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Comparison between cutting versus retraction of anterior cervical musculature during endoscopic thyroidectomy

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Abstract

To compare the different techniques of managing the anterior cervical muscle group during endoscopic thyroidectomy via the trans-thoraco-areolar approach. A total of 90 patients with thyroid tumors less than 3 cm were evaluated. The time for each intraoperative step, total surgery duration, intraoperative blood loss volume, pathology results, number of lymph nodes dissected and patient satisfaction with esthetics were assessed. Intraoperative blood loss volume, drainage volume on the first postoperative day, number of lymph nodes dissected in the central region, postoperative hospitalization duration, number of transient laryngeal nerve palsy cases, and number of transient hypocalcemia cases were similar between the muscle transection (MT) and muscle retraction (MR) groups. The MT group had significantly higher postoperative pain scores after 12 hours, but pain scores at 48 hours postoperatively were not significantly different between the 2 groups. In the unilateral thyroidectomy subgroup, the durations of isthmus resection, freeing the lateral thyroid, exposing the laryngeal recurrent nerve, and management of the inferior pole were similar for both muscle management methods. The muscle dissection and suture time was significantly longer for the MT group than that for the MR group; in contrast, the upper pole management time of the muscle resection group was significantly shorter. In the bilateral resection subgroup, both muscle management methods required similar durations for managing the contralateral upper pole after ipsilateral thyroidectomy. However, intraoperative blood loss was significantly higher for MR than for MT, while postoperative pain was relatively mild. In the malignant tumor subgroup, duration of inferior thyroid pole management was significantly less for MT than for MR. There are significant differences between the 2 muscle management methods in handling and suturing muscles. Both methods have satisfactory postoperative outcomes for resection of thyroid nodules with diameters ≤3 cm. For tumors located in the upper pole, transection of the anterior cervical muscles confers higher feasibility of the thyroidectomy technique; however, suturing becomes difficult in such scenarios.

Abbreviations: ET = endoscopic thyroidectomy, LAC = linea alba cervicalis, MR = muscle retraction, MT = muscle transection, TN = Thyroid nodules, TTAA = trans-thoraco-areolar approach.

Keywords: anterior cervical muscle group, benign tumors, endoscopic thyroidectomy, thyroid cancer, thyroid nodules, trans-thoraco-areolar approach

1. Introduction

The thyroid is an important butterfly-shaped endocrine gland located in the lower part of the neck. It is present anterior and lateral to the trachea below the larynx. The thyroid plays a crucial role in the regulation of the basal metabolic rate, stimulation of the physical and intellectual development and reproductive capacity, and calcium metabolism.[1–3] Thyroid nodules (TN) are a very common lesion of the endocrine system and are often detected by imaging techniques (mainly ultrasound). the prevalence of TN detected by physical examination is commonly 4% to 7%[4], and that by imaging studies is 30% to 67%.[5] Although most TN are benign lesions, a significant number of tumors are malignant. When a thyroid nodule is potentially malignant or exhibits symptoms of compression, surgery is the definite option.

DL and WC contributed equally to this work.

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This study was approved by the Institutional Ethics Committee of the authors' institution. Informed consent was obtained from all the individuals recruited for participation in the study.

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Recently, the incidence of sporadic TN has been increasing every year and such nodules have been detected in several people through palpation on physical examination during outpatient visits and imaging. The incidence of malignant TN has also been increasing.[4] The first endoscopic thyroid surgery was reported by Huscher et al in 1997.[6] After over 20 years of development, endoscopic thyroid surgery has become a widely accepted surgical procedure. The main advantages of endoscopic thyroid surgery compared to conventional open thyroid surgery are absence of visible scar on the neck, lesser pain, shorter length of hospitalization, and better esthetic results.[7–12] However, due to insufficient exposure and difficulties in surgery, the choice of the surgical method is exceptionally important; a better surgical method is beneficial for clinical surgery. Summarizing the surgical experience and analyzing the timing of each step will help to standardize and promote better endoscopic surgical methods. Currently, various endoscopic thyroid surgery techniques have been in practice, including the trans-axillary,[10] anterior breast,[13] and transcervical[14] approaches and some hybrid approaches such as the axillary bilateral breast approach,[15] bilateral axillo-breast approach,[16] and the unilateral trans-axillary–trans-mammary approach. These new techniques transfer the surgical wound site from the neck to the other areas of the upper extremity that can be covered with clothing.

In endoscopic thyroid surgery, the creation of space, especially the management of the anterior cervical muscle group, is very important. Transection and retraction are the 2 common methods currently applied in the management of the anterior cervical musculature. For nodules measuring >3 cm in diameter, muscle transection (MT) is generally used to obtain good visualization; however, there is no conclusive approach for those measuring <3 cm. This retrospective study included 90 patients who underwent endoscopic thyroid nodule resection via the trans-thoraco-areolar approach (TTAA). We analyzed and compared the parameters of duration of surgery, postoperative pain scores, and postoperative complications between the 2 muscle management modalities (MT and MR) during endoscopic thyroidectomy (ET) via the TTAA. Furthermore, subgroup analyses based on nodal benignity/malignancy and unilateral/bilateral thyroidectomy were performed. There are only few reports describing both these muscle management modalities during ET via the TTAA; hence, our study aimed to provide new insights on muscle management during this procedure.

