RESEARCH

Lobectomy and completion thyroidectomy rates increase after the 2015 American Thyroid Association Differentiated Thyroid Cancer Guidelines update

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Abstract

Background: The 2015 American Thyroid Association (ATA) Guidelines permit thyroid lobectomy (TL) or total thyroidectomy in the management of low-risk papillary thyroid cancer (PTC). As definitive risk-stratification is only possible post-operatively, some patients may require completion thyroidectomy (CT) after final histopathological analysis.
Methods: A retrospective cohort study of patients undergoing surgery for low-risk PTC in a tertiary referral centre was undertaken. Consecutive adult patients treated from January 2013 to March 2021 were divided into two groups (pre- and post-publication of ATA Guidelines on 01/01/2016). Only those eligible for lobectomy under rule 35(B) of the ATA Guidelines were included: Bethesda V/VI cytology, 1–4 cm post-operative size and without pre-operative evidence of extrathyroidal extension or nodal metastases. We examined rates of TL, CT, local recurrence and surgical complications.
Results: There were 1488 primary surgical procedures performed for PTC on consecutive adult patients during the study period, of which 461 were eligible for TL. Mean tumour size ($P = 0.20$) and mean age ($P = 0.78$) were similar between time periods. The TL rate increased significantly from 4.5 to 18% in the post-publication period ($P < 0.001$). The proportion of TL patients requiring CT (43 vs 38%) was similar between groups ($P = 1.0$). There was no significant change in complications ($P = 0.55$) or local recurrence rates ($P = 0.24$).
Conclusion: The introduction of the 2015 ATA Guidelines resulted in a modest but significant increase in the rate of lobectomy for eligible PTC patients. In the post-publication period, 38% of patients who underwent TL ultimately required CT after complete pathological analysis.

Key Words

- differentiated thyroid cancer
- papillary thyroid cancer
- completion thyroidectomy
- 2015 American Thyroid Association Guidelines

Endocrine Oncology (2023) **3**, **e220095**

https://eo.bioscientifica.com
https://doi.org/10.1530/EO-22-0095

Introduction

Papillary thyroid carcinoma (PTC) is the most common subtype of differentiated thyroid cancer, which comprises over 90% of all thyroid cancers (Sherman 2003, Haugen 2016). PTC has the best prognosis of all thyroid cancer subtypes (Haugen 2016). We examine the impact of the American Thyroid Association's '2015 Management Guidelines for Adult Patients with Thyroid Nodules and Differentiated Thyroid Cancer' (2015 ATA Guidelines) (Haugen 2016) on the treatment of PTC in a tertiary-referral endocrine surgery unit (the Unit).

There has been a recent trend towards more conservative management of PTC, based on population studies which demonstrated no difference in disease-specific survival between thyroid lobectomy (TL) and total thyroidectomy (TT) for low-to-intermediate risk patients (Mendelsohn *et al.* 2010, Adam *et al.* 2014). This is reflected in the 2015 ATA Guidelines, which permit either TL or TT for PTCs of 1–4 cm without evidence of extra-thyroidal extension or nodal metastases (eligible PTCs) (Haugen 2016). In contrast, previous guidelines recommended TT for PTCs ≥1 cm whilst reserving TL for unifocal PTCs <1 cm (Cooper 2009).

Due to the indolent nature of PTC, there have been no prospective randomised trials assessing the surgical management of eligible PTCs (Papachristos *et al.* 2021). Instead, the 2015 ATA Guidelines are based on large retrospective analyses such as Bilimoria *et al.* (2007) and Adam *et al.* (2014) which utilised population-level data from the National Cancer Database. Since the publication of the 2015 ATA Guidelines, a re-analysis of the same data by Rajjoub *et al.* (2018) found that patients with PTC from 2 to 4 cm performed worse when treated with TL vs TT, which highlights the difficulty in interpreting retrospective population data. This uncertainty has recently been acknowledged in recent guidelines from the American Association of Endocrine Surgeons, recommending that initial management of PTCs of 1–4 cm should be individualised (Patel *et al.* 2020).

The 2015 ATA Guidelines suggest that TL alone is sufficient for 'low-risk' eligible PTCs that do not require radioiodine therapy (Haugen 2016). Proponents of this approach argue that TL minimises the risk of complications (Welch & Doherty 2018) and may obviate the need for life-long thyroxine replacement (Chaker *et al.* 2017). However, there is an increased risk of local recurrence and a need to monitor the contralateral lobe (Mazzaferri & Jhiang 1994, Haugen 2016). Furthermore, the utility of serum thyroglobulin as a sensitive tumour marker to detect disease recurrence is lost.

