Indian J Surg Oncol (March 2018) 9(1):90–96
DOI 10.1007/s13193-017-0661-2

REVIEW ARTICLE

Extent of Thyroidectomy in Differentiated Thyroid Cancers—Review of Evidence

Samskruthi P. Murthy[1] · Deepak Balasubramanian[1] · Adharsh Anand[1] · Shashikant Vishnubhai Limbachiya[1] · Narayana Subramaniam[1] · Vasantha Nair[2] · Krishnakumar Thankappan[1] · Subramania Iyer[1]

Received: 5 January 2017 / Accepted: 20 April 2017 / Published online: 9 May 2017
© Indian Association of Surgical Oncology 2017

Abstract Differentiated thyroid cancers (DTC) are seen with increasing incidence in clinical practice. These tumours have good prognosis and the extent of surgery can be tailored to the size and pathological characteristics of the lesion. Historically total thyroidectomy was the recommended procedure for tumours >1 cm; however, current recommendations suggest a more conservative approach. This review focuses on the evolution of the extent of surgery in differentiated thyroid cancer.

Keywords Differentiated thyroid cancer · Papillary thyroid cancer · Thyroidectomy

Introduction

Differentiated thyroid cancers (DTC) arising from follicular cell origin include papillary, follicular and Hurthle subtypes. These constitute over 90% of thyroid malignancies with papillary carcinoma thyroid being the most common pathology. There is a steep rise in incidence of DTC especially papillary carcinoma thyroid in the recent decade. Studies have shown an increase in micro papillary as well as tumours measuring 1–4 cm in size. Surgery is the main treatment modality in management of DTC. However opinions are divided regarding extent of surgery especially in low-risk group patients.

✉ Deepak Balasubramanian
dr.deepak.b@gmail.com

[1] Department of Head & Neck Surgery, Amrita Institute of Medical Sciences, Amrita Vishwa Vidyapeetham University, Kochi, Kerala 682041, India

[2] Department of Endocrinology, Amrita Institute of Medical Sciences, Amrita Vishwa Vidyapeetham University, Kochi, Kerala, India

Papillary carcinoma thyroid has excellent outcomes with less than <10% patients expected to die of the disease in 10 years or more. There exists no randomised trial to study the outcomes of different treatment modalities. Most of the current recommendations are made on retrospective data. There are various single institution reviews, which have accurate surgical, treatment and outcome data but have limited numbers. Multi-institutional database studies have a large number of patients, but the data collected in terms of treatment, extent of surgery, histopathological features and outcome are incomplete. The purpose of this article is to review the outcomes with regard to the extent of thyroidectomy in differentiated thyroid cancer.

Rise in Incidence

With the increasing use of office ultrasound, there has been an increase in the diagnosis of thyroid nodules particularly the so-called "incidentalomas". Davies et al. in 2002 [1] evaluated patients with thyroid cancer using the Surveillance, Epidemiology and End Results (SEER) program and data on thyroid cancer mortality from the National Vital Statistics System. He showed a 2.4-fold increase in incidence of thyroid cancer from 3.6 per 100,000 in 1973 to 8.7 per 100,000 in 2002. The majority consisted of tumours measuring 1 cm or smaller. They attributed the increasing incidence of thyroid cancer to increased detection of small papillary cancers by enhanced neck imaging. However, this may not reflect a true increase in incidence. Other authors differed in this regard by showing an increase in the incidence of DTC based on epidemiological data. Chen et al. in 2009 [2] analysed patterns of incidence in DTC by size, age, race and sex using the National Cancer Institute's surveillance epidemiology and end results dataset. The study showed an increase in incidence of DTC for all sizes and also of distant disease, suggesting that the reasons

for increase in incidence including environmental, dietary and genetic causes need to be explored. With regard to the increase in the number of larger tumours, Morris et al. [3] detailed a population-based analysis of incidence trends in well-differentiated thyroid carcinoma (1973–2006) in the Surveillance Epidemiology and End Results (SEER) cancer registry. He showed a 2-fold increase in the incidence for large DTCs, including those >4 or >6 cm, tumours with extrathyroidal extension and with cervical metastases. This suggests the need to identify an alternative hypothesis to explain the true increase in cancer incidence. So, it may seem from the current trends that there exists an increase in the diagnosis of differentiated thyroid cancers across different stages.

Papillary Microcarcinoma—More or Less?

