

# Increasing the Size Limit of Benign Thyroid Lesions Resectable by Endoscopic Thyroidectomy via a Unilateral Axillo-breast Approach Without Gas Insufflation

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## Abstract

**Background** Endoscopic thyroidectomy is rarely attempted in patients with large goitrous lesions. We examined the feasibility and safety of endoscopic thyroidectomy via a unilateral axillo-breast approach without gas insufflation for resection of large thyroid tumors ( $\geq 4$  cm).

**Methods** The study included 111 patients: 82 in group 1 (tumor diameter  $< 4$  cm) and 29 in group 2 ( $\geq 4$  cm). Ninety-one patients underwent hemithyroidectomy and 20 underwent total thyroidectomy. Local complications, surgical outcomes, and pathological outcomes were compared between groups.

**Results** Postoperative permanent pathology revealed 24 follicular adenomas and 87 nodular hyperplasias. The mean tumor size in group 2 was  $51.10 \pm 7.66$  mm compared to  $25.24 \pm 8.14$  mm in group 1. The mean volume of the thyroid gland in group 2 was  $15.60 \pm 3.45$  cm<sup>3</sup> compared to  $11.27 \pm 2.40$  cm<sup>3</sup> in group 1 ( $p = 0.000$ ). Mean operating time did not differ significantly between groups ( $p = 0.520$ ). Postoperatively, minor hematomas were encountered in three patients (3.7%) in group 1. Three patients in group 1 (3.7%) and two in group 2 (6.9%) developed transient unilateral vocal cord palsy ( $p = 0.604$ ).

Won Shik Kim and Hyun Jun Hong have contributed equally to this work as co-first authors.

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Temporary hypocalcemia was observed in six and one patients in groups 1 and 2, respectively ( $p = 1.000$ ). No permanent recurrent laryngeal nerve palsy or hypoparathyroidism occurred in either group.

**Conclusion** Our data support the safety and feasibility of endoscopic thyroidectomy via a unilateral axillo-breast approach without gas insufflation, even for the treatment of benign thyroid lesions  $\geq 4$  cm.

## Introduction

Although there have been a few reports on endoscopic neck surgery for malignant thyroid tumors, the currently accepted indication for endoscopic thyroidectomy is the management of benign thyroid disease [1–5]. Indications for surgical therapy in benign thyroid disease include symptoms of esophageal and/or tracheal compression, progressive glandular enlargement, suspected malignancy, hyperthyroidism, and cosmesis [6, 7]. Recently, neck, anterior chest wall, axillary, and breast endoscopic approaches have been used in thyroid surgery, each with its own advantages [8–17]. However, most endoscopic approaches have limitations in their application to large thyroid lesions ( $> 3$ – $4$  cm in diameter or  $> 20$  ml in volume) [2, 4, 6, 8, 18]. As the size of a benign thyroid lesion increases, so too does the potential necessity for surgical treatment. Therefore, endoscopic thyroidectomy may be useful in larger lesions or enlarged glands. It has been reported that lesions up to 60 mm and enlarged glands can be removed endoscopically via an axillary or breast approach [6, 18].

Recently, we developed a unilateral axillo-breast approach for endoscopic thyroid surgery without gas insufflation [19]. Over time, the practice of endoscopic thyroidectomy within our institute has stabilized, and we

have modified the inclusion criteria for endoscopic thyroidectomy to include larger tumors.

In this study we examined surgical outcomes and post-operative complications after endoscopic thyroidectomy via a unilateral axillo-breast approach without gas insufflation in patients with small (<4 cm in diameter, group 1) versus large ( $\geq 4$  cm, group 2) tumors.

## Methods

### Study population

One hundred ninety-one patients with various thyroid diseases have undergone endoscopic thyroidectomy via a unilateral axillo-breast approach at Soonchunhyang Hospital since 2007. The present study sample consisted of those who underwent endoscopic thyroid surgery for benign thyroid lesions at the Department of Otolaryngology-Head and Neck Surgery, Soonchunhyang University College of Medicine, between January 2007 and September 2008. In most patients, this surgical method was chosen to correct cosmetic disfigurement arising from a noticeably enlarging gland, or it was performed under the advice of an endocrinologist after unsuccessful medical therapy. During this study period, we recommended endoscopic thyroidectomy to all patients with a benign nodule who were not over 60 years old. Accordingly, fewer than 20 patients, who were reluctant to have endoscopic thyroidectomy or were over 60 years old, underwent conventional open procedures during that period. This was a retrospective analysis of the surgical outcomes of endoscopic thyroidectomies performed by the same surgeon (YWK) and was not intended initially to be a comparison. The minimum follow-up period was 6 months.

Based on previous positive experiences with this technique, we recently began to perform endoscopic thyroidectomy even in cases of micropapillary carcinoma. However, the inclusion criteria in this study were restricted to benign nodules or follicular neoplasm on final pathology. Endoscopic thyroidectomy was not applied to patients with a history of thyroiditis, previous neck or thyroid surgery, or irradiation. We also excluded cases that required the completion of thyroidectomy because of postoperative pathology or those with micropapillary carcinoma found coincidentally during resection for multinodular goiter or Graves' disease. All patients were evaluated preoperatively via sonography and/or computed tomography (CT) and fine-needle aspiration cytology. The determination of thyroid volume was done with CT volumetry by three-dimensional reconstruction of the image using Vworks<sup>TM</sup> 4.0 (CyberMed Inc., Irvine, CA, USA). In case of bilateral multinodular goiter, the volume of the lobe with dominant

thyroid goiter was measured. Thyroid function test results were normal in all patients.