The primary difficulty in deciding which patients are suitable for TL is the inability to perform accurate pre-operative risk stratification. Pathological features, such as vascular invasion and lymph node metastases, often prompt reclassification to the 'intermediate risk' category under the ATA's modified 2009 Risk Stratification System, which would ordinarily warrant adjuvant treatment with RAI and thus require completion thyroidectomy (CT) (Haugen 2016). Indeed, we have previously evaluated the rate of discordance between pre-operative criteria for lobectomy and definitive post-operative risk stratification and postulated it to be as high as 43.5% (Haugen 2016, DiMarco *et al.* 2019). The aim of this study is to examine the real-world rate of TL and CT with reference to the 2015 ATA Guidelines.

Materials and methods

A retrospective cohort study of consecutive patients undergoing surgical intervention for PTC at the Endocrine Surgery Unit of a single academic tertiary-referral centre was undertaken. We aimed to assess the impact of the 2015 ATA Guidelines on the rates of TL, CT, surgery for local recurrence and major complications in adult patients with eligible PTCs. Ethics approval to access the de-identified data was obtained from the Northern Sydney Local Health District Research Governance Office (2020/ETH02787).

All adult patients surgically treated for PTC through the Unit from January 2013 to March 2020 were considered for inclusion. De-identified data were collected from a prospectively maintained endocrine surgery database, including patient age, sex, pre-operative fine-needle aspirate (FNA) cytology, type of operation, surgical complications and post-operative histopathology. Immediate complication data are routinely recorded for all patients at the time of admission. Post-operative PTH is routinely measured on all patients undergoing CT or TT, and all patients with temporary hypoparathyroidism are followed up until it resolves, or until they are classified as having permanent hypoparathyroidism. Permanent hypoparathyroidism is defined as a need for ongoing calcium or calcitriol supplementation at 12 months post-operative and includes patients with partial recovery of PTH levels.

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Patients considered eligible for TL as definitive surgical management under the ATA Guidelines were included for analysis. Specifically, these patients had (i) Bethesda V/VI FNA cytology; (ii) tumour diameter >1 and ≤4 cm and (iii) no pre-operative evidence of extrathyroidal extension or lymph node metastases (Haugen 2016). Post-operatively measured tumour size was used as a proxy for pre-operative tumour size. All patients underwent pre-operative ultrasonographic assessment of the central and lateral compartments, and inclusion was contingent on a clinical N0 nodal status.

Patients were divided into two cohorts, determined by whether their initial operation was before or after the publication of the 2015 ATA Guidelines: January 2013–December 2015 (pre-publication) and January 2016–March 2020 (post-publication).

For each cohort, we compare the rate of TL and TT as a percentage of primary procedures. We also describe the rates of CT among patients initially treated with TL, re-operative surgery for local recurrence and major complications (defined as permanent hypoparathyroidism, permanent recurrent laryngeal nerve palsy, re-operation for haemorrhage, wound infection or death). Where the initial surgical procedure occurred in the pre-publication period, any follow-up procedures (including CT and re-operation for local recurrence) were also counted in the pre-publication period. The initial treatment episode included index operation and any subsequent procedures planned in the immediate post-operative period. Local recurrence was defined as patients who required a follow-up lymph node dissection alone, after completion of their initial treatment episode, or patients with FNA-confirmed pathological lymph nodes managed conservatively during the follow-up period. Patients with contralateral lobe recurrence were also considered to have recurrent disease.

Patient age, sex, tumour size and FNA cytology were compared between the pre- and post-publication periods using an independent two-sample t-test in the Real Statistics Resource Pack for Microsoft Excel. All statistical tests were two-sided, with a significance level of 0.05. Primary and secondary outcomes were compared between the pre- and post-publication periods using a χ^{-2} test (Yates 1934, Swinscow 1997). Fisher's exact test was used when the smallest expected value was <5 (Cochran 1954).

Results

Patient demographics and tumour characteristics

A total of 461 cases met inclusion criteria for the study: 156 pre-publication and 305 post-publication (Fig. 1). As described in Table 1, there was no significant difference in age, sex, tumour size or pre-operative cytology between the pre-publication and post-publication periods.

