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Value of surveillance ultrasound following hemithyroidectomy

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Abstract

Background. There is limited evidence or agreement on the benefit, duration and frequency of post-operative surveillance neck ultrasound in patients with differentiated thyroid cancer treated with hemithyroidectomy alone. This study's primary aim was to assess the benefit of neck ultrasound in this situation, with a secondary aim to assess the detection of malignancy in the contralateral lobe in patients undergoing completion surgery.

Methods. A retrospective observational study was conducted involving patients who had differentiated thyroid cancer found at diagnostic hemithyroidectomy between 1 December 2013 and 31 December 2016.

Results. Of 105 patients, 74 underwent completion thyroidectomy. Thirty-five per cent of these patients had malignancy identified in the contralateral lobe, the majority were unsuspected sonographically. Of 31 hemithyroidectomy patients, 1 had a nodule classified as 'U3' (indeterminate) at the first ultrasound surveillance, ultimately identified as incidental papillary microcarcinomas on completion thyroidectomy. There was no other disease recurrence or malignancy at a median of 3.8 years' follow up.

Conclusion. The findings indicate a limited role for ultrasound follow up of patients with differentiated thyroid cancer treated with hemithyroidectomy alone.

Main Article

Owen O'Brien takes responsibility for the integrity of the content of the paper

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Introduction

The incidence of differentiated thyroid cancer has increased worldwide over the past four decades.[1] Despite this, mortality rates from thyroid cancer have remained stable.[2] This is likely a result of the relative increase in low-risk papillary microcarcinoma, defined as 1 cm or smaller, which is often discovered incidentally after surgery for benign pathology, and is widely reported in autopsy studies with prevalence ranging from 2 to 35.6 per cent.[3]

Tumour–node–metastasis (TNM) staging provides information on disease-specific survival, with $T_{1/2}N_0M_0$ thyroid cancers having an estimated disease-specific survival at 20 years of 99 per cent.[4] Traditionally, total thyroidectomy was the procedure of choice for differentiated thyroid cancer followed by radioiodine remnant ablation, a treatment model often disproportionate to excellent patient prognosis. A more conservative approach with hemithyroidectomy alone in low-risk differentiated thyroid cancer is increasingly considered an appropriate treatment strategy,[5,6] with studies demonstrating good clinical outcomes in appropriately selected patients, with structural recurrence rates ranging from 0 to 10.6 per cent over 0.6 to 30.5 years.[7–10]

The definition of 'low risk' is continuously evolving, but, at present, includes clinically staged N_0M_0 tumours sized less than 4 cm, and tumours without adverse features such as extrathyroidal extension, and with no multifocality, angioinvasion or positive family history. A three-tier initial risk stratification system developed by the American Thyroid Association and modified in 2015[11] divides patients after initial therapy into low, intermediate and high risk of structural disease recurrence, although this risk level, and complete TNM status, is only possible to determine post-operatively. In patients with larger tumours or with intermediate or high-risk histological features following lobectomy, completion thyroidectomy is indicated, to facilitate radioiodine remnant ablation.

Dynamic risk assessment, recommended by the British Thyroid Association, the American Thyroid Association and the European Society for Medical Oncology, allows re-evaluation of the initial risk of structural disease recurrence. Based on serum thyroglobulin and anti-thyroglobulin antibody assays, along with imaging, the patient's response to therapy is graded as excellent, indeterminate, biochemically incomplete or structurally incomplete.[11–13] While originally developed based on studies of patients who underwent total thyroidectomy and radioiodine remnant ablation, Momesso and colleagues developed (in 2014)[14] and validated (in 2016)[15] serum thyroglobulin values for excellent and biochemically incomplete response categories for both lobectomy and total thyroidectomy patients without radioiodine remnant ablation.