We performed hemithyroidectomy (HT) or total thyroidectomy (TT) according to bilaterality or multiplicity of thyroid lesions. In this retrospective study, our patients were separated in two groups. Group 1 consisted of patients with tumor diameters <4 cm and group 2 consisted of patients with tumor diameters  $\geq 4$  cm. Informed consent was not required for this retrospective analysis, but written informed consent was obtained regarding possible conversion to open surgery or reoperation (completion of thyroidectomy for the contralateral thyroid gland using an open or endoscopic procedure, and lymph node dissection using open surgery), depending on the final pathological results. The institutional review board of Soonchunhyang University College of Medicine approved this retrospective study.

### Unilateral axillo-breast approach

The patient was placed in the supine position under general anesthesia. The neck was extended slightly and the lesion-side arm was raised to fully expose the axilla. The surgical team consisted of the surgeon and one assistant, who was required to hold a 30° rigid endoscope and a suction-irrigator. A 4.5–5.5-cm skin incision was made parallel to a skin crease in the axillary fossa, through which we inserted the rigid endoscope and endoscopic instruments (Fig. 1a). The skin was elevated above the pectoralis major muscle exclusively under direct vision, using monopolar cauterization through the axillary skin incision, until the anterior border of the sternocleidomastoid muscle was exposed (Fig. 1b). To create a working space, we inserted an external retractor (Sejong Medical Corporation, Gyoha-eup, Korea) through the skin incision in the axilla, which was raised using a lifting device (Sejong Medical Corporation). A second 1.0-cm skin incision was made along the upper margin of the mammary areola on the tumor side for inserting a 12-mm trocar, which was directed to the midline of the sternal notch (Fig. 1a). Using only a harmonic scalpel (Harmonic Ace 36P<sup>®</sup>; Johnson & Johnson Medical, Cincinnati, OH, USA), we dissected the anterior border of the sternocleidomastoid muscle from the sternohyoid muscle and, in some cases, divided the omohyoid muscle.

The thyroid gland was exposed by dissection of the sternothyroid muscle with the harmonic scalpel (HS) and lateral traction of the sternocleidomastoid muscle (Fig. 2a, d). In all cases, only the HS was used for vascular control of the thyroid gland and strap muscles. The superior, middle, and inferior thyroidal arteries and veins were controlled using a low-power level (70- $\mu$ m vibration) to improve hemostasis. The other small vessels and

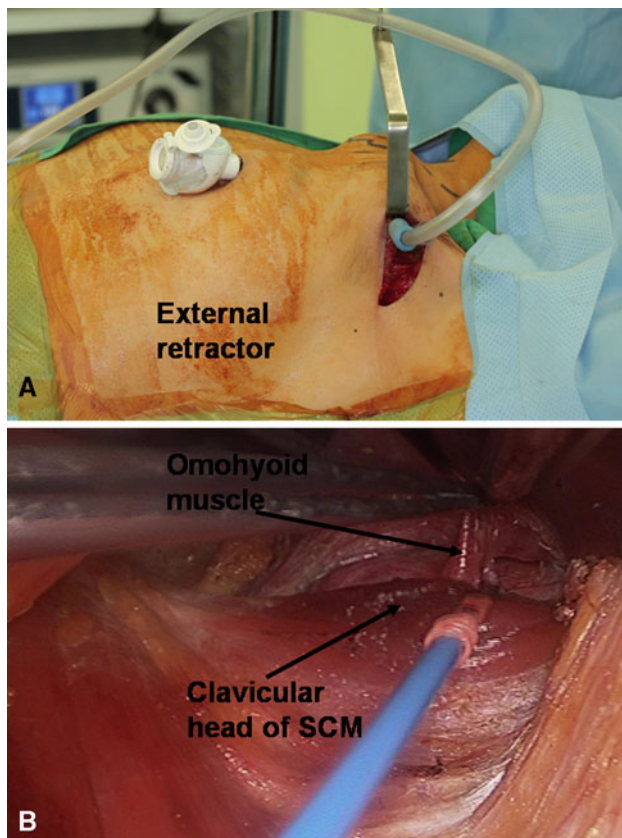


**Fig. 1** Unilateral axillo-breast approach. **a** 4.0–5.5-cm skin incision parallel to a skin crease was made in the axillary fossa, and a second 1.0-cm skin incision was made along the upper margin of the mammary areola on the tumor side for insertion of a 12-mm trocar. **b** The subplatysmal skin flap was elevated above the pectoralis major muscle exclusively under direct visualization using a Bovie coagulator through the axillary skin incision, until the anterior border of the sternocleidomastoid muscle was exposed

