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Can Robotic Thyroidectomy Be Performed Safely in Thyroid Carcinoma Patients?

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Since the adoption of the Da Vinci robotic system for remote access thyroid surgery, robotic thyroidectomy (RT) has become a popular surgical option for patients who want to avoid neck scars. Surgeons in South Korea pioneered this surgical technique and have reported successful outcomes. Although many studies have reported that RT is a feasible and safe therapeutic alternative, concerns over the surgical and oncological safety of RT remain. This article reviews the advantages and disadvantages of RT and compares the surgical safety and oncological completeness of RT with conventional open thyroidectomy.

Keywords: Thyroid neoplasms; Robotic thyroidectomy; Robot-assisted thyroidectomy; Transaxillary thyroidectomy; Bilateral axillo-breast approach

INTRODUCTION

Thyroid carcinoma is the most common endocrine malignancy [1]. Although the treatment of choice has been conventional open thyroidectomy (OT), this method inevitably results in neck scars due to the anatomical location of the thyroid gland. To avoid cosmetically undesirable outcomes, various remote approaches have been utilized for patients with low risk of recurrence, the two most common techniques being the transaxillary approach (TAA) and bilateral axillo-breast approach (BABA).

In the TAA, the patient's lesion-side arm is raised over the head, and a 5- to 6-cm vertical skin incision is made in the axilla. Surgical instruments are inserted through a subcutaneous skin flap running from the axilla to the anterior neck, with surgery continuing from the lateral side (Fig. 1) [2]. In contrast, BABA uses two 0.8-cm-sized axillar incisions and two circumareolar incisions, measuring 0.8-cm on the left and 1.2-cm on the right side. The 1.2-cm circumareolar incision is used as a camera port and can be moved to the left side if the surgeon prefers [3]. Both the TAA and BABA techniques were originally developed for endoscopic surgery, but they have been generally replaced by robotic surgery since the adoption of the Da Vinci robotic system in 2007. Robotic surgery has advantages over endoscopic surgery, including superior field of view, ergonomic improvement, and learning curve [4,5]. The merits of the robotic system, including high-definition three-dimensional imaging, high degree of freedom of motion, and a tremor filtering system, have increased the popularity of robotic thyroidectomy (RT).

Despite many studies reporting that RT is effective and safe in patients with thyroid cancer, not all thyroid surgeons advo-

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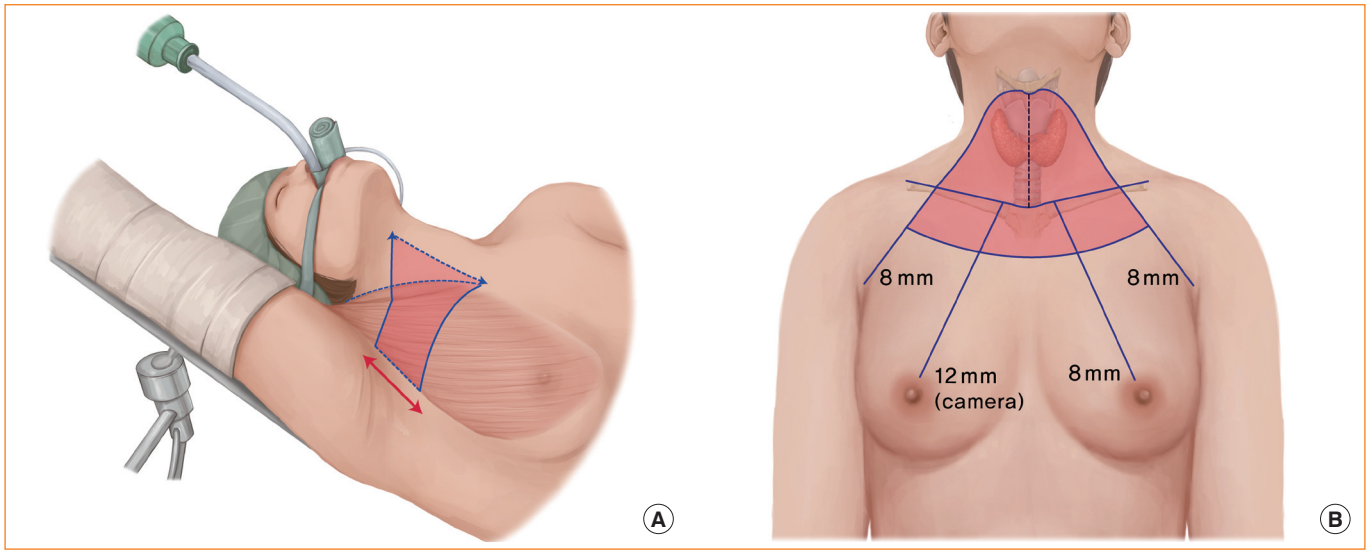

