# Thyroid Radiofrequency Ablation

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## Introduction

Ultrasound (US)-guided radiofrequency ablation (RFA) for thyroid lesions is a minimally invasive surgical treatment method alternative to surgery in patients with symptomatic benign thyroid nodules as well as in patients with recurrent thyroid cancers at high surgical risk or in inoperable symptomatic condition. Since the Korean Society of Thyroid Radiology (KSThR) has proposed preliminary recommendations for thyroid RFA in 2009 and second recommendations in 2012, abundant meaningful evidence and consensus expert opinions led to a new updated recommendation in 2017 regarding the use of thyroid RFA[1-3]. Based on recent updated recommendations, the purpose of this lecture is to review the current evidences of thyroid RFA, focusing on its efficacy and safety, and to introduce the recent issues.

## Indications for thyroid RFA

1) Radiofrequency ablation is indicated for patients with benign thyroid nodules complaining of symptomatic or cosmetic problems. Thyroid nodules should be confirmed as benign on at least two US-guided fine-needle aspirations (FNA) or core needle biopsy (CNB) before RFA.
2) Radiofrequency ablation can be indicated for either toxic or pre-toxic autonomously
functioning thyroid nodule (AFTN).
3) Radiofrequency ablation can be performed for curative or palliative purposes in the recurrent thyroid cancers at the thyroidectomy bed and cervical lymph nodes for patients at
high surgical risk or who refuse surgery.
4) Follicular neoplasms or primary thyroid cancers remains still debatable.

**Pre-procedural checklist from 2017 Thyroid Radiofrequency Ablation Guideline**

| Benign Thyroid Nodule | Recurrent Thyroid Cancer |
|---|---|
| Pathologic diagnosis | Pathologic and/or serologic diagnosis |
| Benign diagnosis at least two US-guided FNA or CNB | Cancer recurrence at US-guided FNA or CNB |
| Benign diagnosis at least one US-guided FNA or CNB in AFTN | Increased washout Tg level in aspirate or Tg immunostain of CNB specimen |
| Benign diagnosis at least 1 US-guided FNA or CNB in thyroid nodules with highly specific benign US features | Increased washout calcitonin level in aspirate or calcitonin immunostaining of CNB specimen in patients with medullary cancer |
| US | US |
| Features of nodule and surrounding critical structures | Features of nodule and surrounding critical structures |
| Nodule volume | Tumor volume |
| Symptom score | |
| Cosmetic score | |
| Laboratory tests | Laboratory tests |
| Complete blood count | Complete blood count |
| Blood coagulation battery | Blood coagulation battery |
| Thyroid function test | Thyroid function test |
| Serum TSH | Serum TSH |
| Serum T3 | Serum T3 |
| Serum fT4 | Serum fT4 |
| CT or MRI* | CT or MRI* |
| $^{99m}$Tc pertechnetate or $^{123}$I thyroid scan† | |

*Selectively indicated, †Indicated for AFTN. AFTN = autonomous functioning thyroid nodule, CNB = core-needle biopsy, CT = computed tomography, FNA = fine-needle aspiration, fT4 = free thyroxine, MRI = magnetic resonance imaging, Tg = thyroglobulin, TSH = thyrotropin, T3 = triiodothyronine

**Standard techniques and Devices**

For pain control of RFA of benign thyroid nodules, local anesthesia, rather than general anesthesia or deep sedation, is recommended. Perithyroidal lidocaine injection is recommended for local anesthesia technique.

For RFA of benign thyroid nodules, the trans-isthmic approach method and moving-shot technique are recommended as the standard procedure.

For RFA of recurrent thyroid cancers, perilesional lidocaine injection, the hydrodissection technique, and the moving-shot technique are recommended as standard techniques.

In 'moving-shot technique', thyroid nodules are divided into multiple small conceptual ablation units and RFA is performed unit by unit by moving the electrode. RFA is terminated when all conceptual ablation units of the targeted nodule have become transient hyperechoic zones. A modified, straight-type, internally cooled electrode for thyroid RFA is short (7 cm) and thin (18-19G) for easy to control, with active tips of various sizes (0.5, 0.7, 1.0, or 1.5 cm). The RF power and size of active tip is decided depending on the size and the internal characteristics of the nodules. With 1 cm active tip, ablation is usually performed with 30–50 watts of RF power.

As an innovative method, artery-first ablation technique can be applied to hypervascular thyroid nodules with prominent feeding artery[4]. This technique ablates the main feeding artery as the first step, and can be easily applied to a nodule with a feeding artery entering through the isthmus. Marginal venous ablation technique is used for thyroid nodules with prominent marginal draining veins.

Regarding the devices, a new 3.8 mm electrode tip is developed for the treatment of smaller recurrent cancers. New bipolar electrode simplifies the procedure without grounding pads and makes a safe treatment in pregnant women and in patients with implanted electrical devices. Virtual needle tracking system proposed is helpful for less-experienced operators for continuous monitoring of the needle tip during the RFA[5] New unidirectional ablation electrode (270° of insulation) creates a half-moon-shaped ablation zone, which ablates tumors that are partially attached to a critical structure without causing thermal injury[6]. An adjustable electrode can use various sized active tips within one electrode, which is economical. The smaller units are treated using the smaller active tip of the adjustable electrode, whereas the larger units are treated using the larger active tip of the adjustable electrode by controlling the button in a single electrode. This electrode can reduce RFA procedure time for a large nodule.