surrounding connective tissue were controlled using a higher-power level (100- $\mu$ m vibration) for easy cutting. After elevating the skin flap with monopolar cauterization, we used only the HS and an endoscopic dissector for vessel sealing and tissue dissection throughout the operation. With careful dissection, the upper pole was fully exposed. In all cases, no nerve monitoring of any kind was used intraoperatively. The superior thyroid vessels were identified and divided close to the thyroid gland using the HS, while avoiding injury to the external branch of the superior laryngeal nerve (SLN) (Fig. 2b, c). The superior parathyroid gland was identified during the dissection and left intact (Fig. 3a). The lateral view from the axillary port made it easy to observe the upper pole of the thyroid and to divide the vessels. We identified the tracheal wall, exposed it as a landmark for the midline, and dissected the lower pole from the adipose tissue and trachea. During this procedure, care was taken to avoid injury to the tracheal wall with the HS. Next, the inferior

thyroid vein was divided close to the thyroid gland using the HS to avoid injury to the inferior parathyroid gland. The thyroid gland was then retracted medially, and the perithyroidal fascia was divided and dissected using an endoscopic dissector and the HS. We performed a careful dissection to identify the inferior thyroid artery and recurrent laryngeal nerve (RLN) in the tracheoesophageal groove. The inferior thyroid artery was divided close to the thyroid gland to avoid injury to the RLN (Fig. 3b). In this procedure, the lateral view of the thyroid gland from the axillary port helped to ensure complete preservation and exposure of the nerve (Fig. 3b). The proper application of an endoscopic cottonoid and the dissector to Berry's ligament realized the complete dissection of the thyroid gland from the trachea. To prevent thermal injury, especially near Berry's ligament, we took great care to maintain a distance of at least 5 mm from the major neurovascular structures and the trachea. The thyroid gland was then dissected from the trachea, and the isthmus was resected using the HS (Fig. 3c, d). The resected specimen was extracted through the axillary skin incision. In cases of TT, a contralateral endoscopic lobectomy was performed via the contralateral axillo-breast approach (Fig. 4a, b). During the whole procedure, we made every effort to perform an *en bloc* resection without rupturing the tumor. We placed a Jackson-Pratt closed suction drain (200-ml, 3.2-mm diameter; Barovac Sewoon Medical, Seoul, Korea) in the wound and closed the wound with 4-0 Vicryl (subcutaneous) and 5-0 nylon (skin) sutures.

#### Surgical outcome assessment

The following variables were compared between groups: local complications (hemorrhage, hematoma, seroma, vocal cord palsy, hypocalcemia, and injury to adjacent structures including the trachea and esophagus), surgery-related outcomes (RLN identification, preservation of parathyroid gland, operating time, length of hospitalization, duration of drain placement, and total amount of drainage), and pathological outcomes (diameter of the primary tumors).

We checked for postoperative seromas and hematomas for at least 2 weeks postoperatively. We defined operating time as the time interval between skin incision and closure of the skin. The volume of drainage was measured over 24 h, and the drain was removed postoperatively if the volume was <20 ml in 24 h. Most patients were discharged the day after drain removal. Laryngoscopic examinations were used to evaluate vocal cord mobility preoperatively and 1 week postoperatively in all patients. Clinical symptoms and signs of hypocalcemia (numbness of the lips and hands, Chvostek's or Trousseau's sign, carpopedal spasm) and serum calcium concentrations were assessed in patients

