



# Novel approach of thyroid radiofrequency ablation for huge nodules – Eggshell technique (evenly margin-preserving ablation): a case report

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**Background:** Radiofrequency ablation (RFA) for huge thyroid nodules often requires multiple sessions to achieve long-term efficacy. We present our experience with a stepwise approach utilizing a nodule margin-preserving ablation, termed the Eggshell technique, in the treatment of a thyroid nodule exceeding 9 cm in diameter.

**Case Description:** A 44-year-old woman presented with compressive symptoms due to a large left thyroid solid nodule measuring 5.81 cm × 3.19 cm × 9.26 cm, with a volume of 90.84 mL. Cytopathology, including core needle biopsy, confirmed Bethesda Category II in two separate evaluations. RFA was performed under local anesthesia using the Eggshell technique, which preserved the nodule margin while ablating the internal tissue. The procedure lasted 83 minutes, delivering a total energy of 38.59 kJ. At 6 months, the nodule volume decreased to 29.75 mL [volume reduction ratio (VRR) 67.25%]. After three additional sessions, the volume further reduced to 1.59 mL (VRR 98.25%) at 42 months. The patient experienced minimal pain (pain score 1), with no hemorrhage, post-ablation edema, or nodule rupture. Serial ultrasonography allowed precise visualization of residual tissue, optimizing the timing of subsequent ablations.

**Conclusions:** This case suggests that the Eggshell technique, an evenly margin-preserving RFA strategy, may be a valuable option for managing huge thyroid nodules that inevitably require multiple sessions. By minimizing patient discomfort and complications, and facilitating decision-making during follow-up, this approach can complement conventional RFA techniques for large nodules.

**Keywords:** Thyroid; goiter; radiofrequency ablation (RFA); technique; case report

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## Introduction

When treating thyroid nodules that cause nodule-related discomfort with radiofrequency ablation (RFA), achieving long-term therapeutic effects comparable to surgery requires

ablating as much of the nodule as possible to minimize the risk of marginal regrowth. This may necessitate multiple ablation sessions (1). In the case of a huge goiter, nodules often extend beyond the thyroid parenchyma and are in

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contact with surrounding organs, with prominent blood vessels around the nodules. Therefore, when ablating the margin of the nodule, patients may experience more pain during treatment, and there is a higher risk of hemorrhage and hematoma of the blood vessels around the nodule margin, which can make it difficult to obtain an adequate ultrasound view (2). Ultimately, the rate of complications related to the possibility of heat damage to surrounding tissues increases. The duration of RFA procedure also extends. Additionally, adhesion of nodules and surrounding tissues or nodule rupture related to such as inflammatory changes in the ablated nodule during long-term follow-up is also an important complication. Since large nodules often require additional treatment, the probability of such complications is elevated (3).

While there have been studies on the need and timing of additional treatment and procedural tips to reduce complications in thyroid RFA, there is no unified or recommended strategy for treating large nodules that inevitably have a viable portion remaining after the first treatment (1,4-6). In this article, we present our experience and opinions on this subject. We present this article in accordance with the CARE reporting checklist (available at <https://gs.amegroups.com/article/view/10.21037/gs-2025-270/rc>).

### Highlight box

#### Key findings

- A >9 cm benign thyroid nodule was successfully treated with radiofrequency ablation (RFA) using the Eggshell technique, which intentionally preserves the nodule margin evenly.
- This technique minimized patient discomfort and procedural complications while enhancing follow-up ultrasound visualization, allowing precise timing for additional treatments.

#### What is known and what is new?

- Large thyroid nodules often require multiple RFA sessions, but no standardized approach addresses residual margins.
- We propose an intentionally margin-preserving RFA technique that provides safer treatment, improved comfort, and streamlined follow-up.

#### What is the implication, and what should change now?

- Margin-preserving RFA may reduce complications and improve decision-making during follow-up.
- It can serve as a neoadjuvant strategy or as a minimally invasive, scar-free alternative to surgery.