Thyroid lobectomy rate

In the post-publication period, of the 305 procedures that were eligible for lobectomy under the 2015 ATA Guidelines, 56 (18%) were managed initially with TL (Table 2). This compares to 7 of 156 (4.5%) in the pre-publication period and represents a statistically significant increase ($n = 461$, df = 1, $\chi^2 = 16$, $P < 0.0001$). In the pre-publication period, five of the seven patients treated with TL had Bethesda V lesions and two had Bethesda VI lesions. One Bethesda V lesion was 35 mm, and the others were between 10 and 20 mm in size.

Completion thyroidectomy rate

In the pre-publication period, three of seven patients treated with TL required CT (43%). This compared to 21 of 56 (38%) patients managed initially with TL in the post-publication period ($P = 1.0$). The reasons for CT were consistent between the two periods, as depicted in Fig. 2. Post-operative features leading to CT were multifactorial in the majority (63%) of cases, involving a combination of nodal involvement, local invasion or lymphovascular invasion.

Notably, of the 249 total thyroidectomies performed for 'eligible PTCs' in the post-publication period, 159 (64%) had intermediate or high-risk features on post-operative histopathology that would have necessitated CT, had TL initially been performed. The reasons for this post-operative risk re-categorisation in these cases are set out in Table 3. There were no cases where distant metastases led to post-operative risk re-categorisation.

Predicting the need for CT

We did not identify a pre-operative risk factor able to accurately predict the risk of needing CT. In the post-publication period, we observed an increased tendency

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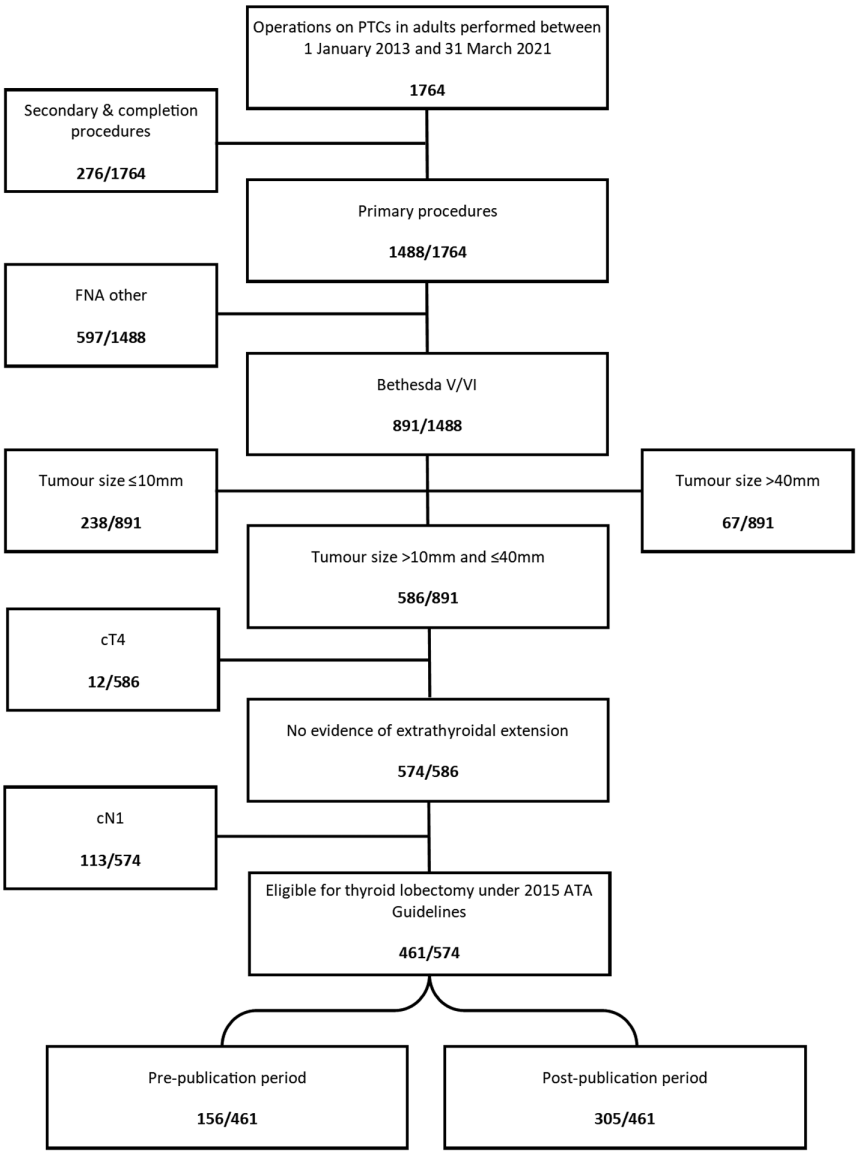

Figure 1
Case selection.