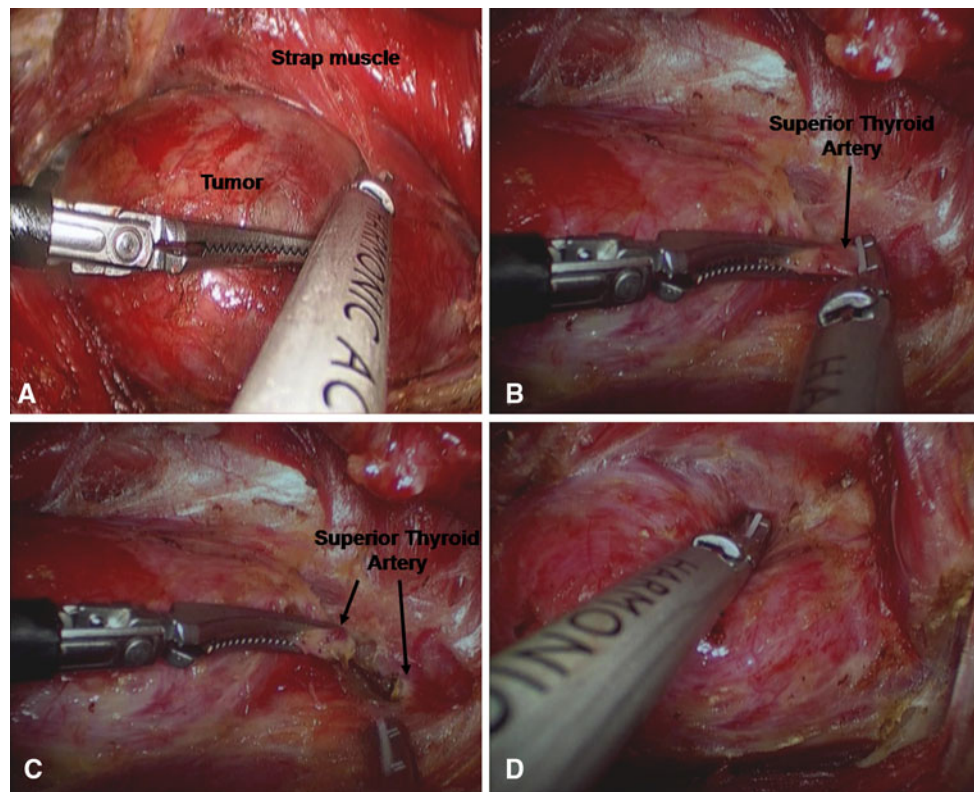


**Fig. 2** **a** The left thyroid gland was exposed by dissection of the sternothyroid muscle using a harmonic scalpel. **b** The left superior thyroid vessels were identified and divided close to the thyroid gland using a harmonic scalpel, avoiding injury to the external branch of the

superior laryngeal nerve. **c** Exposing and identifying the tracheal wall was important as a marker for the midline. **d** After dividing the left superior thyroid vessels, the isthmus portion was identified to avoid injury to the tracheal wall

treated with TT. Hypocalcemia was defined as serum calcium  $<8$  mg/dl during the immediate postoperative period and normocalcemia was serum calcium  $>8$  mg/dl at 6 months postoperatively without calcium supplements. Vocal cord palsy and hypocalcemia were considered permanent when no evidence of recovery was observed within 6 months postoperatively.

All patients were asked to grade postoperative pain in the neck or anterior chest wall at 1, 4, and 7 days, and 1 month. A pain intensity grade (I, no pain; II, very slight; III, slight; IV, moderate; and V, severe) was used [19]. Six months after surgery, all patients were asked to evaluate hypoesthesia or paresthesia in the neck or anterior chest wall, swallowing difficulty, shoulder dysfunction, and satisfaction with the cosmetic results, as described in our previous study [19].

#### Statistical analysis

Statistical analyses were performed using Student's *t* test, the  $\chi^2$  test, Fisher's exact test, or Mann–Whitney *U* test. A  $p < 0.05$  was deemed statistically significant.

#### Results

A total of 111 patients (98 women, 13 men; mean age =  $40.38 \pm 9.79$  years; range = 15–60 years; Table 1) were included in the study. Group 1 included 82 patients and group 2 had 29 patients. Ninety-one patients underwent endoscopic HT and 20 had endoscopic TT. In group 1, we performed 17 TTs and 65 HTs. In group 2 we performed three TTs and 26 HTs. The age and gender distributions of both groups were similar (Table 1). Postoperative permanent pathology revealed 24 follicular adenomas and 87 nodular hyperplasias (Table 1).

The mean tumor size in group 1 was  $25.24 \pm 8.14$  mm and that in group 2 was  $51.10 \pm 7.66$  mm. The mean volume of thyroid gland with the dominant goiter was  $11.27 \pm 2.40$  (group 1) and  $15.60 \pm 3.45$  (group 2) ( $p = 0.000$ ). The mean operating time for HT was  $109.62 \pm 37.77$  min in group 1 and  $115.77 \pm 40.93$  min in group 2 ( $p = 0.495$ ; Table 2). The mean operating time for TT was  $165.59 \pm 43.12$  min in group 1 and  $185.00 \pm 47.70$  min in group 2 ( $p = 0.487$ ; Table 2). Overall, the mean operating time for HT was significantly shorter than that for TT in both groups.