## Case presentation

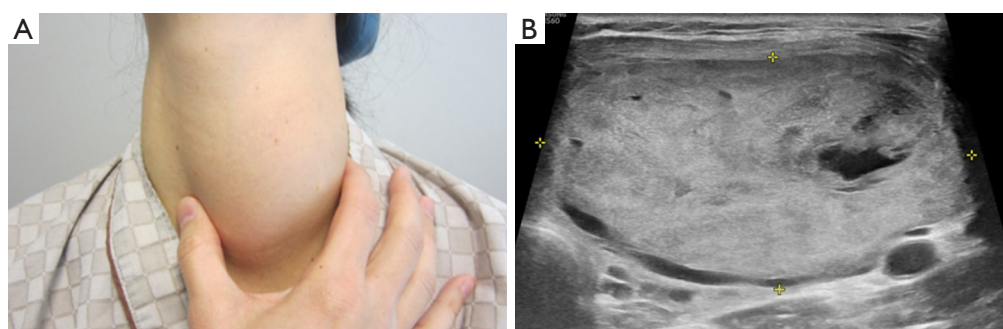
### Patient information

A 44-year-old female presented with a left anterior bulging neck and pressure symptoms (*Figure 1A*). Ultrasonographic examination identified a solid left thyroid nodule with notable perinodular vasculature, measuring 5.81 cm in width, 3.19 cm in depth, 9.26 cm in height, and a volume of 90.84 mL (*Figure 1B*). Bethesda Category II was confirmed in two cytopathologic evaluations including core needle biopsy. She had no history of prior surgery or interventional treatment for the thyroid nodule. The patient desired a scar-free neck, but due to the volume of the nodule, more than three or four sessions of RFA were expected (7), and considering the diameter and volume of the nodule, immediate remote access (endoscopic or robotic) surgery was not feasible (8). Therefore, a two-step approach was planned, involving neoadjuvant therapy with RFA followed by debulking of the nodule to enable remote access thyroidectomy, maintaining a scar-free neck through transoral robotic thyroidectomy.

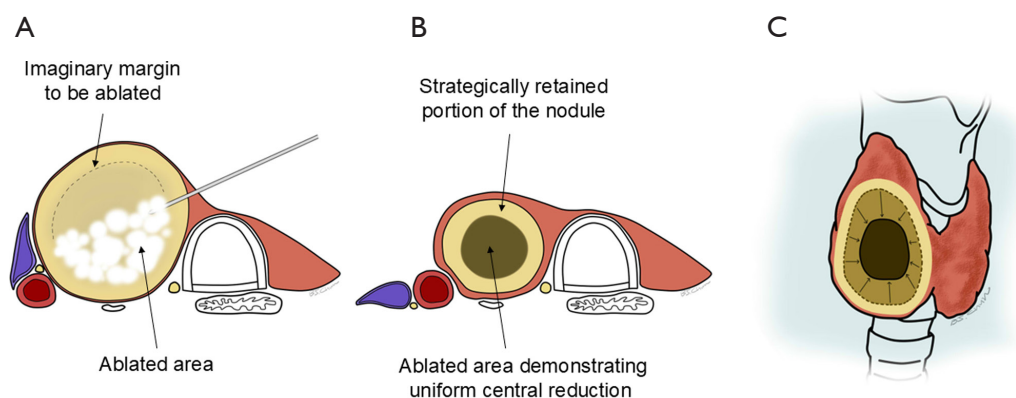
### RFA with an evenly margin-preserving ablation technique (Eggshell technique)

When treating huge thyroid nodules, the authors intentionally conducted RFA while preserving the nodule margin, naming it the Eggshell technique (*Figure 2*). The Eggshell technique involves conducting ablation while preserving the margin tissues closely located to the nodule capsule. Typically, conduction heat can affect approximately 3–5 mm, so a virtual margin (Eggshell) of about 5 mm thickness is set from the electrode tip, and only the interior is ablated (9). The interior is treated using the moving shot technique similar to conventional RFA (*Figure 2A*). RFA was conducted using RF300 generators (Apro-Korea, Gunpo, Republic of Korea) and straight-type modified internally cooled electrodes, CoATherm (Apro-Korea), featuring active tip lengths of 7 mm. The procedure lasted 83 minutes and utilized a total energy of 38.59 kJ. The patient reported a minimal pain score of 1.

