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Thermal Ablation for Treatment of Benign Thyroid Nodules in Cirrhotic Patients

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Abstract

Benign thyroid nodules is a common disease. Microwave ablation (MWA) is a new non-invasive treatment of benign thyroid nodules. We assessed 30 benign thyroid nodules of 30 patients underwent microwave (MW) ablation and followed up for 6 months. The patients were cirrhotic diagnosed by U/S and virology tests with sizable thyroid nodule exerting compressive and/or cosmetic problems with benignity results by cytology. MW ablation was performed using KY2000-A MWA generator., Canyon Medical, China. We evaluated the pre and post procedural three-dimension volume of thyroid nodules and clinical symptoms. The Aim of this study is to assess efficacy and safety of US-guided microwave (MW) ablation as a modality to treat sizable benign thyroid nodules. The volume reduction ratio (%) of assessed thyroid nodules was significant by statistical analysis. The mean VRR ± SD was 39.2±11.6 at 1 month, 46.3±15.4 at 3 months and 51.3±16.9 at 6 months. P value was < 0.001. The microwave ablation had no effect on thyroid function of the 30 patients, 28 of them showed preprocedural normal thyroid function. The median of the compressive symptoms scoring was significantly decreased, it was 5 (IQR 5 – 6) at 1 month, 4 (IQR 3 – 5) at 3 months and 3 (IQR 2 – 3) at 6 months compared to 9 (IQR 7 – 9) before MW ablation, P value <0.001. Cosmetic problem scoring showed median of 3 (IQR 2 – 3) after1 month, 2 (IQR 1 – 2) after 3 months and 1 (IQR 1 – 1) after 6months compared to 4 (IQR 3 – 4) before treatment, P value <0.001. There were no life-threatening complications. Microwave ablation is considered an effective and safe modality used to reduce the benign thyroid nodules size and reduce the compressive and/or cosmetic problems.

Keywords: Microwave ablation; Benign thyroid nodule; Cirrhotic patients; Volume reduction ratio.

1. Introduction

Thyroid nodule is considered a common disease, and almost 4-7% of the population have thyroid nodules[1]. Treatment is required in many cases of benign thyroid

nodules exerting compression and or cosmetic symptoms.[2]. There are many considerations related to surgery as line of treatment including marked injury, high occurrence of complications, neck scar, thyroid function affection and post procedural medications [3]. Consequently, minimally invasive techniques such as chemical and thermal ablation including radiofrequency ablation (RFA), laser ablation (LA), microwave ablation (MWA), and high intensity focused ultrasound (HIFU) have been considered different treatment modalities for solid benign thyroid nodules [4]. Microwave ablation (MWA) is a minimally invasive modality for treatment of tumors, MWA has many advantages over RFA as it has larger ablation zone and less time of ablation. [5].

2. Patients and Methods

2.1 Patients

This is a non-randomized prospective study which was conducted on the period from July 2021 to July 2023 and included thirty cirrhotic patients received microwave ablation to treat benign thyroid nodules exerting compressive symptoms in National Liver institute – Menofia University, with NLI IRB Protocol Number**:** 00716 / 2025. A preprocedural informed consent was acquired from all patients. The inclusion criteria were as following: Cirrhotic patients with benign thyroid nodule exerting compressive problems, benignity was confirmed by cytological assessment using two US-guided fine needle aspiration biopsy (FNAB) or one FNAB with ultrasonographic findings of benignity [6, 7].

2.2 Preparation and participation

We assessed compression symptoms and cosmetic problems clinically, measures the three-dimensional volume of benign thyroid nodule and assessed the nodule's composition (either solid, complex, or cystic) using Ultra-Sound imaging [8], also thyroid function tests were obtained for all patients [9]. We did two FNAB under ultrasound guidance with a linear probe of 10 MHz. We measured the three dimensions of thyroid nodule (i.e., the largest diameter and the other two diameters were measured perpendicular) using ultrasound and calculated nodule volume by the following equation $\pi abc/6$ (where (a) is the largest diameter, (b) and (c) are the other two perpendicular diameters). We assessed clinically the compressive symptoms on a 10-point score ranging from 0 to 10 [10,11,12] and also cosmetic problems were assessed using 4 point grading score as following: (1) no palpable neck mass, (2) no cosmetic affection but a palpable thyroid mass, (3) a cosmetic problem appears only on swallowing, and (4) established cosmetic problem [10,11,12]. We obtained thyroid function tests for all patients.