2. Materials and methods

2.1. Study population

This study enrolled 90 patients with thyroid tumors measuring <3 cm, who underwent endoscopic thyroid surgery by the same team at our institution from January 2018 to January 2020. All patients were treated by the transaxillary mammary approach, which was divided into MT mode (n = 46) and MR mode (n = 44) according to the different ways of managing the anterior cervical muscle group. The inclusion criteria for this study were TN measuring <3 cm in diameter, no serious organic lesions in the important organs such as heart, lungs, or kidneys, age 16 to 75 years. The exclusion criteria were TN measuring >3 cm in diameter, previous history of neck surgery, poor general condition or ineligible for surgery.

2.2. Surgical method

2.2.1. Anesthesia and positioning. Endotracheal intubation was performed and general anesthesia induced for all the patients. The patient was placed in a supine position with pillows under the shoulders and neck, and the neck was in a slightly hyperextended position. Routine iodophor disinfection and draping were performed. The monitor was located at the head of the patient, with the surgeon and assistant standing on either side.

2.2.2. Operation space establishment. An expansion solution (500,000 parts of epinephrine saline; approximately 80 mL) was injected into the anterior cervical area starting from the anterior chest wall above the areola. A 1-cm long curved incision was made above the areola, and a cystic cavity was formed by repeated punctures with a separating rod along the injection layer upwards, making the cavity as triangular as possible. A cannula and 30˚-endoscope were inserted. Carbon dioxide gas was injected at a pressure of 6 to 8 mm Hg, and a 5-mm arc incision was made at the bilateral areola. The cannula was punctured subcutaneously into the surgical site, and the deep surface gap of the platysma muscle was separated with an electric hook or ultrasonic knife upwards to the thyroid cartilage and on both sides of the lateral sternocleidomastoid muscle under direct view to establish a subcutaneous surgical operating space.

2.2.3. Management of the anterior cervical muscle group. In the MT group, an ultrasound knife was used to transect the middle of the anterior cervical musculature, and the upper stump of the musculature was sutured and retracted to expose the superior pole of the thyroid gland. In the MR group, an ultrasound knife or electric hook was used to make a longitudinal cut in the linea alba cervicalis (LAC), and the anterior cervical muscle group was sutured and retracted bilaterally to expose the thyroid gland.

2.2.4. Excision of the thyroid gland. After exposing the thyroid gland, the trachea was first determined as the landmark, and the inferior pole vessels below the anterior trachea were dissected with an ultrasonic knife. The lateral thyroid was dissected, and the median veins, if present, were resected with an ultrasonic knife. The isthmus was dissected, the suspensory ligament was dissociated, and the superior pole blood vessels were severed with an ultrasonic knife. At this point, the gland could be turned inwards and upwards, and the laryngeal nerve could be found in the tracheoesophageal groove and traced into the larynx. The recurrent laryngeal nerve and parathyroid glands were protected, and total or near-total thyroidectomy was performed. If the pathology test result was malignant, the lymph nodes in area VI (including the tracheoesophageal groove, anterior trachea, and anterior larynx) were dissected. If the contralateral thyroid gland was to be resected, the inferior pole, lateral thyroid gland, and superior pole were freed in the same way, and the laryngeal nerve and parathyroid glands were exposed and protected. The contralateral thyroid gland was subjected to total, near-total, or subtotal resection. The specimen was excised, the operative field was rinsed, the wound was examined, and hemostasis was performed carefully.

2.2.5. Suturing of the anterior cervical muscle group. In the MT group, intermittent transverse suturing of the anterior cervical musculature was conducted. Suturing requires that the sternohyoid, sternothyroid, and omohyoid muscles be aligned. In the MR group, intermittent longitudinal suturing of the sarcolemma of the anterior cervical musculature was conducted.

The drainage tube was inserted, and the incision was sutured or glued, thus completing the procedure.

2.3. Observation markers

The intraoperative blood loss volume, postoperative day 1 drainage volume, postoperative complications, postoperative pathological results, number of lymph nodes dissected, postoperative hospitalization duration, postoperative pain at

12 and 48 hours (visual analog scale scoring from "0" [no pain] to "10" [most severe unbearable pain]), esthetics of the skin incision (visual analog scale scoring from "0" [extremely unsatisfactory] to "10" [very satisfactory]) were compared between the 2 muscle management modalities. Moreover, the time spent in completing each step of the procedure, including establishment of the surgical space, management of the anterior cervical musculature, freeing the lateral thyroid (middle thyroid vein), management of the inferior pole (including freeing the recurrent laryngeal nerve), management of the superior pole, exposing the parathyroid gland, glandular excision, freeing the lateral, inferior, and superior poles of the contralateral thyroid gland, exposing and protecting the recurrent laryngeal nerve and parathyroid gland, excision of the contralateral gland, muscle suturing, and insertion of the drainage tube were compared. The total surgery duration was also assessed.

