Curr Surg Rep (2022) 10:133–139
https://doi.org/10.1007/s40137-022-00321-0

ROBOTIC SURGERY (E BERBER, SECTION EDITOR)

Robotic *Versus* Endoscopic Transoral Thyroidectomy with Vestibular Approach: A Literature Review Focusing on Differential Patient Suitability

Dawon Park[1] · Hoon Yub Kim[1] · Antonella Pino[2,3] · Francesco Frattini[3] · Viola Villardita[3] · Alessandro Matarese[3] · Che-Wei Wu[4] · Gianlorenzo Dionigi[3,5] · Fausto Fama[2]

Accepted: 27 May 2022 / Published online: 25 June 2022

Abstract

Purpose of Review The purpose of this study was to evaluate the characteristics of patients who underwent transoral robotic thyroidectomy (TORT) in the worldwide literature, especially in comparative studies with transoral endoscopic thyroidectomy by vestibular approach (TOETVA), to better define the ideal appropriate patient.

Recent Findings TORT allows a more precise and complete dissection due to the enlarged and three-dimensional surgical vision and the tremor filtering. Current inclusion criteria for TORT mainly concern ultrasonographically estimated nodules as having a maximum diameter $\leq$ 70 mm, the papillary thyroid carcinoma with minimal extrathyroidal extension (T1 to T3) with or without evidence of central lymph node metastasis, and Graves' disease with an estimated volume $\leq$ 50 mL. Overall, although TORT requires a longer operating time than TOETVA, it allows for more complex surgical procedures, obtaining better oncological results. A clear definition of the inclusion and exclusion criteria for patients to undergo robotic surgery is essential to obtain the most reliable results in future large comparative and non-comparative studies.

Summary The purpose of this review article is to analyze both the main comparative studies between TORT and TOETVA series and those involving cohorts of patients operated by TORT, always paying attention to the inclusion and exclusion criteria adopted.

This article is part of the Topical Collection on *Robotic Surgery*.

✉ Dawon Park
dawon.park@gmail.com

✉ Fausto Fama
ffama@unime.it

Hoon Yub Kim
hoonyubkim@gmail.com

Antonella Pino
pino.antonella@virgilio.it

Francesco Frattini
francescofrattini79@gmail.com

Viola Villardita
viola.villardita@unimi.it

Alessandro Matarese
alessandro.matarese@unimi.it

Che-Wei Wu
cwwu@kmu.edu.tw

Gianlorenzo Dionigi
gianlorenzo.dionigi@unimi.it

[1] Department of Surgery, KUMC Thyroid Center, Korea University Hospital, Korea University College of Medicine, Seoul, Korea

[2] Department of Human Pathology of Adulthood and Childhood, University of Messina, Via Consolare Valeria n.1, Messina 98125, Italy

[3] Division of Surgery, Istituto Auxologico Italiano IRCCS (Istituto Di Ricovero E Cura a Carattere Scientifico), Milan, Italy

[4] Department of Otorhinolaryngology-Head and Neck Surgery, Faculty of Medicine, College of Medicine, Kaohsiung Medical University Hospital, Kaohsiung Medical University, No. 100 Tzyou First Road, Kaohsiung 807, Taiwan

[5] Department of Pathophysiology and Transplantation, University of Milan, Milan, Italy

Keywords Robotic thyroidectomy · Endoscopic thyroidectomy · Transoral robotic thyroidectomy · Transoral endoscopic thyroidectomy vestibular approach · Remote access thyroidectomy · Minimally invasive surgery

Introduction

Conventional thyroidectomy (CT) is still considered the standard of care for patients with differentiated thyroid cancer (DTC) [1]. The safety and feasibility of both transoral robotic thyroidectomy (TORT) and transoral endoscopic thyroidectomy (TOETVA) compared with CT have been demonstrated in many reports, including oncologic outcomes, and their surgical indications have been progressively expanded [2]. Intraoperative neuromonitoring can be used in both TORT and TOETVA and helps limit the complication rate [3, 4].

