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Original Article

Advantages of ultrasound-guided radio frequency ablation for benign thyroid nodules

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Abstract: To explore the effect of ultrasound-guided radio frequency ablation (RFA) on patients with benign thyroid nodules (BTN). A total of 73 patients with BTN admitted to our hospital from March 2017 to August 2019 were selected, of which 42 patients were treated with ultrasound-guided radio frequency ablation (RFA group) and 31 patients were treated with traditional surgery (tradition-operation group). The operation condition, pain score, cure rate, postoperative cosmetic score, complication rate, changes of ablation area volume before and after ablation, between the two groups were observed and compared. The average operation time, postoperative hospitalization, intraoperative blood loss and pain score in the tradition-operation group were higher than those in the RFA group. The cure rate and postoperative cosmetic score in the RFA group were notably higher than those in the tradition-operation group. The incidence of complications in the two groups was not statistically different ($P > 0.05$). The maximum diameter and volume of nodules were notably reduced at the 1st, 3rd and 6th months after ablation ($P < 0.05$), and the maximum diameter and volume at the 1st, 3rd and 6th months after ablation were significantly different from that before treatment ($P < 0.05$). After treatment, the content of T3, T4 and FT4 in RFA group were remarkably lower than that in RFA group ($P < 0.05$). In conclusion, ultrasound-guided RFA can reduce pain and improve curative effects in patients with BTN, which is worthy of clinical promotion.

Keywords: Ultrasound guidance, radio frequency ablation, benign thyroid nodules, curative effect

Introduction

In recent years, with the popularization of thyroid ultrasound examination, the detection rate of thyroid nodules has also increased, and its incidence rate is 20%-76% [1, 2]. Although the malignant transformation rate of benign thyroid nodules (BTN) is relatively low, most patients choose radical treatment because of the pressure on thyroid tissues or psychological burden. Therefore, finding appropriate treatment methods for thyroid nodule patients is of great significance [3-5].

At present, surgical resection is the main method for the treatment of thyroid nodules in clinical practice. However, there are defects in traditional surgery such as large amount of blood loss, severe trauma, postoperative scars, large resection area, and multiple complications, which limit the application for surgical treatment of BTN [6, 7]. With the increase in people's demand for aesthetic appearance, minimally invasive treatments of thyroid nodules have attracted more and more attention [8]. At present, the minimally invasive treatments for thyroid nodules applied clinically include absolute ethanol injection sclerotherapy, microwave ablation, ultrasound-guided radio frequency ablation (RFA), and laser ablation, etc. [9]. RFA is the release of high energy through radio frequency current, which leads to high-speed movement of positive and negative particles in cells due to rapid changes of electromagnetic fields in human tissues. Such high-speed movement will cause a rapid transient temperature rise in cells within radio-frequency irradiation areas, this kind of high temperature will cause evaporation, drying, solidification and necrosis of water inside and outside cells; this minimally invasive technique has a simple operation and exact effects [10, 11]. In recent years, RFA technology has gradually expanded from the treatment of diseases such as liver and lung to the treatment of thyroid nodules. It can effectively reduce the volume of nodules, reduce nodule

symptoms and eliminate the problem of appearance changes caused by nodules. RFA technology can meet the needs of patients for physical beauty while achieving the therapeutic purpose, but there is little research on this treatment for thyroid nodules [12-14].

In this study, the clinical application value of ultrasound-guided RFA in the treatment of benign thyroid nodules (BTN) was investigated by comparing the curative effect, pain and cure of patients with thyroid nodules treated by surgical resection and ultrasound-guided RFA, so as to provide references for clinical practice.

Materials and methods

General data

Altogether 73 patients with BTN treated in the Central Hospital from March 2017 to August 2019 were selected. They were divided into a tradition-operation group (31 cases) and a RFA group (42 cases) according to the treatment method. All patients were informed of the treatment process and signed an informed consent form. Inclusion indexes: Patients had a single nodule and the largest diameter of the nodule > 2 cm. Preoperative ultrasound examination of patients confirmed that the nodule was mainly solid, and its solid component was ≥ 80%. Preoperative biopsy of patients showed benign nodules. Patients signed an informed consent and cooperated with treatment and follow-up. Exclusion criteria: Patients had abnormal coagulation function, significantly decreased platelet count, or hyperthyroidism. Patients were accompanied with severe respiratory and circulatory diseases. Patients with poor compliance and non-cooperative. Patients with abnormal routine blood work, unconsciousness, or malignant tumors. Patients whose ultrasonography showed malignant signs. Patients with a history of cranial surgery or radiotherapy. Patients with hypertension, diabetes or coagulation disorders.