Fig. 1. Patient position and flap dissection area (red color) of transaxillary approach (A) and bilateral axillo-breast approach (B).

cate RT. RT has several disadvantages, including being costly, technically demanding, and requiring advanced training [6]. To date, however, no randomized controlled study has compared RT with OT. This review of previously published studies compares the outcomes of RT with those of OT.

COSMETIC OUTCOMES OF ROBOTIC THYROIDECTOMY

The most important motivation for patients to choose RT is the absence of neck scarring. For example, a prospective questionnaire study of 41 patients who underwent RT and 43 patients who underwent OT evaluated cosmetic satisfaction 3 months postoperatively [7]. In a second study, cosmetic satisfaction was assessed after 1 day, 1 week, and 1 or 3 months in 75 patients who underwent RT and 226 who underwent OT [8]. In both studies, cosmetic satisfaction was greater in the RT than in the OT group at all recorded time points. Cosmetic satisfaction in patients who underwent modified radical neck dissection (MRND) was also higher in the RT than in the OT group [9]. Thus, the cosmetic benefits of RT seem to be established.

POSTOPERATIVE PAIN AFTER ROBOTIC THYROIDECTOMY

Since RT requires the formation of a larger skin flap than OT, concerns have arisen that postoperative neck and chest pain may be greater after RT. Contrary to this assumption, levels of pain were similar after RT and OT. For example, a questionnaire evaluation of patients 24 hours after thyroidectomy found no significant difference in pain after RT and OT [7]. Another study evaluating pain on a visual analogue scale 30 minutes, 4 hours, and 1, 2, 3, and 10 days after RT or OT found no difference in analgesic use, with the pain score being lower in the RT group than in the OT group at 1 and 2 days after surgery [10]. An evaluation of neck and chest pain found that neck pain was similar in the RT and OT groups, although anterior chest pain was significantly greater in the RT group [8]. However, chest pain score in the RT group was lower than neck pain score in both groups.

SURGICAL SAFETY

Recurrent laryngeal nerve injury

Table 1 shows the incidence of transient and permanent recurrent laryngeal nerve injury (RLNI) who underwent robotic or OT. Most of the studies defined transient RLNI as hoarseness or vocal cord palsy persisting less than 6 months. Six studies comparing RT with OT found similar rates of transient/permanent RLNI [7,8,11-14]. The incidence of transient RLNI in patients who underwent RT varied from 0% to 20%, with most studies reporting a rate less than 15%. Permanent RLNI was observed in only 0.2% to 0.3% of the patients [4,15-18], a rate comparable to that of open surgery [19].

Hypoparathyroidism

Although the definition of hypoparathyroidism differs among

Table 1. Incidence of Transient and Permanent Recurrent Laryngeal Nerve Injury

First author	Affiliate	Approach	No. of patient (RT vs. OT)	No. of TT (RT vs. OT)	Evaluation	Incidence of transient RLNI		*P* value	Incidence of permanent RLNI		*P* value
						RT	OT		RT	OT	
Lee et al. [7] (2010)	Ajou University	TAA	41 vs. 43	26 vs. 26	Laryngoscopy	1 (2.4)	0 (0.0)	0.308	0 (0.0)	0 (0.0)	1.000
Kim et al. [11] (2011)	Sungkyunkwan University	BABA	69 vs. 138	69 vs. 138	Laryngoscopy	1 (1.4)	1 (0.7)	0.626	0 (0.0)	0 (0.0)	1.000
Tae et al. [8] (2012)	Hanyang University	TAA	75 vs. 226	29 vs. 204	Laryngoscopy	6 (8.0)	7 (3.1)	0.097	0 (0.0)	1 (0.4)	1.000
Landry et al. [12] (2012)	M.D. Anderson Cancer Center	TAA	25 vs. 25	0 vs. 0	Not mentioned	5 (20.0)	4 (16.0)	1.000	0 (0.0)	1 (4.0)	1.000
Yoo et al. [15] (2012)	Catholic University of Korea	TAA	46	30	Laryngoscopy	0 (0.0)	-	-	0 (0.0)	-	-
Kim et al. [16] (2012)	Korea University	BABA	93	72	Not mentioned	3 (3.2)	-	-	0 (0.0)	-	-
Lee et al. [4] (2013)	Seoul National University	BABA	1,026	872	Laryngoscopy	124/872 (14.2)	-	-	2/872 (0.2)	-	-
Noureldineet al. [13] (2013)	Tulane University	TAA	24 vs. 35	14 vs. 25	Laryngoscopy	1 (4.1)	2 (5.7)	0.760	0 (0.0)	0 (0.0)	1.000
Yi et al. [17] (2013)	Ulsan University	TAA	98 vs. 423	98 (100) vs. 423 (100)	Not mentioned	-	-	-	1 (1.0)	2 (0.5)	0.466
Kim et al. [14] (2014)	Chung-Ang University	BABA	123 vs. 392	100 vs. 364	Laryngoscopy	6 (4.9)	24 (6.1)	0.607	0 (0.0)	1 (0.3)	1.000
Ban et al. [18] (2014)	Yonsei University	TAA	3,000	1,090	Not mentioned	37 (1.2)	-	-	8 (0.3)	-	-