A key factor affecting the results of technical and oncologic outcome studies is the difference in patient selection settings [1, 5, 6]. Therefore, the proposal of our study was to evaluate the characteristics of patients who underwent TORT in the worldwide literature, especially in comparative studies with TOETVA, to better define the ideal appropriate patient.

Inclusion and Exclusion Criteria

A major nodal diameter estimated by ultrasound (US) $\leq$ 70 mm, papillary thyroid carcinoma (PTC) with minimal extrathyroidal extension (i.e., T1, T2, and T3) with or without evidence of central lymph node metastasis (N0 and N1a), and/or Graves' disease (GD) with a thyroid volume estimated by US of $\leq$ 50 mL represent the usual indications for patients to undergo TORT [5].

TOETVA patients expect inclusion criteria to be the presence of a benign tumor (including thyroid cyst and single- or multinodular goiter), a US-estimated thyroid diameter $\leq$ 10 cm and volume $\leq$ 45 mL, a US-estimated major nodule $\leq$ 50 mm, follicular neoplasia, or papillary microcarcinoma without evidence of nodal metastases [6].

Patients with DTC with posterior wide extrathyroidal extension (T4) and/or lateral lymph node compartment metastasis (N1b) or distant metastases are still contraindicated for both surgical transoral procedures. In addition, patients who have received prior radiotherapy to the head and neck region and/or signs of tracheoesophageal infection and/or recurrent laryngeal nerve palsy are also ineligible [6].

Overall, the robotic system provides a magnified, expanded, and three-dimensional surgical view that, when combined with tremor filtering, ensures a more precise and complete dissection, especially for the central lymph node area, than other remote techniques, including TOETVA [1]. These features favor the preservation of critical structures such as the recurrent laryngeal nerve and parathyroid glands, and also minimize perineural thyroid tissue [5, 6]. In addition, TORT allows the best resection of both the upper thyroid pole and the pyramidal lobe due to the effect of the articulated movement of the arm compared to the rigid instruments of the other procedures [5–7].

Discussion

Since 2011, reports on the feasibility of robotic thyroid surgery have appeared in the literature, initially tested on cadavers [8, 9•], while endoscopic transoral thyroid surgery began to emerge as an alternative to the traditional open technique as early as 2008 [10–15].

Three recent comparative studies on TORT (with vestibular approach) and TOETVA series have shown that these techniques are safe and provide comparable results (Table 1) [16–18•]. In all cases, the mean operative time was significantly longer for TORT than for TOETVA [16–18•] and the criteria used were specified in only the two most numerous studies [16, 18•]. The inclusion criteria were a nodal size of 5–8 cm and, in both cases, a PTC with a maximum diameter of less than 3 cm; exclusion criteria included macroscopic extrathyroidal extension and involvement of the lateral lymph node compartment or distant metastases (Table 1) [16, 18•]. However, these studies analyzed relatively small patient samples, most of which involved unilateral procedures, and only one of these studies included more than 100 cases [18•].

The comparative, prospective, nonrandomized study by Tae et al. [16] compared the outcomes of 21 patients who underwent TORT (2 of whom were converted to postauricular access and excluded) and 14 patients who underwent TOETVA. Seventy-four percent of the cases were partial procedures (lobectomy/isthmusectomy in 16 cases at TORT and in 10 cases at TOETVA), whereas total thyroidectomies were performed in 25.7% of the cases (5 robotic and 4 endoscopic). The number of patients with malignant disease was 17/21 (80.5%) in the TORT and 10/14 (71.4%) in the TOETVA cohort. No other statistically significant differences were found between the 2 groups [16]. In a previous comparative retrospective study, 5 (5/7, 71%) thyroid lobectomies were successfully completed by TORT and 19 (19/20, 95%) by TOETVA [17]. Chen et al. performed an interesting and extensive retrospective comparative study in 150 patients in 2021 [18•], analyzing 154 surgical procedures (55 TORT and 99 TOETVA), which were performed uni-laterally in 81.2%