Despite widespread use of dynamic risk assessment, there is limited consensus on the duration and frequency of surveillance neck ultrasound in the hemithyroidectomy-only differentiated thyroid cancer group. The European Society for Medical Oncology

guidelines, published in 2019, recommend a single neck ultrasound scan with serum thyroglobulin and thyroglobulin antibody assays at 6–18 months post-treatment. If there is no evidence of structural disease in a low-risk differentiated thyroid cancer patient at this first follow up, 12–24-monthly biochemical assessment is advised, with repeat neck ultrasound only necessary in cases of rising thyroglobulin and/or thyroglobulin antibody levels.[13]

In order to determine the value of surveillance neck ultrasound, we evaluated findings and outcomes in patients with differentiated thyroid cancer found at hemithyroidectomy, who were considered sufficiently low risk that there was no mandate for completion surgery. In addition, in order to determine the utility of ultrasound for the detection of small contralateral cancers, we assessed the histological outcome, compared with initial ultrasound findings, in the remnant thyroid of those patients meeting the criteria for primary completion surgery.

Materials and methods

Study design and subjects

Research ethics committee advice was sought using the online tool from the National Health Service Health Research Authority and Medical Research Council website,[16] and ethical approval was deemed not required.

Included in this retrospective study were patients who had differentiated thyroid cancer identified between 1 December 2013 and 31 December 2016 following hemithyroidectomy or isthmusectomy, performed either as a diagnostic or therapeutic procedure with curative intent, with at least one follow-up ultrasound scan in the hemithyroidectomy-only patients. A total of 105 patients met the inclusion criteria. Exclusion criteria were: patients outside the health board whose samples were sent for tertiary opinion, patients who underwent a core biopsy only or initial total thyroidectomy, and patients with anaplastic carcinoma, medullary carcinoma or lymphoma histological types. One further patient was excluded as co-morbidities rather than low-risk status precluded completion thyroidectomy. All patients were discussed by the regional thyroid cancer multidisciplinary team.

Imaging techniques

Ultrasound examinations were performed across 6 hospital sites on several different ultrasound machines, by 1 of 14 consultant radiologists with a head and neck specialist interest, or 1 of 5 sonographers with experience in thyroid ultrasound. Images were captured on a picture archiving and communications system, and a formal written report linked to the Radiology Information System. Reports described nodules using the British Thyroid Association 'U' classification, from July 2014 onwards, or an opinion on whether a nodule was considered generally benign, indeterminate or suspicious with fine needle aspiration (FNA) biopsy utilised as indicated.

Image and data analyses

For all included patients, clinical notes and histology reports were reviewed. Post-operative surveillance neck ultrasound reports in the hemithyroidectomy-only group were examined, as well as initial ultrasound reports, when relevant, in the completion surgery group.

The variables recorded were: patient age and sex, type and date of surgical procedure, histological type and size of either the largest or the worst prognosis cancer, tumour multifocality, pathological TNM status (the American Joint Committee on Cancer seventh edition of the *AJCC Cancer Staging Manual* was in use during the study period, but the eighth edition classification was also recorded to increase the future applicability of the study[17,18]), presence of and degree of extrathyroidal extension, vascular invasion, and positive nodal status. If the patient proceeded to primary completion thyroidectomy, we recorded time to completion (days), histological results and pre-operative ultrasound findings regarding the contralateral lobe. If the patient did not proceed to initial completion, follow-up ultrasound appointments and results, further management, later histology findings, when relevant, and last clinic date were recorded. The main clinical outcomes were locoregional recurrence detected at ultrasound within five to seven years in hemithyroidectomy-only patients, and the incidence, nature and sonographic conspicuity of remnant malignancy in patients undergoing primary completion surgery.

Statistical methods

Continuous data are presented as means and standard deviations, or as medians and interquartile ranges. Categorical data are recorded as whole numbers ± percentages. Microsoft Excel® spreadsheet software (2016 version) was used for these descriptive statistics.

Results

The study included 105 patients, consisting of 25 males and 80 females. Initial surgery comprised hemithyroidectomy ($n = 101$) or isthmusectomy ($n = 4$).