2.3 Procedure

We gave all patients one dose of antibiotic through intravenous route and an anti-oedematous drug preprocedural. A generator belongs to KY2000-A MWA., Canyon Medical, China was used 18-gauge microwave needle measures 7 cm with internally cooled electrode and demonstrated active tip measures about 3 mm (12,13). We used fentanyl with midazolam as conscious sedation and local anaesthesia with 2% lidocaine at the puncture site. we performed hydro-dissection for all patients under ultra-sound guidance, using 5% dextrose, under the skin (to prevent skin burns) and to distance other critical structures as common carotid artery. 5% dextrose was re-injected and it was re-absorbed under ultrasound guidance [13]. It was important to preserve the surrounding structures to prevent complications as injury of recurrent laryngeal nerve. We used trans-isthmic and moving shot techniques during thermal ablation [14,15,16]. Ablation was started

with 15W power and then gradually increased to 30W. A transient hyperechoic thermal cloud was seen surrounding the tip of the electrode (Fig. 1), then we moved the electrode to the untreated unit. This approach is called “moving-shot approach” as demonstrated in Fig. 2. We divided the nodule into multiple areas and demonstrated “the most lateral portion of the nodule and the most medial portion of the nodule near to the critical neck vascular and nervous structures” into units. We the moving shot approach to treat each unit of the nodule [17, 18]. The time of ablation was 5 to 10 min and power of ablation ranged from 15–30 W. Thermal ablation was ended when all units of the thyroid nodule had transformed to hyper echoic regions [19]. We applied ice packs intra and post thermal procedure to prevent any burns could happen at the skin. We discharged all patients within 2 hours post procedural with prescribtion of oral antibiotics (Amoxycillin), analgesics (Paracetamol), and anti-inflammatoty drugs (Alphintern) for 1 week. Were assessed complications during and after the procedure using clinical compressive and cosmetic symptoms. We evaluated thyroid nodule using US at 1, 3, and 6 months through measuring the VRR using the equation: volume reduction ratio (%) = (the initial volume of the nodule (ml) − the final volume of the nodule (ml)) × 100)/ the initial volume of the nodule.

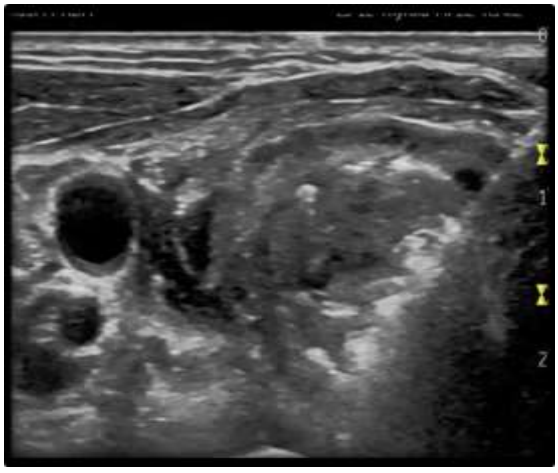


Fig.1 Ultrasonographic findings of the antenna of microwave needle seen at the thyroid nodule with hyperechoic thermal cloud around it.

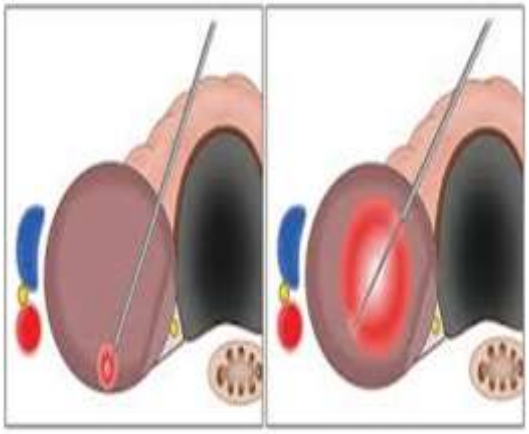


Fig.2 Trans-isthmic and moving shot techniques.

3. Results

3.1 Baseline characteristics

The characteristics and the clinical data of the patients are demonstrated in Table 1 and the baseline data of the thyroid nodules are summarized in Table 2. The evaluated median of compressive symptoms score pretreatment was 9 (IQR 7-9), was ranging from 6 to 9, The evaluated median of cosmetic symptoms score pretreatment was 4 (IQR 3-4), was ranging from 3 to 4. Twenty-eight patients showed normal thyroid function at the start of the study, and two patients showed hyperthyroidism.

3.2 Volume of the thyroid nodules

As show in fig 3 the estimated median of volume of the nodules was diminished in a significant way at different follow up periods of 1, 3 and 6 months, median of 1 month follow up was (22, (IQR 5-35), 3 months follow up median was 20 (IQR 4.5-32) and 6 months follow up median was 18 (IQR 4 - 28.3) in comparison to preprocedural mean of 40 (IQR 10–46) with P value < 0.001. The estimated volume reduction ratio (%) was significant in the statistical analysis. The estimated mean VRR ± SD was 39.2±11.6 at 1 month follow up, 46.3±15.4 at 3 months follow up and 51.3±16.9 at 6 months follow up.