This experiment had the approval of the Medical Ethics Committee of the Central Hospital and this study is in line with the Declaration of Helsinki.

Treatment methods

Patients in RFA group were treated with RFA under ultrasound guidance, that is, the patients were instructed to maintain a supine position, given a shoulder cushion, and tilted the head back to fully expose the operative area. Routine disinfection and a surgical drape were applied, local anesthesia was given with 2% lidocaine, and the route and puncture point were determined according to preoperative ultrasound examination. If the lesion was adjacent to the recurrent laryngeal nerve of the patient, an appropriate amount of sodium chloride injection was injected into the capsule space between the lesion and the surrounding tissues to form an isolation zone to reduce thermal injury. If the lesion was superficial and adjacent to its jugular anterior fascicles, lidocaine was injected into the middle of anterior thyroid membrane and jugular anterior fascicles of thyroid anterior membrane to prevent severe pain during operation. Puncture and needle insertion were carried out from the longitudinal section and the transverse section of the thyroid gland, radio frequency electrode needles were sent into the lesion under the guidance of ultrasound. The needle tip was placed into the edge of the deep part of the nodule. The radiofrequency ablation system was started, and the nodules were treated with regional thermal ablation until the gasification area was completely covered and exceeded the edge of the nodules. The patients in the tradition-operation group were treated with traditional surgery, i.e. general anesthesia with tracheal intubation. A 5-8 cm long arc incision was made 2 cm above the sternal notch to expose the thyroid gland and its lesion site. The lesion site was completely excised. Attention was paid to protect the recurrent laryngeal nerve. After complete hemostasis, a drainage tube was retained and the incision was sutured.

Outcome measures

The operation time, postoperative hospitalization, postoperative blood loss, complication rate, and hospitalization expenses of RFA group and tradition-operation group were compared. Visual analogue scale (VAS score) [15] was used to compare the pain of patients 24 hours after operation: a score of 0 indicated painless, and a score of 10 indicated severe pain. Patients were scored 24 hours after operation. The cosmetic score of the patient's wound was performed using the numerical score system (NSS) [16]: 0 was the worst and 10 was the best. The aesthetic satisfaction of incision scar

Table 1. Comparison of clinical data between RFA group and tradition-operation group

Factors	Tradition-operation group (n=31)	RFA group (n=42)	t/χ^2 value	P
Gender			0.479	0.489
Male	8 (25.81)	14 (33.33)		
Female	23 (74.19)	28 (66.67)		
BMI	23.56±4.14	23.27±3.16	0.34	0.735
Age (years)	48.75±9.86	46.98±7.56	0.869	0.388
Diameter of the longest nodule (cm)	2.36±0.77	2.28±0.81	0.426	0.672
Number of nodules			0.478	0.976
1	16 (51.61)	21 (50)		
2	9 (29.03)	12 (28.57)		
3	6 (19.35)	9 (21.43)		

Table 2. Comparison of operation conditions between RFA group and tradition-operation group

Type	Operation time (min)	Postoperative hospitalization (d)	Blood loss (ml)
Tradition-operation group	74.45±14.67	4.58±1.06	23.45±8.41
RFA group (n=42)	42.78±7.31	2.47±0.59	1.61±0.71
T	12.12	10.84	16.79
P	< 0.01	< 0.01	< 0.01

was scored 3 and 6 months after operation. Patients in the RFA group were reexamined with thyroid B ultrasound at the 1st, 3rd, and 6th months after operation. During the follow-up period, routine ultrasonic examination was performed to understand the degree of blood perfusion and disappearance of the nodule, and the size of the thyroid nodule was measured. The volume (V) and nodule volume reduction rate [VRR = (volume before treatment - volume after treatment)/(volume before treatment × 100%)]. Ablation of nodules with different ablation risks were observed. The thyroid indexes of the two groups were compared, including T3, T4 and FT4 contents.