Table 1 Pre- and post-publication population characteristics.

	All eligible PTCs ($n = 461$)	**Pre-publication** ($n = 156$)	**Post-publication** ($n = 305$)	**Independent two-sample *t*-test**
Age in years, mean (S.D.)	49 (14)	49 (14)	48 (15)	$t(459) = 0.27$, $P = 0.78$
Sex, *n* (%)				$t(459) = 0.60$, $P = 0.55$
Female	368 (80%)	127 (81%)	241 (79%)	
Male	93 (20%)	29 (19%)	64 (21%)	
FNA cytology, *n* (%)				$t(459) = 0.50$, $P = 0.62$
Bethesda V	135 (29%)	48 (31%)	87 (29%)	
Bethesda VI	326 (71%)	108 (69%)	218 (71%)	
Tumour size in mm, mean (S.D.)	19 (7.4)	20 (7.6)	19 (7.3)	$t(459) = 1.3$, $P = 0.20$
Tumour size category, *n* (%)				
10 mm < x ≤ 20 mm	307 (67%)	99 (64%)	208 (68%)	
20 mm < x ≤ 30 mm	114 (25%)	40 (26%)	74 (24%)	
30 mm < x ≤ 40 mm	40 (8.7%)	17 (11%)	23 (7.5%)	

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Table 2 Management of eligible PTCs in the pre-publication and post-publication periods.

	Pre-publication		Post-publication	
	Number	Percentage	Number	Percentage
Thyroid lobectomies	7	4.5	56	18
Thyroid lobectomies requiring completion	3	43	21	38
Thyroid lobectomies not requiring completion	4	57	35	62
Total thyroidectomies	149	96	249	82
Primary procedures with local recurrence	5	3.2	11	3.6
Primary procedures without local recurrence	151	96.8	294	96.4

to perform TT in older patients ($P = 0.01$) and for patients with a clear preoperative diagnosis of malignancy, that is, Bethesda VI cytology ($P = 0.02$) (Table 4).

Rate of re-operation for local recurrence

Median follow-up time was 6.9 years (range: 5.3–8.2) in the pre-publication period and 2.9 years (range: 0.9–6.2) in the post-publication period. Overall, the rate of re-operation for local recurrence in the study period was 3.6%, with a rate of 3.2% in the pre-publication period and 2.3% in the post-publication period ($P > 0.05$). The median time-to-first-recurrence was 1.4 years (range: 0.08–4.3).

Major complication rate

As described in Table 5, the incidence of major complications did not change significantly between the pre- and post-publication periods ($n = 461$, df = 1, $P = 0.55$). This remained true when we also considered complications associated with follow-up procedures such as CT ($n = 504$, $P = 1$).

In the pre-publication period, there were two cases of permanent recurrent laryngeal nerve (RLN) palsy, and in both cases, the RLN was deliberately sacrificed due to malignant infiltration of the RLN. In the post-publication period, there were two cases of post-operative hematoma requiring re-operation (one of which occurred during a CT procedure) and one case of post-operative infection. We did not identify any cases of permanent hypoparathyroidism in the study period.

Discussion

This study describes the real-world impact of the introduction of the 2015 ATA Guidelines on decision-making in the surgical management of low-risk PTC