Differentiated papillary thyroid cancers <1 cm in size are classified into micropapillary carcinomas. Their clinical behaviour has been disputed with arguments for and against their indolent behaviour. The earliest report of the outcomes of papillary microcarcinoma thyroid came from Hay's group at the Mayo clinic in 1992 [4]. They published their initial results of outcomes of papillary micro carcinomas in 535 patients. Thirty-two percent (32%) of their patients had nodal metastasis. A majority of their patients (91%) underwent total thyroidectomy. However, local recurrences were commoner in the lobectomy group. In 2008, Hay's group again published the results of 900 papillary microcarcinoma patients [5]. Their results showed that patients who had multi-focal tumours and node positivity had a higher recurrence rate. Also, they did not find that surgery more than a lobectomy or RIA reduced the recurrence rates compared to lobectomy alone. Lee and colleagues in 2014 [6] compared patients who underwent lobectomy and total thyroidectomy for papillary micro carcinoma with central compartment neck dissection. After adjusting for clinicopathological risk factors, there was no difference in the risk of death and loco regional recurrence. Hence, they recommend that a lobectomy is sufficient and a wait and watch policy after lobectomy is acceptable for micropapillary carcinoma.

While recent reports of multifocality in papillary carcinoma suggest a more aggressive pathological presentation and behaviour, the multifocality in papillary micro carcinoma is less aggressive. In a study of 1391 patients with papillary microcarcinoma of the thyroid from Austria [7], the authors found that even multifocal microcarcinomas can be managed safely with limited thyroidectomy. Nodal metastasis was rare, and even if recurrences occurred, it could be managed safely with lymphadenectomy.

Evolution of Surgery—A Case for Total Thyroidectomy?

Surgery is the main cornerstone in the management of DTC. The current ATA [8] recommends two types of surgeries for DTC namely hemithyroidectomy (lobectomy) and total thyroidectomy. There has been a constant debate regarding the type of surgery based on the tumour size. The recent ATA guidelines mentions that for a low-risk thyroid cancer less than 4 cm, a lobectomy may be considered with a total thyroidectomy reserved for patients with >4-cm tumour. Prior to the 2015 ATA guidelines, literature recommended a total thyroidectomy for DTC especially for tumours >1 cm. One of the early reports supporting this recommendation came from Mazzaferri's group in 1977 [9]. They analysed outcomes of 576 patients who were treated at US air force medical service and found that cancer-related death and recurrence was higher in patients who underwent less than total thyroidectomy. The series was updated in 1994 [10] to include 1355 patients treated both in the US Air Force and Ohio State University Hospital. Again, the study demonstrated a link between more aggressive primary surgery and improved outcomes. The main limitations were that the study was multi-institutional, and treatment modality was not standardised across all patients. The patient groups were not stratified by age, histology and extent of disease. Seventeen percent (17%) of patients underwent less than lobectomy making comparison between the groups difficult. This study provided strong data supporting total thyroidectomy as standard of care for DTC. They stressed that following radio iodine ablation (RIA), whether given for thyroid remnant ablation or cancer therapy, recurrence and the likelihood of cancer death were reduced by at least half, despite the existence of more adverse prognostic factors in patients given I-131.

Hay and colleagues from the Mayo clinic [11] reported the outcomes in 1685 low-risk AMES (age, extent, metastasis and size) patients operated between 1940 and 1991 and showed that there was no difference in the cause specific mortality in the patients who underwent lobectomy, but there was a significantly higher loco regional recurrence. Hay's group also took into account the use of RIA in the total thyroidectomy group in their analysis. They showed that patients with node negative and intra thyroid tumour, who had lobectomy, had seven times greater risk of loco regional recurrence compared to the total thyroidectomy group at 20 years.

The previous American Thyroid Association (ATA) 2009 guidelines recommended [12] "a total thyroidectomy for all lesions over 1 cm in size and lobectomy reserved only for the smallest tumours in the absence of any other risk factors". These guidelines were based on National Cancer Database outcomes reported by Bilimoria in 2007 [13]. The study included 50,000 patients with DTC. Patients were grouped into lobectomy and total thyroidectomy, and their outcomes were analysed with respect to size of tumour and extent of surgery.