3.3 Clinical evaluation

As show in fig 4 and 5 he median of the compressive symptoms scoring was diminished in a significant way, the median of 1 month follow up was 5 (IQR 5 – 6), the median of 3 months follow up was 4 (IQR 3 – 5) and the median of 6 months follow up was 3 (IQR 2 – 3) in comparison to estimated median of 9 (IQR 7 – 9) pre ablation, with P value <0.001. The estimated median of cosmetic problem score of 1 month follow up was 3 (IQR 2 – 3), the median of 3 months follow up was 2 (IQR 1 – 2) and the median of 6 months follow up was 1 (IQR 1 – 1) in comparison to estimated median of 4 (IQR 3 – 4) pretreatment with P value <0.001.

3.4 Thyroid function tests

As show in Table .1 all patients showed normal thyroid functions remained euthyroid at all different follow up periods of 1, 3 and 6 months. Two patients showed hyperthyroidism transformed back to normal at one month follow up. Thyroid nodules volume follow-up of the patients‟ symptoms, and the thyroid functions is demonstrated.

The correlation between sonographic texture of thyroid nodules and the power of ablation

As show in table 2 and fig 6 in current study, there was a significant correlation between the sonographic texture of the thyroid nodule administrated by US and the power of the ablation process used to reduce the nodule volume properly. The estimated mean thermal power used was 23.3±3.9 SD for solid thyroid nodules and was 37.2±2.6 SD for mixed thyroid nodules. Data are demonstrated.

As show in table 3 and fig 7 The relation between the thyroid nodule's composition and thyroid nodules volume reduction ratio During follow up studies there was no significant relation between thyroid nodule's composition and the volume percentage of the treated thyroid nodule at different follow up periods of 1, 3 and 6 months. The estimated mean volume percentage of the treated nodule after 1 month was 31.5±35.4SD for solid thyroid nodules and was 38.8±36.8 SD for mixed thyroid nodules. After 3 months, it was 28.6±32.1SD for the solid nodules and 34.3±33.2SD for the mixed nodules. After 6 months, it was 26.7±30.5SD for the solid nodules and31.1±31.7 SD for the complex nodules. P value was > 0.05. The collected data is demonstrated.

Complications of MW ablation procedure

As show in table 4 and fig.8. the complications of thermal ablation are classified by the Society of Interventional Radiology (SIR) into major complication (if not treated, it will threaten the patient's life, lead to morbidity) and all other than this are considered minor complications. Nine patients (29.9%) of total thirty patients did not show any complications. One of the thirty patients (3.3%) developed a major complication of voice change (grade C) during the ablation procedure; the thyroid nodule was located near the recurrent laryngeal nerve location we stopped the technique immediately and put him under observation for 8 hours. The cause was the surrounding edema which was absorbed by the tissues later and the patient showed complete recovery after 6 hours. 21 patients (70.1%) showed minor complications. Fourteen patients (46.7%) developed pain post procedural at site of procedure, the pain was transient for 6 – 24 hours and responded to analgesic and completely resolved 2nd day post procedure. Five patients (16.7%) had ecchymosis at site of insertion needle detected shortly after the procedure. It recovered completely after about 3-5days duration with topical treatment. Two patients (6.7%) showed small hematoma (grade A) due to slight touch of common carotid artery through electrode's tip as the thyroid nodule was close to the common

carotid artery, we stopped the procedure immediately and did neck compression for about 10 minutes, then the hematoma resolved completely after 4 hours. There were no life threating complications happened. Complications are demonstrated.

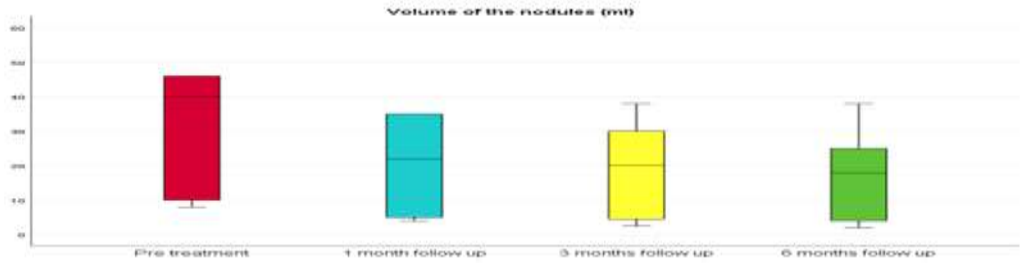


Fig.3 Reduction of estimated thyroid nodules volume at different follow up periods of 1, 3 and 6 months.

