Comparative Analysis of Oncological Outcomes and Quality of Life After Robotic versus Conventional Open Thyroidectomy With Modified Radical Neck Dissection in Patients With Papillary Thyroid Carcinoma and Lateral Neck Node Metastases

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Objectives: Robotic total thyroidectomy (TT) with modified radical neck dissection (MRND) using a gasless transaxillary approach has been reported safe and effective in patients with N1b papillary thyroid carcinoma (PTC), with notable cosmetic benefits when compared with conventional open TT. We have compared oncological outcomes and quality of life (QoL) in PTC patients undergoing robotic TT and MRND and those undergoing conventional open procedures.

Materials and Methods: Between March 2010 and July 2011, 128 patients with PTC and lateral neck node metastases underwent TT with MRND, including 62 who underwent robotic and 66 who underwent open TT. We compared oncologic outcomes and safety as well as functional outcomes such as postoperative subjective voice and swallowing difficulties. We also evaluated neck pain, sensory changes, and cosmetic satisfaction after surgery using various QoL symptom scales. Neck and shoulder disability was assessed using arm abduction tests (AAT) and questions from the neck dissection impairment index (NDII).

Results: Although the mean operating time was significantly longer in the robotic (mean, 271.8 $\pm$ 50.2 min) than in the open group (mean, 208.9 $\pm$ 56.3 min) ($P < .0001$), postoperative complication rates and oncologic outcomes, including the results of radioactive iodine scans and postoperative serum Tg concentrations, did not differ significantly. Subjective voice outcomes and postoperative AAT and neck dissection impairment index were also similar, but postoperative swallowing difficulties ($P = .0041$) and sensory changes ($P < .0001$) were significantly more frequent in the open than in the robotic group. In particular, mean cosmetic satisfaction score was significantly higher in the robotic than in the open group ($P < .0001$).

Conclusions: Robotic TT with MRND yielded similar oncologic outcomes and safety as conventional open procedures, with similar recovery of neck and shoulder disability. However, the robot technique resulted in better QoL outcomes, including better cosmetic results and reductions in neck sensory changes and swallowing discomfort. **(*J Clin Endocrinol Metab* 98: 2701–2708, 2013)**

The advent of the da Vinci surgical robot has revolutionized the surgical management of thyroid cancer in Korea within the robotic environment and the transition beyond open or endoscopic thyroidectomy with neck dissection. The surgical techniques involved in robotic thyroidectomy and neck dissection continue to be refined, building on the principles and framework of new head and neck operative procedures (1–3). These refinements in-

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Abbreviations: AAT, arm abduction test; FNAC, fine-needle aspiration cytology; LN, lymph node; MRND, modified radical neck dissection; NDII, Neck Dissection Impairment Index; PTC, papillary thyroid carcinoma; QoL, quality of life; RLN, recurrent laryngeal nerve; SAN, spinal accessory nerve; SIS-6, Swallowing Impairment Score; Tg, thyroglobulin; TT, total thyroidectomy; US, ultrasonography; VHI-10, Voice Handicap Index.

clude the safety of robotic thyroidectomy, identification of proper oncologic outcomes, and approaches to patient quality of life (QoL), including subjective symptoms, functional outcomes, and emotional satisfaction.

Studies to date have shown that the oncologic outcomes and safety of robotic thyroidectomy compare favorably with those of open thyroidectomy and neck dissection (1–10). Robotic modified radical neck dissection (MRND) using a gasless transaxillary approach has been utilized in patients with papillary thyroid carcinoma (PTC) and lateral lymph node (LN) metastases (N1b) (11, 12). Compared with open procedures, robotic total thyroidectomy (TT) and MRND yielded similar rates and types of postoperative complications, similar lengths of hospital stay and time to convalescence, and similar oncologic outcomes, including the results of postoperative RAI whole-body scans and serum thyroglobulin (Tg) concentrations.

In recent years, increasing attention has been given to QoL outcomes after robotic thyroidectomy and neck dissection, including postoperative pain, sensory changes, voice and swallowing functions, shoulder discomfort, movement disability, and cosmetic satisfaction. Robotic thyroidectomy has been reported to provide better cosmetic outcomes and lower rates of postoperative neck paresthesia (8, 13, 14), as well as better functional recovery of voice and swallowing ability, than open thyroidectomy (13, 15, 16). To date, however, no analyses have directly compared the effects of robotic and open MRND on postoperative QoL, including shoulder disability. We therefore analyzed the postoperative outcomes of patients with PTC and lateral neck node metastases (N1b) who underwent robotic or conventional open TT with MRND, with all operations performed by the same surgeon. We also compared the impact of robotic and conventional TT with MRND on postoperative patient QoL.