We further divided the patients into unilateral thyroidectomy and bilateral thyroidectomy subgroups and benign tumor surgery and malignant tumor surgery subgroups based on the postoperative pathological findings. The aforementioned intraoperative and postoperative markers were compared in the subgroup analysis. Additionally, the time spent in completing each intraoperative step and the total duration of surgery were compared.

2.4. Statistical processing

Statistical Product and Service Solutions, version 19.0, was used for statistical analysis. Normally distributed quantitative data are expressed as $\bar{x} \pm$ s. Independent samples *t* test was used for inter-group comparisons. Non-normally distributed quantitative data are expressed as medians and interquartile ranges[M(Q1,Q3)]. The rank-sum test was used for comparison between the groups. The Mann-Whitney *U* chi-square test was used for inter-group comparison of qualitative data. *P*-values <.05 were considered statistically significant.

3. Results

3.1. Baseline information

As shown in Table 1, 90 patients were recruited for this study, of which 16 (17.78%) were male and 74 (82.22%) were female. There were 8 men and 38 women in the MT group and 8 men and 36 women in the MR group. The mean age of the participants was 41.67 years (range, 19–72 years), with a mean height of 165.52 cm, mean weight of 67.97 kg, and mean body mass index of 24.69 kg/m^2. The mean tumor size of the patients undergoing surgery was 1.52 cm.

Table 1

Baseline data of 2 groups of patients.

	Overall (n = 90)	MT (n = 46)	MR (n = 44)	Statistical value	*P* value
Gender (male/female)	16/74	8/38	8/36	0.010	.922
Age (yr)	41.67 ± 11.33	41.17 ± 11.02	39.89 ± 12.79	$t = 0.512$	.610
Tumor size (cm)	1.52 ± 0.73	1.78 ± 0.75	1.52 ± 0.79	$t = 1.571$	.120
Height (cm)	165.52 ± 7.83	163.91 ± 7.88	164.07 ± 7.20	$t = -0.970$	.923
Weight (kg)	67.97 ± 13.63	66.09 ± 13.82	62.08 ± 11.56	$t = 1.488$	.140
BMI	24.69 ± 3.95	24.46 ± 4.05	22.92 ± 2.79	$t = 2.099$	.039*

BMI = body mass index, MR = muscle retraction, MT = muscle transection.
*$P < .05$.

3.2. Overall comparison of the MT and MR methods

As shown in Table 2, 46 patients underwent MT and 44 underwent MR. Laparoscopic surgery was completed in all 90 patients without intraoperative conversion to open surgery. Among them, 49 were diagnosed with papillary thyroid cancer based on the postoperative pathological analysis. Intraoperative blood loss volume, postoperative day 1 drainage volume, number of lymph nodes dissected in the central region, and postoperative hospitalization duration were similar between the 2 groups. No serious complications such as bleeding, permanent parathyroid injury, or laryngeal nerve injury occurred postoperatively, and the probability of the occurrence of transient laryngeal nerve palsy and transient hypocalcemia were relatively similar between the 2 groups. The MT group had significantly higher postoperative pain scores at 12 hours than those in the MR group ($P < .05$); however, the difference between the pain scores of the groups at 48 hours was not significant. Moreover, patients in both groups were satisfied with the esthetic results of the incision. When comparing the surgical steps, the total surgery duration did not differ significantly between the 2 methods. However, there was a statistically significant difference in the time spent on freeing the ipsilateral laryngeal recurrent nerve and management of the ipsilateral superior and inferior poles between the 2 muscle management methods. Notably, the time required for the treatment of the ipsilateral superior pole in the MT method was significantly shorter than that in the MR method. However, the statistical difference between the 2 methods in the management of the contralateral side for the same condition was not significant.

3.3. Comparison of the 2 muscle management methods in unilateral thyroidectomy

As shown in Table 3, 42 patients underwent unilateral thyroidectomy, with MT performed in 20 and MR in 22 cases. The durations of each intraoperative step for both muscle management techniques are shown in Table 3. The time required for muscle dissection and suturing during the surgery was significantly longer in the MT group than that in the MR group ($P < .05$). In contrast, the time required for managing the superior pole was significantly lesser in the MT group than in the MR group because of the convenience of exposing the transected muscle in the former group ($P < .05$).

3.4. Comparison of the 2 muscle management methods in bilateral thyroidectomy

Likewise, as shown in Table 4, in the bilateral thyroidectomy group, MT and MR were performed in 26 and 22 cases, respectively. The time spent in each intraoperative step for both muscle management modalities is shown in Table 4. The MR group had higher volumes of intraoperative blood loss than the MT group; however, the latter had a higher postoperative pain score after 12 hours than the former. However, the time spent on dissection and suturing was significantly greater in the MT group than that in the MR group ($P < .05$). In the MT group, the time required for managing the superior pole and recurrent laryngeal nerve on the affected side was significantly less than that in the MR group.