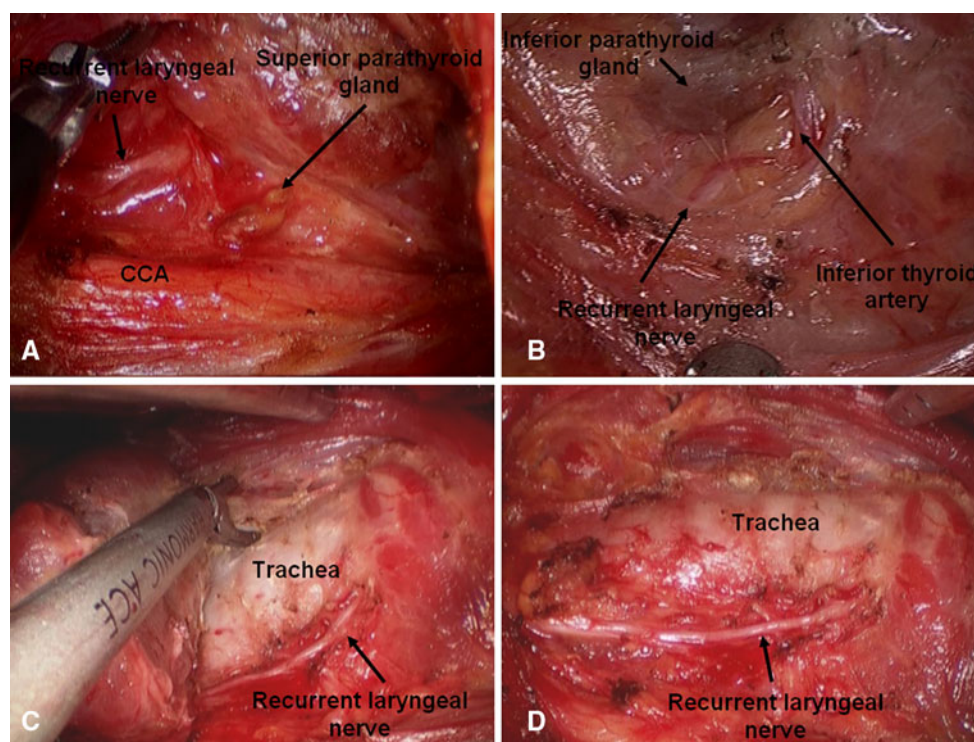


**Fig. 3** **a** The left superior parathyroid gland was identified and preserved between the recurrent laryngeal nerve and common carotid artery (CCA). **b** The left inferior thyroid artery was identified close to the left recurrent laryngeal nerve. **c** The left thyroid gland was then

dissected from the trachea, and the isthmus was resected using the harmonic scalpel. **d** The left endoscopic hemithyroidectomy was completed

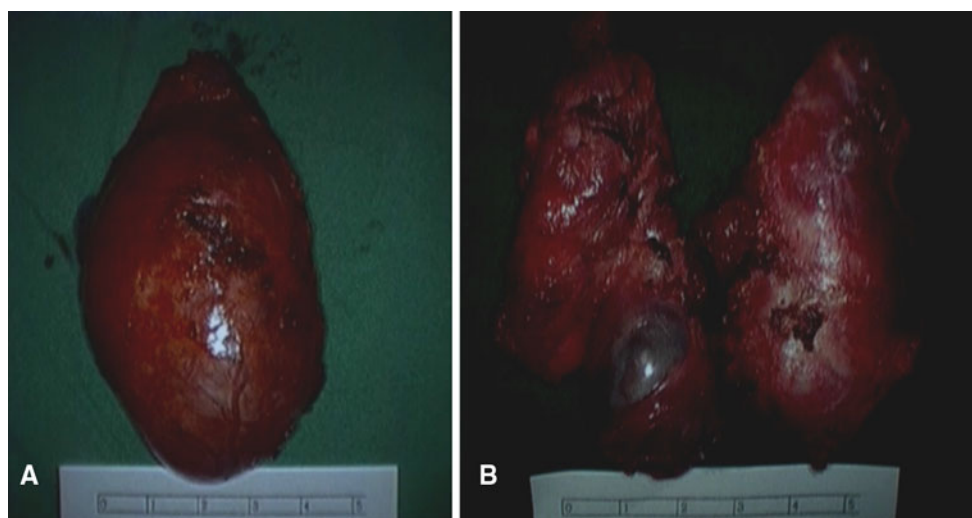


**Fig. 4** **a** A specimen resected via hemithyroidectomy (HT). **b** A specimen resected via total thyroidectomy (TT). The surgical specimens showed that thyroidectomy was accomplished without violation of the thyroid capsule

There was no significant difference between the two groups with respect to preservation of the parathyroid gland. We defined preservation of the parathyroid gland as an anatomical identification of it and the preservation of its vascular pedicle by endoscopic assessment. It was easier to identify and preserve the superior parathyroid gland than

the inferior parathyroid, irrespective of study group or operation type (Table 3).

Minor injury to the tumor capsule was encountered in some cases. However, all thyroid tumors were removed successfully without spillage of the tumor. The RLN was identified in all patients. All endoscopic procedures were

**Table 1** Demographic data and histopathologic diagnosis

|                     | Group 1      | Group 2       | <i>p</i> Value |
|---------------------|--------------|---------------|----------------|
| Number of patients  | 82           | 29            |                |
| HT                  | 65           | 26            | 0.211          |
| TT                  | 17           | 3             |                |
| Female/male         | 71/11        | 27/2          | 0.508          |
| Mean age (years)    | 40.00 ± 9.25 | 41.45 ± 11.27 | 0.496          |
| Histopathology      |              |               |                |
| Follicular adenoma  | 20           | 4             | 0.719          |
| Nodular hyperplasia | 62           | 25            |                |

*HT* hemithyroidectomy, *TT* total thyroidectomy

**Table 2** Postoperative outcomes

|                                                          | Group 1<br>( <i>n</i> = 82)  | Group 2<br>( <i>n</i> = 29)   | <i>p</i> Value |
|----------------------------------------------------------|------------------------------|-------------------------------|----------------|
| Primary tumor size (mm)                                  | 25.24 ± 8.14                 | 51.10 ± 7.66                  |                |
| Thyroid gland volume of dominant side (cm <sup>3</sup> ) | 11.27 ± 2.40<br>(7.40–21.50) | 15.60 ± 3.45<br>(10.90–22.80) | 0.000          |
| RLN identification                                       | All                          | All                           |                |
| Conversion to open surgery                               | 0                            | 0                             |                |
| Operation time (min)                                     |                              |                               |                |
| HT                                                       | 109.62 ± 37.77<br>(75–290)   | 115.77 ± 40.93<br>(80–230)    | 0.495          |
| TT                                                       | 165.59 ± 43.12<br>(85–260)   | 185.00 ± 47.70<br>(140–235)   | 0.487          |
| Amount of drainage (ml)                                  | 349.76 ± 135.60<br>(120–620) | 310.00 ± 99.61<br>(180–520)   | 0.151          |
| Duration of drainage (day)                               | 4.52 ± 1.37<br>(3–7)         | 4.14 ± 1.27<br>(3–7)          | 0.187          |
| Duration of hospital stay (day)                          | 5.71 ± 1.19<br>(4–8)         | 5.28 ± 1.03<br>(4–8)          | 0.086          |