Materials and Methods

Study patients

We prospectively assessed a cohort of consecutive patients with PTC and lateral neck node metastases (N1b) who underwent robotic TT with MRND using a gasless transaxillary approach or conventional open TT with MRND at Severance Hospital from June 2010 to July 2011. All patients were followed up for at least 12 months after surgery. All patients provided informed consent before filling out a self-administered survey questionnaire assessing patient QoL, and the study protocol was approved by the Institutional Review Board of our hospital.

Patients with PTC were included if they had clinically palpable lateral neck LNs or lateral LNs with a suspicious appearance on ultrasonography (US), as shown by preoperative staging US, and underwent fine-needle aspiration cytology (FNAC). Lateral LN metastases were evaluated preoperatively by US-guided FNAC and by Tg concentrations in FNAC wash out fluid (12). Patients were excluded if they had 1) a history of previous neck surgery or irradiation; 2) unrelated pathologic conditions of the neck or shoulder; 3) known recurrent disease at the time of evaluation; 4) suspicious tumor invasion of an adjacent organ, such as the recurrent laryngeal nerve (RLN), esophagus, or trachea; 5) suspicious perinodal infiltration to adjacent structures, such as the internal jugular vein or major nerves for lateral metastatic LNs; or 6) distant metastases.

Due to differences in surgical costs, all patients were offered both options preoperatively. Accordingly, assignment to open or robotic thyroidectomy with MRND was made simply based on patients' preferences.

Treatment protocol

The operative procedures for both open and robotic TT with MRND, the latter using a gasless transaxillary approach, have been described previously in detail (11, 12). In open surgery, TT with MRND was performed through a 10- to 12-cm standard collar incision, which was made approximately 2 fingerbreadths above the sternal notch. In robotic surgery, a 7- to 8-cm vertical skin incision is placed in the axilla along the anterior axillary fold and the lateral border of the pectolaris major muscle, and this axillary scar is completely covered by the patient's arm in a natural position. In both approaches, we followed the prescribed extent of MRND for PTC (selective neck dissection; sublevels IIA, III, IV, and Vb), with LNs at levels IIB and VA not routinely dissected. However, if an enlarged or suspicious LN at level I, IIB, or VA was encountered by palpation or by preoperative imaging, those compartments were included in en bloc dissection. All robotic and open procedures were performed by a single surgeon (W.Y.C.).

Vocal cord mobility was evaluated preoperatively and postoperatively in all patients by flexible laryngoscopy. Parathyroid function was determined by measuring serum calcium and intact parathyroid hormone level preoperatively and at 1 week and 3 months postoperatively. Hypoparathyroidism was defined as any decrease in serum intact parathyroid hormone level below the normal limit, regardless of hypocalcemic symptoms. Permanent RLN palsy or hypoparathyroidism was defined as nonrecovery within 6 months.

All patients underwent high-dose (150 mCi) RAI ablation 4 to 8 weeks postoperatively with serum concentrations of Tg measured and RAI whole-body scans performed after RAI ablation. Serum Tg concentrations were evaluated and RAI whole-body scans and neck US were performed regularly during follow-up. Following initial surgery, all patients received levothyroxine to suppress the secretion of TSH.

Evaluation of postoperative QoL

QoL was evaluated in all patients 6 months after conventional open or robotic TT with MRND on an outpatient basis during routine follow-up care. All the patients answered and returned completed questionnaires evaluating pain score of the surgical scar, sensory score, cosmetic outcome score, Voice Handicap Index (VHI-10), Swallowing Impairment Score (SIS-6), and Neck Dissection Impairment Index (NDII) (13, 17). Arm abduction test (AAT) was also performed 6 months after surgery (18).