3.5. Comparison of the 2 muscle management methods in thyroidectomy for benign thyroid tumors

As shown in Table 5, the postoperative pathology test results revealed findings of benign tumors in 41 patients, including 19 patients who underwent MT and 22 who underwent MR. As regards the duration of each intraoperative step, both muscle resection and retraction required the same time for completing

Table 2

Overall comparison of the MT and MR methods.

	MT (n = 46)	MR (n = 44)	Statistical value	*P* value
Intraoperative blood loss volume (mL)	10.00 (10.00, 20.00)	20.00 (10.00, 30.00)	−1.319	.187
Postoperative day 1 drainage volume (mL)	58.7 ± 36.28	52.5 ± 31.56	0.863	.391
Pathology results (malignant/benign)	24/22	25/19	0.196	.658
Number of lymph nodes dissected	6.63 ± 1.81	7.00 ± 1.80	−0.726	.472
Postoperative recurrent laryngeal nerve paralysis	2	4	0.813	.367
Postoperative hypocalcemia	4	1	1.768	.184
Postoperative hospitalization duration (d)	2 (2, 3)	2.5 (2, 3)	−0.536	.490
12 h postoperative pain score	3 (2, 3)	2 (2, 3)	−1.979	**.048**
48 h postoperative pain score	1 (1, 1)	1 (1, 1)	−0.686	.493
Esthetics score	9.00 (8.00, 9.75)	9.00 (8.00, 9.75)	−1.051	.293
Establishment of the surgical space	19.90 (18.85, 20.90)	20.45 (19.23, 22.13)	−1.402	.161
Management of the anterior cervical musculature	6.70 (6.10, 8.00)	3.95 (3.40, 5.00)	−7.254	**<.001***
Cut the isthmus	3.00 (2.50, 4.50)	3.50 (2.90, 4.00)	−0.832	.405
Freeing the lateral poles	2.90 (2.13, 4.10)	3.20 (2.58, 4.20)	−1.151	.250
Freeing the recurrent laryngeal nerve	7.90 (7.20, 9.05)	8.90 (8.20, 10.00)	−2.853	**.004***
Management of the inferior pole	5.00 (5.00, 5.88)	6.05 (5.55, 7.00)	−3.227	**<.001***
Exposing the parathyroid gland	4.00 (3.43, 4.60)	4.00 (3.80, 4.50)	−0.341	.733
Management of the superior pole	6.20 (4.10, 8.10)	9.30 (7.38, 11.00)	−4.833	**<.001***
Part IV of the clean lymph nodes	7.33 ± 1.59	7.65 ± 1.75	−0.675	.503
Freeing the lateral poles of the contralateral thyroid gland	3.08 ± 1.28	3.36 ± 1.60	−0.671	.506
Freeing the contralateral recurrent laryngeal nerve	8.08 ± 1.64	8.78 ± 1.96	−1.333	.189
Management the inferior poles of the contralateral thyroid gland	5.20 (4.70, 6.20)	6.00 (5.40, 6.88)	−2.353	**.019**
Exposing the contralateral parathyroid gland	4.00 (3.50, 4.98)	3.90 (3.83, 4.38)	−0.540	.589
Management of the superior poles of the contralateral thyroid gland	6.10 (4.00, 8.00)	7.30 (5.53, 8.95)	−1.481	.139
Flushing and taking sample	4.80 (4.00, 7.70)	6.00 (5.00, 7.40)	−1.210	.226
Muscle suturing	8.77 ± 1.95	4.59 ± 1.93	10.510	**<.001***
Insertion of the drainage tube	5.00 (4.43, 6.00)	4.70 (3.80, 5.70)	−2.648	**.008***
The total surgery duration (min)	100.40 (81.13, 111.28)	97.85 (77.55, 112.90)	0.496	.620

MR = muscle retraction, MT = muscle transection.

*$P < .05$.

Table 3

Comparison of the 2 muscle management methods in unilateral thyroidectomy.