Group A consisted of 74 out of 105 patients (70 per cent) who underwent primary completion thyroidectomy, with a median time to completion of 56 days (interquartile range = 42, 77). Thirty-five per cent of group A patients (26 of 74) were found to have at least one malignant nodule in the subsequently excised contralateral lobe. Apart from one patient who was found to have follicular cancer and four papillary microcarcinoma foci in the thyroid remnant, these were all papillary microcarcinomas, with a mean diameter of 2.9 mm (± 2.3 mm). Regarding the completion contralateral lobe on pre-operative ultrasound, 15 out of 26 had sonographically benign nodules or normal appearances reported. A further eight patients had sub-centimetre nodules reported, which were either unclassified ($n = 6$) or 'of doubtful significance' ($n = 2$). In two patients, the contralateral lobe was not mentioned in the report. The ultrasound report for the final patient was not accessible as the scan was performed privately.

Group B comprised 31 out of 105 patients (30 per cent) who underwent follow up after hemithyroidectomy only. No patients in this group had pathological lymph nodes. Thirty patients (97 per cent) would have been considered low-risk according to the American Thyroid Association system and 1 (3 per cent) as intermediate risk. Group B had a median clinical follow-up duration of 3.8 years (interquartile range = 2.6, 6.3) and underwent surveillance neck ultrasound over a median duration of 3.7 years (interquartile range = 0.9, 5.3).

A total of 106 surveillance neck ultrasound scans were carried out, with each patient undergoing an average of 3.4 (± 2.2) neck ultrasound examinations over the follow-up period. Twenty-two patients have since been discharged, one patient

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died of unrelated causes and a further patient moved to a different health board.

Table 1 shows the demographics, tumour size, histological findings and TNM status of both groups.

During the follow up of group B, one patient with a contralateral nodule graded 'U3' (indeterminate) at the first surveillance neck ultrasound two years post-operatively underwent FNA biopsy with Thy3f cytology. Multifocal papillary microcarcinoma was discovered on later completion, with two foci measuring 7.9 and 1.2 mm; there were no intermediate or high-risk features, and no further treatment was required. Another patient had a contralateral 'U2' graded nodule upgraded to 'U3' at their third annual ultrasound surveillance follow-up scan with Thy3a cytology on FNA biopsy. At later completion thyroidectomy, this lesion was found to be a benign adenoma. A third patient had a 3 mm 'unclassifiable nodule' in the remnant lobe on the first surveillance neck ultrasound at three months post-operatively, with Thy1 cytology on FNA biopsy nine months later. A further surveillance neck ultrasound in this patient at 33 months demonstrated no change to the tiny nodule, ultimately labelled 'of limited significance'. A final patient has had a static 1.3 mm remnant 'hypoechoic area' under ultrasound surveillance for over three years. The remaining patients had normal appearances or sonographically benign nodules with no cervical lymphadenopathy demonstrated on follow-up ultrasound scans and no clinical recurrences.

Table 1. Baseline patient characteristics

Characteristics	Group A	Group B
Patients (*n* (%))	74 of 105 (70)	31 of 105 (30)
Age at diagnosis (mean ± SD; years)	45.1 ± 16.3	46.2 ± 17.7
Age range (years)	12–81	15–75
Histology (*n* (%))		
– Papillary	43 (58)	28 (90)
– (Papillary microcarcinoma)	(18 of 43) (42)	(19 of 28) (68)
– Follicular	25 (34)	3 (10)
– Hürthle cell	5 (7)	0 (0)
– Poorly differentiated thyroid cancer	1 (1)	0 (0)
Size of largest primary tumour (mm)		
– Mean ± SD	27.4 ± 19.8	10.3 ± 10.2
– Range	0.3–80	0.2–39
Multifocality? (*n*)		
– Yes	20	1
– No	54	30
AJCC TNM 7th edn[17] pathological tumour (T) stage (*n*)		
– T_{1a}	14	16
– T_{1b}	5	7
– T_2	26	5
– T_3	29	3
– T_4	0	0
AJCC TNM 8th edn[18] pathological tumour (T) stage (*n*)		
– T_{1a}	20	19
– T_{1b}	8	7
– T_2	27	5
– T_3	19 (T_{3a})	0
– T_4	0	0
Extrathyroidal extension? (*n*)		
– Yes	15 (10 minimal, 1 microscopic)	3 (minimal)
– No	59	28
Vascular invasion? (*n*)		
– Yes	33	2 (1 PMC & 1 follicular)
– No	41	29
If papillary cancer, was it incidental? (*n*)		
– Yes	11 of 18	15 of 19
– No	7 of 18	4 of 19