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Declaration of Helsinki and its subsequent amendments. Written informed consent for publication of this case report



**Figure 1** Eggshell technique of RFA. (A) The Eggshell technique of RFA is utilized when treating huge nodules where it is inevitable to have a viable portion remaining post-treatment. This technique involves treating the interior of the nodule while maintaining a consistent distance from surrounding structures. (B) After the central portion of the nodule has been adequately absorbed as observed in follow-up ultrasound examinations, reassessment is conducted. If necessary, the same technique is repeated. Once the nodule is sufficiently separated from surrounding structures, complete ablation of the nodule is performed. (C) An oblique view of a treated thyroid nodule shows uniform reduction towards the center, indicating a centripetal pattern. This allows for easier prediction of the treated and retained portions of the nodule during follow-up observations after RFA, minimizing damage to surrounding tissues and providing flexibility in selecting additional treatment options. RFA, radiofrequency ablation.



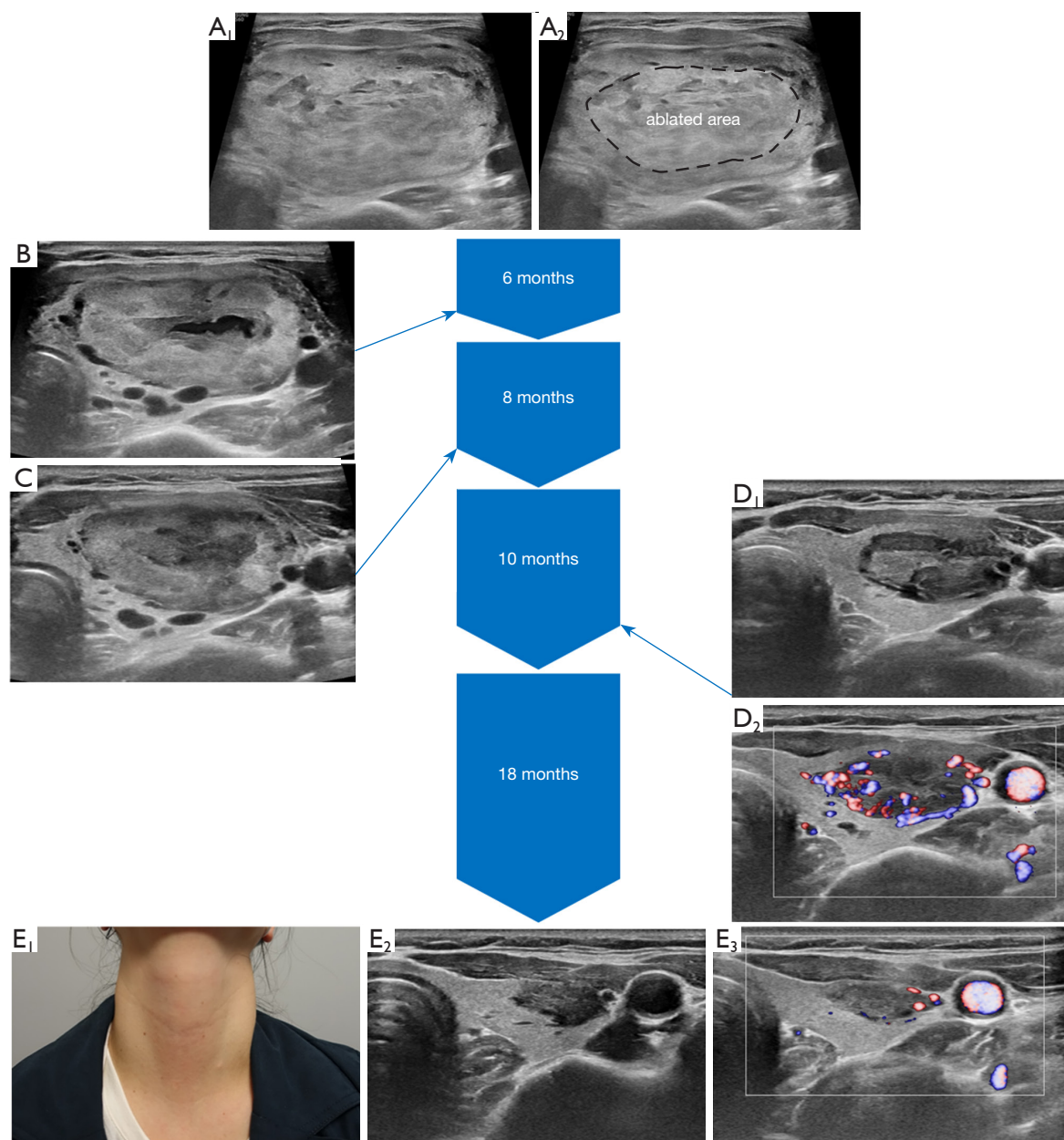
**Figure 2** Patient profile and thyroid US. (A) A 44-year-old female presenting with an anterior neck bulge and pressure symptoms. (B) US shows a predominantly solid, isoechoic nodule in left thyroid lobe, measuring 5.81 cm × 3.19 cm × 9.26 cm (width × depth × height), with an estimated volume of 90.84 mL. The nodule was confirmed to be benign based on two cytopathologic evaluations, including one core needle biopsy. US, ultrasonography.