Data are expressed as number (%)
RT, robotic thyroidectomy; OT, open thyroidectomy; TT, total thyroidectomy; RLNI, recurrent laryngeal nerve injury; TAA, transaxillary approach; BABA, bilateral axillo-breast approach.

studies, it is generally based on parathyroid hormone, calcium level, or on hypocalcemic symptoms (Table 2). In most studies, a diagnosis of permanent hypoparathyroidism required the condition to last more than 6 months. In six studies comparing RT and OT [7,8,11,13,14,17], the incidence of permanent hypoparathyroidism was similar in the two groups, although one study [17] reported a higher rate of transient hypocalcemia in the RT group.

Other complications

Other rare complications are described in Table 3. Unique complications associated only with RT included brachial injury and skin flap perforation, although their incidence was only 0.1% in the study with the largest patient population [18]. Bleeding is considered a major complication of both RT and OT, but hematomas requiring reoperation were uncommon in the RT group [4,8,12,18].

Sensory changes

Since RT requires the formation of a larger skin flap than OT, RT may be accompanied by sensory changes in the corresponding skin area. For example, an evaluation of cutaneous light-pressure thresholds in patients who underwent BABA RT found sensory changes in the anterior chest area; however, these became normalized 3 months after surgery [20]. Similar results were observed in patients who undewent TAA RT. Two studies prospectively comparing sensory changes in patients who underwent TAA RT and OT found that sensory changes in the anterior neck area were similar or more common in the OT group, whereas sensory changes in the anterior chest were more common in the RT group. Anterior chest discomfort in the RT group became comparable with that in the OT group 1.5 years after surgery [21]. Sensory changes, therefore, were considered fairly minor.

Table 2. Incidence of Transient and Permanent Hypoparathyroidism

First author	Affiliate	Approach	No. of patient (RT vs. OT)	No. of TT (RT vs. OT)	Definition of transient hypoparathyroidism	Transient hypoparathyroidism			Permanent hypoparathyroidism		
						RT	OT	*P* value	RT	OT	*P* value
Lee et al. [7] (2010)	Ajou University	TAA	41 vs. 43	26 vs. 26	Not defined	5/26 (19.2)	4/26 (15.3)	0.758	0 (0.0)	0 (0.0)	1.000
Kim et al. [11] (2011)	Sungkyunkwan University	BABA	69 vs. 138	69 vs. 138	PTH normalized within 6 mo	23/69 (33.3)	38/138 (27.5)	0.583	1/69 (1.4)	4/138 (2.9)	0.352
Tae et al. [8] (2012)	Hanyang University	TAA	75 vs. 226	29 vs. 204	PTH normalized within 6 mo	8/29 (27.5)	112/226 (49.5)	<0.001	0/29 (0.0)	4/204 (2.8)	0.575
Yoo et al. [15] (2012)	Catholic University of Korea	TAA	46	30	PTH <5 pg/mL within 6 mo	5 (16.7)			0 (0.0)		
Kim et al. [16] (2012)	Korea University	BABA	93	72	Not defined	17/72 (23.6)			0/72 (0.0)		
Lee et al. [4] (2013)	Seoul National University	BABA	1,026	872	PTH normalized within 6 mo	341/872 (39.1)			13/872 (1.5)		
Noureldine et al. [13] (2013)	Tulane University	TAA	24 vs. 35	14 vs. 25	PTH normalized within 3 mo	2/14 (14.3)	4/25 (16.0)	0.902	0 (0.0)	0 (0.0)	1.000
Yi et al. [17] (2013)	Ulsan University	TAA	98 vs. 423	98 vs. 423	Not defined	52/98 (53.1)	182/423 (43.0)	0.046	3/98 (3.1)	3/423 (0.7)	0.084
Kim et al. [14] (2014)	Chung-Ang University	BABA	123 vs. 392	100 vs. 364	Serum calcium <4.0 mEq/L	29/100 (29.0)	80/364 (22.0)	0.161	0 (0.0)	0 (0.0)	1.000
Ban et al. [18] (2014)	Yonsei University	TAA	3,000	1,090	Requires calcium less than 6 mo	408/1,090 (37.4)			12/1,090 (1.1)		