Criteria for efficacy determination

The curative effects of patients were divided into recovered, markedly effective, improved and ineffective. ① Recovered: Thyroid nodules disappeared completely. ② Markedly effective: Thyroid nodule volume reduced by more than 50%. ③ Improved: Thyroid nodule volume reduced by 25-49%. ④ Ineffective: The volume of thyroid nodules decreased by less than 25%. Cure rate = number of patients recovered/100% of total number.

Statistical methods

SPSS 22 statistical software was used to analyze all the data in this study: the counting data were expressed by the number of cases (n), and the inter-group rate (%) was compared by chi-squared test. Mean standard deviation ($\bar{x} \pm s$) was used to express the measurement data, and t test was used for comparison. There was statistical difference when $P < 0.05$.

Results

Comparison of clinical data between the RFA group and tradition-operation group

There was no statistically significant difference in gender, age, BMI, number of nodules and diameter of the longest nodule between the two groups ($P > 0.05$), as shown in **Table 1**.

Comparison of operation conditions between the RFA group and tradition-operation group

Compared with the operation situation of the RFA group, tradition-operation group had a longer average operation time, postoperative hospitalization, and larger amount of intraoperative blood loss, and the differences were statistically significant ($P < 0.05$), as shown in **Table 2**.

Postoperative pain score of the two groups

The postoperative pain scores was compared, and the result showed that the average pain score 24 h after operation of the tradition-oper-

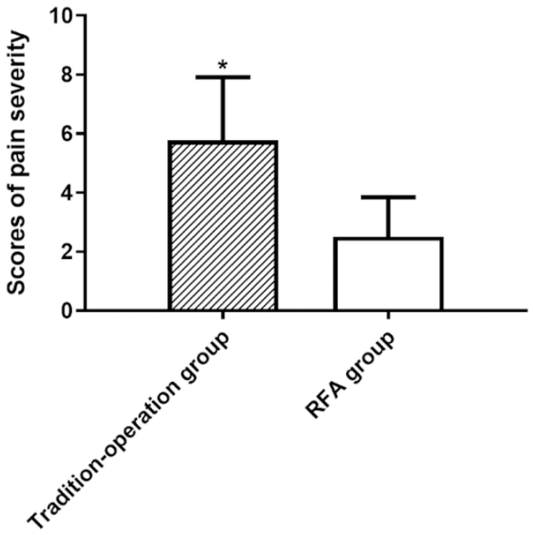

Figure 1. Postoperative pain score of the two groups. The postoperative pain scores was compared, and the result showed that the average pain score 24 h after operation of the tradition-operation group was higher than that of RFA group ($P < 0.05$).

ation group was higher than that of RFA group ($P < 0.05$), as shown in **Figure 1**.

Cure rate of two groups of patients

Comparison of cure rates between the two groups showed that the cure rate of the RFA group was 90.48%, and that of tradition-operation group was 51.61%. The RFA group was notably higher than that in the tradition-operation group ($P < 0.05$), as shown in **Table 3**.

Comparison of postoperative cosmetic scores between the two groups

Comparison of postoperative cosmetic score between the two groups showed that the RFA group had higher scores than tradition-operation group, and the differences were statistically significant ($P < 0.05$), as shown in **Figure 2**.

Comparison of postoperative complications between the two groups

The incidence rate of complications in the traditional operation group was 12.9% (4 cases), with 1 case of transient hypothyroidism, 1 case of transient recurrent laryngeal nerve injury, 1 case of sub-flap hemorrhage (secondary operation hemostasis) and 1 case of subcutaneous ecchymosis. All the above complications healed well after treatment. In the RFA group, only one patient had a small amount of intraoperative blood loss, with an incidence of complications of 2.38%. There was no statistical significance in incidence of complications between the two groups ($P > 0.05$). As shown in **Table 4**.

Changes of ablation area volume in the RFA group before and after ablation

After ablation, the maximum diameter and volume of nodules decreased significantly at the 1st, 3rd and 6th months ($P < 0.05$), and the maximum diameter and volume at the 1st, 3rd and 6th months after ablation were remarkably different from that before treatment. As shown in **Table 5** and **Figure 3**.

Comparison of thyroid indices between the two groups after treatment

After treatment, the thyroid index of the two groups was compared, and the content of T3, T4 and FT4 in the RFA group was remarkably lower than that in the RFA group ($P < 0.05$), as shown in **Table 6**.