Table 1 Results of comparative studies between clinical series of patients operated by TORT (with vestibular approach) and TOETVA

Author, year, reference	Type of the study, time interval	Number of pts TORTvs TOETVA	Histological diagnoses	RLN injury and HypoPTH rates	Patient selection criteria for transoral thyroid surgery	Notes
Chen et al., 2021 [18•]	Comparative Retrospective June 2017–May 2019	55 *vs* 99 154 operations performed in 150 patients (28/154, 18.2% bilateral procedures)	Benign 103 Malignant 51* * associated CND in 40 pts	Transient RLN injury 1 pt TORT 2 pts TOETVA Permanent RLN injury 1 pt TORT Transient HypoPTH 1 pt TORT 7 pts TOETVA Permanent HypoPTH 1 pt TOETVA	Inclusion criteria benign or indeterminate thyroid nodules with a maximum diameter < 8 cm; malignant or suspicious nodules with a maximum diameter < 3 cm and GD Exclusion criteria: high anesthetic risk due to multiple comorbidities; previous neck irradiation; macroscopic extrathyroid neoplastic extension or lymph node metastases of the central compartment of the neck; simultaneous transoral surgical procedure on the parathyroid glands	da Vinci Xi surgical robotic system Mean operative time significantly longer in the TORT cohort (308 *vs* 228 min, $P < 0.001$)
Tae et al., 2019 [16]	Comparative prospective not-randomized July 2017–Feb 2018	21 *vs* 14 (9/35 bilateral procedures)	AH 6 (16.2%) FA 1 (2.7%) PTC 30 (81.1%)	Transient RLN injury 1 pt TOETVA Transient HypoPTH 1 pt TORT 1 pt TOETVA	Inclusion criteria - follicular thyroid neoplasm or benign nodules with a maximum diameter < 5 cm; - PTC with a maximum diameter < 3 cm Exclusion criteria: - huge goiter; - thyroid tumor with macroscopic extrathyroid extension; - lymph nodes metastases of the lateral compartment, or metastases at a distance; - previous cervical irradiation or neck surgery	da Vinci Si surgical robotic system Mean operative time significantly longer in the TORT cohort (182 *vs* 158 min, $P = 0.035$)
Ravazi et al., 2018 [17]	Comparative retrospective Apr 2016–Sept 2017	7 *vs* 20 * (All unilateral procedures) *analyzed 7 *vs* 7	Benign 20 Malignant 7 (3 PTC, 2 Hurthle cell carcinoma, and 2 NIFT-P)	No complications were reported	The inclusion and exclusion criteria are not described. The tables show only that the patients analyzed were all women, with a mean BMI 32.8 vs 28.3 and a mean nodule diameter of 5.1 vs 4.5 cm in the TORT and TOETVA cohort, respectively	da Vinci Si surgical robotic system Mean operative time significantly longer in the TORT cohort (322 *vs* 213 min, $P = 0.01$)

Original table

pt patient, *min* minutes, *TORT* transoral robotic thyroidectomy, *TOETVA* transoral endoscopic thyroidectomyvestibular approach, *PTC* papillary thyroid carcinoma, *AH* adenomatous hyperplasia, *FA* follicular adenoma, *NIFT-P* noninvasive follicular thyroid neoplasm with papillary-like nuclear features, *GD* Graves' disease, *CND* central neck dissection, *RLN* recurrent laryngeal nerve, *HypoPTH* hypoparathyroidism, *BMI* body mass index

(126/154) of cases and for malignancy in 33.1% (51/154). The authors pointed out that the total number of central lymph nodes and metastatic lymph nodes removed was not significantly different between the two groups [18•].