Values are expressed as number (%).
RT, robotic thyroidectomy; OT, open thyroidectomy; TT, total thyroidectomy; TAA, transaxillary approach; BABA, bilateral axillo-breast approach; PTH, parathyroid hormone.

SURGICAL COMPLETENESS

Among the clinical parameters used to evaluate surgical completeness after thyroidectomy are the number of retrieved lymph nodes, stimulated thyroglobulin (sTg) concentration, and raidioactive iodine uptake (RAI) on whole body scans (WBS).

Lymph node retrieval

Since papillary thyroid carcinomas metastasize via the surrounding lymph nodes, central lymph node dissection is routinely performed in most centers in order to assure oncological safety. In most studies, the numbers of retrieved central lymph nodes were comparable during RT and OT (Table 4). In two studies [8,14], however, the absolute number of retrieved lymph nodes was lower in patients undergoing RT than OT (4.4±2.4 and 8.7±5.1, respectively), although the absolute numbers of the former were similar to those in other studies.

Stimulated thyroglobulin level

sTg level is measured before RAI treatment after elevating thyroid stimulating hormone (TSH) either by thyroid hormone withdrawal or by injection of recombinant human TSH (Thyrogen, Genzyme, Cambridge, MA, USA). Elevated sTg after total thyroidectomy suggests the presence of remnant thyroid tissue; therefore, low sTg is a good indicator of complete thyroid removal. Table 4 shows the results of sTg at the first RAI treatment after RT or OT. While four studies (three BABA, one TAA) reported similar sTg levels in these two groups [11,14,22,23], the other two studies (both TAA) reported that sTg was significantly higher in the RT than in the OT group [8,17]. However, in these two studies, sTg levels turned out to be similar after stage subclassification [17] or after the first RAI treatment [8].

Whole body scan

Remnant thyroid tissue can also be measured by thyroid uptake count ratio on WBS. For example, in one study, RAI uptake in the thyroid bed was higher in the RT than in the OT group when assessed by WBS [23]. The higher uptake in the RT group may have been due to the characteristics of TAA, in

Table 3. Complications of Robotic Thyroidectomy

First author	Affiliate	Approach	No. of patient	No. of TT	Tracheal injury	Brachial plexus injury	Hematoma	Seroma	Chyle leakage
Lee et al. [7] (2010)	Ajou University	TAA	41	26	NA	NA	0 (0.0)	2 (4.9)	NA
Kim et al. [11] (2011)	Sungkyunkwan University	BABA	69	69	NA	NA	NA	1 (1.4)	1 (1.4)
Tae et al. [8] (2012)	Hanyang University	TAA	75	29	NA	NA	2 (2.6)	6 (8.0)	NA
Landry et al. [12] (2012)	M.D. Anderson Cancer Center	TAA	25	0	NA	2 (8.0)	3 (12.0)	3 (12.0)	NA
Yoo et al. [15] (2012)	Catholic University of Korea	TAA	46	30	NA	NA	NA	NA	1 (0.2)
Kim et al. [16] (2012)	Korea University	BABA	93	72	NA	NA	0 (0.0)	0 (0.0)	NA
Lee et al. [4] (2013)	Seoul National University	BABA	1,026	872	NA	NA	4 (0.4)	NA	NA
Yi et al. [17] (2013)	Ulsan University	TAA	98	98	NA	NA	0 (0.0)	NA	0 (0.0)
Kim et al. [14] (2014)	Chung-Ang University	BABA	123	100	NA	NA	0 (0.0)	NA	NA
Ban et al. [18] (2014)	Yonsei University	TAA	3,000	1,090	6 (0.2)	4 (0.1)	11 (0.4)	52 (1.7)	11 (0.4)

Values are expressed as number (%).
TT, total thyroidectomy; TAA, transaxillary approach; NA, not available; BABA, bilateral axillo-breast approach.