Discussion

Thyroid nodules have a high incidence in the general population. With the popularization of high-resolution ultrasound examination, the detection rate of thyroid nodules is as high as 19%-67%, and only 5%-15% are malignant [17, 18]. However, BTNs have the possibility of malignant transformation. Arora N et al. [19] believed that 20% of BTNs can transform into malignant nodules, so the treatment of BTN needs to be paid attention to.

Traditional surgical resection is the best treatment method for the vast majority of nodules, but it has defects such as trauma and remaining neck scars. Therefore, people have higher requirements for minimally invasive treatment of thyroid nodules [20]. Ultrasound-guided RFA therapy has the advantages of an accurate location, less trauma and no scarring, which has attracted increasing attention [21]. It mainly uses high-frequency alternating electromagnetic waves generated by radio frequency instruments to make polar molecules and ions in tissues that vibrate and rub around the electrodes according to the directional changes of alternating current and converts them into heat energy, and then local tissues solidify and become necrotic due to the high temperature.

Table 3. Comparison of cure rates between the two groups

Group	Recovered	Markedly effective	Improved	Ineffective	Cure rate (%)
Tradition-operation group	16	8	7	0	51.61
RFA group (n=42)	38	3	0	0	90.48
χ^2					17.18
P					< 0.01

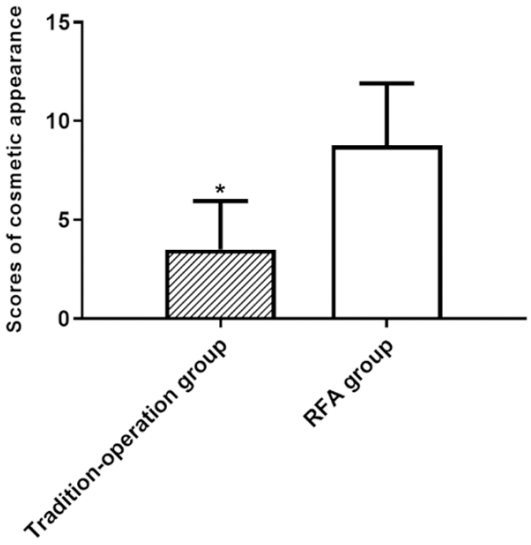

Figure 2. Comparison of postoperative cosmetic scores between the two groups. The postoperative cosmetic scores of RFA group were higher than those of tradition-operation group (P < 0.05).

At the same time, the necrotic tissues form a protective net to block the blood supply of nodular tissues. Finally, the volume of ablation area gradually shrinks and softens, and the inactivated tissues are absorbed by the body (lymphatic vessels or blood vessels) [22-24]. RFA therapy is mainly applied to primary or secondary tumors of liver and lung and small renal tumors, but there are only a few studies on the application of RFA technology to treat BTN [25]. In this study, RFA technology is used to treat BTN. The results showed that the cure rate of patients in RFA group was notably higher than that in tradition-operation group (P < 0.05). Ultrasound-guided needle insertion has the advantages of real-time adjustments of the needle insertion direction, accurate puncture points, and avoidance of large blood vessels and adjacent organs. In this experiment, the operation situation between the two groups was compared, and the results showed that tradition-operation group had longer average operation time, postoperative hospitalization, and larger amount of intraoperative blood loss than RFA group (P < 0.05), and RFA group had lower postoperative pain scores, higher cosmetic scores and better thyroid function indexes than tradition-operation group. All of these above suggest that RFA can reduce the pain of patients, reduce facial injury, and optimize thyroid indexes. In the first month after treatment, the volume of the necrotic tissue in the nodule gradually decreased as it was reabsorbed. The nodule shrank significantly 6 months after treatment. One study suggested that the volume reduction rate of nodule was 46%~93%, and no recurrence or increase was found in the follow-up for 4 years [26]. After RFA treatment, the volume reduction rates of 1st, 3rd, and 6th months were 21.58%, 45.67%, and 74.57%, respectively, which was consistent with previous studies, suggesting that thyroid RFA has a good clinical effect for the treatment of BTN.