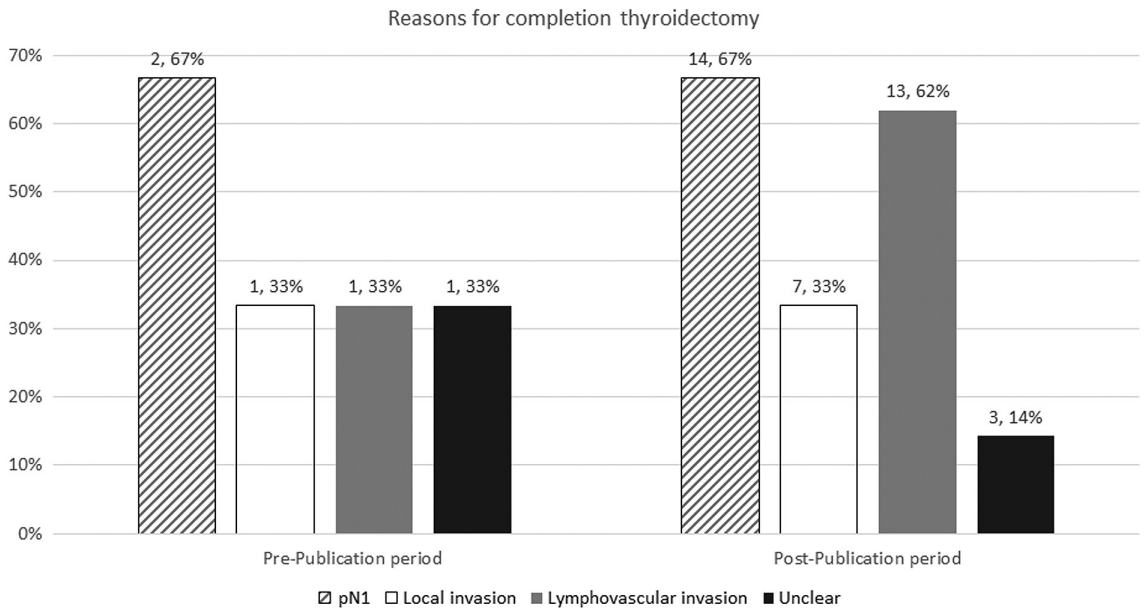

Figure 2
Reasons for completion thyroidectomy.

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Table 3 Reasons for post-operative risk re-categorisation of eligible PTCs managed primarily with total thyroidectomy.

Results of post-operative histopathology	Number	Percentage
Remains 'low' risk	90	36.1
Upstaged to 'intermediate' or 'high' risk	159	63.9
Lymph node metastases	129	51.8
Local invasion	91	36.6
Lymphovascular invasion	77	30.9
Total	251	100

at an endocrine tertiary referral centre. After the introduction of the 2015 ATA Guidelines, the rate of TL for eligible PTCs increased significantly; however, the majority (82%) of eligible PTCs were still treated with TT. Our findings are similar to observations based on the Surveillance Epidemiology and End Results (Sutton *et al.* 2022) and National Surgery Quality Improvement Program databases (Ullmann *et al.* 2019). The modest engagement with the ATA recommendations can be partially attributed to the high incidence of multinodular goitre in the area in which the group practice, which contributes significantly to the fact that TT is frequently recommended as the initial treatment for patients with PTC highlights. However, the results also underscore the complexity of the decision-making process, through which a variety of disease factors, patient factors and clinician factors must be considered before committing to an operative approach.

Among the 56 (18%) patients treated with TL, 21 (38%) required CT based on post-operative histological findings. This finding reinforces the work of Hirshoren *et al.* (2018), DiMarco *et al.* (2019) and Kuo *et al.* (2021) in highlighting the inaccuracy of our currently available pre-operative risk stratification systems. The pathological indication for upstaging to intermediate or high risk, and recommendation of CT were multifactorial in the majority of patients. The subtleties of interpretation of the clinical and pathological data, informed by clinical experience in a multidisciplinary forum, mean that the application of the guidelines to real-world practice is inevitably shaped by clinician judgement, rather than strict adherence. Interpretation of risk associated with certain pathological findings may be associated with inter-observer variability. For example, the distinction between lymphatic and vascular invasion is often not possible to make because it is difficult to differentiate morphologically small lymphatics from small vascular spaces on haematoxylin and eosin slides. Ultimately, the decision to perform CT is driven by the post-operative risk assessment and need for RAI treatment and so the RAI treatment philosophy of the treating team is an important determinant of the viability of TL as an initial surgical approach (Papachristos *et al.* 2021). Hence, we acknowledge that institutional practices may vary with respect to the interpretation of the guidelines, and ongoing longitudinal analysis of outcomes and recurrence data is important in evaluating the impact of their introduction.

No pre-operative risk factor has been shown to predict the need for CT (DiMarco *et al.* 2019). Authors such as Kluijfhout *et al.* (2017), Dhir *et al.* (2018) and DiMarco *et al.* (2019) predicted an increase in TL would translate to an increase in completion thyroidectomies because high-risk features such as local invasion and lymphovascular invasion – which may be indications for TT to facilitate RAI treatment – cannot be assessed pre-operatively. Our real-world data, demonstrating that approximately 40% of eligible patients initially treated with TL will ultimately require CT, confirm previously published theoretical calculations. This contributes valuable information to the preoperative informed consent discussion and

Table 4 Descriptive statistics of post-publication procedures.