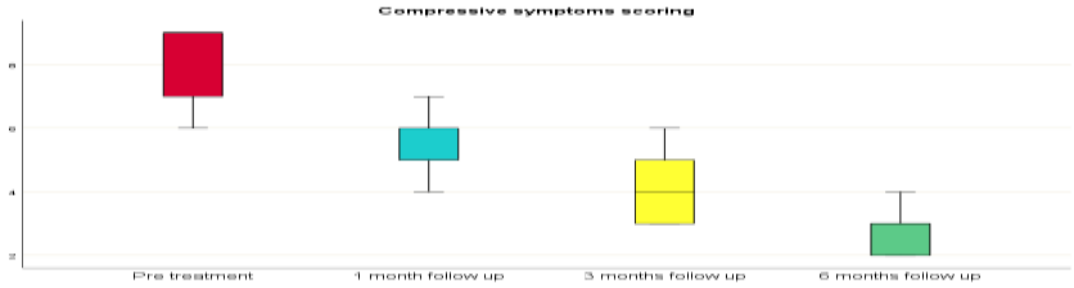
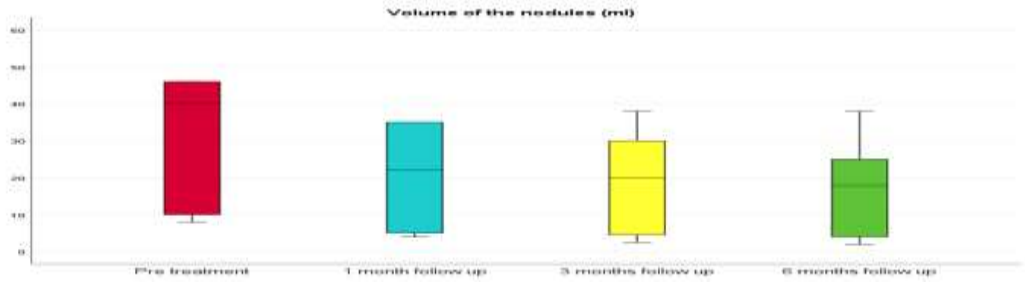


Fig. 4 Scoring of the compression effect shows reduction during follow up.



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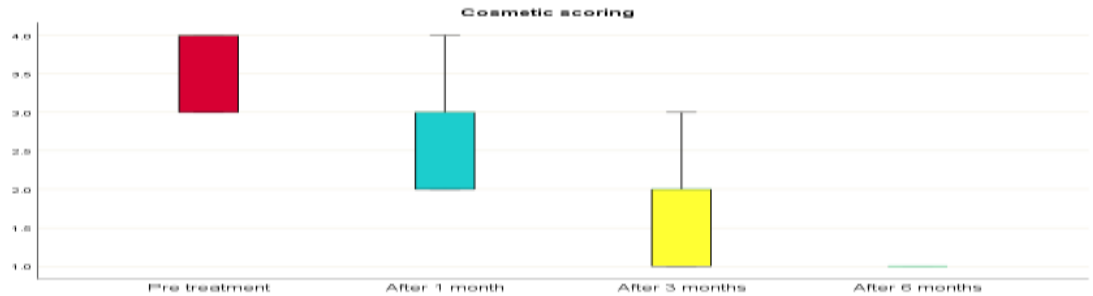

Fig. 5 Reduction of scoring of cosmetic symptoms at 1, 3 and 6 months follow up.

Table 1: Summary of volume, patients' symptoms at different periods of follow up.

Item	Pretreatment	1 month follow up	3 months follow up	6 months follow up	Test of significance
Volume of the nodules					
Mean ± SD Min- max Median (IQ)	50.6±49.9 8-145 40(10-46)	33.6±35.4 4-100 22(5-35)	30.3±31.9 2.5-90 20(4.5-32)	28 ± 30.4 2-85 18(4-28.3)	Friedman test=80.4, p <0.001
Test of significance and p value	----	Wilcoxon =4.79 P= <0.001	Wilcoxon =4.80 P= <0.001	Wilcoxon =4.73 P= <0.001	-----
Volume reduction percentage					
Mean ± SD Min- max Median (IQ)	---	39.2±11.6 16.7-50 45(29.5-50)	46.3±15.4 5-68.8 50(37.1-58.3)	51.3±16.9 0-75 55(41.4-62.5)	Friedmann =46.3 P= <0.001
Test of significance and p value	-----	----	Wilcoxon =3.81 P= <0.001	Wilcoxon =3.92 P= <0.001	
Compressive symptom score					
Mean ± SD Min- max Median (IQ)	8.2±1.2 6-9 9(7-9)	5.2±0.91 4-7 5(5-6)	4.1±0.94 3-6 4(3-5)	2.66±0.61 2-4 3(2-3)	Friedmann =79.1 P= <0.001
Test of significance and p value	-----	Wilcoxon =4.71 P= <0.001	Wilcoxon=4.71 P= <0.001	Wilcoxon =4.71 P= <0.001	
Cosmetic score					
Mean ± SD Min- max Median (IQ)	3.5±0.51 3-4 4(3-4)	2.6±0.56 2-4 3(2-3)	1.63±0.56 1-3 2(1-2)	1.0±0.0 1-1 1(1-1)	Friedmann =85.4 P= <0.001
Test of significance and p value		Wilcoxon =4.46 P= <0.001	Wilcoxon =4.90 P= <0.001	Wilcoxon =4.93 P= <0.001	
Thyroid function					
Euthyroid Hyperthyroid	28(93.3%) 2(6.7%)	30(100%) 0(0%)	30(100%) 0(0%)	30(100%) 0(0%)	X^2 =6.1 P= 0.1068

P-value > 0.05: Nonsignificant; P-value < 0.05: Significant; P-value <0.01: Highly significant, *: Wilcoxon test; ##: Friedman test

Table 2: The correlation between sonographic texture of thyroid nodules and ablation power.