As various complications may occur during RFA, it is extremely important to know the possible complications and surgical techniques for safe ablation. Complications of RFA in the treatment of thyroid nodules may include large vascular injury, thermal nerve injury, and postoperative complications such as infection and abscess [27]. Previous studies have confirmed the safety and effectiveness of RFA in the treatment of BTN [28, 29]. Baek et al. [30] enrolled 1,459 patients in a multi-center study and found that the incidence of complications after RFA was 3.3%, and the incidence of major complications was 1.4%, including pain, voice change, skin burn, hematoma, nodule rupture and thyroid dysfunction. Voice changes after RFA are uncommon, but the most serious complication, is considered to be the result of thermal injury of recurrent laryngeal nerve or vagus nerve, and most patients can recover within 3 months [31]. In this study, the injection of liquid isolation zone between the carotid artery, trachea, esophagus and other important organs and tumor can effectively prevent the heat gener-

Table 4. Incidence of postoperative complications in the two groups

Group	Transient hypothyroidism	Transient recurrent laryngeal nerve injury	Bleeding	Subcutaneous ecchymosis	Incidence (%)
Tradition-operation group	1	1	1	1	12.9
RFA group (n=42)		0	1	0	2.38
χ^2					3.095
P					0.078

Table 5. Changes of ablation area volume before and after ablation

Group	Maximum nodule diameter (cm)	Volume (mL)	VRR (%)
Before treatment	2.45±1.17	6.68±2.74	
1 month after treatment	2.03±0.63*	5.37±2.13*	21.58±10.67
3 month after treatment	1.73±0.62*	3.82±1.76*	45.67±14.63
6 month after treatment	1.29±0.37*	1.91±0.67*	74.57±5.58
F	17.58	45.5	247
P	< 0.01	< 0.01	< 0.01

Note: *significant difference compared with before treatment.

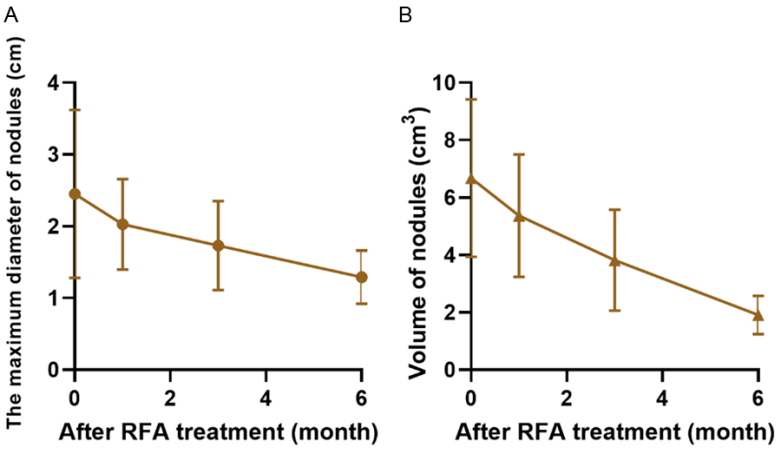

Figure 3. Changes of ablation area volume before and after ablation in RFA group. The maximum diameter and volume of nodules decreased significantly at the 1st, 3rd and 6th months, and the ratio of maximum diameter volume at each stage after ablation to that before treatment was significantly different ($P < 0.05$).

Table 6. Comparison of thyroid index between the two groups after treatment

Group	T3 (ng/mL)	T4 (ng/mL)	FT4 (pg/mL)
Tradition-operation group	1.09±0.45	78.41±6.58	7.73±2.59
RFA group (n=42)	1.91±0.75	114.78±6.24	16.01±3.84
T	5.406	24.05	10.38
P	< 0.01	< 0.01	< 0.01

ated by high-frequency ablation needle from causing collateral damage to the surrounding trachea, and there is no serious complication in the study of patients. In this study, only one patient in RFA patient had a small amount of intraoperative blood loss, and the complication rate was 2.38%. The reason this happened was considered to be that the small blood vessels around thyroid gland were damaged during operation, and the ablation was continued after the bleeding and the bleeding point was stopped by electrode burning during the operation.

Although this study confirmed the clinical effects of ultrasound-guided RFA, its long-term effects on patients with BTN need further observation due to the short follow-up time of the study, and it is hoped to be supplemented in future studies.

To sum up, ultrasound-guided RFA can reduce the pain of patients with BTN and improve the curative effect, which is worthy of clinical promotion.