	MT (n = 20)	MR (n = 22)	Statistical value	*P* value
Intraoperative blood loss volume (mL)	20 (10, 20)	20 (10, 20)	−0.132	.895
Postoperative day 1 drainage volume (mL)	50 (30, 70)	37.5 (13.75, 60)	−1.393	.164
Pathology results (malignant/benign)	4/16	7/15	0.757	.384
Number of lymph nodes dissected	6.5 (5.25, 7.75)	7 (6, 8)	−0.482	.630
Postoperative hypocalcemia	1/19	0/22	0.002	.962
Postoperative recurrent laryngeal nerve paralysis	0/20	1/21	0.000	1.000
Postoperative hospitalization duration (d)	2 (2, 3)	2 (2, 3)	−0.740	.459
12 h postoperative pain score	2 (2, 3)	2 (2, 3)	1.125	.261
48 h postoperative pain score	1 (1, 1)	1 (1, 1)	1.165	.244
Postoperative esthetics score	9 (9, 9)	9 (8, 9)	1.339	.180
Establishment of the surgical space	19.95 ± 2.95	20.13 ± 2.68	−0.210	.835
Management of the anterior cervical musculature	7.00 ± 1.57	4.15 ± 1.38	6.252	**<.001***
Cut the isthmus	3.00 (2.28, 4.38)	3.25 (2.78, 4.00)	−0.507	.612
Freeing the lateral thyroid	2.50 (1.88, 4.00)	3.10 (2.20, 4.05)	−0.907	.364
Freeing the recurrent laryngeal nerve	7.70 (7.05, 9.05)	8.90 (8.15, 10.23)	−2.067	.039
Management of the inferior pole	5.44 ± 1.11	6.09 ± 1.06	−1.930	.061
Exposing the parathyroid gland	4.28 ± 1.41	4.34 ± 1.30	−0.146	.885
Management of the superior pole	5.65 (4.10, 8.10)	9.30 (7.00, 11.00)	−3.228	**<.001***
Part IV of the clean lymph nodes	7.50 (6.63, 9.88)	7.50 (7.00, 8.00)	0.096	.923
Flushing and taking sample	5.99 ± 2.82	6.45 ± 1.96	−0.612	.544
Muscle suturing	9.07 ± 1.98	4.64 ± 1.96	7.279	**<.001***
Insertion of the drainage tube	5.00 (4.23, 6.00)	4.55 (3.78, 5.70)	1.664	.096
The total surgery duration (min)	79.60 (72.70, 85.55)	77.50 (73.33, 80.80)	0.932	.351

*$P < .05$.

MR = muscle retraction, MT = muscle transection.

each intraoperative step. In particular, the MT group required significantly longer time for the muscle processing (cutting) and suturing stages than the MR group, whereas the MR group required significantly lesser time than the MT group for managing the upper pole.

3.6. Comparison between muscle resection and contraction in thyroidectomy for malignant thyroid tumors

As shown in Table 6, 49 patients had findings of malignant thyroid tumors from histopathological evaluations following

Table 4

Comparison of the 2 muscle management methods in bilateral thyroidectomy.

	MT (n = 26)	MR (n = 22)	Statistical value	*P* value
Intraoperative blood loss volume (mL)	10 (10, 20)	20 (10, 37.5)	−2.031	**.042***
Postoperative day 1 drainage volume (mL)	50.00 (50.00, 87.50)	70.00 (35.00, 97.50)	−0.491	.623
Pathology results (malignant/benign)	20/6	18/4	0.004	.953
Number of lymph nodes dissected	6.65 ± 1.93	7.00 ± 1.81	−0.726	.472
Postoperative recurrent laryngeal nerve paralysis	2/24	3/19	0.039	.843
Postoperative hypocalcemia	3/23	1/21	0.122	.727
Postoperative hospitalization duration (d)	2 (2, 3)	3 (2, 3)	0.255	.799
12 h postoperative pain score	3 (3, 3)	2.5 (2.3)	1..597	.110
48 h postoperative pain score	1 (1, 1)	1 (1, 1.75)	−1.802	.071
Postoperative esthetics score	9 (8, 9.75)	9 (8, 9.75)	0.270	.787
Establishment of the surgical space	19.75 ± 3.23	21.18 ± 2.10	−1.776	.082
Management of the anterior cervical musculature	6.7 (6.13, 8.08)	4.15 (3.63, 4.98)	5.301	**<.001***
Cut the isthmus	3.53 ± 1.58	3.60 ± 1.06	−0.176	.861
Freeing the lateral thyroid	3.43 ± 1.52	3.65 ± 1.05	−0.560	.578
Freeing the recurrent laryngeal nerve	8.00 (7.20, 9.05)	8.90 (8.20, 9.98)	−1.958	**.050**
Management of the inferior pole	5.00 (5.00, 5.88)	6.05 (5.60, 7.00)	−2.433	**.015**
Exposing the parathyroid gland	4.00 (3.43, 4.60)	4.00 (3.83, 4.50)	−0.541	.589
Management of the superior pole	6.37 ± 2.40	9.34 ± 2.23	−4.409	**<.001***
Part IV of the clean lymph nodes	7.20 ± 1.56	7.63 ± 1.93	−0.764	.450
Freeing the lateral poles of the contralateral thyroid gland	3.08 ± 1.28	3.36 ± 1.60	−0.671	.506
Freeing the contralateral recurrent laryngeal nerve	8.08 ± 1.64	8.78 ± 1.96	−1.333	.189
Management of the inferior poles of the contralateral thyroid gland	5.20 (4.70, 6.20)	6.00 (5.40, 6.88)	−2.353	**.019**
Exposing the contralateral parathyroid gland	4.00 (3.50, 4.98)	3.90 (3.83, 4.38)	0.540	.589
Management of the superior poles of the contralateral thyroid gland	6.27 ± 2.40	7.27 ± 2.24	−1.492	.143
Flushing and taking sample	4.80 (4.30, 7.70)	5.50 (5.00, 7.35)	−0.664	.507
Muscle suturing	8.77 ± 1.95	4.59 ± 1.93	7.445	**<.001***
Insertion of the drainage tube	5.45 ± 1.15	4.85 ± 1.42	1.616	.113
The total surgery duration (min)	111.72 ± 8.56	113.67 ± 7.06	−0.854	.397

MR = muscle retraction, MT = muscle transection.