The results of robotic surgery have been evaluated in some reports (Table 2). Park et al. [19•] recently analyzed 200 consecutive PTC patients who underwent TORT (187 unilateral/partial and 13 bilateral procedures) and found a

Table 2 Results of studies involving cohorts of patients operated by TORT (with vestibular approach)

Author, year, reference	Type of the study, time interval	Number of pts	Histological diagnoses	RLN injury and HypoPTH rates	Patient selection criteria for transoral thyroid surgery	Notes
Park et al., 2020 [19•]	Retrospective Mar 2016–Feb 2018	200 TORT (13/200 bilateral procedures)	PTC T1a 105 (52.5%) T1b 14 (7.0%) T3 81 (40.5%)	Transient RLN injury 2 pts Transient HypoPTH 1 pt	Inclusion criteria TORT was selected based on the patient's choice, pathology, and size of the nodule Exclusion criteria previous neck and chin surgical procedure; clinically evident lateral cervical lymph node metastases; distant metastasis; suspicious neoplastic infiltration in neighboring organs, such as the esophagus or trachea	da Vinci Xi surgical robotic system was used in 145 pts da Vinci Si surgical robotic system was used in 55 pts
Tae et al., 2020 [20]	Prospective not-randomized Jul 2017–Feb 2019	100 TORT (71) - TOETVA (29*) (23/100 bilateral procedures) *vs* 207 CT (79/207 bilateral procedures) *3 procedures were converted to robotic facelift or transcervical approach	Malignant 89/100 TORT-TOETVA * (87/89 PTC) 169/207 CT** (164/169 PTC) * associated CND in 20 pts ** associated CND in 88 pts	Transient RLN injury 5 pts TORT-TOETVA 7 pts CT Permanent RLN injury 2 pts CT Transient HypoPTH 7 pts TORT-TOETVA 25 pts CT Permanent HypoPTH 1 pt TORT-TOETVA 1 pt CT	Inclusion criteria follicular thyroid neoplasm or benign nodules with a maximum diameter < 5 cm; DTC with a maximum diameter < 3 cm; Exclusion criteria - huge goiter; - thyroid tumor with macroscopic extrathyroid extension; - lymph nodes metastases of the lateral compartment, or distant metastases; - previous cervical irradiation or neck surgery	da Vinci Si surgical robotic system
Chae et al., 2020 [21]	Retrospective Feb 2009–Apr 2019	14 TORT vs 56 BABART (All unilateral procedures)	PTC, stage I (100%)	No RLN injuries were reported	Inclusion criteria Pts who underwent lobectomy with or without CND for thyroid cancer; Exclusion criteria Pts who underwent lobectomy for benign nodules or lobectomy with lateral neck dissection	da Vinci Si surgical robotic system
Kim et al., 2018 [22]	Retrospective Mar 2016–May 2017	58 TORT da Vinci Xi (4/58 bilateral procedures) vs 58 TORT da Vinci Si (6/58 bilateral procedures)	Malignant 96.6% TORT with da Vinci Xi (56/58 PTC) 91.4% TORT with da Vinci Si (53/58 PTC)	No RLN injuries and HypoPTH were reported	Inclusion criteria Benign thyroid nodule or PTC with a maximum diameter < 4 cm without lymph node involvement on preoperative ultrasound Prophylactic ipsilateral CND was routinely performed in pts with suspicious preoperative cytology for PTC	da Vinci Xi surgical robotic system da Vinci Si surgical robotic system

Table 2 continued

Author, year, reference	Type of the study, time interval	Number of pts	Histological diagnoses	RLN injury and HypoPTH rates	Patient selection criteriafor transoral thyroid surgery	Notes
Kim et al., 2018 [23]	Retrospective Mar 2016–Feb 2017	100 TORT (9/100 bilateral procedures)	PTC stage I (77%), stage II (23%)	Transient RLN injury 1 pt	Inclusion criteria Cytological suspicious malignancy or malignant (Bethesda category V or VI) with a maximum diameter < 3 cm, without macroscopic extrathyroid extension or lymphadenopathy on preoperative ultrasound Exclusion criteria Previous cervical surgery and lymph nodes metastases of the lateral compartment Total thyroidectomy was performed for the pts with bilateral PTC or tumor size > 2 cm	da Vinci Xi surgical robotic system 42 pts da Vinci Si surgical robotic system 58 pts
Kim et al., 2018 [24]	Retrospective Sept 2012–Jun 2016	24 TORT (All unilateral procedures)	PTC (83.3%, 20/26)	No RLN injuries and HypoPTH were reported	Inclusion criteria A thyroid nodule with a maximum diameter < 4 cm on preoperative ultrasound Exclusion criteria Pts with suspected lateral lymph node neck or extensive central nodal involvement	da Vinci Si surgical robotic system