Disclosure of conflict of interest

None.

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References

[1] Beano AM, Zmaili MA and Zayed AA. Thyroid nodules. N Engl J Med 2016; 374: 1294.

[2] Burman KD and Wartofsky L. CLINICAL PRACTICE. Thyroid nodules. N Engl J Med 2015; 373: 2347-56.

[3] Pemayun TG. Current diagnosis and management of thyroid nodules. Acta Med Indones 2016; 48: 247-257.

[4] Ukrainski MB, Pribitkin EA and Miller JL. Increasing incidence of thyroid nodules and thyroid cancer: does increased detection of a subclinical reservoir justify the associated anxiety and treatment? Clin Ther 2016; 38: 976-985.

[5] Wong R, Farrell SG and Grossmann M. Thyroid nodules: diagnosis and management. Med J Aust 2018; 209: 92-98.

[6] Jackson BS. Controversy regarding when clinically suspicious thyroid nodules should be subjected to surgery: review of current guidelines. Medicine (Baltimore) 2018; 97: e13634.

[7] Sim JS and Baek JH. Long-term outcomes following thermal ablation of benign thyroid nodules as an alternative to surgery: the importance of controlling regrowth. Endocrinol Metab (Seoul) 2019; 34: 117-123.

[8] Papini E, Pacella CM, Solbiati LA, Achille G, Barbaro D, Bernardi S, Cantisani V, Cesareo R, Chiti A, Cozzaglio L, Crescenzi A, De Cobelli F, Deandrea M, Fugazzola L, Gambelunghe G, Garberoglio R, Giugliano G, Luzi L, Negro R, Persani L, Raggiunti B, Sardanelli F, Seregni E, Sollini M, Spiezia S, Stacul F, Van Doorne D, Sconfienza LM and Mauri G. Minimally-invasive treatments for benign thyroid nodules: a Delphi-based consensus statement from the Italian minimally-invasive treatments of the thyroid (MITT) group. Int J Hyperthermia 2019; 36: 376-382.

[9] Ahrens P, Mueller D, Siebenlist S, Lenich A, Stoeckle U and Sandmann GH. The influence of radio frequency ablation on intra-articular fluid temperature in the ankle joint - a cadaver study. BMC Musculoskelet Disord 2018; 19: 413.

[10] ASGE Technology Committee, Navaneethan U, Thosani N, Goodman A, Manfredi M, Pannala R, Parsi MA, Smith ZL, Sullivan SA, Banerjee S and Maple JT. Radiofrequency ablation devices. VideoGIE 2017; 2: 252-259.

[11] Johnson BA, Sorokin I and Cadeddu JA. Ten-year outcomes of renal tumor radio frequency ablation. J Urol 2019; 201: 251-258.

[12] Lee YN, Jeong S, Choi HJ, Cho JH, Cheon YK, Park SW, Kim YS, Lee DH and Moon JH. The safety of newly developed automatic temperature-controlled endobiliary radiofrequency ablation system for malignant biliary strictures: a prospective multicenter study. J Gastroenterol Hepatol 2019; 34: 1454-1459.

[13] Oladeji LO and Cook JL. Cooled radio frequency ablation for the treatment of osteoarthritis-related knee pain: evidence, indications, and outcomes. J Knee Surg 2019; 32: 65-71.

[14] Wang LJ, Zhang ZY, Yan XL, Yang W, Yan K and Xing BC. Radiofrequency ablation versus resection for technically resectable colorectal liver metastasis: a propensity score analysis. World J Surg Oncol 2018; 16: 207.

[15] Angell TE and Alexander EK. Thyroid nodules and thyroid cancer in the pregnant woman. Endocrinol Metab Clin North Am 2019; 48: 557-567.

[16] Aysan E, Idiz UO, Akbulut H and Elmas L. Single-session radiofrequency ablation on benign thyroid nodules: a prospective single center study: radiofrequency ablation on thyroid. Langenbecks Arch Surg 2016; 401: 357-363.

[17] Baek JH, Lee JH, Sung JY, Bae JI, Kim KT, Sim J, Baek SM, Kim YS, Shin JH, Park JS, Kim DW, Kim JH, Kim EK, Jung SL and Na DG; Korean Society of Thyroid Radiology. Complications encountered in the treatment of benign thyroid nodules with US-guided radiofrequency ablation: a multicenter study. Radiology 2012; 262: 335-342.