*HT* hemithyroidectomy, *TT* total thyroidectomy, *PTG* parathyroid gland, *RLN* recurrent laryngeal nerve, *R* right side, *L* left side

**Table 3** Preservation of parathyroid glands

|              | Group 1<br>( <i>n</i> = 82)        | Group 2<br>( <i>n</i> = 29)    | <i>p</i> Value |
|--------------|------------------------------------|--------------------------------|----------------|
| HT           |                                    |                                |                |
| Sup. PTG (%) | 52/65 (80.0)                       | 20/26 (76.9)                   | 0.744          |
| Inf. PTG (%) | 32/65 (49.2)                       | 14/26 (53.8)                   | 0.691          |
| TT           |                                    |                                |                |
| Sup. PTG (%) | R: 14/17 (82.4)<br>L: 16/17 (94.1) | R: 2/3 (66.7)<br>L: 2/3 (66.7) | 0.509<br>0.284 |
| Inf. PTG (%) | R: 5/17 (29.4)<br>L: 9/17 (52.9)   | R: 1/3 (33.3)<br>L: 1/3 (33.3) | 1.000<br>1.000 |

*HT* hemithyroidectomy, *TT* total thyroidectomy, *PTG* parathyroid gland, *Sup.* superior, *Inf.* inferior *R* right side, *L* left side

**Table 4** Postoperative complications

|                              | Group 1<br>( <i>n</i> =82) | Group 2<br>( <i>n</i> =29) | <i>p</i> Value |
|------------------------------|----------------------------|----------------------------|----------------|
| RLN palsy: “Nerves at Risk”  |                            |                            | 0.604          |
| Temporary (%)                | 3/82 (3.7)                 | 2/29 (6.9)                 |                |
| Permanent (%)                | 0 (0.0)                    | 0 (0.0)                    |                |
| Hypoparathyroidism in TT     |                            |                            | 1.000          |
| Temporary (%)                | 6/17 (35.3)                | 1/3 (33.3)                 |                |
| Permanent (%)                | 0 (0.0)                    | 0 (0.0)                    |                |
| Hemorrhage (%)               | 0 (0.0)                    | 0 (0.0)                    |                |
| Hematoma (%)                 | 3/82 (3.7)                 | 0/29 (0.0)                 | 0.565          |
| Seroma (%)                   | 12/82 (14.6)               | 3/29 (10.3)                | 0.755          |
| Tracheoesophageal injury (%) | 0 (0.0)                    | 0 (0.0)                    |                |

*HT* hemithyroidectomy, *TT* total thyroidectomy, *PTG* parathyroid gland, *RLN* recurrent laryngeal, *Hemorrhage* hemorrhage requiring reoperation, *Nerves at Risk* the RLN of lesion side in HT or the RLN of dominant nodule side in cases of TT

performed successfully with no conversions. The volume and duration of postoperative drainage were similar between the groups (349.76 ± 135.60 ml and 4.52 ± 1.37 days in group 1 and 310.00 ± 99.61 ml and 4.14 ± 1.27 days in group 2; Table 2). The postoperative hospital stay was also similar between the groups (5.71 ± 1.19 days for group 1 and 5.28 ± 1.03 days for group 2; Table 2).

Although no statistically significant difference between the groups was observed for injury to the RLN (*p* = 0.604), transient unilateral vocal cord palsy was slightly higher in group 2 than in group 1 (6.9 vs. 3.7%) (Table 4). All the temporary RLN palsies that resolved spontaneously within 3 months postoperatively developed among the RLN of the lesion side in HT or the RLN of the dominant nodule side in TT (nerves at risk).

Clinical manifestations of hypocalcemia (numbness in the lips and hands, Chvostek’s or Trousseau’s sign, or carpopedal spasm) were observed in six patients in group 1 (35.3%) and two in group 2 (33.3%), but the frequency of this complication did not differ between groups (*p* = 1.000; Table 4). The mean serum calcium concentration in these hypocalcemic patients was 6.74 mg/ml (range = 6.1–7.3 mg/ml; normal range = 8–10 mg/ml). All patients with transient postoperative hypocalcemia were discharged on a therapeutic regimen of oral calcium and vitamin D, and their serum calcium concentrations increased to the normal range within a mean period of 1.63 months (range = 1–3 months). No case of permanent hypocalcemia or vocal cord paralysis was observed.