	Post-publication thyroid lobectomies ($n = 56$)	Post-publication total thyroidectomies ($n = 249$)	Independent two-sample t-test
Age in years, mean (S.D.)	44.0 (13.9)	49.5 (14.5)	$t(305) = 2.61$, $P = 0.01$
Sex, *n* (%)			$t(305) = 0.44$, $P = 0.66$
Female	43 (76.8%)	198 (79.5%)	
Male	13 (23.2%)	51 (20.5%)	
Tumour size in mm, mean (S.D.)	17.9 (5.1)	19.5 (7.6)	$t(305) = 1.78$, $P = 0.07$
Tumour size category, *n* (%)			
10 mm < x ≤ 20 mm	41 (73.2%)	167 (67.1%)	
20 mm < x ≤ 30 mm	14 (25.0%)	60 (24.1%)	
30 mm < x ≤ 40 mm	1 (1.8%)	22 (8.9%)	
FNA cytology, *n* (%)			$t(305) = 2.32$, $P = 0.02$
Bethesda V	23 (41.1%)	64 (25.7%)	
Bethesda VI	33 (58.9%)	185 (74.3%)	

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Table 5 Complications.

		Pre-publication		Post-publication	
		Number	Percentage	Number	Percentage
Primary procedures	Major complication	2	1.3	1	0.3
	No major complication	154	98.7	304	99.7
	Total	156	100	305	100
Primary procedures + subsequent procedures	Major complication	2	1.2	3	0.9
	No major complication	162	98.8	337	99.1
	Total	164	100	340	100

ensures patients understand the relative likelihoods of the potential management pathways. Many patients may accept the risk of a staged procedure given the 60% chance of avoiding TT.

We did not observe any significant change in local recurrence despite a modest increase in lobectomy rates. However, our study was not powered to assess differences in rates of local recurrence. Furthermore, PTC is an indolent tumour and rates of local recurrence are low even at 10 years (Grant & Hay 1988). The median follow-up time was significantly lower in the post-publication period (2.9 years) than in the pre-publication period (6.9 years), resulting in potential follow-up time bias.

Kandil *et al.* (2013) reported that TL is less risky than TT, even in the hands of high-volume surgeons (Hauch *et al.* 2014, Haugen 2016) and this contributes to the drive to de-escalate surgical management. Due to the excellent prognosis of PTC regardless of management algorithms, any complications that occur must be evaluated with the utmost scrutiny. In our series, the overall complication rate was less than 1% and similar regardless of the operative approach. We acknowledge, however, that in non-specialist units the rates of permanent recurrent laryngeal nerve injury and permanent hypoparathyroidism may be as high as 1.5% (Sosa *et al.* 1998) and 12.5% (Annebäck *et al.* 2020, Koimtzis *et al.* 2021), respectively. Therefore, given more than half of thyroidectomies are performed by surgeons who perform fewer than five thyroidectomies per year, these risks must be carefully weighed in the decision to perform TT vs TL.

This study is limited by its retrospective design and associated potential for statistical bias in the collection and interpretation of retrospective data. Secondly, patients were included according to post-operative tumour size despite ultrasound being used for preoperative decision-making. Ultrasound tends to overestimate size (particularly for microcarcinomas <1 cm), meaning that some PTCs may have been excluded from our analysis because they were <1 cm post-operatively, despite being treated as 1–4 cm based on pre-operative ultrasound (Hahn *et al.* 2016). We excluded 205 microcarcinomas with a median size of 8 mm that would have been eligible PTCs if >1 cm.

Our analysis was also confined to histopathologically confirmed PTC. However, pre-operative decision-making is based on FNA which gives a likelihood of malignancy (60–75% for Bethesda V and 97–99% for Bethesda VI) (Cibas *et al.* 2009). Therefore, some lesions which would have been treated as PTCs on the basis of FNA may have been excluded from our analysis because they turned out to be benign on post-operative histopathology.

Conclusions

While the TL rate in this cohort of 'low-risk' PTC patients remains low, we observed a significant increase after the publication of the 2015 ATA Guidelines. Approximately 40% of patients with eligible PTCs treated with TL ultimately require CT. Patients should be counselled regarding the likelihood of this outcome during the informed consent process.

Declaration of interest
The authors declare that they have no relevant or material financial interests that relate to the research described in this paper.

Funding
This study received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Author contribution statement
The authors confirm contribution to the paper as follows: Study conception and design: MS, BW; Data collection: AA, AP; Analysis and interpretation of results: MS, AP, BW; Draft manuscript preparation: AP, BW, AA, AG, SS, RCB, DL, VT, MG, BR, MS. All authors reviewed the results and approved the final version of the manuscript.