Original table

pt patient, *TORT* transoral robotic thyroidectomy, *TOETVA* transoral endoscopic thyroidectomyvestibular approach, *CT* conventional thyroidectomy, *BABART* bilateral axillo-breast approach robotic thyroidectomy, *PTC* papillary thyroid carcinoma, *DTC* differentiated thyroid cancer, *CND* central neck dissection, *RLN* recurrent laryngeal nerve, HypoPTH hypoparathyroidism

statistically significant difference ($P = 0.005$) only for the sex of the patients in the evaluation of the subgroups DT or difficult thyroidectomy and NDT or nondifficult thyroidectomy (each consisting of 45 patients, DT [33 women/12 men] and NDT [42 women/3 men]) [19•]. In the same year, other authors [20] prospectively compared 100 patients who underwent transoral surgery (71 TORT and 29 TOETVA) with 207 patients operated on by CT. The authors excluded from the CT group patients who had advanced (severe extrathyroidal extension) or metastatic disease or who had undergone second-look thyroid surgery or concomitant lateral neck dissection. The mean operative time was longer in the transoral group, but esthetic outcomes were better, while no significant differences were found between the 2 groups [20].

Chae et al. [21] comparatively studied two groups of patients who underwent unilateral surgery for malignancy: 14 by TORT and 54 by bilateral axillo-breast robotic thyroidectomy (BABART). Interestingly, in addition to the longer average operative time in the TORT group, the authors found that pain scores on postoperative day 2 and 3, as assessed by the visual analog scale, were significantly higher in the TORT group [21].

Kim et al. [22] in a 2018 clinical series compared two groups of 58 patients each who underwent TORT with both the da Vinci Xi and da Vinci Si robotic surgical systems for the predominant treatment of malignant thyroid disease (96.6% and 91.4%, respectively). In the Xi group, patients underwent unilateral surgery in 54 cases and in the Si group in 52 cases. No significant differences were found between the two groups, except for significantly lower mean postoperative pain in group Xi. The authors noted several technical advantages to using the da Vinci Xi for TORT, including fewer instrumental collisions, precise dissection in a limited space, greater volume of lymph nodes harvested, less postoperative pain, and a shorter inpatient stay [22]. The same group of authors published an initial clinical series of 24 unilateral procedures [23] and subsequently, in 2019, a series of 100 nonconverted TORT (91 unilateral and 9 bilateral procedures) performed to treat 100 PTC patients [24].

Conclusions

TORT is performed in a very limited number of centers [16, 17, 23, 24] and, like TOETVA, is reportedly safe and comparable to conventional CT [25–27].

TORT, like other remote access techniques, is expanding its scope among cervical scarless techniques [6, 18•,

19•, 20, 22]. It is well known that TORT requires a longer operative time than TOETVA, but this technique allows performing more complex surgical procedures and achieving better oncologic outcomes by expanding the inclusion criteria (i.e., tumor node size and location, nodal involvement) for patients with advanced pathologies [18•, 20, 23].

The cost of the robotic system has a natural impact on TORT and can be appropriately managed in high-volume robotic thyroid surgery centers. Clear definition of the inclusion and exclusion criteria for patients to undergo robotic surgery is essential to achieve the most reliable results in future comparative and non-comparative large studies.

Author Contributions Conceptualization, HYK, GD; Formal analysis: DP, HYK, GD, FaFa; Data curation: AP, FrFr, VV, AM, GD, FaFa; Methodology: HYK, CWW, GD; Writing—original draft preparation, DP, HYK, GD, FaFa; Writing—review and editing, DP, HYK, AP, FrFr, VV, AM, CWW, GD, FaFa; All authors have read and agreed to the published version of the manuscript.