**Post-procedural checklist from 2017 Thyroid Radiofrequency Ablation Guideline**

| Benign Thyroid Nodule | Recurrent Thyroid Cancer |
|---|---|
| US<br>Features of ablated zone to detect under-ablated portion with vascularity on color-Doppler US | US<br>Features of ablated zone to detect under-ablated portion with vascularity on color-Doppler US |
| Nodule volume | Tumor volume |
| Symptom score | - |
| Cosmetic score | - |
| Laboratory tests<br>Thyroid function test* | Laboratory tests<br>Thyroid function test |
| Serum TSH | Serum TSH |
| Serum T3 | Serum T3 |
| Serum fT4 | Serum fT4 |
| | Serum Tg, anti-Tg antibody |
| CT or MRI*<br>$^{99m}$TC pertechnetate or $^{123}$I thyroid scan† | CT or MRI* |

*Selectively indicated, †Indicated for AFTN.

**Clinical outcomes**

Many clinical trials have demonstrated the mean volume reduction rate of 32.7–58.2% at 1 month and 50.7–84.8% at 6 months for RFA of benign thyroid nodules. Nodule-related symptoms and cosmetic problems are also significantly improved or disappeared in most patients. In a long term follow-up study, RFA was effective over a 4- year follow-up period with consistently decreasing the nodule volume until the last follow-up, up to 93.5%. A systematic review with meta-analysis, and indirect comparison study with laser ablation, also presented a strong evidence of RFA for benign thyroid nodules .

RFA for AFTNs showed volume reduction rates of 52.6 to 70.7% at 6 months, and improved or normalized thyroid function in most patients. In a multicenter study, hyperthyroidism caused by AFTN improved in all patients and completely normalized in

81.8% of patients; therefore, they concluded that RFA can be considered an alternative to surgery or radioiodine therapy. However, since untreated peripheral portions of AFTNs could interfere with improvements in thyroid function, complete ablation is required for AFTNs. A greater number of treatment sessions are usually required for AFTN than non-functioning nodules (2.2 versus 1.4).

RFA also effectively controlled locoregional, recurrent thyroid cancers. The volume reduction rate was 56.0-95.1% and complete disappearance was 42.0–82.0% in previous studies. Serum thyroglobulin levels were also decreased after treatment in most patients and recurrences of the completely treated lesions were uncommon. Therefore, it was suggested that RFA may replace "berry picking surgery" in selected patients. RFA of inoperable patients with symptomatic, recurrent cancers resulted in a mean volume reduction of 50.9% and symptom relief in 63.6% patients.

**Complications of Thyroid RFA**

For benign nodules, the overall complication rate was 2.11% and the major complication rate was 1.27%. For recurrent thyroid cancers, the overall complication rate was higher, 10.98% and the rate of major complications of 6.71%. Various complications have been reported including nerve injuries (recurrent laryngeal nerve, cervical sympathetic ganglion, brachial plexus, and spinal accessory nerve), nodule rupture, permanent hypothyroidism as a major complication and hematoma, vomiting, skin burn, transient thyrotoxicosis, lidocaine toxicity, hypertension and pain as a minor complication. However, there were no life-threatening complications and the sequale rate was 0.21%.

Among the complications, the nerve injuries could be a serious problem in practice. Several nerves are located around the thyroid gland such as recurrent laryngeal nerve, vagus nerve, cervical sympathetic ganglion, cervical/brachial plexus, phrenic nerve, and spinal accessory nerve, and they could be damaged during the procedure. Voice changes, by thermal injury to the recurrent laryngeal nerve or vagus nerve, are the most common major complication, reported to be approximately 1.0%. Horner syndrome by injury to the middle cervical sympathetic ganglion, tingling sense by injury to the brachial plexus, or drooping shoulder by injury to the spinal accessory nerve also have been reported after RFA of benign thyroid nodules and/or recurrent thyroid cancers. To prevent the nerve injuries, identification of a nerve by US and careful observation during the procedure is necessary; then, if the nerve is located close to the thyroid nodule, it is necessary to under-treat the nodule margin to prevent the nerve injuries. The 'trans-isthmic approach' and 'moving-shot technique' are helpful to prevent the nerve injuries.

Nodule rupture and hypothyroidism are rare, but possible complications. Delayed bleeding from intranodular microvascular leakage, post-procedural massage or movements of the neck are the causes of nodule rupture. Although conservative

treatment without aspiration is usually enough for the treatment, surgical drainage could be required if the mass causes abscess formations. Regarding the hypothyroidism, patients with elevated thyroid antibodies before the treatment or patients with AFTN seems to have a higher risk for developed hypothyroidism after the treatment. Therefore, it is recommended to warn the patients with thyroid antibodies or the patients with AFTN about the possibility of hypothyroidism before the procedure.

**Conclusion**

RFA is an effective and safe option for the treatment of benign thyroid nodules and recurrent thyroid cancers with a low incidence of complications. Thyroid RFA should be performed by well-trained experts and facilities. Acceptable indications under the guidelines should be chosen.

**References**

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