Virtually-tracked US-guided Radiofrequency Ablation (RFA) of Benign Thyroid Nodules: Preliminary Results

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1. Purpose

Benign thyroid nodules represent common findings during clinical examination and US evaluation. Basically they do not represent any serious problem for the patient, anyway, sometimes, may require treatment for associated symptoms and/or because of cosmetic problems. As a curative therapy, surgery has several limitation due to its intrinsic risks, further, not all patients may easily undergo surgery; hence nonsurgical, minimally invasive percutaneous treatment modalities, such as radiofrequency ablation (RFA), have been used to treat thyroid nodules. The results of this modality of treatment have been promising and no significant complication have been observed; in this setting the skills of the radiologist play a determinant role for the RFA outcomes. Recently a virtual guiding system for the RFA of nodules under US examination has been presented in order to help the operators dealing with most difficult cases.

Our purpose was to evaluate the safety and effectiveness of virtual needle tracking system for US-guided percutaneous RFA of benign thyroid nodules as compared to standard RFA.

2. Materials and Methods

VIRTUALLY-TRACKED RFA PROCEDURE

Prior to treatment thyroid nodules were examinated by ultrasound in order to evaluate their morphologic and intrinsic features and the anatomic relationships between them and the critical surrounding anatomic structures. The virtual needle tracking system (VirtuTRAX, CIVCO, USA) was used together with the volume navigation system (V-Nav, LOGIQ-E9; GE Healthcare, USA). The system has a GPS tracking capability able to generate a three-dimensional operating volume around the patient. Two electromagnetic position sensors connected with a position-sensing unit were attached on a 6-15 MHz linear probe (GE Healthcare, USA) through a bracket. For the needle tracking a similar sensor was secured on the shaft of the 18-gauge RF electrode (STARmed, Korea). The expected needle path is graphically superimposed on the B-mode image with a line in different colours according to its orientation with the imaging plane.

Virtual Tracking components

![Virtual Tracking components](image)

Left: Magnetic field generator. Center: Probe with sensors. Right: RFA needle with sensor.

All patients were pre-treated with 2-5 ml of 2% lidocaine for local anesthesia. The ablation procedure was performed using a radiofrequency generator (Viva RF generator VRS01, STARmed, Korea). The nodules were treated with the “transisthmic approach” and “moving shot” technique, with steps of 5-10 s (RF power range between 70-80W in the centre of the nodule; 30-40 W in proximity of nodule margins). During the procedure and right after it patients conditions were monitored in order to make safety the priority of our treatments. After the procedure patients were
clinically evaluated in order to detect the presence of voice changes and skin burns and re-evaluated with US to have a preliminary assessment of the outcomes and to exclude any kind of complication such as the presence of haematoma, then they were sent home after about 1 hours.

**US-guided approach**

The radiologist keep in the left hand the probe with sensors, and in the other the RFA needle performing an in-plane approach.

**PATIENTS**

Twenty-three patients, 18 females and 5 males, with a mean age of 57, range 43-71, were included in our study; they had been selected because each of them presented a non-functioning thyroid nodule causing compression symptom or resulting in aesthetic discomfort. All nodules (mean volume ± SD: 14.2±5.6 ml) were composed of at least 80% of solid component and were confirmed as ‘not malignant’ (classified as Thy2 following the THY diagnostic category system for fine needle aspirations) on two consecutive ultrasound-guided fine needle aspiration. Another inclusion criterion was the impossibility of the patient to undergo surgery either for the nodules’ features or for the presence of co-morbidity. Then patients were randomized into two groups in respect of the modality of treatment: group A, including 13 subjects (mean volume±SD 10±6.3 ml) and treated with RFA using the Virtual Tracker guiding system; group B, composed by 10 patients (mean volume±SD 11±4.2 ml) treated with RFA but without it the virtual guidance system. A contrast-enhanced US follow-up (CEUS) was performed after 1 week in order to have a precise assessment of the obtained area of necrosis in each patient.
Virtually-guided RFA Procedure

In-plane approach showing the expected needle path: two consecutive scans. A green line appears on the B-mode scan according to the angulation and advancement of the needle, and its tip is located with a green cross. The path that needle has travelled is a dashed line, while the prospective needle path is a dotted line. N: nodule; *: RF artifact; Arrow: hyperechoic area representing tissue ablation around needle tip.
RFA Procedure

The B-mode scan shows the needle inserted into the nodule starting to ablate the adjacent tissue (hyperechoic area around the needle tip).