Funding No funding was received.

Declarations

Conflict of interest The authors have no conflict of interest to disclose, and no other funding or financial relationship with the surgical industry.

Ethical Approval The Institution's Ethical Board Committee approved the review.

References

Papers of particular interest, published recently, have been highlighted as:

- Of importance

1. Kim WW, Lee J, Jung JH, Park HY, Tufano RP, Kim HY. A comparison study of the transoral and bilateral axillo-breast approaches in robotic thyroidectomy. J Surg Oncol. 2018;118(3):381–7. https://doi.org/10.1002/jso.25175.
2. Razavi CR, Vasiliou E, Tufano RP, Russell JO. Learning curve for transoral endoscopic thyroid lobectomy. Otolaryngol Head Neck Surg. 2018;159(4):625–9. https://doi.org/10.1177/0194599818795881.
3. You JY, Kim H, Park DW, Yang HW, Dionigi G, Tufano RP. Prevention of transoral thyroidectomy complications: an analysis of surgical outcomes in 423 consecutive series. Surgery. 2021;170(4):1155–9. https://doi.org/10.1016/j.surg.2021.05.003.
4. Ji YB, Ko SH, Song CM, Sung ES, Lee BJ, Wu CW, Chiang FY, Tae K. Feasibility and efficacy of intraoperative neural monitoring in remote access robotic and endoscopic thyroidectomy. Oral Oncol. 2020;103: 104617. https://doi.org/10.1016/j.oraloncology.2020.104617.
5. Sun H, Dionigi G. Applicability of transoral robotic thyroidectomy: Is it the final solution? J Surg Oncol. 2019;119(4):541–2. https://doi.org/10.1002/jso.25362.
6. Dionigi G, Tufano RP, Russell J, Kim HY, Piantanida E, Anuwong A. Transoral thyroidectomy: advantages and limitations. J Endocrinol Invest. 2017;40(11):1259–63. https://doi.org/10.1007/s40618-017-0676-0.
7. Anuwong A, Ketwong K, Jitpratoom P, Sasanakietkul T, Duh QY. Safety and outcomes of the transoral endoscopic thyroidectomy vestibular approach. JAMA Surg. 2018;153(1):21–7.
8. Richmon JD, Pattani KM, Benhidjeb T, Tufano RP. Transoral robotic-assisted thyroidectomy: a preclinical feasibility study in 2 cadavers. Head Neck. 2011;33(3):330–3.
9. • Kahramangil B, Mohsin K, Alzahrani H, Bu Ali D, Tausif S, Kang SW, Kandil E, Berber E. Robotic and endoscopic transoral thyroidectomy: feasibility and description of the technique in the cadaveric model. Gland Surg. 2017;6(6):611–9. https://doi.org/10.21037/gs.2017.10.03. *An important study describing both techniques, i.e., robotic and endoscopic.*
10. Russell JO, Noureldine SI, Al Khadem MG, Chaudhary HA, Day AT, Kim HY, Tufano RP, Richmon JD. Transoral robotic thyroidectomy: a preclinical feasibility study using the da Vinci Xi platform. J Robot Surg. 2017;11(3):341–6. https://doi.org/10.1007/s11701-016-0661-1.
11. Clark JH, Kim HY, Richmon JD. Transoral robotic thyroid surgery. Gland Surg. 2015;4(5):429–34. https://doi.org/10.3978/j.issn.2227-684X.2015.02.02.
12. Witzel K, von Rahden BH, Kaminski C, Stein HJ. Transoral access for endoscopic thyroid resection. Surg Endosc. 2008;22(8):1871–5. https://doi.org/10.1007/s00464-007-9734-6.
13. Wilhelm T, Metzig A. Endoscopic minimally invasive thyroidectomy (eMIT): a prospective proof-of-concept study in humans. World J Surg. 2011;35(3):543–51.
14. Anuwong A. Transoral endoscopic thyroidectomy vestibular approach: a series of the first 60 human cases. World J Surg. 2016;40(3):491–7. https://doi.org/10.1007/s00268-015-3320-1.
15. Dionigi G, Lavazza M, Bacuzzi A, Inversini D, Pappalardo V, Tufano RP, Kim HY, Anuwong A. Transoral endoscopic thyroidectomy vestibular approach (TOETVA): from A to Z. Surg Technol Int. 2017;30:103–12.
16. Tae K, Lee DW, Song CM, Ji YB, Park JH, Kim DS, Tufano RP. Early experience of transoral thyroidectomy: comparison of robotic and endoscopic procedures. Head Neck. 2019;41(3):730–8. https://doi.org/10.1002/hed.25426.
17. Razavi CR, Khadem MGA, Fondong A, Clark JH, Richmon JD, Tufano RP, Russell JO. Early outcomes in transoral vestibular thyroidectomy: robotic versus endoscopic techniques. Head Neck. 2018;40(10):2246–53. https://doi.org/10.1002/hed.25323.
18. • Chen YH, Kim HY, Anuwong A, Huang TS, Duh QY. Transoral robotic thyroidectomy versus transoral endoscopic thyroidectomy: a propensity-score-matched analysis of surgical outcomes. Surg Endosc. 2021;35(11):6179–89. https://doi.org/10.1007/s00464-020-08114-1. *This is the largest comparative study between cohorts of patients operated on with transoral robotic thyroidectomy and endoscopic transoral thyroidectomy with a vestibular approach.*
19. • Park D, Kim HY, Kim HK, You JY, Dionigi G, Russell JO, Tufano RP. Institutional experience of 200 consecutive papillary thyroid carcinoma patients in transoral robotic thyroidectomy surgeries. Head Neck. 2020;42(8):2106–14. https://doi.org/10.1002/hed.26149. *This is the study with the largest series of patients operated on for papillary thyroid cancer by transoral robotic thyroidectomy surgery.*
20. Tae K, Ji YB, Song CM, Park JS, Park JH, Kim DS. Safety and efficacy of transoral robotic and endoscopic thyroidectomy: the