Pain score of the surgical scar, scores on questionnaires, and the presence of hyperesthesia and paresthesia in the neck and anterior chest 6 months after surgery were graded as minimal, moderate, or severe. Cosmetic results, including wound appear-

VHI 10

Statement	Score				
1. My voice makes it difficult for people to hear me.	0	1	2	3	4
2. People have difficulty understanding me in a noisy room.	0	1	2	3	4
3. My voice difficulties restrict my personal and social life.	0	1	2	3	4
4. I feel left out of conversations because of my voice.	0	1	2	3	4
5. My voice problem causes me to lose income.	0	1	2	3	4
6. I feel as though I have to strain to vocalize.	0	1	2	3	4
7. The clarity of my voice is unpredictable.	0	1	2	3	4
8. My voice problem upsets me.	0	1	2	3	4
9. My voice makes me feel handicapped.	0	1	2	3	4
10. People ask, "What's wrong with your voice?"	0	1	2	3	4
Total score					

SIS 10

Statement	Score				
1. It requires great effort to swallow.	0	1	2	3	4
2. I feel a throat obstacle during swallowing.	0	1	2	3	4
3. I feel pharyngeal annoyance during bolus transit.	0	1	2	3	4
4. I cough during bolus transit.	0	1	2	3	4
5. I feel a sensation of a foreign body in my pharynx.	0	1	2	3	4
6. I have some difficulties in swallowing fluids.	0	1	2	3	4
Total score					

Instructions: These are statements that many people have used to describe their voices and swallowing symptoms and the effects their voices and swallowings have on their lives. Circle the response that indicates how frequently within the past month you have had a similar experience.

0=Never; 1=Almost never; 2=Sometimes; 3=Almost always; 4=Always.

Figure 1. Voice Handicap Index 10 (VHI 10) and Swallowing Impairment Index 6 (SIS 6).

ance and complaints, were evaluated using a verbal response scale with 5 possible responses: extremely satisfied, excellent, acceptable, dissatisfied, and extremely dissatisfied.

Voice and swallowing functions were assessed by subjective voice and swallowing evaluations 6 months after surgery (13). The frequency of voice abnormalities was determined using the VHI-10, a validated, reliable self-assessment tool that measures patient assessment of voice quality and the effect of voice changes on QoL. The VHI-10 consists of 10 questions, with responses to each scaled from 0 (no voice alteration) to 40 (highest voice impairment) (Figure 1). Swallowing difficulties were assessed using the SIS-6, a self-administered, 6-item assessment of symptoms related to dysphagia that has been validated for diagnosis of impairment. The scoring of each item on the SIS-6 ranged from 0 (no swallowing alteration) to 24 (highest swallowing impairment) (Figure 1). The SIS-6 score was also utilized to assess nonvoice symptoms in the throat, including coughing, choking, and throat clearing, all of which occur after thyroidectomy.

Shoulder function after neck dissection was analyzed both subjectively and objectively 6 months after surgery. The subjective score was calculated using an NDII questionnaire (17). Mean NDII scores in each group were determined, with the patient instructed to confine their responses to the previous 4 weeks. Individual items from the 10-question NDII were scored using a Likert scale with 5 response options, ranging from 1 to 5 (Figure 2).

Upper limb function was assessed objectively by measuring AAT parameters (18). Patients were instructed to abduct their arms with their palms down and were asked to rate the abduction from 0 to 5 according to their symptoms and objective measurements of their active range of shoulder, with 5 = up to 180° without pain or effort, 4 = up to 180° but with pain or effort, 3 = >150° but <180°, 2 = >90° but <150°, 1= >90°, 0 = <90° (Figure 2).

All statistical analyses were performed using Statistical Product and Service Solutions, version 15.0 for Windows (SPSS Inc, Chicago, Illinois). A P value of .05 or less was considered statistically significant.

Results

Table 1 shows the clinicopathologic characteristics of patients in the open and robotic groups. The 2 groups had similar distributions of age and body mass index, as well as tumor, nodes, metastasis stage, mean tumor size, frequency of extrathyroidal extension, and multiplicity and bilaterality of the tumors. The ratio of male-to-female patients was significantly higher in open group (P = .0121). The mean retrieved numbers of central and lateral LNs and the rate of LN metastasis were also similar in the open and robotic groups. Although the operation time was significantly longer in the robotic than in the open group ($P < .0001$), the duration of hospital stay in the 2 groups did not differ significantly (P = .0814).