3. Results and Discussion

In all 23 cases a wide area of nodule ablation was safely obtained. The positioning system accurately guided the needle tip inside the target and allowed for a correct treatment of the lesions with RF with a single puncture of the skin. At the contrast enhanced (CEUS) follow-up we observed a mean area of ablated tissue constantly higher than 70% of the entire nodules (group A: 87±5%, group B: 76±7%). A significant increase of the area of necrosis after RFA was found in group A compared to group B (p=0.003).
Pre-treatment nodule

B-mode US evaluation of a big solid non-malignant nodule occupying almost the whole lobe of the thyroid and undergoing RFA.
Thermal ablation using radiofrequency is a minimally invasive modality that is a safe and reliable alternative to surgery in patients with non-malignant thyroid nodules. Although it is an effective and safe treatment, it requires adequate skills and experience to execute an optimal ablation of the nodule, especially avoiding important structures sited nearby, such as the recurrent laryngeal nerve, the esophagus, neurovascular bundle. In this setting, the Virtual Tracking, being able to track the needle tip independently from the US visibility of the needle path using electromagnetic technology and real-time navigation, has great potential in providing more accurate and radical sessions of RFA in several situations: for example when the needle tip is ‘covered’ by the bubbles produced during the ablation procedure as well as when the needle tip is next to the nodule margins and accuracy and precision is required. Further, the virtual needle guidance allow to reach and to treat easily also the deepest part of the nodule. Therefore, unexperienced operators may take advantage of this kind of guidance system granting a more reliable localization of the needle tip, thus allowing for a shorter learning curve. We noticed great satisfaction of the patients who had undergone the procedure: this reflects the fact that the procedure provides the patients good cosmetic results and fast return to daily routine. Our study has some limitations such as the limited number of patients included and, more important, the too short follow-up of the treated nodules, anyway the CEUS evaluation provided a precise assessment of the area of necrosis obtained with RF demonstrating the high amount of ablated tissue reachable with this kind of treatment. This finding persuade us about the probable good outcomes at future follow-ups. Overall, during the 23 procedures no complications occurred and, after them, the patients could be discharged from our department in about 1 hour.
CEUS follow-up

Left: B-mode scan; Right: corresponding enhanced image showing the 'dark area' of ablation.

4. Conclusion

The Virtual tracker allows to easily perform nodules RFA with US-guided approach, providing the clear visualization of the virtual needle tip and shaft, even if the real needle is not visible due to the ablation artifact. The excellent level of safety provided by the Virtual Tracker allows to perform RFA with high confidence achieving a shortening of the learning curve and granting a significant increase in the nodule area of ablation.
5. Mediafiles

**CEUS follow-up**

Left: B-mode scan; Right: corresponding enhanced image showing the 'dark area' of ablation.

**Needle insertion**

RF Needle insertion with virtual tracking
B-mode scan of the right lobe of the thyroid showing the area in which the nodule was sited, as it presents after the RFA.
Pre-treatment nodule

B-mode US evaluation of a big solid non-malignant nodule occupying almost the whole lobe of the thyroid and undergoing RFA.
RFA Procedure

The B-mode scan shows the needle inserted into the nodule starting to ablate the adjacent tissue (hyperechoic area around the needle tip).

RFA ablation

RFA ablation with artifacts and virtual tracking
US-guided approach

The radiologist keep in the left hand the probe with sensors, and in the other the RFA needle performing an in-plane approach.

Virtual Tracking components

Left: Magnetic field generator. Center: Probe with sensors. Right: RFA needle with sensor.
Virtually-guided RFA Procedure

In-plane approach showing the expected needle path: two consecutive scans. A green line appears on the B-mode scan according to the angulation and advancement of the needle, and its tip is located with a green cross. The path that needle has travelled is a dashed line, while the prospective needle path is a dotted line. N: nodule; *: RF artifact; Arrow: hyperechoic area representing tissue ablation around needle tip.