Item	Solid	Mixed	Test of significance and p value
	(n=21)	(n=9)	
MW ablation power (w)			
Mean ± SD Min- max Median (IQ)	23.3±3.9 15-30 25(20-25)	37.2±2.6 35-40 35(35-40)	U=4.45 P=<0.001

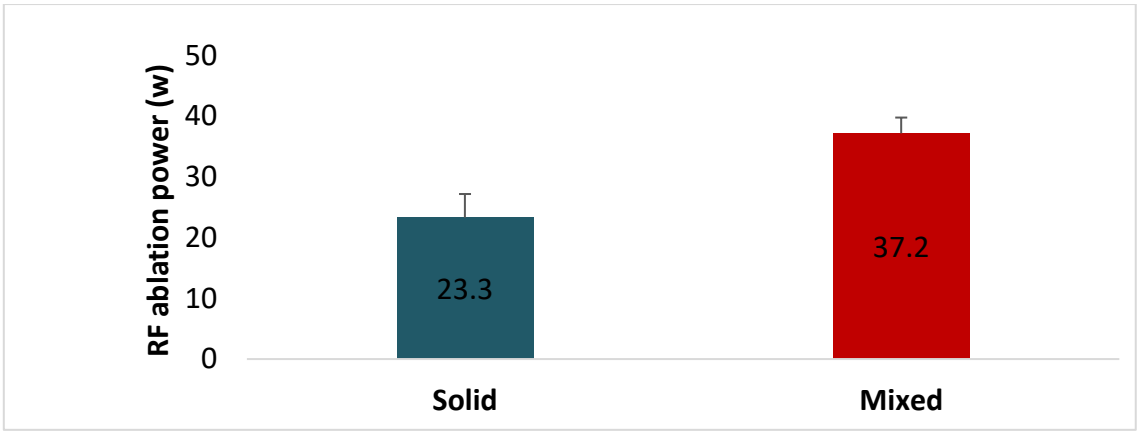

Fig. 6: The mixed nodules needed more ablation power than solid nodules.

Table .3

Item	Solid (n=21)	Mixed (n=9)	Test of significance and p value
One month post treatment			
- Mean ± SD - Min- max - Median (IQ)	31.5±35.4 4-100 20(5-35)	38.8±36.8 5-100 35(12-35)	U=0.962 P=0.336
Three months post treatment			
- Mean ± SD - Min- max - Median (IQ)	28.6±32.1 2.5-90 20(4.5-30)	34.3±33.2 4.5-90 30(10-30)	U=0.779 P=0.436
Six months post treatment			
- Mean ± SD - Min- max - Median (IQ)	26.7±30.5 2-85 18(4-25)	31.1±31.7 4-85 25(9-25)	U=0.779 P=0.436

P-value > 0.05: Nonsignificant; P-value < 0.05: Significant; P-value <0.01: Highly significant, •: One Way ANOVA test.