The entire surgical procedure of robotic TT with MRND was completed successfully in all patients in the robotic group, with none requiring conversion to open surgery. Postoperative complication rates were similar in the 2 groups (Table 2). No patient experienced permanent hypoparathyroidism or RLN palsy. Of 128 total TT with MRND cases, transient hypoparathyroidism did not show significant differences in the 2 groups (P = .5612). Three patients (4.5%) showed temporary RLN palsy in open group and 2 patients (3.2%) showed temporary RLN palsy in robotic group by postoperative laryngoscopic examination, but this difference was not significant (P = .2103). All 5 patients with temporary RLN palsy resolved within 2 months, as confirmed by laryngoscope. All chyle leakages were minor and successfully managed conservatively.

Serum Tg concentrations 6 months postoperatively remained low in most patients. Although 4 patients in the

NDII

1. Are you bothered by neck or shoulder pain or discomfort?
2. Are you bothered by neck or shoulder stiffness?
3. Are you bothered by difficulty with self-care activities because of your neck or shoulder (for example, combing hair, dressing, bathing, etc.)?
4. Have you been limited in your ability to lift light objects because of your shoulder or neck?
5. Have you been limited in your ability to lift heavy objects because of your shoulder or neck?
6. Have you been limited in your ability to reach up for objects because of your shoulder or neck (for example, from shelves, tables, counters)?
7. Are you bothered by your overall activity level because of your shoulder or neck?
8. Has the treatment of your neck affected your participation in social activities?
9. Have you been limited in your ability to do leisure or recreational activities because of your neck or shoulder?
10. Have you been limited in your ability to work (including work at home) because of your neck or shoulder?

*Respondents answered 'not at all'(5), 'a little bit'(4), 'a moderate amount'(3), 'quite a bit'(2), or 'a lot'(1). Standardization for score of 100: [(raw score-10)/40] x100

AAT

Please raise your arm with your palm down and rate from the following scale

Patient can raise his or her arm

5. up to 180 degrees without pain or effort ( )
4. up to 180 degrees but with pain or effort ( )
3. up to more than 150 degrees but less than 180 degrees ( )
2. up to more than 90 degrees but less than 150 degrees ( )
1. up to around 90 degrees ( )
0. up to less than 90 degrees ( )

Figure 2. Modified questionnaire from Ten-item Neck Dissection Impairment Index (NDII) and Arm Abduction Test (AAT).

open group (6.1%) and 4 in the robotic group (6.4%) had serum Tg >1 ng/mL, none showed evidence of abnormal foci of increased radioiodine uptake in postoperative ^{131}RAI scan. Moreover, the mean Tg concentrations after RAI ablation and the results of RAI scans did not differ significantly in the 2 groups (Table 3). After follow-up for mean 8.4 (range, 6–12) months, no patient in either group showed tumor recurrence on neck US and other imaging modalities.

Postoperative pain score of the surgical scar, neck pain, sensory changes, and cosmetic satisfaction are summarized in Table 4. At 6 months postoperatively, there were no significant differences in pain score of the surgical scar and neck pain. Sensory changes in the neck were significantly more frequent in the open than in the robotic group, whereas sensory changes in the anterior chest were slightly more frequent in the robotic group. Cosmetic satisfaction after 6 months was significantly greater in the robotic than in the open group, because the incision scar in the axilla could be completely concealed in the former when the arm was down in its natural position and the small anterior chest wall incision (0.8 cm) was almost inconspicuous over time. There were no significant between-group differences in mean VHI-10 score after 6 months, although the mean SIS-6 score was significantly higher in the open than in the robotic group.

We also assessed neck and shoulder function 6 months after neck dissection, using scores on the NDII and AAT (Table 4). The mean NDII scores in the open and robotic groups were 87.1 ± 13.4 and 88.4 ± 11.2, respectively, whereas the mean AAT scores were 4.1 ± 1.9 and 3.9 ± 1.8, respectively, with neither showing a significance between group differences.

Discussion

In comparing the oncologic outcomes, safety, and QoL of patients with similar clinical and pathological characteristics who underwent either robotic or conventional open TT with MRND, we found that robotic TT with MRND was as effective and safe as conventional open surgery. We also found that robotic TT with MRND was associated with lower degrees of postoperative neck stiffness and sensory change, a higher degree of patient cosmetic satisfaction, and subjective improvements in swallowing discomfort. In addition, the recovery from neck and shoulder disability after MRND did not differ in the 2 groups. To our knowledge, this is the first demonstration that robotic TT with MRND is not only safe and effective but also offers several QoL advantages compared with open surgery.