The study showed that 10-year recurrence rate increased with increasing tumour size and was 7.7% in total thyroidectomy group and 9.8% for lobectomy group. Ten-year survival rates declined with increasing tumour size and were significantly higher for total thyroidectomy group. For patients with <1-cm tumour, there was no difference in recurrence or survival between the groups, while tumours with >1 cm dimension were associated with 15% higher risk of recurrence and 31% higher risk of death. This is one of the largest studies to have analysed outcome of DTC with relation of tumour size. However, there were several criticisms to this study. Being a multi-institutional study, the true extent and completeness of surgery could not be commented upon. Standards of treatment modality might not have been uniform as TSH suppression details were not mentioned. Fifty-six percent (56%) of patients in total thyroidectomy group did not receive RIA. High-risk histologic features were not mentioned in the study. Preoperative imaging characteristics were not recorded; hence, contralateral lobe involvement in lobectomy group cannot be assessed. The lobectomy group contained patients with nodal disease also. Recurrence in the study considered locoregional recurrences and were not separated to local and regional recurrences.

A recent meta-analysis was performed by Macedo in 2015 [14] with 305 published articles from literature. He concluded that because of the few mortality events, no conclusion could be made about the benefit of either surgical procedure, but noted a trend towards lesser mortality in total thyroidectomy.

Proponents of total thyroidectomy state that the risk of finding contralateral lobe tumour in total or completion thyroidectomy is high with the range between 20 and 40% [15, 16]. However, these tumours could be micro papillary carcinomas. These contralateral tumours have no adverse effect on outcomes if they are treated adequately with surgery and post-operative radio iodine ablation [17].

Recently, Kluijfhout et al. [18] analysed pathological data from three different centres. In their study of a 1000 patients, who underwent total thyroidectomy for 1–4-cm tumours, 287 patients would have been eligible for a lobectomy as per ATA. But on analysis of the pathological data, 43% of patients would have required a completion thyroidectomy for reasons of aggressive histology (3%), vascular invasion (12%), positive central nodes (17%), positive margin (18%), extra thyroidal extension (17%) and ipsilateral multifocality (25%). Also, if the analysis was restricted to patients with 1–2-cm tumours, 36% would have required a completion thyroidectomy. When patients with pre-operative bilateral nodules were excluded, 48% of the patients would still require a total thyroidectomy based on the histopathological features. So, the authors caution that the risks of lobectomy versus the need for completion thyroidectomy should be considered when the initial surgery is planned.

A summary of the above-mentioned studies is in Table 1.

Table 1 Studies favouring total thyroidectomy

Sl no	Author	Study period	Institute	Type of surgery	Number of patients	Follow-up period (mean, in years)	Conclusion
1	Mazzaferri et al. [10]	1962–1993	US Air Force physician and Ohio State University Hospitals	Total/near total thyroidectomy vs less than near total thyroidectomy	1355	15.7	Tumours >1.5 cm near total thyroidectomy with radio iodine therapy offers better outcome
2	Hay et al. [11]	1940–1991	Mayo clinics	Unilateral resection (ipsilateral lobectomy + isthumectomy) vs Bilateral subtotal thyroidectomy (near total /total)	1656	18	No survival benefit with more aggressive surgery but associated with significant lower risk of recurrence.
3	Bilimoria et al. [13]	1985–1998	National Cancer Data	Lobectomy with or without isthumectomy vs total/near total/subtotal thyroidectomy	52,173	5.8	Total thyroidectomy is associated with lower recurrence rate and improved survival compared with lobectomy

Studies Supporting the Safety of Lobectomy

The recommendations to perform lobectomy in a low-risk patient are borne out of the fact that the disease rarely causes mortality and these patients do not require RIA or intensive follow-up.

In 1976, Cady et al. [19] reported results of 792 patients who were operated at Lahey Clinic for well differentiated thyroid cancer (WDTC). Their work suggested no improvement in survival resulting from excision of a seemingly uninvolved contralateral lobe. Hay and colleagues [20] from the Mayo Clinic analysed their outcomes in 860 patients with PTC. They found that for patients with low-risk disease, total thyroidectomy did not result in improved outcomes when compared with lobectomy.

In 1993, a matched pair analysis of older patients with disease limited to the gland who underwent total thyroidectomy versus lobectomy at Memorial Sloan Kettering Cancer Center demonstrated no advantage of more aggressive surgery, with the authors concluding that thyroid lobectomy should be used selectively in tumours less than 4 cm in size, limited to the gland and without evidence of disease in the contralateral lobe [21].