*$P < .05$.

thyroidectomy, including 24 patients who underwent MT and 25 others who underwent MR. Intraoperative blood loss was significantly higher for MR than for MT. Postoperative pain scores at 12 hours were higher for MT than for MR; however, no significant difference was observed in the scores at 24 hours. Regarding the time taken for each intraoperative step, the time required for muscle dissection and suturing with drainage tube insertion and wound closure was significantly greater for MT than for MR ($P < .05$). However, the time taken for upper pole management of the ipsilateral side and the inferior pole was significantly shorter for MT than that for MR ($P < .05$).

4. Discussion

The anterior chest wall approach[17] chosen in this study is most widely used in China,[18] since it provides a wider field-of-view as that in open surgery, while avoiding the coaxial (chopstick) effect.[19] Therefore, early career surgeons can master this technique, and use it for bilateral thyroidectomy or other complicated cases. The anterior cervical muscle group (strap muscles) presents significant challenges in exposing the thyroid gland, and its differential management can lead to different exposure results. Therefore, adequate resection of the anterior cervical musculature is useful for getting a better visualization, especially for large tumors.

However, resection could cause greater damage in comparison to the resection of the *LAC* with retraction of the anterior cervical muscles to the sides, which is less traumatic and provides good exposure. The objective of this study was to determine the appropriate management of the anterior cervical muscle group for patients with tumors measuring <3 cm.

For experienced surgical teams that have overcome the learning curve, the duration of the surgical procedure is an important metric for assessing the difficulty of the procedure. Furthermore, the time required for completing each step should be assessed. Many quality control training systems assess surgical proficiency based on the duration of the procedure. Hence, in this study we used the duration of each postoperative step as an evaluation criterion. Our study showed that intraoperative blood loss volume, drainage volume on the first postoperative day, postoperative hospitalization duration, and the probability of complications including transient recurrent laryngeal nerve palsy and transient hypocalcemia were relatively similar for both muscle management methods in the TTAA. Moreover, as the skin incision was similar in both methods, postoperative esthetic scores were good. The point of difference was the postoperative pain scores at 12 hours, although the anterior chest wall approach has a relatively low pain score relative to the emerging transoral ET vestibular approach,[20] which were significantly higher for MT than that for MR, especially for the resection of malignant thyroid tumors. However, there was no significant difference in the scores at 48 hours postoperatively. Since both methods ensure adequate visualization of the anterior cervical musculature, both methods took almost the same time for the management of the isthmus, lateral thyroid, recurrent laryngeal nerve, parathyroid glands, and lymph nodes in the central region.

There were differences between the 2 techniques in the time necessary for muscle management and suturing, and the management of the recurrent laryngeal nerve. Besides, a significant difference was noted in the time required for the management of the superior and inferior poles of the thyroid gland, especially the superior pole. This is because most of the attachment points of the anterior cervical muscle group are in the thyroid cartilage and hyoid bone, which are closer to the superior pole of the thyroid gland.[21] If the muscle is not resected, but only retracted, the exposure would be limited. However, MT can facilitate suture suspension and provide sufficient retraction to expand the upper space, thus enabling better exposure of the superior pole of the

Table 5

Comparison of the 2 muscle management methods in thyroidectomy for benign thyroid tumors.

	MT (n = 22)	MR (n = 19)	Statistical value	*P* value
Intraoperative blood loss volume (mL)	20.00 (10.00, 20.00)	20.00 (10.00, 20.00)	−0.579	.563
Postoperative day 1 drainage volume (mL)	64.18 ± 40.20	47.37 ± 33.64	−0.650	.158
Postoperative recurrent laryngeal nerve paralysis	0	0	–	–
Postoperative hypocalcemia	1/18	0/22	0.006	.940
Postoperative hospitalization duration (d)	2.00 (2.00, 3.00)	2.00 (2.00, 3.00)	−0.590	.516
12 h postoperative pain score	2.50 (2.00, 3.00)	2.00 (2.00, 3.00)	−0.861	.389
48 h postoperative pain score	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)	−0.019	.985
Postoperative esthetics score	9.00 (8.25, 9.00)	8.00 (7.75, 8.50)	−0.847	.397
Establishment of the surgical space	19.67 ± 2.95	20.40 ± 2.61	−0.830	.411
Management of the anterior cervical musculature	6.96 ± 1.54	4.27 ± 1.40	5.888	**<.001***
Cut the isthmus	3.00 (2.50, 4.375)	3.50 (2.90, 4.00)	−0.500	.617
Freeing the lateral thyroid	3.15 (2.10, 3.65)	3.20 (3.00, 4.10)	−1.257	.209
Freeing the recurrent laryngeal nerve	7.60 (6.78, 8.43)	8.80 (8.10, 10.1)	−2.382	.017
Management of the inferior pole	5.00 (4.85, 6.25)	6.10 (5.60, 6.60)	−2.221	.026
Exposing the parathyroid gland	4.00 (3.80, 4.90)	3.90 (3.75, 4.25)	−0.670	.503
Management of the superior pole	5.10 (4.10, 8.05)	9.10 (7.00, 10.85)	−3.342	**<.001***
Freeing the lateral poles of the contralateral thyroid gland	2.15 (1.80, 3.33)	3.40 (2.80, 4.13)	−0.960	.365
Freeing the contralateral recurrent laryngeal nerve	8.10 (7.20, 9.23)	8.75 (7.80, 9.70)	−0.126	.903
Management of the superior poles of the contralateral thyroid gland	4.95 (4.70, 5.28)	5.70 (5.40, 6.13)	−2.436	**.041***
Exposing the contralateral parathyroid gland	4.05 (3.85, 4.78)	4.45 (3.93, 4.93)	−0.406	.695
Management of the superior poles of the contralateral thyroid gland	5.40 (4.00, 7.55)	7.30 (6.45, 7.95)	−1.147	.284
Flushing and taking sample	7.40 (4.00, 8.50)	6.00 (5.00, 7.40)	−0.210	.834
Muscle suturing	4.75 ± 2.03	8.94 ± 2.01	6.614	**<.001***
Insertion of the drainage tube	5.00 (4.225, 6.00)	4.70 (3.75, 5.10)	−1.899	.058
The total surgery duration (min)	80.45 (73.63, 95.90)	77.40 (72.95, 79.90)	−1.216	.224