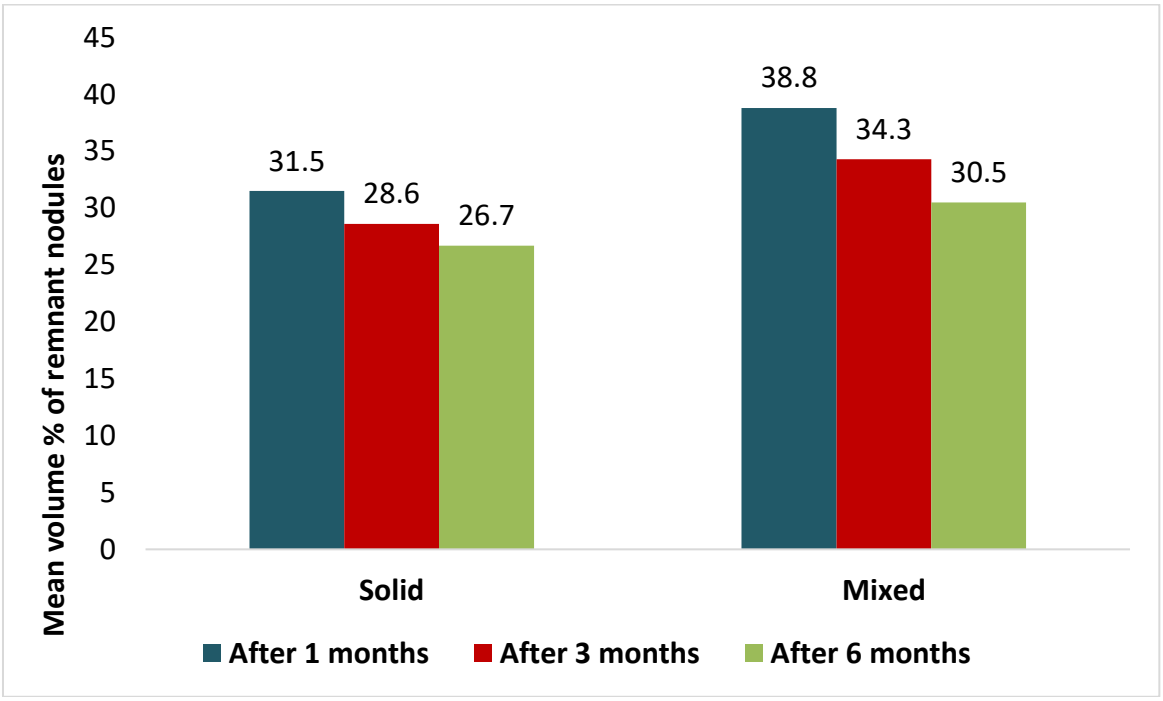

Fig. 7 No relation between thyroid nodules composition and the volume of the remnant thyroid nodule

Table 4: Demonstration of MW ablation complications

Item	Frequency(no=30)	Percentage
Major complications		
- Technical errors	1	3.3
- No	29	96.7
Minor complications		
- Ecchymosis	5	16.7
- Hematoma	2	6.7
- Pain	14	46.7
- No	9	29.9

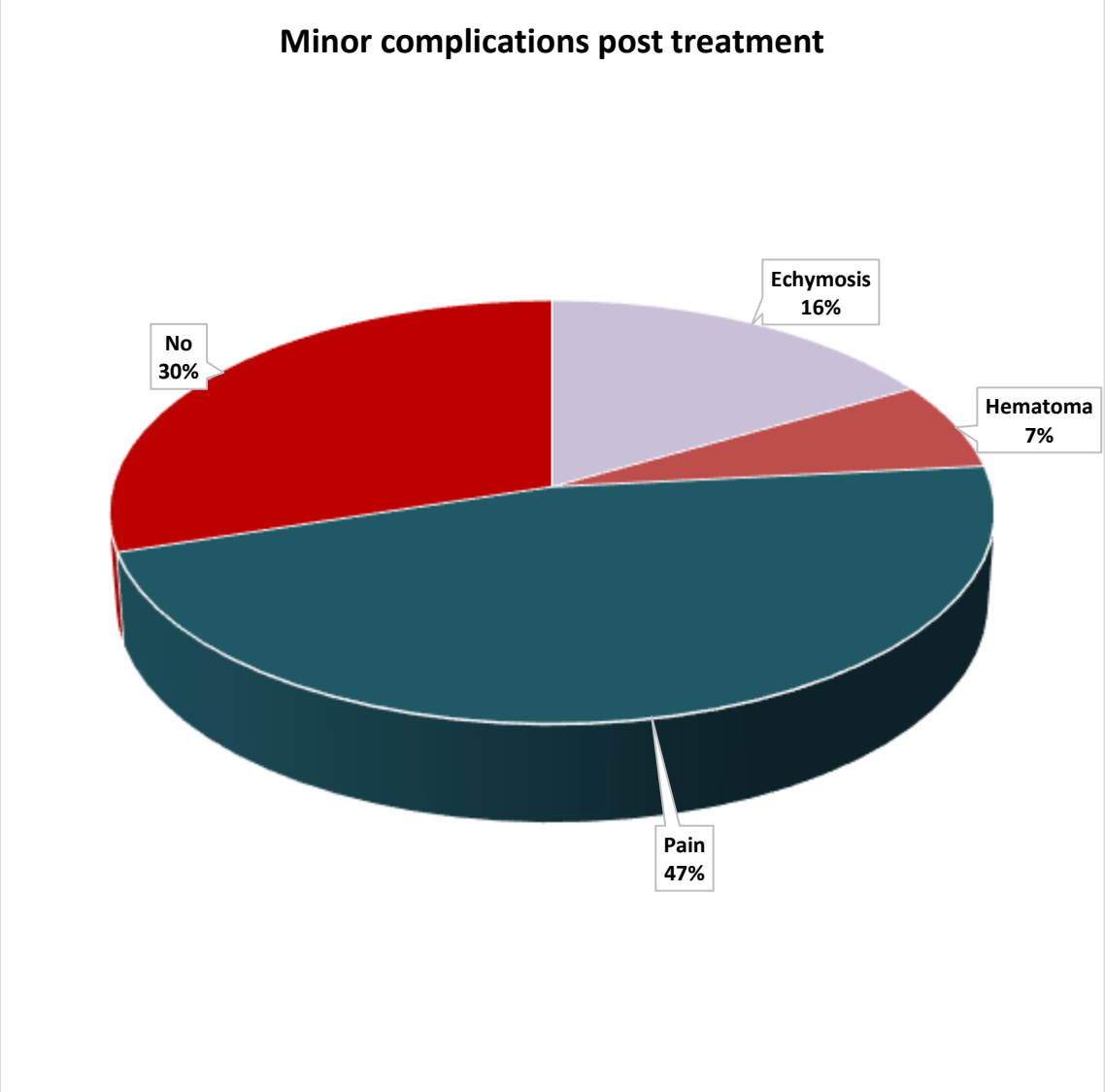

Fig. 8 Summary of complications.

