effects [RR 1.12, 95% CI (1.01, 1.24)] and was associated with a shorter hospitalization time [SMD −4.01, 95% CI (−4.22, −3.81)] than conventional thyroidectomy (p < 0.05) (Figure 3(B,C)). The chi-square test and i² statistic indicated no heterogeneity (i² = 0%, p = 0.34) in postoperative cosmetic effects but significant heterogeneity (i² = 95%, p < 0.000001) in hospitalization time. The results of the sensitivity analysis for hospitalization time were stable. Subgroup analyses of hospitalization time were conducted according to the publication year, study type and ablation method, but no source of heterogeneity was found.

Publication bias

A funnel plot suggested that publication bias of the included literature was less likely.

Discussion

This systematic review and meta-analysis of 1289 patients provides strong evidence through a comparison between thermal ablation and conventional thyroidectomy for the treatment of benign TNs. This study shows that, for benign TNs, ultrasound-guided thermal ablation may offer potential advantages in terms of safety, cosmetic effects and reduced hospitalization time compared with conventional thyroidectomy, while symptom improvement is the same.

Conventional thyroidectomy is the standard therapy for benign TNs requiring treatment, but it is not always the best choice. This method may lead to complications, cosmetic concerns, long hospital stays and other problems [24–26]. Whether it is worthwhile for patients to experience these problems in the course of treatment for benign disease is controversial [27]. Additionally, some patients’ poor health conditions make them unfit for thyroidectomy. Ultrasound-guided thermal ablation may be an excellent potential alternative treatment for benign TNs. The efficacy of thermal ablation for benign TNs has been demonstrated [28–30]. However, for benign TNs, it remains unknown whether thermal ablation is equivalent or even superior to conventional thyroidectomy. To our knowledge, no systematic reviews or meta-analyses evaluating the differences in safety and efficacy between ultrasound-guided thermal ablation and conventional thyroidectomy for benign TNs have been conducted.

This study shows that thermal ablation is safer than conventional thyroidectomy. Safety is a very important consideration when choosing a treatment for benign TNs. Serious complications resulting from the treatment of benign disease make the loss outweigh the gain. When the efficacy of different treatments is similar, we prefer to adopt thermal ablation. This view is consistent with some published guidelines and recommendations [31–33] on the treatment of TNs by thermal ablation. In a consensus [33] published by 29 physicians, based on literature review and consensus opinion of interdisciplinary experts, the possibility of thermal ablation as a first-line treatment for benign TNs was clearly proposed. In this study, we compare the safety of thermal ablation and conventional thyroidectomy in terms of three aspects: hoarseness, hypothyroidism and postoperative pain. Based on the previous systematic review of Mainini et al. [3] and Ha et al. [34], thermal ablation performed well in terms of safety. The incidence of major complications (including hoarseness and hypothyroidism) ranged from 0% (0/65) to 3.9% (9/233), and the incidence of minor complications (including postoperative pain) ranged from 0% (0/20) to 38.3% (224/584), which is consistent with our findings. In our study, the incidence of hoarseness was 1.56% (7/448) in the thermal ablation group and 4.78% (23/481) in the conventional thyroidectomy group; for hypothyroidism, it was 0% (0/520) and 31.10% (172/553); for postoperative pain, it was 32.24% (79/245) and 62.59% (174/278), respectively.
Our study showed that thermal ablation was superior to conventional thyroidectomy in the above aspects.

Hoarseness is a common major complication after thyroidectomy that may seriously affect the quality of life of patients. Our study showed that thermal ablation was superior to conventional thyroidectomy in terms of hoarseness, and the absence of heterogeneity indicated that the results were reliable. When thermal ablation is used to treat benign TNs, hydrodissection can be used to protect important blood vessels and nerves adjacent to TNs. Those who have difficulty implementing the hydrodissection technique can also choose to forego the treatment of dangerous areas adjacent to important blood vessels or nerves and instead only perform thermal ablation in relatively safe areas. Therefore, the incidence of hoarseness caused by thermal ablation is reasonably low.

Our study shows that the incidence of hypothyroidism in the thermal ablation group was significantly lower than that in the conventional thyroidectomy group. The impact on thyroid function is another important consideration in the treatment of benign TNs. Some patients may have hypothyroidism after surgery and will require lifelong levothyroxine, which will not only increase the financial burden but also cause long-term problems. Hypothyroidism occurred in none of the 520 patients in our study who underwent thermal ablation. However, the chi-square test and \( I^2 \) statistic indicated significant heterogeneity (\( I^2 = 100\%, p < 0.00001 \)). Subgroup analyses and a sensitivity analysis showed that the source of heterogeneity was the study by CHE [19]. This may be because of the large proportion (151/200) of patients who underwent total thyroidectomy, resulting in a relatively large proportion (143) of hypothyroidism in the conventional thyroidectomy group, which was much more than the proportion in the other studies. Since removing the study of CHE [19] had no effect on the results, we consider the results to be valid. Thermal ablation is a delicate treatment performed under ultrasound guidance, and this technique causes less damage to normal thyroid tissue around TNs. Therefore, patients with normal thyroid function rarely experience hypothyroidism after ablation. We believe that this is the most important advantage of thermal ablation.