and accompanying images could not be obtained from the patient or her relatives despite all reasonable efforts.

### Post-ablation follow-up

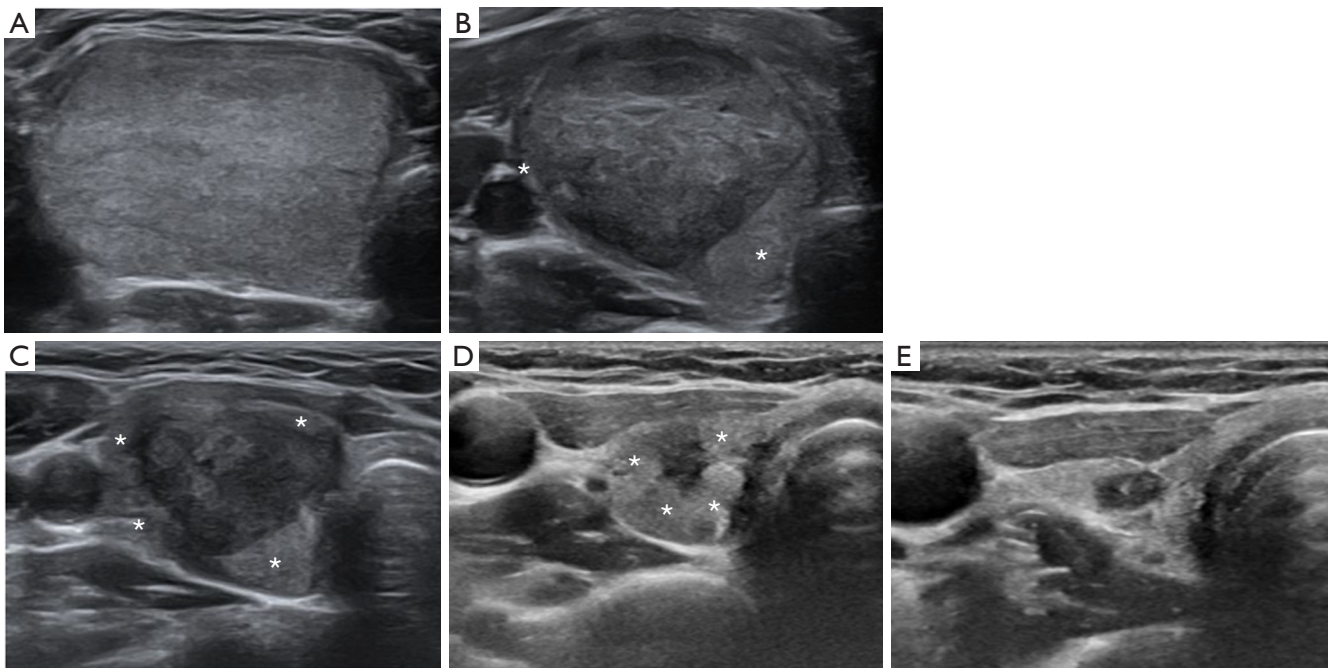
Right after RFA, the internal ablated area and the outer preserved area were clearly distinguishable, with no evidence of peri-nodular hemorrhage or edema (*Figure 3A*). Six months later, the volume of the nodule decreased to 29.75 mL, and it was confirmed, and easily discernible

on follow-up ultrasound, that the ablated area had been sufficiently absorbed (*Figure 3B*). As the volume was considered suitable for remote access surgery, the plan was to proceed with transoral robotic thyroidectomy. However, due to the favorable response to the initial RFA, the patient preferred an additional RFA session. In consultation with the patient, the previously planned remote access thyroidectomy was postponed, and a decision was made to perform another RFA session followed by re-evaluation. To minimize potential impact on any future