The use of robotic thyroidectomy is increasing, with over 6000 such operations performed in Korea between 2007 and 2011. Robotics enhances the visual perspective of surgical anatomy and instrumental flexibility, with significant modifications of this technique found to improve postoperative outcomes (1–3). Moreover, robotic thyroidectomy has been associated with improved ergonomics and a shortened learning curve, resulting in a dramatic paradigm shift in the practice of thyroid surgery (1, 5). The early phases in the development of robotic thyroidectomy and neck dissection were characterized by the rapid evolution of robotic surgical techniques and training programs (1–7). The next phases of development should be

Table 1. Clinicopathologic Characteristics of Patients in the Open and Robot Groups

	Open Group (n = 66)	Robot Group (n = 62)	*P* Value
Age, y	45.1 ± 12.8	40.2 ± 11.8	.0915
Gender ratio, male:female	12:54	5:57	.0121
Body mass index, kg/m^2	23.9 ± 4.4	22.7 ± 5.1	.7951
Operation time, min	208.9 ± 56.3	271.8 ± 50.2	<.0001
Postoperative hospital stay, d	7.9 ± 4.1	6.9 ± 3.9	.0814
Tumor size, mm	16.7 ± 6.9	13.9 ± 5.1	.1027
Extrathyroidal extension	70 (81.4%)	71 (86.6%)	.6218
Multiplicity, %	26/66 (39.4%)	22/682 (35.5%)	.2178
Bilaterality, %	13/46 (28.3%)	11/40 (27.5%)	.6075
Total numbers of harvested central and lateral lymph nodes	37.9 ± 16.8	38.0 ± 14.1	.5120
Central lymph nodes	7.9 ± 6.2	8.1 ± 6.7	.2138
Lateral lymph nodes	31.8 ± 12.4	32.8 ± 11.2	.4105
TNM stage			
T1/T2/T3/T4a, %	7 (10.6%)/0 (0%)/55 (83.3%)/4 (6.5%)	9 (14.5%)/1 (1.6%)/51 (82.3%)/1 (1.6%)	.2410
N0/N1a/N1b, %	0 (0%)/0 (0%)/66 (100%)	0 (0%)/0 (0%)/22 (100%)	
Stage			.1077
I/IV	46 (69.7%)/20 (30.3%)	48 (77.4%)/14 (22.6%)	

Abbreviation: TNM, tumor, nodes, metastasis.

directed toward better perioperative assessment of oncologic outcomes and safety (1, 4–12), with the final phases of development directed toward the impact of this procedure on patient QoL, including better functional outcomes (1, 8, 13–16).

In the present study, we compared safety and oncologic outcomes of robotic MRND with open MRND, including the numbers of dissected LNs and the completeness of thyroid resection. We found that the total numbers of retrieved central and lateral LNs were similar for robotic and open procedures (37.9 ± 16.8 vs 38.0 ± 14.1, $P = .5120$). These findings suggested that the magnified, 3-dimensional view provided by the robotic system results in accurate dissection planes, allowing careful manipulation by multiarticulated robotic arms. Furthermore, LNs can be optimally dissected by a traction/countertraction technique during surgery. We also found that the serum concentrations of Tg, a marker of the completeness of thyroid resection, were similar in patients who underwent open and robotic TT (0.51 ± 0.48 ng/mL vs 0.61 ± 0.49 ng/mL, $P = .7411$). In addition, RAI whole-body scans after high-dose RAI ablation showed no abnormal uptake in either group, and follow-up US showed no evidence of recurrence in any patient. Moreover, there were no between group differences in the rates of postoperative complications. Although transient hypoparathyroidism was common in both groups (34.8% vs 38.7%, $P = .5612$), no patient experienced these symptoms for more than 6 months and none experienced permanent hypoparathyroidism. There were no inadvertent injuries to the trachea, esophagus, or nerves during surgery, and no injuries to the brachial plexus or shoulders. These findings therefore suggest that, in experienced hands, robotic TT with MRND is equivalent in oncologic outcomes and safety to open TT with MRND.