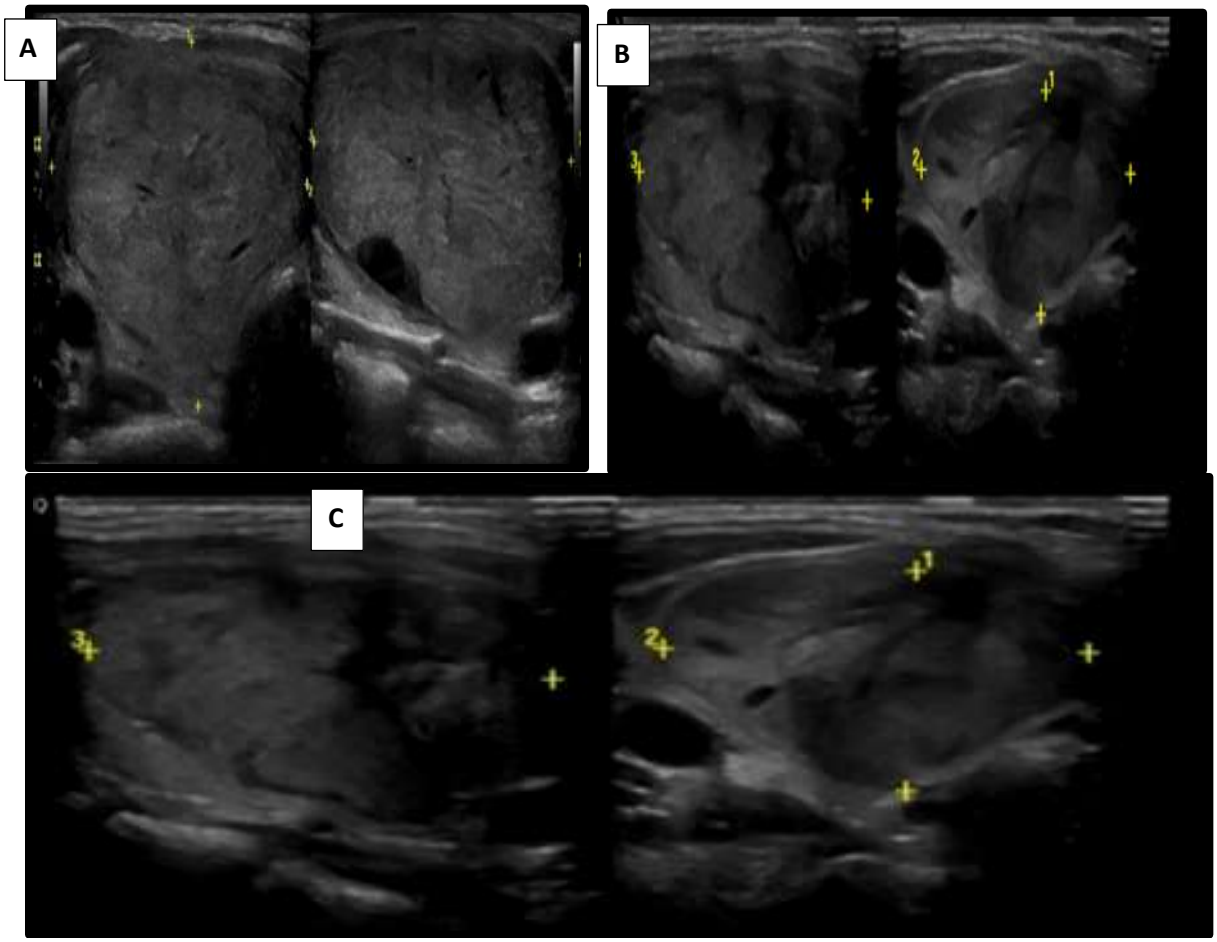

Fig. 9 Reduction of the nodule size of a 18 year-old female (A) Pre-procedural nodule's volume 45ml. (B) Nodule's volume on 1-month follow-up " 25ml". (C) Nodule's volume on 3-month follow-up " 20 ml".