Although postoperative pain is not a serious complication, it is still an indicator of great concern to patients. In this study, the incidence of postoperative pain in the thermal ablation group was significantly lower than that in the conventional thyroidectomy group. The chi-square test and \( I^2 \) statistic for postoperative pain indicated significant heterogeneity (\( I^2 = 95\%, p < 0.00001 \)). A sensitivity analysis showed that the source of heterogeneity was the study by YUE [18]. We suspect that this finding might be related to the pain

![Figure 2](image-url)
grading method, the timing of pain assessment or the anesthetic method used for thermal ablation; however, these factors were not elaborated in the articles, so our hypotheses cannot be verified. Although the heterogeneity of postoperative pain was significant, removing the study of YUE [18] had no effect on the results, so we propose that the results are valid. Since thermal ablation is a minimally invasive treatment compared with thyroidectomy, it is reasonable that this approach will cause less postoperative pain.

In addition to safety, another important concern in the treatment of benign TNs is efficacy. Since patients with benign TNs mainly undergo treatment due to symptoms of compression and cosmetic problems, we mainly compared the efficacy of thermal ablation and conventional thyroidectomy in terms of symptom improvement, postoperative cosmetic effects and hospitalization time. Previous studies [35–39] have shown that the volume of benign TNs can be significantly reduced within 12 months after treatment with any kind of thermal ablation, and this reduction in size will continue during long-term follow-up. Some recent meta-analyses [40,41] have indicated that thermal ablation can not only significantly reduce the volume of benign nonfunctioning solid TNs, but also be effective for autonomous functioning TNs. Therefore, both conventional thyroidectomy and thermal ablation can significantly improve the patient’s symptoms. Our included clinical trials showed that the benign TN volume decreased significantly after thermal ablation, and the nodules continued to shrink over time. The difference between thermal ablation and conventional thyroidectomy was not statistically significant in terms of symptom improvement (p = 0.58). Therefore, the efficacy of thermal ablation can be considered to be the same as that of thyroidectomy. We also compared the postoperative cosmetic effects and hospitalization time of the two treatments. As thermal ablation is a minimally invasive treatment, patients may experience better cosmetic satisfaction and shorter hospitalization times. These findings were confirmed in our study. Thermal ablation performed better in terms of the postoperative cosmetic effects and showed no heterogeneity (I² = 0%, p = 0.34), which indicated that the results were reliable. As thermal ablation is a minimally invasive treatment (the surgical incision is only 1–2 mm for laser, radiofrequency and microwave ablation, and there is no wound for high-intensity focused ultrasound ablation), the cosmetic effects after thermal ablation are significantly better than those after conventional thyroidectomy. Furthermore, because of the rapid recovery after minimally invasive treatment, the hospitalization time of patients treated with thermal ablation is considerably shorter than that of patients treated with conventional thyroidectomy.

Although thermal ablation is superior to conventional thyroidectomy in many aspects, it should be noted that the pathological results before thermal ablation were obtained by fine-needle aspiration (FNA) or core needle biopsy (CNB), which could yield false negative or false positive results. Therefore, we believe that patients should undergo thermal

Figure 3. (A) Forest plot of symptom improvement. Forest plot of symptom improvement analyzed by relative risk (RR) ratio with 95% confidence intervals. The size of the data markers indicates the weight in the analysis. (B) Forest plot of postoperative cosmetic effect. Forest plot of postoperative cosmetic effect analyzed by relative risk (RR) ratio with 95% confidence intervals. The size of the data markers indicates the weight in the analysis. (C) Forest plot of hospitalization time. Forest plot of hospitalization time analyzed by standard mean difference (SMD) with 95% confidence intervals. The size of the data markers indicates the weight in the analysis.
Thermal ablation may have potential advantages in terms of safety, cosmetic effects and shorter hospitalization time compared with conventional thyroidectomy. However, the complete absence of surgery should be the first-choice treatment [42]. Consequently, we believe that a comprehensive preoperative evaluation should be performed that includes a reliable preoperative diagnosis and assesses the feasibility of thermal ablation. Only when these two conditions are simultaneously satisfied is thermal ablation preferred for benign TNs.

To our knowledge, our study is the first systematic review and meta-analysis to compare the safety and efficacy of thermal ablation and conventional thyroidectomy in terms of multiple parameters, including hoarseness, hypothyroidism, postoperative pain, symptom improvement, postoperative cosmetic effects and hospitalization time. The strengths of the review include the multilevel article screening system, the comprehensive and up-to-date search, the scientific assessment of evidence risk and publication bias and rigorous data extraction and analysis. Overall, our study had a low risk of bias. Although some results were heterogeneous, and sensitivity and subgroup analyses were performed, the results were still reliable.

It should be emphasized that inhomogeneity still exists in how the information of thermal ablation is presented and reported among different studies, which have not only caused some difficulties to our analysis, but also created barriers to academic exchanges between different institutions and doctors. The proposal of the Italian working group [43] on the standardization of terminology and reporting criteria is really helpful to avoid such problems, which also reminds us of our future research.

There were some limitations in our study. First, because of some practical difficulties, such as patient recruitment, physical condition and subjective intention, there was not a sufficient number of RCTs for inclusion, which may have led to selection bias. Second, the selection of different surgical methods, including total thyroidectomy and hemithyroidectomy, may have led to bias. Third, to compare two completely different therapies, surgery and thermal ablation, we pooled several types of thermal ablation together for the analysis, which presented a meaningful hypothesis but may have led to bias. Finally, the included studies showed that the maximum follow-up period was up to one year after treatment, and there were not enough long-term follow-up data for further study.

Conclusion

This study shows that for benign TNs, ultrasound-guided thermal ablation may have potential advantages in terms of safety, cosmetic effects and shorter hospitalization time compared with conventional thyroidectomy, while symptom improvement is the same.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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