**Figure 3** Timeline of case progression. Chronological summary of key clinical and imaging findings. (A<sub>1</sub>,A<sub>2</sub>) US immediately after the first RFA using the Eggshell technique shows intentionally preserved viable tissue at the nodule margin. No edema or hematoma is observed within the nodule or surrounding thyroid parenchyma. (B) Six-month follow-up US demonstrates a reduction in nodule volume, with shrinkage of the central ablated area. The volume decreased to 29.75 mL, suitable for the pre-planned remote access thyroidectomy. However, the patient opted to continue with RFA, and a second session using the Eggshell technique was performed. (C) Eight months after the second RFA, US reveals exposure of the anterior and lateral thyroid parenchyma surrounding the nodule. The nodule volume had decreased to 15.51 mL, making any treatment modality feasible. The patient chose to proceed with a third RFA, and surgical intervention was no longer considered. Complete ablation was achieved using the conventional RFA technique. (D<sub>1</sub>,D<sub>2</sub>) Ten months after the third RFA, US shows a further reduction in volume to 5.29 mL. Color Doppler reveals intranodular vascularity, and an additional RFA session was performed to prevent regrowth. (E<sub>1</sub>-E<sub>3</sub>) Eighteen months after the fourth RFA (42 months after the initial RFA), the nodule volume decreased to 1.59 mL. Symptom resolution was achieved, and perilesional vascularity markedly decreased. RFA, radiofrequency ablation; US, ultrasonography.





**Figure 4** Conventional thyroid RFA procedure. During initial treatment, most of the nodule is ablated, except for areas adjacent to the tracheoesophageal groove (“danger triangle”) and major surrounding structures. Asterisk indicates undertreated viable portions of the nodule. (A) Pre-treatment ultrasonography shows an isoechoic thyroid nodule approximately 20 mL in volume (confirmed to be benign based on two separate cytopathologic evaluations), causing nodule-related symptoms. (B) Immediate post-RFA image following selective preservation of areas adjacent to the danger triangle and carotid sheath. (C) Seven months post-RFA. As the treated area shrinks over time, multiple residual lesions appear unintentionally along the nodule margins. (D) Thirty-four months post-RFA. Most of the ablated area has been absorbed, with residual lesions observed along the nodule periphery. At this stage, hydrodissection was employed to protect adjacent structures during additional RFA. (E) Nineteen months after the additional RFA. The nodule is now seen as a small, scar-like remnant. RFA, radiofrequency ablation.

surgery, the same approach (Eggshell technique) was applied. Fourteen months later (8 months after the second treatment), the volume of the nodule decreased to 15.51 mL (*Figure 3C*). It was determined that the volume was sufficient for any type of remote access thyroidectomies and also suitable for further RFA treatment. The patient opted for additional RFA treatment, and this time, it was agreed not to perform additional surgical procedures, assuming that all nodule margins were ablated. Twenty-four months later (10 months after the third treatment), the volume of the nodule decreased to 5.29 mL (*Figure 3D, D<sub>1</sub>*). As there was vascularity observed on Color Doppler, an additional treatment was performed to prevent regrowth (*Figure 3D, D<sub>2</sub>*). Forty-two months later (18 months after the fourth treatment), the volume of the nodule decreased to 1.59 mL, and the vascularity on Color Doppler had significantly decreased and remained stable (*Figure 3E*).

## Discussion

To minimize damage to surrounding organs while maximizing ablation of nodules, it is recommended to treat nodules by preserving areas where the recurrent laryngeal nerve, located within the danger triangle (tracheoesophageal groove), and other structures such as the vagus nerve (laterally) and sympathetic ganglion (posteriorly) are closely positioned (10). However, as the treated area diminishes, unexpected viable portions of the nodule margin may be observed during the follow-up process (1). Especially in the case of huge nodules, not only specific areas such as the tracheoesophageal groove and carotid sheath but also adjacent tissues outside the thyroid parenchyma are often in contact with the nodules due to their large initial volume. Moreover, changes in the anatomical positions of surrounding structures such as vessels, nerves occur due to

the large volume of the nodule (11). In other words, after performing the initial RFA, not only specific areas serving as landmarks like the danger triangle are preserved, but also multiple residual lesions within the irregular nodule interior and margin are left behind (*Figure 4*). This results in uneven reduction of the nodules during the follow-up process, which may not affect the treatment outcome in the short term but could lead to regrowth if left untreated in the long term, making additional treatment challenging. Therefore, residual lesions observed during the follow-up process at the nodule margin must be treated, and additional treatment should be planned after the ablated area has sufficiently absorbed and reduced (1,4). Hydrodissection may be concurrently performed during this process (5,6).