A multivariate analysis of the SEER data base was done by Mendelsohn et al. [22] which included a cohort of 20,000 patients. The study found that the extent of thyroidectomy conferred no survival benefit after adjusting for the tumour size. This was excluded in previous population-based studies. Also, the study has shown that advanced age, increased tumour size, extrathyroidal extension, and regional and distant metastasis significantly affect disease-specific and overall survival.

Recently, Adam and colleagues [23] used the National Cancer Database between to examine the survival benefit of total thyroidectomy in tumours between 1 and 4 cm. They identified 61,775 patients and concluded that there was no survival benefit associated with a total thyroidectomy in these tumours.

The current American Thyroid Association guidelines [8] recommends "Patients with unifocal tumours <4 cm and no evidence of extra thyroidal extension or lymph node metastasis by examination or imaging, the initial surgery can be either bilateral procedure or unilateral procedure (lobectomy)". However, the treatment team may choose total thyroidectomy to enable RIA therapy or to enhance follow-up based upon disease features and/or patient preferences. This is based on a single institution study by Nixon et al. [24] in 2012. The study included 1810 patients treated at MSKCC between 1986 and 2005. Analysis showed that age >45 years and male gender were independent predictors of poorer outcome, whereas T stage and extent if surgery was not. Total thyroidectomy group and lobectomy group showed no difference in local recurrence or regional recurrence. Among the lobectomy group, in the patients who underwent completion thyroidectomy, only 2.7% had contralateral disease. This being a single institution study extent of surgery, histology features and use of RIA are all standardised. But, the study lobectomy group were younger than total thyroidectomy group, which may account for the better outcomes.

Three reasons have been used to justify a total thyroidectomy. First was the appearance of tumours in the contralateral lobe. This was studied by Matsuzu and colleagues [25] in 2014 in their cohort of 1088 patients. They reported that the remnant-thyroid recurrence-free survival (RT-RFS) rate, the regional-lymph-node recurrence-free survival (L-RFS) rate and the distant-recurrence-free survival (D-RFS) rate as of 25 years after surgery were 93.5, 90.6 and 93.6%, respectively. The cause-specific survival (CSS) rate at 25 years was 95.2%. They concluded that lobectomy without RIA offered excellent results in 1–4-cm tumours.

The second reason for recommending a total thyroidectomy had been to facilitate RIA. The current ATA [26] has modified the 2009 risk assessment of tumours based on the pathological criteria. Patients who have had low-risk tumours have not shown any benefit from radio iodine ablation in several studies and a meta-analysis [27, 28]. There are randomised trials currently underway to examine the benefits of RIA in low- and intermediate-risk DTC. A more selective use of RIA has been advocated in low- and intermediate-risk groups.

Lastly was the difficulty in follow-up of patients who have undergone a lobectomy by using thyroglobulin as a tumour marker. This is not required in low-risk patients as the recurrence rate is low.

A summary of the above-mentioned studies is in Table 2.

Our current recommendation is to perform a total thyroidectomy in tumours more than 4 cm. In tumours less than 4 cm, a lobectomy is sufficient in low-risk patients. But, the patient needs to be counselled adequately regarding the nature of the disease, the need for follow-up and the need for completion thyroidectomy.

Complications

Debate over extent of thyroidectomy relates in part to complications of total thyroidectomy. This includes recurrent laryngeal nerve (RLN) palsy and hypocalcaemia. Most of the thyroid surgery is still performed in community hospitals where the experience with thyroid surgery may be lower when compared to larger institutions. Several recent publications have highlighted the better outcomes of thyroid surgery when operated by a high-volume centre [29, 30].

Hypocalcaemia and Recurrent Laryngeal Nerve Palsy

In a retrospective analysis of 517 patients by Bhattacharyya [31], the rate of post-operative hypocalcaemia was 6.2%. Bergenfelz and colleagues reported the complications of

Table 2 Studies favouring conservative thyroidectomy

Sl no	Author	Study period	Institute	Type of surgery	Number of patients	Follow-upperiod (mean, in years)	Conclusion
1	Cady et al. [19]	1931–1970	Lahey clinic foundation	Nodule excision/lobectomy vs subtotal excision	631	15	Patients at low-risk or with small carcinomas can be treated satisfactorily by lobectomy
2	Shah et al. [21]	1930–1980	Memorial Sloan Kettering cancer centre	Lobectomy vs total thyroidectomy	146	20	Lobectomy in low-risk patients is as safe as total thyroidectomy
3	Mandelsohn et al. [22]	1988–2001	SEER Database	Lobectomy vs total thyroidectomy	22,724	9.1	Extent of surgical resection does not significantly impact over all or disease specific survival
4	Nixon et al. [24]	1986–2005	Memorial Sloan Kettering cancer centre	Lobectomy vs total thyroidectomy	889	8.25	No significant difference between the two surgical groups in overall survival/disease-specific survival/local recurrence/distant recurrence rate
5	Adam et al. [23]	1998–2006	National Cancer Database	Lobectomy vs total thyroidectomy	61,775	6.8	Overall survival was similar in patients undergoing total thyroidectomy versus lobectomy for tumours 1.0–4.0 cm