References

Adam MA, Pura J, Gu L, Dinan MA, Tyler DS, Reed SD, Scheri R, Roman SA & Sosa JA 2014 Extent of surgery for papillary thyroid cancer is not associated with survival: an analysis of 61,775 patients. *Annals of Surgery* **260** 601–605. (https://doi.org/10.1097/SLA.0000000000000925)

American Thyroid Association (ATA) Guidelines Taskforce on Thyroid Nodules and Differentiated Thyroid Cancer, Cooper DS, Doherty GM, Haugen BR, Kloos RT, Lee SL, Mandel SJ, Mazzaferri EL, McIver B, Pacini F, *et al.* 2009 Revised American Thyroid Association management guidelines for patients with thyroid nodules and differentiated thyroid cancer. *Thyroid* **19** 1167–1214. (https://doi.org/10.1089/thy.2009.0110)

Annebäck M, Hedberg J, Almquist M, Stålberg P & Norlén O 2020 Risk of permanent hypoparathyroidism after total thyroidectomy for benign disease. *Annals of Surgery* **274** e1202–1208.

Bilimoria KY, Bentrem DJ, Ko CY, Stewart AK, Winchester DP, Talamonti MS & Sturgeon C 2007 Extent of surgery affects survival for papillary thyroid cancer. *Annals of Surgery* **246** 375–381. (https://doi.org/10.1097/SLA.0b013e31814697d9)

Chaker L, Bianco AC, Jonklaas J & Peeters RP 2017 Hypothyroidism. *Lancet* **390** 1550–1562. (https://doi.org/10.1016/S0140-6736(17)30703-1)

Cibas ES, Ali SZ & NCI Thyroid FNA State of the Science Conference 2009 The Bethesda system for reporting thyroid cytopathology. *American Journal of Clinical Pathology* **132** 658–665. (https://doi.org/10.1309/AJCPPHLWMI3JV4LA)

Cochran WG 1954 Some methods for strengthening the common X^2 tests. *Biometrics* **10** 417–451. (https://doi.org/10.2307/3001616)

Dhir M, Mccoy KL, Ohori NP, Adkisson CD, Lebeau SO, Carty SE & Yip L 2018 Correct extent of thyroidectomy is poorly predicted preoperatively by the guidelines of the American Thyroid Association for low and intermediate risk thyroid cancers. *Surgery* **163** 81–87. (https://doi.org/10.1016/j.surg.2017.04.029)

DiMarco AN, Wong MS, Jayasekara J, Cole-Clark D, Aniss A, Glover AR, Delbridge LW, Sywak MS & Sidhu SB 2019 Risk of needing completion thyroidectomy for low-risk papillary thyroid cancers treated by lobectomy. *BJS Open* **3** 299–304. (https://doi.org/10.1002/bjs5.50137)

Grant CS & Hay D 1988 Local recurrence of papillary thyroid carcinoma after unilateral or bilateral thyroidectomy. *Wiener Klinische Wochenschrift* **100** 342–346.

Hahn SY, Shin JH, Oh YL & Son YI 2016 Discrepancies between the ultrasonographic and gross pathological size of papillary thyroid carcinomas. *Ultrasonography* **35** 220–225. (https://doi.org/10.14366/usg.15077)

Hauch A, Al-Qurayshi Z, Randolph G & Kandil E 2014 Total thyroidectomy is associated with increased complications for low- and high-volume surgeons. *Annals of Surgical Oncology* **21** 3844–3852. (https://doi.org/10.1245/s10434-014-3846-8)

Haugen BR, Alexander EK, Bible KC, Doherty GM, Mandel SJ, Nikiforov YE, Pacini F, Randolph GW, Sawka AM, Schlumberger M, *et al.* 2016 2015 American Thyroid Association management guidelines for adult patients with thyroid nodules and differentiated thyroid cancer: The American Thyroid Association Guidelines Task Force on Thyroid Nodules and Differentiated Thyroid Cancer. *Thyroid* **26** 1–133. (https://doi.org/10.1089/thy.2015.0020)

Hirshoren N, Kaganov K, Weinberger JM, Glaser B, Uziely B, Mizrahi I, Eliashar R & Mazeh H 2018 Thyroidectomy practice after implementation of the 2015 American Thyroid Association guidelines on surgical options for patients with well-differentiated thyroid carcinoma. *JAMA Otolaryngology– Head and Neck Surgery* **144** 427–432. (https://doi.org/10.1001/jamaoto.2018.0042)

Kandil E, Noreldine SI, Abbas A & Tufano RP 2013 The impact of surgical volume on patient outcomes following thyroid surgery. *Surgery* **154** 1346–1352. (https://doi.org/10.1016/j.surg.2013.04.068)