Table 4. Surgical Completeness of Robotic Thyroidectomy

First author	Affiliate	Approach	No. of TT (RT vs. OT)	Retrieved lymph node		*P* value	Stimulated thyroglobulin, ng/mL		*P* value
				RT	OT		RT	OT	
Lee et al. [7] (2010)	Ajou University	TAA	26 vs. 26	4.4±2.1	4.3±2.9	0.842	Not measured	Not measured	
Kim et al. [11] (2011)	Sungkyunkwan University	BABA	69 vs. 138	4.7±2.7	4.8±2.8	0.802	0.8±1.4	0.8±2.0	0.978
Lee et al. [23] (2011)	Seoul National University	BABA	108 vs. 108	NA	NA		1.4±3.8	1.4±3.9	0.564
Tae et al. [8] (2012)	Hanyang University	TAA	29 vs. 204	4.4±2.4	7.8±5.5	<0.001	12.7±15.0	4.9±8.6	0.031
Yi et al. [17] (2013)	Ulsan University	TAA	98 vs. 423	6.5	7.0	0.580	74.0%[a]	89.4% [a]	0.001
Kwon et al. [24] (2013)	Yonsei University	TAA	43 vs. 51	4.9±2.9	6.3±4.2	0.058	4.91±1.4	4.2±1.2	0.674
Lee et al. [4] (2013)	Seoul National University	BABA	889 (RT)	4.9±3.7			0.4		
Kim et al. [14] (2014)	Chung-Ang University	BABA	100 vs. 364	8.7±5.1	10.4±6.1	0.006	1.4±3.0	1.2±2.6	0.652

Values are expressed as number (%).
TT, total thyroidectomy; RT, robotic thyroidectomy; OT, open thyroidectomy; TAA, transaxillary approach; BABS, bilateral axillo-breast approach; NA, not available.
[a]Percentage of the patients who had <2 ng/mL of stimulated thyroglobulin at the first radioactive iodine treatment.

which removal of the contralateral thyroid gland is made difficult by the unilateral approach. However, RAI uptake was similar in the RT and OT groups at the second WBS after the first RAI treatment. In contrast, when BABA RT and OT were compared after propensity score matching to minimize selection bias, RAI uptake was similar at the first WBS in the two groups [22].

ROBOTIC THYROIDECTOMY IN CERTAIN DISEASES

Robotic thyroidectomy in Graves disease

Graves disease has been regarded as a contraindication for endoscopic thyroidectomy or RT because bleeding control is hampered by the narrow operative view, hypervascularity, and the large-sized thyroid gland. However, recent technical advances and accumulated experience have enabled RT in patients with Graves disease. Kwon et al. [24] reported successful RT in 30 patients with Graves disease, with a tolerable complication rate. In the study, one patient experienced permanent hypoparathyroidism, but none had major complications such as bleeding, open conversion, or permanent RLNI. The other retrospective study comparing RT and OT in Graves' disease patients [25], in which those with smaller-sized thyroid underwent RT, found no significant between-group differences in operation time, blood loss, or complication rate. RT might be performed safely in selected Graves' disease patients.

Robotic modified radical neck dissection in thyroid carcinoma patients

Robotic surgery has also been utilized for MRND [26]. Since extensive incision scars are inevitable in patients undergoing traditional MRND, robotic MRND may be a good alternative to avoid scarring. Both TAA and BABA have shown outcomes similar to open conventional MRND. For example, a similar number of lateral lymph nodes was retrieved following BABA robotic and open MRND, without causing hypocalcemia, RLNI, or bleeding [27]. In addition, a comparison of patients undergoing TAA or open MRND reported similar complication, surgical completeness, and recurrence rates [9].

CONCLUSIONS

RT offers better cosmetic satisfaction to patients than OT, and RT is as safe and effective as OT in thyroid cancer patients, with similar complication rates. RT also showed similar oncologic safety as OT, as assessed by lymph node harvest, complete removal of thyroid tissue, and RAI success rates. RT is a good alternative surgical modality for patients who wish to avoid neck scars.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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