thyroid surgery from a Scandinavian audit with 3660 patients [32]. The rate of hypocalcaemia was 9.9% in patients post-surgery and 4.4% patients had persistent hypocalcaemia at 6 months. This was higher than what is generally quoted in literature. This could presumably be avoided if lobectomy is practised.

Seo and colleagues reported the outcomes after total thyroidectomy in 52,707 patients and identified a permanent hypocalcaemia rate of 4.6% in these patients [33]. Rosato et al. showed persistent hypoparathyroidism in 1.7% and temporary hypoparathyroidism in 8.3%. Permanent palsy of the laryngeal recurrent nerve occurred in 1.0% of patients, transient palsy in 2.0%. The superior laryngeal nerve was damaged in 3.7%; dysphagia occurred in 1.4% of cases [34]. Both studies were multi-institutional studies and may better represent the complications in the community, though complication rate may be significantly less in high-volume institutes.

Grover and colleagues from the UK [35] studied that the patient perceived morbidity of thyroidectomy and found persistent moderate voice and swallowing problems after thyroid surgery. Their study included both lobectomy and total thyroidectomy patients, and the individual outcomes for each were not reported. It remains to be studied if these problems are less in lobectomy versus total thyroidectomy patients.

Bhattacharyya [31] reported the rates of unilateral and bilateral recurrent laryngeal nerve palsy following total thyroidectomy. The incidence was 0.7% had unilateral palsy and 0.39% had bilateral palsy. This number suggests that complications following total thyroidectomy are rare if performed in experienced thyroid and endocrine surgery centres. Jeannon and colleagues [36] performed a systematic review with regard to the recurrent laryngeal nerve palsy in 25,000 patients and concluded that the risk of temporary RLN palsy is 9.8% and permanent palsy is 2.3%.

Cost-Effective Analysis

With regard to the financial implications between lobectomy and total thyroidectomy, the evidence is unclear. The merits of a total thyroidectomy include the ease of follow-up with the use of thyroglobulin and obviating the need for serial ultrasound of the neck. However, the need for lifelong thyroxine supplementation and possible calcium supplementation should be considered especially for tumours 1–4 cm.

Shrime and colleagues [37] reported the 20-year cost-effectiveness of initial hemithyroidectomy versus total thyroidectomy in low-risk papillary carcinoma patients. The costs were measured as per the 2005 standard from the US Department of Health and Human Services. Their analysis reported that total thyroidectomy was preferred from a cost-effective point of

view, but they cautioned that because of the heterogeneity in the outcomes, further prospective studies were required to validate their findings.

Hirsch from Israel [38] also highlighted the more intensive follow-up regimen required in patients who have had an initial lobectomy. This fact remains to be validated in a larger series.

Problems in Conducting a Randomised Trial

Recurrence rates are low especially in low-risk groups. Prospective randomised control studies to characterise disease outcomes and impact of interventions will need huge number patients with extensive years of follow-up and are not considered feasible [39].

Udelsman et al. [40] noted that to compare the outcomes of the initial operation of the thyroid, a total of 12,000 patients would need to be included in a trial to compare survival outcomes and also mentioned the problems with follow-up in the lobectomy arm. Considering the problems associated with such studies, Esnaola et al. [41] from MD Anderson Texas performed a decision analysis and concluded that in low-risk patients, lobectomy and total thyroidectomy resulted in 31.7 and 32.9 quality-adjusted life years, respectively. Lobectomy became the preferred strategy if subjects were willing to give up 1.5 years of life to avoid thyroid hormone dependency and a remote risk of RIA-induced malignancy.

Are the Complications Rates More for Completion Thyroidectomy?