Kluijfhout WP, Pasternak JD, Drake FT, Beninato T, Shen WT, Gosnell JE, Suh I, C L & Duh QY 2017 Application of the new American Thyroid Association guidelines leads to a substantial rate of completion total thyroidectomy to enable adjuvant radioactive iodine. *Surgery* **161** 127–133. (https://doi.org/10.1016/j.surg.2016.05.056)

Koimtzis GD, Stefanopoulos L, Giannoulis K & Papavramidis TS 2021 What are the real rates of temporary hypoparathyroidism following thyroidectomy? It is a matter of definition: a systematic review. *Endocrine* **73** 1–7. (https://doi.org/10.1007/s12020-021-02663-8)

Kuo LE, Angell TE, Pandian TK, Moore AL, Alexander EK, Barletta JA, Gawande AA, Lorch JH, Marqusee E, Moore FD, *et al.* 2021 Completion thyroidectomy is less common following updated 2015 American Thyroid Association guidelines. *Annals of Surgical Oncology* **28** 484–491. (https://doi.org/10.1245/s10434-020-08709-x)

Mazzaferri EL & Jhiang SM 1994 Long term impact of initial surgical and medical therapy on papillary and follicular thyroid cancer. *American Journal of Medicine* **97** 418–428. (https://doi.org/10.1016/0002-9343(94)90321-2)

Mendelsohn AH, Elashoff DA, Abemayor E & St John MA 2010 Surgery for papillary thyroid carcinoma: is lobectomy enough? *Archives of Otolaryngology–Head and Neck Surgery* **136** 1055–1061. (https://doi.org/10.1001/archoto.2010.181)

Papachristos AJ, Glover A, Sywak MS & Sidhu SB 2021 Pros and cons of hemi-thyroidectomy for low-risk differentiated Thryoid cancer. *ANZ Journal of Surgery* **91** 1704–1710. (https://doi.org/10.1111/ans.16553)

Patel KN, Yip L, Lubitz CC, Grubbs EG, Miller BS, Shen W, Angelos P, Chen H, Doherty GM, Fahey TJ, *et al.* 2020 The American Association of endocrine surgeons guidelines for the definitive surgical management of thyroid disease in adults. *Annals of Surgery* **271** e21–e93. (https://doi.org/10.1097/SLA.0000000000003580)

Rajjoub SR, Yan H, Calcatera NA, Kuchta K, Wang CE, Lutfi W, Moo-Young TA, Winchester DJ & Prinz RA 2018 Thyroid lobectomy is not sufficient for T2 papillary thyroid cancers. *Surgery* **163** 1134–1143. (https://doi.org/10.1016/j.surg.2017.12.026)

Sherman SI 2003 Thyroid carcinoma. *Lancet* **361** 501–511. (https://doi.org/10.1016/s0140-6736(03)12488-9)

Sosa JA, Bowman HM, Tielsch JM, Power NR, Gordon TA & Udelsman R 1998 The importance of surgeon experience for clinical and economic outcomes from thyroidectomy. *Annals of Surgery* **228** 320–330. (https://doi.org/10.1097/00000658-199809000-00005)

Sutton W, Crepeau PK, Canner JK, Karzai S, Segev DL & Mathur A 2022 Impact of the 2015 American Thyroid Association guidelines on treatment in older adults with low-risk differentiated thyroid cancer. *American Journal of Surgery* **224** 412–417. (https://doi.org/10.1016/j.amjsurg.2022.01.033)

Swinscow T 1997 8. The chi-squared tests. London, UK: BMJ Publishing Group. (available at: https://www.bmj.com/about-bmj/resources-readers/publications/statistics-square-one/8-chi-squared-tests)

Ullmann TM, Gray KD, Stefanova D, Limberg J, Buicko JL, Finnerty B, Zarnegar R, Fahey TJ & Beninato T 2019 The 2015 American Thyroid Association guidelines are associated with an increasing rate of hemithryoidectomy for thyroid cancer. *Surgery* **166** 349–355. (https://doi.org/10.1016/j.surg.2019.03.002)

Welch HG & Doherty GM 2018 Saving thyroids - overtreatment of small papillary cancers. *New England Journal of Medicine* **379** 310–312. (https://doi.org/10.1056/NEJMp1804426)

Yates F 1934 Contingency tables involving small numbers and the X^2 test. *Supplement to the Journal of the Royal Statistical Society* **1** 217–235. (https://doi.org/10.2307/2983604)

Received 25 February 2023
Accepted 13 March 2023
Available online 13 March 2023
Version of Record published 6 April 2023