Group A = primary completion thyroidectomy; group B = hemithyroidectomy only. SD = standard deviation; AJCC = American Joint Committee on Cancer; TNM = tumour–node–metastasis; edn = edition; PMC = papillary microcarcinoma

Discussion

This study analysed 105 consecutive patients with differentiated thyroid cancer discovered at hemithyroidectomy. The patient cohort was subdivided into two groups: those who underwent primary completion surgery and those who underwent hemithyroidectomy only with ultrasound follow up. The follow-up ultrasound findings and rate of disease recurrence were identified in the hemithyroidectomy-only group, while the rate of remnant malignancy and its pre-operative ultrasound identification were assessed in those who underwent primary completion surgery.

In 35 per cent of the primary completion thyroidectomy specimens, remnant malignancy was found. This was papillary microcarcinoma in all but 1 of the 26 cases, multifocal in most. The vast majority of these patients had no concerning findings in the contralateral lobe on pre-operative ultrasound. This confirms previous reports that papillary microcarcinoma can be sonographically occult. In a study using whole-specimen mapping, multifocal papillary microcarcinomas were found histologically in 45 per cent of patients with ultrasound-identified 'solitary' papillary carcinoma.[19]

Almost all patients (97 per cent) in group B (hemithyroidectomy-only group) were classified as low-risk according to the American Thyroid Association system. In just under half of the patients, the histologically identified tumour was an incidental unifocal papillary microcarcinoma. A low rate of structural disease recurrence of 3.2 per cent (1 of 31) was found in the contralateral lobe in the hemithyroidectomy-only group. This was a multifocal papillary microcarcinoma, with no adverse histological features. We found no cervical nodal recurrences. A relatively similar rate of structural recurrence, of 4.2 per cent, was found by Vaisman *et al.*, in 72 lobectomy cases, with median follow up of five years.[8] Lee *et al.*,[20] in a 2022 study, also found a similar low recurrence rate of 4.3 per cent in 46 hemithyroidectomy cases with median follow up of 3.5 years. These recurrence rates are similar to the 2–6 per cent recurrence rates described in the American Thyroid Association guidelines for low-risk papillary thyroid cancer,[11] although they are notably lower than the pooled recurrence rate of 9 per cent reported by Chan *et al.*[21] in their 2020

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systematic review of post-hemithyroidectomy low-risk differentiated thyroid cancer patients.

Despite the recognised favourable outcomes, there has been an increase in the use of imaging in post-treatment differentiated thyroid cancer patients. Banerjee *et al.*[22] observed a substantial increase in imaging in a cohort of 28 220 differentiated thyroid cancer patients studied from 1998 to 2011 that included 5317 lobectomy patients. That study revealed an association between neck ultrasound usage and increased recurrence treatment with surgery and radioactive iodine therapy, but there was no effect on disease-specific survival.

Furthermore, surveillance ultrasound in post-treatment patients is associated with a high false-positive rate, as described by Yang *et al.*[23,24] Regarding post-total-thyroidectomy patients with or without radioiodine remnant ablation, they found a false-positive rate of 67 per cent and 57 per cent in 171 American Thyroid Association low-risk and 90 American Thyroid Association intermediate-risk papillary thyroid cancer patients, respectively, who had initial unremarkable post-treatment ultrasound scan findings. There was a corresponding 1.2 per cent and 10 per cent structural recurrence rate.