Fig. 10: Disappearance of the neck bulging of a 18-year-old female after 1 month duration post MW ablation. (A) Neck of the patient pre-procedural. (B) Neck of the patient on 1-month follow-up

4. Discussion

In our study, we demonstrate the efficacy of microwave ablation with appreciable results in reducing nodule volume and subsequently reducing compressive symptoms caused by benign thyroid nodule (**Fig.9)** with VRRs of 39.2% to 51.3% in 6 months follow up compared to 82.5%–90.0% at 12-month follow-up study as Chen et al., reported. **(20).** This is similar to what Luo et al. **(21)** and Liu et al. **(22)** concluded as regard to the estimated mean volume reduction rate of thyroid nodules which was 93.2% and 97.1%, respectively. In our study, thirty patients had thirty nodules were treated using MW ablation modality, and the patients were followed up for 6 months. The follow-up study demonstrated that MW ablation showed efficiency in treatment BTNs, and this is in agreement with Du et al., who reported that the long-term follow-up results of the study showed that MW ablation was effective and also safe to treat the BTNs (23). The current study shows that MW ablation results of volume reduction of the benign thyroid nodules were significant. The VRR (%) was 51.3±16.9SD during the 6months follow up study. In other studies, Wei et al., reported that the mean VRR at 6 months follow-up was 45.9–65%(24). In our opinion, there is no significant relation between the composition of the thyroid nodules and the volume of the residual thyroid nodule as shown in our study. Additionally, Zhi et al., reported that volume reduction rate of cystic thyroid nodules was much better than solid nodules at 3 and 6 months follow up studies which is similar to the study (25). This is in contrary to Wi et al., who found that complex thyroid nodules decreased in volume in a rapid manner because of removal of the internal cystic component and also ablation of the solid area then water molecules were absorbed, and a scar was formed (24). MWA improved the clinical symptoms including compressive and/or cosmetic problems (Fig.10). With no affection of the function of thyroid gland. Agreed with Du et al., that reported nodule decreasing in size was associated by clinical improvement in compressive symptoms (23). In our study we didn't notice any complete nodular disappearance of any nodules, and this is similar to Wu et al., that reported no thyroid nodules demonstrated complete disappearance at 12-months follow-up study. (26). This is in disagreement with Du et al., that reported complete nodular disappearance with rate of 29.7% and also Yue's study, that showed complete nodular disappearance rate of 30.7% (23). In current study, there was significant relation between the ultrasonographic texture of BTNs and the MW ablation power to accomplish significant volume regression. Mixed nodules need much higher MW power than the solid nodules. This is in disagreement with Korkusuz et al., reported that the solid nodules usually require much more thermal energy than cystic nodules and this could be explained by the much higher water content(27). Trans-isthmic and moving-shot techniques improved the efficacy, and this is in agreement with Morelli et al., that found trans isthmic and moving-shot techniques improved the efficacy of ablation (28). There was no strong relation between nodule's composition and VRR at different follow up periods at 1, 3 and 6 months. In agreement with Jeong et al., who reported that cystic nodules decreased in size more than the other types in the follow up studies (P = 0.000 and 0.007, respectively) (29). In our study, there was no life-threatening complications occurred and 9 patients (29.9%) out of 30 patients did not develop any complications. 21 patients (70.1%) had minor complications similar to Lim's study that showed complication rate of 3.6% (23). In current study, two patients (6.7%) developed bleeding in a lower rate than Korkusuz et al., (27) and Deandrea et al., (30) who experienced bleeding rates of 7.1% and 15%, respectively. One patient (3.3%) developed hoarseness of voice, and the procedure has been stopped immediately,

and we considered it as technical error that recovered after 3 months. That was lower than Cheng's study (5.8%) (31) but is similar to Zhi Xi's study (3.6%) (25) and much higher than Deandrea's study (0.4%) (30).

5. Conclusion

Microwave ablation is an effective and safe minimally invasive method used as an alternative to surgery for treatment of benign thyroid nodules. It can reduce the size of thyroid nodules and improves compressive and cosmetic problems with minimal complications.

Abbreviations

AFTN:
Autonomously functioning thyroid nodule

FNAB:

Fine needle aspiration biopsy

HIFU:
High Intensity Focused Ultrasound

IQR:
Interquartile Range

MW:
Microwave

MWA:
Microwave Ablation

RFA:
Radiofrequency Ablation

TSH:
Thyroid Stimulating Hormone

T3:
Triiodothyronine

T4:
Thyroxine

VRR:
Volume Reduction Ratio

US:
Ultrasound

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Authors' contributions:

All authors cooperated in designing the work, data collection, resources detection, formal analysis, interpretation of data, validation and methodology and revision of the paper.

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Competing interests:

The authors declare that there is no conflict of interest.

Ethics approval: The National Liver Institute Menofia University Research Ethics Committee and its Diagnostic Radiology subcommittee approvals were obtained to perform this study. Informed consents detailing potential risks, complications and alternative treatments and emphasizing on the rights to refuse or withdraw from the study as well as the right to confidentiality were obtained from all patients.

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