We also found that the duration of hospital stay was similar in the robotic and open groups. Although the duration of hospital stay by our patients was longer than in

Table 2. Comparison of Postoperative Complications Between the Open and Robot Groups

	Open Group (n = 66)	Robot Group (n = 62)	*P* Value
Hypoparathyroidism			
Transient	23 (34.8%)	24 (38.7%)	.5612
Permanent	0 (0%)	0 (0%)	
Recurrent laryngeal nerve palsy			
Transient	3 (4.5%)	2 (3.2%)	.2103
Permanent	0 (0%)	0 (0%)	
Postoperative bleeding	0 (0%)	0 (0%)	
Wound problems (seroma, infection, etc)	4 (6.1%)	2 (3.2%)	.0914
Transient chyle leakage	2 (3.0%)	1 (1.6%)	.2145
Nerve injury (Horner's syndrome, vagus nerve injury, spinal accessory nerve injury, brachial plexus neuropraxia, etc)	0 (0%)	0 (0%)	
Adjacent organ injury (tracheal injury, esophageal injury, etc)	0 (0%)	0 (0%)	

Table 3. Comparison of Postoperative Oncologic Outcomes in the Open and Robot Groups

	Open Group (n = 66)	Robot Group (n = 62)	*P* Value
RAI-avid lesion outside the thyroid bed in postoperative 131 RAI scan	0 (0%)	0 (0%)	
Postoperative serum Tg level, ng/mL	0.51 ± 0.48	0.61 ± 0.49	.7411
Abnormal Tg (off Tg) >1 ng/mL	4 (6.1%)	4 (6.4%)	.3985
Recurrence at follow-up by imaging study (US or neck CT) (postoperative mean 8.4 [range, 6–12] mo)	0 (0%)	0 (0%)	

other countries, length of hospitalization was not associated with the roughness or morbidity of the operation, but rather to differences in usual hospitalization among countries. In Korea, a large amount of hospital charges are covered by the national health insurance system, allowing most patients to prolong their stay until their stitches and closed-suction drains are removed. However, the total operation time of the robotic procedure was significantly longer than that of the open procedure. Robotic procedures include 3 stages: a stage of creating a working space, a docking stage, and a console (actual operation) stage. Unlike robotic abdominal surgery, no preformed space is available in the head and neck area, and flap dissection is always necessary. Thus, robotic TT with MRND usually requires more time than open surgery. However, if we exclude the time required to create a working space and the docking stage, the operation time for the robotic procedure would be similar to that of the open procedure. In addition, the operation time for robotic TT with MRND would be expected to decrease as a surgeon becomes more familiar with the robotic procedure.

Radical neck dissection has been modified to improve the quality of treatment results without jeopardizing oncologic outcomes. However, these modifications were based essentially on an oncologic point of view, with few studies specifically focusing on QoL after neck dissection. We found that cosmetic satisfaction was significantly higher in the robotic than in the open group, suggesting that the most significant advantage of robotic TT with MRND is its generally excellent cosmetic outcomes. Be-

Table 4. Postoperative Functional Outcomes and Quality-of-Life Measures in the Open and Robot Groups 6 mo After Operation

	Open Group (n = 66)	Robot Group (n = 62)	*P* Value
Pain score in operative scar (0–10)	2.0 ± 0.9	1.5 ± 1.0	.1087
Neck pain (No pain/very slight/slight/moderate/severe)	55 (83.3%)/6 (9.1%)/ 1 (1.5%)/4(6.1%)/0 (0%)	53 (85.5%)/5 (8.1%)/ 2 (3.2%)/2(3.2%)/0 (0%)	.3587
Sensory change; hyperesthesia or paresthesia in the neck (minimal/moderate/severe)	12 (18.2%)/41 (62.1%)/ 13 (19.7%)	49 (79.0%)/12 (19.4%)/ 1 (1.6%)	<.0001
Sensory change; hyperesthesia or paresthesia in the anterior chest (minimal/ moderate/severe)	58 (87.9%)/8 (12.1%)/ 0 (0%)	36 (58.1%)/26 (41.9%)/ 0 (0%)	.0394
Postoperative voice changes; Voice Handicap Index 10 (0–40)	7.5 ± 4.7	7.0 ± 3.8	.2150
Postoperative swallowing discomfort; Swallowing Impairment Score 10 (0–24)	7.9 ± 5.4	4.1 ± 2.3	.0041
Cosmetic outcomes 6 mo after surgery (extremely satisfied/satisfied/acceptable/ dissatisfied/extremely dissatisfied)	22 (33.3%)/26 (39.4%)/ 10 (15.2%)/5(9.1%)/3 (4.8%)	46 (74.2%)/10 (16.1%)/ 6 (9.7%)/0(0%)/0 (0%)	<.0001
Neck Dissection Impairment Index (0–100)	87.1 ± 13.4	88.4 ± 11.2	.0917
Pain	4.3 ± 0.9	4.6 ± 1.3	.4121
Stiffness	3.1 ± 1.7	4.0 ± 2.1	.2137
Appearance	3.7 ± 1.4	4.3 ± 2.0	.1121
Self-care	4.1 ± 1.9	3.9 ± 1.9	.5421
Light lifting	4.3 ± 0.7	4.1 ± 1.3	.8541
Heavy lifting	4.4 ± 1.1	4.3 ± 0.9	.5110
Activity	3.9 ± 1.4	4.1 ± 1.7	.2127
Reaching	4.0 ± 0.9	3.9 ± 1.2	.6127
Leisure and recreation	4.5 ± 1.1	4.1 ± 1.7	.1064
Work	4.0 ± 1.8	3.9 ± 1.7	.3189
Arm abduction test (0–5)	4.1 ± 1.9	3.9 ± 1.8	.1025