[18] Bergasa NV and Jones EA. Assessment of the visual analogue score in the evaluation of the pruritus of cholestasis. J Clin Transl Hepatol 2017; 5: 203-207.

[19] Arora N, Scognamiglio T, Zhu B and Fahey TJ 3rd. Do benign thyroid nodules have malignant potential? An evidence-based review. World J Surg 2008; 32: 1237-1246.

[20] Cesareo R, Palermo A, Pasqualini V, Simeoni C, Casini A, Pelle G, Manfrini S, Campagna G and Cianni R. Efficacy and safety of a single radiofrequency ablation of solid benign non-functioning thyroid nodules. Arch Endocrinol Metab 2017; 61: 173-179.

[21] Jawad S, Morley S, Otero S, Beale T and Bandula S. Ultrasound-guided radiofrequency ablation (RFA) of benign symptomatic thyroid nodules - initial UK experience. Br J Radiol 2019; 92: 20190026.

[22] Jiang WJ, Yan PJ, Zhao CL, Si MB, Tian W, Zhang YJ, Tian HW, Feng SW, Han CW, Yang J, Yang KH and Guo TK. Comparison of total endoscopic thyroidectomy with conventional open thyroidectomy for treatment of papillary thyroid cancer: a systematic review and meta-analysis. Surg Endosc 2020; 34: 1891-1903.

[23] Ladurner R, Beuschlein F, Hallfeldt K, Angele M, Werner J and Sommerey S. Thyroid nodules--Indication for surgery? MMW Fortschr Med 2016; 158: 51-54.

[24] Lee GM, You JY, Kim HY, Chai YJ, Kim HK, Dionigi G and Tufano RP. Successful radiofrequency ablation strategies for benign thyroid nodules. Endocrine 2019; 64: 316-321.
[25] Sparchez Z, Mocan T, Hajjar NA, Bartos A, Hagiu C, Matei D, Craciun R, Mocan LP, Sparchez M and Leucuta DC. Percutaneous ultrasound guided radiofrequency and microwave ablation in the treatment of hepatic metastases. A monocentric initial experience. Med Ultrason 2019; 21: 217-224.
[26] Barile A, Quarchioni S, Bruno F, Ierardi AM, Arrigoni F, Giordano AV, Carducci S, Varrassi M, Carrafiello G, Caranci F, Splendiani A, Di Cesare E and Masciocchi C. Interventional radiology of the thyroid gland: critical review and state of the art. Gland Surg 2018; 7: 132-146.
[27] Vorlander C, David Kohlhase K, Korkusuz Y, Erbelding C, Luboldt W, Baser I and Korkusuz H. Comparison between microwave ablation and bipolar radiofrequency ablation in benign thyroid nodules: differences in energy transmission, duration of application and applied shots. Int J Hyperthermia 2018; 35: 216-225.
[28] Cesareo R, Pasqualini V, Simeoni C, Sacchi M, Saralli E, Campagna G and Cianni R. Prospective study of effectiveness of ultrasound-guided radiofrequency ablation versus control group in patients affected by benign thyroid nodules. J Clin Endocrinol Metab 2015; 100: 460-466.
[29] Haugen BR, Alexander EK, Bible KC, Doherty GM, Mandel SJ, Nikiforov YE, Pacini F, Randolph GW, Sawka AM, Schlumberger M, Schuff KG, Sherman SI, Sosa JA, Steward DL, Tuttle RM and Wartofsky L. 2015 American thyroid association management guidelines for adult patients with thyroid nodules and differentiated thyroid cancer: the American thyroid association guidelines task force on thyroid nodules and differentiated thyroid cancer. Thyroid 2016; 26: 1-133.
[30] Baek JH, Lee JH, Valcavi R, Pacella CM, Rhim H and Na DG. Thermal ablation for benign thyroid nodules: radiofrequency and laser. Korean J Radiol 2011; 12: 525-540.
[31] Park HS, Baek JH and Na DG. Benign thyroid nodules treatment using percutaneous laser ablation (PLA) and radiofrequency ablation (RFA). Int J Hyperthermia 2017; 33: 953-954.