The primary objective of preserving the nodule margin strategically during RFA (Eggshell technique) is to facilitate easy observation of untreated areas during the follow-up process, particularly in cases where it is inevitable that some portion of the nodule's interior will remain due to its significant size. Additionally, it aims to minimize damage to prominent vessels surrounding the nodule during the procedure, reducing the occurrence of hemorrhage and hematoma, securing adequate ultrasound visibility, and minimizing patient discomfort. Furthermore, by avoiding thermal injury to the tissues surrounding the nodule, it aims to reduce adhesion with surrounding tissues post-treatment, potentially avoiding nodule rupture and interference with subsequent combined procedures like remote access thyroidectomy after volume reduction.

During the ablation using the Eggshell technique, the patient experienced minimal pain (pain score 1), and there were no occurrences of hemorrhage or voice changes during treatment. Treating only the interior of the nodule without the need to be concerned about the anatomical positioning of surrounding structures, which may be altered due to the presence of a large nodule, reduces the risk of surrounding organ injury. Additionally, tracking the reduction in nodule volume during follow-up ultrasound was easy. Especially, measuring the total volume, treated volume, and residual volume was convenient (4). Although this is a single case study, the patient did not experience nodule rupture during repeated treatments. While the patient in the case did not undergo additional surgery after RFA as per the patient's preference, it was confirmed that the volume of the nodule decreased to a level sufficient to proceed with remote access thyroidectomy after debulking (8).

However, the use of this technique as a primary treatment for large nodules has limitations, as it often necessitates

additional therapy such as repeat RFA or transoral robotic thyroidectomy to maintain a scar-free neck. From a surgical perspective, patients should receive thorough counseling before and after RFA with the Eggshell technique. They need to understand that an unsatisfactory response to the initial RFA may limit the benefit of further sessions, making surgery a more appropriate option, and that insufficient debulking could ultimately require conventional thyroidectomy. Importantly, conventional thyroidectomy, as a one-time definitive treatment, may be more cost-effective than multiple RFAs or combined approaches with remote access surgery. Thus, careful discussion is essential to balance the patient's desire to avoid an anterior neck scar and preserve thyroid function against the economic and clinical advantages of conventional surgery.

Further research is necessary to ascertain whether adhesion between the nodule and surrounding tissues is less frequent following RFA utilizing the Eggshell technique compared to conventional RFA. Additionally, it is essential to investigate whether the volume reduction assists in the extraction of the thyroid gland and nodule during remote access thyroidectomy. Nevertheless, there remains a possibility of combining two seemingly contrasting treatment strategies—surgical removal and interventional therapy—and in such an approach, nodule margin-preserving ablation could play a supportive role. Although this technique was applied and followed up more than once in the same patient, broader validation is required. In particular, it will be important to compare outcomes across a larger patient cohort through multicenter studies where similar techniques are consistently applied, to better establish reproducibility and clinical applicability.

### *Patient perspective*

I was fully informed about the advantages, disadvantages, and possible complications of conventional surgery, remote access surgery, and interventional therapy. I preferred to avoid surgery under general anesthesia and wanted to preserve my thyroid function if possible. I understood the limitations of each treatment option and the need for careful decision-making, and I actively participated in the process through discussions with my physician.

### **Conclusions**

The nodule margin preserving ablation technique (Eggshell technique) is expected to be helpful when treating huge

thyroid nodules by reducing patient pain during treatment and avoiding damage to surrounding tissues. It also facilitates easy monitoring of nodule volume reduction during the follow-up process. Furthermore, it is anticipated that utilizing neoadjuvant ablation as a method can aid in planning a combined approach, incorporating additional remote access surgery to maintain a scar-free neck.

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## Footnote

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**Ethical Statement:** The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Declaration of Helsinki and its subsequent amendments. Written informed consent for publication of this case report and accompanying images could not be obtained from the patient or her relatives despite all reasonable efforts.

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