ginning at 6 months postoperatively, the rate of neck hyperesthesia or paresthesia was significantly lower in the robotic than in the open group, perhaps due to the dissection of strap muscle and anterior neck area being reduced in the robotic compared with the open group. Voice and swallowing disturbances are common complaints after thyroidectomy, even in the absence of discrete clinical findings. Because voice changes and swallowing symptoms after thyroidectomy have been associated mainly with the routine healing process, less invasive techniques, such as smaller incisions, limited dissection, and reduced trauma to the strap muscles, may prevent these symptoms (8, 16). Although we found that subjective voice function did not differ in the robotic and open groups, robotic surgery was associated with a significantly lower percentage of patients reporting swallowing discomfort 6 months after surgery. These findings suggest that robotic thyroidectomy may reduce swallowing impairment, despite the dissected area of the skin flap being larger than during the open procedure. The reduction in swallowing impairment may be due to the absence of a cervical skin incision, the absence of a midline dissection of the strap muscle, and the reduced adhesion among the strap muscles, subcutaneous tissues, and skin in robotic compared with open TT with MRND (13, 16).

Despite attempts to completely preserve functional structures including the spinal accessory nerve (SAN), all types of MRND have been found to result in mild fibrosis in the neck and adhesive capsulitis of the SAN, leading to feelings of stiffness and constriction of the neck and shoulder discomfort. In patients who underwent MRND, the peak torque of neck and shoulder movements involving flexion-extension and abduction-adduction was significantly lower at 1 month after than before surgery, but returned to preoperative torque 6 months after surgery (18, 19). In this study, we found that all patients in both groups showed favorable outcomes of arm and shoulder function, as assessed by the NDII and AAT. Although the operation time was longer and the extent of flap dissection was greater in the robotic than in the open group, there were no significant between group differences in objective and subjective measures of functional neck and shoulder ability 6 months after surgery. During robotic MRND, the patient is placed in a natural position, without arm elevation, and the delicate manipulations of the major organs, especially the SAN, including traction, skeletonization, and devascularization, are similar to those of the open procedure.

This study had several limitations. First, our analysis was based on a relatively small group of patients, suggesting that a larger study is required to confirm these findings. Second, the follow-up period was not sufficient to determine any long-term effects on oncologic outcomes and QoL, indicating that longer follow-up may be required to determine whether the procedure is oncologically appropriate. Third, we did not randomize patients to robotic vs open surgery, due to differences in surgical costs. Robotic surgery is not covered by the national health insurance system in Korea, so patients have to pay a substantial amount for it. Its cost is 3 times higher than conventional open or endoscopic thyroidectomy in Korea. The fact that the choice of procedure would be influenced by patient's ability and willingness paying for the robotic approach might introduce selection bias. Further randomized clinical trials, comparing the functional outcomes of robotic and open TT with MRND, are needed to confirm the advantages of the robotic technique.

In conclusion, we found that robotic and conventional open TT with MRND yielded similar oncologic outcomes and safety. The recovery of neck and shoulder disability after MRND did not differ between the 2 groups. However, the robot technique was associated with improved QoL, including excellent cosmetic results and reductions in neck sensory changes and swallowing discomfort after surgery. To our knowledge, this is the first clinical report to evaluate QoL after robotic TT with MRND. The advantages of robotic over open surgery suggest that robotic TT with MRND may become the preferred surgical option for patients with N1b PTC. These findings indicate that further prospective randomized trials are warranted.

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