A high relative financial cost in the surveillance of a low-risk group is also a consideration. Wang *et al.*[25] found an imbalance of a factor of 7 in the cost to detect recurrence between low- and high-risk papillary cancer following total thyroidectomy. Another consideration is patients' mental well-being. Ongoing, unnecessary ultrasound surveillance may provoke continuing patient anxiety regarding recurrence. A population-based cohort study of 353 Swedish patients with differentiated thyroid cancer[26] found that, despite a low incidence of recurrence (7 per cent), almost half of the 279 patients reported ongoing concerns about recurrence, 14–17 years after initial diagnosis, with a negative impact on health-related quality of life.

Finally, it is also worth discussing the background prevalence of papillary microcarcinoma. Interestingly, similar to the rate of remnant malignancy in group A (primary completion thyroidectomy group), which were almost all papillary microcarcinomas, a prevalence of 35.6 per cent of occult small papillary cancers was found in an autopsy study, which concluded that these small cancers may almost be a 'normal' finding.[27] It is widely accepted that the expanding gap between the incidence of and the mortality from differentiated thyroid cancer, and the high rates of differentiated thyroid cancer in screening populations and at autopsy, suggest overdiagnosis. One could argue that the 3.2 per cent structural recurrence in group B, also papillary microcarcinoma, is entirely reflective of the normal population rate of this disease.

Similar to European Society for Medical Oncology recommendations, Lamartina *et al.*,[28] in their update on the management of low-risk differentiated thyroid cancer, suggest annual monitoring of serum thyroid-stimulating hormone, thyroglobulin and thyroglobulin antibody for five years, and then assessments every two years, in low-risk differentiated thyroid cancer, with neck ultrasound scanning only being performed in patients with abnormal biochemical or clinical findings. Regarding thyroglobulin/thyroglobulin antibody in lobectomy-only patients, Momesso *et al.*[14,15] previously defined an excellent response as a thyroglobulin level of less than 30 ng/ml, and a negative thyroglobulin antibody result with negative imaging findings. They defined a biochemically incomplete response as a thyroglobulin level of more than 30 ng/ml or rising, and/or increasing antibodies, with negative imaging findings. Structural recurrence was detected in 33 per cent of patients with a biochemically incomplete response and in 0 per cent of patients with an excellent response.

While Ritter *et al.*[29] and Park *et al.*[30] did not find a significant difference in thyroglobulin levels in papillary cancer lobectomy patients with disease recurrence compared to non-recurrence, Vaisman *et al.* found a significant association between thyroglobulin trend and recurrence, with a negative predictive value of 98 per cent for a rising thyroglobulin level.[9]

In the current cohort, one hemithyroidectomy patient had a contralateral nodule detected at ultrasound follow up; this prompted completion surgery, where low-risk papillary microcarcinoma was found, requiring no further treatment. Another patient had a sonographically and cytologically indeterminate nodule, which led to further surgery for ultimately benign disease. A further two hemithyroidectomy patients had chronically stable tiny nodules in the contralateral lobe, neither of which required further surgery. Furthermore, apart from a single patient who was found to have follicular cancer in the contralateral excised lobe, all of the contralateral malignancies found in the primary completion specimens were papillary microcarcinomas, the vast majority of which were sonographically occult or considered non-concerning pre-operatively. Allowing for a single patient in the current study being intermediate-risk rather than low-risk, the results would indicate no significant value of indiscriminate ultrasound surveillance in hemithyroidectomy-only patients.

- In recent years, there has been a move to less aggressive treatment for thyroid cancer from traditional total thyroidectomy and radioactive iodine
- Significant numbers of patients are being treated with hemithyroidectomy and surveillance
- Ultrasound is an excellent tool for detecting recurrent disease in the thyroid bed
- There is little evidence on the need for ongoing ultrasound surveillance in patients post-hemithyroidectomy for malignancy

The limitations of our study include relatively small patient numbers. In addition, post-treatment ultrasound scanning was performed by a variety of operators on a number of different ultrasound machines; however, this may widen the applicability of the findings. Thyroglobulin and thyroglobulin antibody levels were not analysed, but these assays did not have a routine role in the follow up of hemithyroidectomy patients in this 2014–2016 cohort. The $BRAF^{V600E}$ mutation status was also not recorded; however, this was not routinely tested during the study period and would not have altered the risk level in the hemithyroidectomy-only group. From a cost–benefit point of view, we did not record the number of clinic visits, other scans performed or blood tests generated as a result of ongoing clinical follow up, but this was beyond the scope of our objectives.