Postoperative hematomas were encountered in three patients (3.7%) in group 1. The hematomas, which arose from tiny hemorrhagic foci in the subplatysmal flap, were evacuated at bedside without difficulty. Twelve patients in

**Table 5** Pain score in the neck or anterior chest wall

|             | I  | II | III | IV | V | <i>p</i> Value |
|-------------|----|----|-----|----|---|----------------|
| POD 1 day   |    |    |     |    |   |                |
| Group 1     | 6  | 15 | 24  | 31 | 6 | 0.575          |
| Group 2     | 4  | 6  | 5   | 13 | 1 |                |
| POD 4 day   |    |    |     |    |   |                |
| Group 1     | 17 | 23 | 17  | 21 | 4 | 0.912          |
| Group 2     | 7  | 9  | 6   | 7  | 0 |                |
| POD 7 day   |    |    |     |    |   |                |
| Group 1     | 41 | 18 | 10  | 11 | 2 | 0.845          |
| Group 2     | 15 | 7  | 5   | 2  | 0 |                |
| POD 1 month |    |    |     |    |   |                |
| Group 1     | 70 | 8  | 3   | 1  | 0 | 0.143          |
| Group 2     | 20 | 6  | 3   | 0  | 0 |                |

I = no pain; II = very slight; III = slight; IV = moderate; V = severe; POD = postoperative day

**Table 6** Patient complaints 6 months after surgery

| Complaint                   | Group 1<br>( <i>n</i> = 82) |    | Group 2<br>( <i>n</i> = 29) |    | <i>p</i> value |
|-----------------------------|-----------------------------|----|-----------------------------|----|----------------|
|                             | Yes                         | No | Yes                         | No |                |
| Hypoesthesia or paresthesia | 6                           | 76 | 3                           | 26 | 0.695          |
| Swallowing difficulty       | 3                           | 79 | 1                           | 28 | 1.000          |
| Shoulder dysfunction        | 0                           | 82 | 0                           | 29 |                |

group 1 (14.6%) and three in group 2 (10.3%) developed postoperative seromas ( $p = 0.755$ ), which were resolved by repeated needle aspiration without compressive dressings.

No inadvertent injury to adjacent structures such as the trachea or esophagus was observed in either group (Table 4).

Results with respect to postoperative pain and discomfort are shown in Tables 5 and 6. No significant difference was observed between groups. Some patients complained of moderate to severe neck or anterior chest wall pain on the first postoperative day. However, postoperative pain decreased thereafter, and few patients complained of moderate or severe pain 7 days after surgery. A few patients complained of hypoesthesia or paresthesia in the neck or anterior chest wall and swallowing difficulty within 6 months.

Data on patient satisfaction with cosmetic results are presented in Table 7. We obtained satisfactory cosmetic results in both groups because the small incision scar in the axilla was completely covered by the patient's arm when it was in a natural position, and the periareolar incision was almost invisible (Fig. 5). These postoperative functional results were consistent with our previous study [19].

**Table 7** Cosmetic results 6 months after surgery

| Cosmetic result            | Group 1<br>( <i>n</i> = 82) | Group 2<br>( <i>n</i> = 29) |
|----------------------------|-----------------------------|-----------------------------|
| I = Extremely satisfied    | 77                          | 26                          |
| II = Satisfied             | 3                           | 1                           |
| III = Average              | 1                           | 2                           |
| IV = Dissatisfied          | 1                           | 0                           |
| V = Extremely dissatisfied | 0                           | 0                           |
| <i>p</i> Value             | 0.421                       |                             |



**Fig. 5** Photograph at 8 weeks after endoscopic thyroidectomy. **a, b** The small axillary scar was completely covered by the patient's arm when in a natural position, and the periareolar incision was almost invisible

## Discussion

Although some studies have demonstrated the use of endoscopic thyroidectomy in the treatment of various lesions, including malignancy, the main indications for this technique remain restricted to small benign lesions with undetermined cytology, follicular neoplasms, and Graves' disease [1–5]. Most patients with benign thyroid lesions may show large symptomatic goiter. However, the use of endoscopic procedures for large goiters remains controversial because of the difficulty in creating a working space

and limitations in instrumentation. For these reasons, there have been few reports published on the feasibility of the use of endoscopic thyroidectomy in treating large benign thyroid lesions [2, 4, 6, 8, 18].

Since the introduction of our endoscopic thyroidectomy approach in 2007, we have performed more than 250 successful endoscopic thyroid operations via the unilateral axillo-breast approach. After an initial period, the surgeon's learning curve gradually tends to stabilize. However, because this technique is still indicated only for a minority of patients, we examined the feasibility and safety of endoscopic thyroidectomy in patients with relatively large ( $\geq 4$  cm) benign tumors. The removal of such tumors may be challenging because of the small working space and the intrinsic difficulty in grasping and manipulating irregularly shaped masses, which may also have a hyper-vascular capsule. Also, it is important to avoid iatrogenic trauma to the thyroid capsule, especially in the case of large goiter, to limit the risk of tumor seeding. The risk of tumor spillage increases when large thyroid tumors are mobilized in small working spaces with sharp instruments.