MR = muscle retraction, MT = muscle transection.

*$P < .05$.

Table 6

Comparison of the 2 muscle management methods in thyroidectomy for malignant thyroid tumors.

	MT (n = 24)	MR (n = 25)	Statistical value	*P* value
Intraoperative blood loss volume (mL)	15 (10, 27.5)	20 (10, 30)	−2.399	**.016***
Postoperative day 1 drainage volume (mL)	53.67 ± 32.32	56.40 ± 29.98	−0.307	.760
Number of lymph nodes dissected	6.63 ± 1.81	7.00 ± 1.80	−0.726	.472
Postoperative recurrent laryngeal nerve paralysis	2/22	3/22	0.000	1.000
Postoperative hypocalcemia	3/21	1/24	0.319	.527
Postoperative hospitalization duration (d)	3 (2, 3)	3 (2, 3)	−0.222	.825
12 h postoperative pain score	3 (2, 3)	2 (2, 3)	1.841	**.066**
48 h postoperative pain score	1 (1, 1)	1 (1, 1)	−0.888	.379
Postoperative esthetics score	9 (8, 10)	9 (8, 9.75)	0.546	.585
Establishment of the surgical space	20.20 (19.00, 20.98)	20.50 (19.50, 22.50)	−0.772	.440
Management of the anterior cervical musculature	5.95 (4.40, 7.15)	4.40 (3.60, 5.40)	5.506	**<.001***
Cut the isthmus	3.10 (2.73, 4.00)	3.00 (2.90, 4.00)	0.553	.580
Freeing the lateral thyroid	3.45 (2.30, 4.60)	3.20 (2.20, 4.10)	−0.271	.787
Freeing the recurrent laryngeal nerve	8.60 (7.65, 9.53)	9.00 (8.20, 10.00)	−1.603	.109
Management of the inferior pole	5.50 (5.00, 6.50)	5.60 (5.00, 7.00)	−2.330	**.020***
Exposing the parathyroid gland	4.00 (3.80, 4.60)	4.00 (3.80, 4.90)	−1.056	.291
Management of the superior pole	6.60 ± 2.47	9.57 ± 2.42	−4.260	**<.001***
Part IV of the clean lymph nodes	7.33 ± 1.59	7.65 ± 1.75	−0.675	.503
Freeing the lateral poles of the contralateral thyroid gland	3.22 ± 1.30	3.33 ± 1.63	−0.237	.814
Freeing the contralateral recurrent laryngeal nerve	7.93 ± 1.53	8.78 ± 2.09	−1.446	.157
Management of the inferior poles of the contralateral thyroid gland	5.95 (5.03, 6.95)	6.00 (5.40, 7.30)	−1.596	.111
Exposing the contralateral parathyroid gland	3.90 (3.55, 4.58)	3.90 (3.83, 4.00)	0.573	.567
Management of the superior poles of the contralateral thyroid gland	6.43 ± 2.54	7.31 ± 2.38	−1.094	.281
Flushing and taking sample	5.00 (4.35, 7.50)	5.00 (4.80, 7.40)	−1.826	.068
Muscle suturing	8.87 ± 1.93	4.51 ± 1.87	8.034	**<.001***
Insertion of the drainage tube	5.53 ± 1.24	4.82 ± 1.23	2.033	**.048***
The total surgery duration (min)	109.70 ± 12.66	106.72 ± 15.09	0.748	.458

MR = muscle retraction, MT = muscle transection.

*$P < .05$.

thyroid gland and reducing the management time. This is particularly evident in tumors located in the superior pole.