Future directions could include continued clinical and ultrasound assessment in the hemithyroidectomy-only patients, in order to obtain a larger cohort and determine the practical validity of biochemical follow up.

Conclusion

Our findings indicate a limited role for the ultrasound follow up of patients with differentiated thyroid cancer treated with hemithyroidectomy alone. Scanning would be preferably directed by a combination of initial sonographic findings and clinical examination, with biochemical assessment a potential adjunct.

Competing interests. None declared

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References

1 Wiltshire JJ, Drake TM, Uttley L, Balasubramanian SP. Systematic review of trends in the incidence of thyroid cancer. *Thyroid* 2016;**26**:1541–52
2 Davies L, Welch HG. Increasing incidence of thyroid cancer in the United States, 1973–2002. *JAMA* 2006;**295**:2164–7
3 Mantinan B, Rego-Iraeta A, Larranaga A, Fluiters E, Sánchez-Sobrino P, Garcia-Mayor RV. Factors influencing the outcome of patients with incidental papillary thyroid microcarcinoma. *J Thyroid Res* 2012;**2012**:469397
4 Shaha AR. Implications of prognostic factors and risk groups in the management of differentiated thyroid cancer. *Laryngoscope* 2004;**114**:393–402
5 Gibelli B, Dionisio R, Ansarin M. Role of hemithyroidectomy in differentiated thyroid cancer. *Curr Opin Otolaryngol Head Neck Surg* 2015;**23**:99–106
6 Geron Y, Benbassat C, Shteinshneider M, Koren S, Or K, Markus E *et al.* Long-term outcome after hemithyroidectomy for papillary thyroid cancer: a comparative study and review of the literature. *Cancers* (*Basel*) 2019;**11**:26
7 Matsuzu K, Sugino K, Masudo K, Nagahama M, Kitagawa W, Shibuya H *et al.* Thyroid lobectomy for papillary thyroid cancer: long-term follow-up study of 1,088 cases. *World J Surg* 2014;**38**:68–79
8 Vaisman F, Shaha A, Fish S, Tuttle RM. Initial therapy with either thyroid lobectomy or total thyroidectomy without radioactive iodine remnant ablation is associated with very low rates of structural disease recurrence in properly selected patients with differentiated thyroid cancer. *Clin Endocrinol* (*Oxf*) 2011;**75**:112–19
9 Vaisman F, Momesso D, Bulzico DA, Pessoa CHCN, da Cruz MDG, Dias F *et al.* Thyroid lobectomy is associated with excellent clinical outcomes in properly selected differentiated thyroid cancer patients with primary tumours greater than 1 cm. *J Thyroid Res* 2013;**2013**:398194
10 Nixon IJ, Ganly I, Patel SG, Palmer FL, Whitcher MM, Tuttle RM *et al.* Thyroid lobectomy for treatment of well differentiated intrathyroid malignancy. *Surgery* 2012;**151**:571–9
11 Haugen BR, Alexander EK, Bible KC, Doherty GM, Mandel SJ, Nikiforov YE. 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* 2016;**26**:1–133
12 Perros P, Colley S, Boelaert K, Evans C, Evans RM, Gerrard GE *et al.*; British Thyroid Association. Guidelines for the management of thyroid cancer. *Clin Endocrinol* (*Oxf*) 2014;**81**:1–122
13 Filetti S, Durante C, Hartl D, Leboulleux S, Locati LD, Newbold K. Thyroid cancer: ESMO clinical practice guidelines for diagnosis, treatment and follow up. *Ann Oncol* 2019;**30**:1856–83
14 Momesso DP, Tuttle RM. Update on differentiated thyroid cancer staging. *Endocrinol Metab Clin North Am* 2014;**43**:401–21