Our study suggests that endoscopic thyroidectomy for tumors  $\geq 4$  cm is feasible and safe. Such large thyroid tumors cannot be removed by minimally invasive video-assisted thyroidectomy (MIVAT) [3, 20–22]. Furthermore, these more conventional approaches may leave disfiguring scars on the neck. Our unilateral axillo-breast approach facilitates the creation of an adequate surgical field with a retractor (rather than gas insufflation), thus enhancing the instrumentation. We are able to use a relatively large incision in the axilla because the scar is completely covered by the patient's arm and natural skin creases. By using an axillary incision, a larger working space is created in comparison with other endoscopic approaches. In terms of instrumentation, we speculated that tumor size is more important than the volume of the thyroid gland in our approach. Since two groups were created depending on the size of the tumor, the distribution of thyroid gland volume between the two groups slightly coincided in our study. In addition, by applying the surgical instruments (endoscopic dissector and HS) at a 45° angle through the axillary and periareolar ports, we achieved safe and complete thyroidectomy with little difficulty, even in cases of large benign thyroid nodules. The HS replaced various instruments routinely used in endoscopic thyroidectomy, namely the dissector, clip applicator, scissors, and electrosurgical hook or spatula.

The rate of conversion to open surgery has been reported at 0–13% [3]. The main reasons for conversion to open surgery are hemorrhage, difficult dissection, tumor size, thyroiditis, and tracheal injury [3]. In the present study, conversion to open surgery was not required in any patient, despite some difficulty in dissecting and grasping the tumor in cases of thyroiditis or large goitrous lesions. We think

that our previous extensive experience in resecting small thyroid lesions reduced the likelihood of capsule injury or conversion to open surgery.

Using the approach described here, we easily identified and preserved the recurrent laryngeal nerve and parathyroid glands, even in those with tumor diameters  $\geq 4$  cm. The superior parathyroid gland was often easier to identify and dissect from the thyroid gland on a vascular pedicle, as in open thyroidectomy. There was no case of permanent hypocalcemia in the TT cases. Although we feel that there is little difference between open and endoscopic thyroidectomy in terms of preserving the parathyroid glands, functional parathyroid preservation should be validated through a large-scale study. We speculate that the sporadic cases of transient RLN palsy in our study resulted from thermal injury from the harmonic scalpel or traction injury during dissection of the RLN.

Our endoscopic thyroidectomy approach has several potential weaknesses in terms of invasiveness, hospital stay, and operating time. Endoscopic thyroidectomy should achieve the same results as traditional surgery, with additional benefits in terms of reduced trauma, better postoperative course, shorter hospital stay, decreased postoperative pain, and improved cosmetic results, the importance of which cannot be underestimated, particularly in women [3, 21, 23]. Although our approach is superior in terms of cosmetic outcome (i.e., invisible scars in neutral positions), it tends to be more invasive than the cervical approach or MIVAT and requires significant dissection to achieve an adequate working space. However, recently, Wang et al. [24] reported that endoscopic thyroidectomy via the anterior chest wall approach did not differ significantly from conventional thyroid surgery with respect to the production of inflammatory markers such as interleukin-6, tumor necrosis factor, C-reactive protein, and cortisol, which indicates the degree of surgical damage. In the present study, we experienced a relatively high frequency of seroma and the mean drainage volume was elevated; these outcomes may reflect the wide skin flap elevation and creation of a large working space from the axilla to the thyroid gland. Although these complications were resolved successfully in all cases, they likely contributed to the relative increase in length of hospital stay compared to that of other studies [9, 14]. Moreover, in Korea, patients and their families prefer to stay in hospital for longer periods because it is covered under the national health insurance program, and patients often actively participate in decisions regarding the time of hospital discharge.

Our results demonstrate that “endoscopic” does not always necessarily mean “minimally invasive” [3]. The technique described here will likely face criticism because it involves excessive tissue dissection (especially in the bilateral approach for total thyroidectomy), longer hospital stays, and a broader learning curve because of the unfamiliar anatomy

[25]. However, we think that the strong point of endoscopic thyroid surgery is the minimal visible scarring at the expense of the above-mentioned weak points. In some cases, even small hypertrophic scars on the neck or chest wall may be unacceptable from an aesthetic viewpoint. To date, we have been unable to find an approach that is both minimally invasive *and* totally scarless in the literature; thus, our technique represents a valuable alternative to more conventional methods of thyroidectomy. Nevertheless, a relatively broad learning curve and the fear of exposing patients to prolonged operating times and morbidity are major obstacles to the application of some endoscopic techniques. In terms of operating times, there was no significant difference between our two groups. However, for our technique, the increased operating time compared to that for traditional open and MIVAT techniques can only be overcome with additional experience.

Cosmetic results are difficult to evaluate because of reliance on the subjective judgment of the patient. However, the majority of patients in both groups were satisfied with their results. Several patients complained of mild hypoesthesia and paresthesia in the neck and anterior chest wall, which ceased within 1 year postoperatively, consistent with our previous study [19].

Our study suggests that endoscopic thyroidectomy via a unilateral axillo-breast approach without gas insufflation is safe and effective, even for benign thyroid lesions  $\geq 4$  cm, although there is room for improvement in terms of invasiveness. Considering that the prevalence of thyroid disease is much higher in young women than in men, scarless endoscopic thyroidectomy is desirable. Therefore, ongoing research should focus on developing simultaneously less invasive but cosmetically sufficient endoscopic thyroidectomy techniques that are applicable in patients with large thyroid tumors.

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