first 100 cases. Head Neck. 2020;42(2):321–9. https://doi.org/10.1002/hed.25999.
21. Chae S, Min SY, Park WS. Comparison study of robotic thyroidectomies through a bilateral axillo-breast approach and a transoral approach. J Laparoendosc Adv Surg Tech A. 2020;30(2):175–82. https://doi.org/10.1089/lap.2019.0585.
22. Kim HK, Kim HY, Chai YJ, Dionigi G, Berber E, Tufano RP. Transoral robotic thyroidectomy: comparison of surgical outcomes between the da Vinci Xi and Si. Surg Laparosc Endosc Percutan Tech. 2018;28(6):404–9. https://doi.org/10.1097/SLE.0000000000000587.
23. Kim HY, Chai YJ, Dionigi G, Anuwong A, Richmon JD. Transoral robotic thyroidectomy: lessons learned from an initial consecutive series of 24 patients. Surg Endosc. 2018;32(2):688–94. https://doi.org/10.1007/s00464-017-5724-5.
24. Kim HK, Chai YJ, Dionigi G, Berber E, Tufano RP, Kim HY. Transoral robotic thyroidectomy for papillary thyroid carcinoma: perioperative outcomes of 100 consecutive patients. World J Surg. 2019;43(4):1038–46. https://doi.org/10.1007/s00268-018-04877-w.
25. Shan L, Liu J. A systemic review of transoral thyroidectomy. Surg Laparosc Endosc Percutan Tech. 2018;28(3):135–8.
26. Camenzuli C, SchembriWismayer P, CallejaAgius J. Transoral endoscopic thyroidectomy: a systematic review of the practice so far. JSLS. 2018;22(3):e2018.00026.
27. Chen S, Zhao M, Qiu J. Transoral vestibule approach for thyroid disease: a systematic review. Eur Arch Otorhinolaryngol. 2019;276(2):297–304.