15 Momesso DP, Vaisman F, Yang SP, Bulzico DA, Corbo R, Vaisman M *et al.* Dynamic risk stratification in patients with differentiated thyroid cancer treated without radioactive iodine. *J Clin Endocrinol Metab* 2016;**101**:2692–700
16 NHS Health Research Authority and Medical Research Council. Is my study research? In: http://www.hra-decisiontools.org.uk/research [1 December 2022]
17 Edge SB, Byrd DR, Compton CC, Fritz AG, Greene FL, Trotti A, eds. *AJCC Cancer Staging Manual*, 7th edn. New York: Springer, 2010
18 Amin MB, Edge SB, Greene FL, Byrd DR, Brookland RK, Washington MK *et al.*, eds. *AJCC Cancer Staging Manual*, 8th edn. New York: Springer, 2017
19 Park SY, Jung Y-S, Ryu CH, Lee CY, Lee YJ, Lee EK *et al.* Identification of occult tumors by whole-specimen mapping in solitary papillary thyroid carcinoma. *Endocr Relat Cancer* 2015;**22**:679–86
20 Lee IA, Moon G, Kang S, Lee KH, Lee SM, Kim JK *et al.* Predictive factors indicative of hemithyroidectomy and close follow-up versus bilateral total thyroidectomy for aggressive variants of papillary thyroid cancer. *Cancers* (*Basel*) 2022;**14**:2757
21 Chan S, Karamali K, Kolodziejczyk A, Oikonomou G, Watkinson J, Paleri V *et al.* Systematic review of recurrence rate after hemithyroidectomy for low-risk well-differentiated thyroid cancer. *Eur Thyroid J* 2020;**9**:73–84
22 Banerjee M, Wiebel JL, Guo C, Gay B, Haymart MR. Use of imaging tests after primary treatment of thyroid cancer in the United States: population based retrospective cohort study evaluating death and recurrence. *BMJ* 2016;**354**:i3839
23 Yang SP, Bach AM, Tuttle RM, Fish SA. Serial neck ultrasound is more likely to identify false-positive abnormalities than clinically significant disease in low-risk papillary thyroid cancer patients. *Endocrin Pract* 2015;**21**:1372–9
24 Yang SP, Bach AM, Tuttle RM, Fish SA. Frequent screening with serial neck ultrasound is more likely to identify false-positive abnormalities than clinically significant disease in the surveillance of intermediate risk papillary thyroid cancer patients without suspicious findings on follow-up ultrasound evaluation. *J Clin Endocrinol Metab* 2015;**100**:1561–7
25 Wang LY, Roman BR, Migliacci JC, Palmer FL, Tuttle RM, Shaha AR *et al.* Cost-effectiveness analysis of papillary thyroid cancer surveillance. *Cancer* 2015;**121**:4132–40
26 Hedman C, Djärv T, Strang P, Lundgren CI. Determinants of long-term quality of life in patients with differentiated thyroid carcinoma – a population-based cohort study in Sweden. *Acta Oncol* 2016;**55**:365–9
27 Harach HR, Franssila KO, Wasenius VM. Occult papillary carcinoma of the thyroid. A "normal" finding in Finland. A systematic autopsy study. *Cancer* 1985;**56**:531–8
28 Lamartina L, Leboulleux S, Terroir M, Hartl D, Schlumberger M. An update on the management of low-risk differentiated thyroid cancer. *Endocr Relat Cancer* 2019;**26**:R597–610
29 Ritter A, Mizrachi A, Bachar G, Vainer I, Shimon I, Hirsch D *et al.* Detecting recurrence following lobectomy for thyroid cancer: role of thyroglobulin and thyroglobulin antibodies. *J Clin Endocrinol Metab* 2020;**105**:e2145–51
30 Park S, Jeon MJ, Oh H-S, Lee Y-M, Sung T-Y *et al.* Changes in serum thyroglobulin levels after lobectomy in patients with low-risk papillary thyroid cancer. *Thyroid* 2018;**28**:997–1003

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