Furthermore, it is especially important because thyroid tumors located in the superior pole were shown to have a higher risk of lymph node metastasis of the central nervous system than those located elsewhere.[22]

In the subgroup comparison between unilateral and bilateral thyroidectomy, intraoperative blood loss volume and 12-hour

postoperative pain scores were significantly greater for MR than for MT, whereas no significant difference between both muscle management methods was noted regarding the time spent on the management of the contralateral superior pole in bilateral thyroidectomy. This was partly attributable to the removal of the thyroid gland on the ipsilateral side and subsequent relative widening of the overall space, which allowed the much easier retraction of the contralateral thyroid gland toward the midline, thus providing better visualization of the superior pole and reducing the difficulty. Therefore, the contralateral upper pole management time of the MR group is similar to that of the MT group.

We found that the time required for muscle dissection and suturing during the surgery was significantly longer for MT than for MR techniques ($P < .05$) in unilateral thyroidectomy, which was attributed to the absence of contralateral thyroid treatment. However, the time required for superior-pole management was significantly lesser with MT than that with MR, which was ascertained to be because of the convenience of exposing the transected muscle in the muscle resection group ($P < .05$).

Additionally, in the comparisons between the benign and malignant subgroups (as shown in Tables 5 and 6), we found that while exposing the inferior pole of the thyroid, ipsilateral inferior pole management required more time with MR than with MT in the malignant tumor subgroup but not in the benign tumor subgroup. Moreover, the postoperative pain score at 12 hours in the malignant tumor subgroup was relatively high for MT than for MR. However, no significant difference in the postoperative pain score at 24 hours was noted for the malignant subgroup, and there was no similar situation in the benign tumor subgroup.

This difference could be attributed to the tighter adherence of malignant tumors to the surrounding tissues with greater damage that requires more intraoperative time for management of the damage and greater degree of postoperative pain, in comparison to benign tumors, especially in the retraction mode. It should be emphasized that in patients with benign tumors, no cases of postoperative complications including recurrent laryngeal nerve paralysis were reported, which is consistent with other reports showing a low probability of postoperative recurrent laryngeal nerve damage due to fewer neurological infiltrates of benign thyroid tumors.[23]

The MT approach has 2 shortcomings based on the data in our study. First, suturing is more difficult in MT than in MR. Hence, the TTAA that provides a bottom-up view should be used for suturing the transverse muscle with the MT technique. Furthermore, muscle suturing runs in parallel to the direction of the conventional stitches and makes it difficult to observe the inferior side of the muscle stump. This requires skilled left-handed manipulation to assist in retraction and to expose the different muscle layers. In contrast, in the MR approach, it is relatively easy to suture only the *LAC*, which is perpendicular to the stitches. Additionally, the transection method is associated with relatively high postoperative pain. Therefore, these factors should be considered when selecting the appropriate surgical method.

This study has several strengths. First, there were 2 controlled conditions. One was a fixed team, wherein all procedures were performed by the same team that had overcome the learning curve, as evidenced by the relatively small discrete trend in the overall surgical duration. The other condition was that there were clear inclusion criteria. All patients with tumors measuring <3 cm were selected so that the overall difficulty was relatively well controlled. Under such study conditions, it is feasible to assess the difficulty of the procedure by measuring the duration of each step. Second, to allow for a more comprehensive assessment of the characteristics of both muscle management modalities, a more diverse range of cases was included. Both benign and malignant lesions were included, with surgical steps covering the dissection of lymph nodes in the central region. Moreover, cases of unilateral and bilateral thyroidectomies were included.

Endoscopic thyroid surgery is an intricate procedure that requires patience because of difficult access and a narrow cavity. When performing this procedure, 1 should be fully aware of the importance of each approach, which includes management of the anterior cervical musculature.

This study has some limitations. First, this study is limited by its retrospective design, which has inherent flaws, including biased recall due to a surgeon practice, loss of patient information, and patients lost to follow-up. Second, our sample size was relatively small, and we only employed 1 surgical approach, which was the TTAA. This method has its own limitations compared to those of the axillary breast approach[24] or other emerging methods. Third, our relatively short follow-up periods may be inadequate to estimate the complication rates and prognosis, and it limits the comparison of the results with the effects of long-term surgery between the 2 muscle management modalities. Fourth, we did not document and analyze the location of the thyroid masses during surgery. Based on the increasing number of studies on the location of thyroid tumors in recent years, the location of the TN can be considered an independent risk factor for thyroid prognosis.[25] Hence, this should be considered in conjunction with tumor location to help select the appropriate surgical procedure. Further studies on screening and optimization of endoscopic thyroid surgery are required to explore a more rational approach for the procedure.

5. Conclusion

There was no significant difference in the total surgery duration and efficacy between the MT and retraction methods used for managing the anterior cervical musculature during ET performed via the TTAA. However, at postoperative 12 hours, the pain was more intense with MT than with MR. When the thyroid tumor was malignant or when bilateral thyroidectomy was performed, more intraoperative blood loss was reported with MR than with MT. For thyroid tumors located in the superior pole, it is recommended that transection or partial resection of the anterior cervical musculature be performed to obtain good visualization when the retraction approach appears difficult.

Author contributions

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