Re-operations of the thyroid are relatively safe. There exists a theoretical possibility of increased complication rates due to the fibrosis of the surgical field (RLN palsy, hypocalcaemia and wound infections). Several studies and a meta-analysis [42] have failed to identify an increased incidence of surgical complications except for an increased hospital stay.

Is there a Role of RIA in the Setting of a Thyroid Lobectomy in Patients who do Not Have Completion Thyroidectomy?

Kiernan and colleagues [43] studied a total of 32,119 patients in the NCD who underwent lobectomy. A total of 24% of patients in that cohort had RIA. Large tumours and advanced stage were the primary indications for adjuvant RIA. The use of RIA was associated with improved survival at both 5 and 10 years in both univariate and multivariate analysis. In the current context based on these results, patients who are not candidates for completion thyroidectomy may benefit from the use of RIA. Studies performed in India have shown similar outcomes between completion thyroidectomy and lobar ablation with radio iodine therapy [44, 45]. This technique is a viable option in patients unfit for completion thyroidectomy or are averse to having a second operation.

Conclusion

Current recommendations for the extent of thyroidectomy suggest a more limited approach for tumours less than 4 cm. Larger tumours and tumours which have adverse pathological features require a total or completion thyroidectomy with RIA. The lack of randomised trials is evident, and this is due to the complexities involved in recruitment and reporting outcomes. Patient decision-making needs more attention and should be factored when the decision for thyroidectomy is being made.

References

1. Davies L, Welch HG (2006) Increasing incidence of thyroid cancer in the United States, 1973-2002. JAMA 295:2164–2167
2. Chen AY, Jemal A, Ward EM (2009) Increasing incidence of differentiated thyroid cancer in the United States, 1988-2005. Cancer 115:3801–3807
3. Morris LG, Myssiorek D (2010) Improved detection does not fully explain the rising incidence of well-differentiated thyroid cancer: a population-based analysis. Am J Surg 200(4):454–461
4. Hay ID, Grant CS, van Heerden JA, Goellner JR, Ebersold JR, Bergstralh EJ (1992) Papillary thyroid microcarcinoma: a study of 535 cases observed in a 50-year period. Surgery 112(6):1139–1146 discussion 1146-7
5. Hay ID, Hutchinson ME, Gonzalez-Losada T, McIver B, Reinalda ME, Grant CS, Thompson GB, Sebo TJ, Goellner JR (2008) Papillary thyroid microcarcinoma: a study of 900 cases observed in a 60-year period. Surgery 144(6):980–987
6. Lee J, Park JH, Lee CR, Chung WY, Park CS (2013) Long-term outcomes of total thyroidectomy versus thyroid lobectomy for papillary thyroid microcarcinoma: comparative analysis after propensity score matching. Thyroid 23(11):1408–1415
7. Gschwandtner E, Klatte T, Swietek N, Bures C, Kober F, Ott J, Schultheis A, Neuhold N, Hermann M (2016) Increase of papillary thyroid microcarcinoma and a plea for restrictive treatment: a retrospective study of 1,391 prospective documented patients. Surgery 159(2):503–511
8. Haugen BR, Alexander EK, Bible KC, Doherty GM, Mandel SJ, Nikiforov YE, Pacini F, Randolph GW, Sawka AM, Schulumberger M, Schuff KG, Sherman SI, Sosa JA, Sterward DL, Tuttle RM, Wartofsky L (2016) 2015 American Thyroid Association management guidelines for adult patients with thyroid nodules and differentiated thyroid cancer: the American Thyroid Association guidelines for adult patients and differentiated thyroid cancer. Thyroid 26(1):1–133
9. Mazzaferri EL, Young RL, Oertel JE, Kemmerer WT, Page CP (1977) Papillary thyroid carcinoma: the impact of therapy in 576 patients. Medicine (Baltimore) 56(3):171–196
10. Mazzaferri EL, Jhiang SM (1994) Long-term impact of initial surgical and medical therapy on papillary and follicular thyroid cancer. Am J Med 97(5):418–428
11. Hay ID, Thompson GB, Grant CS, Bergstralh EJ, Dvorak CE, Gorman CA et al (2002) Papillary thyroid carcinoma man- aged at the Mayo Clinic during six decades (1940–1999): temporal trends in initial therapy and long-term outcome in 2444 consecutively treated patients. World J Surg 26:879–885
12. Cooper DS, Doherty GM, Haugen BR, Kloos RT, Lee SL, Mandel SJ, Mazzaferri EL, McIver B, Pacini F, Schlumberger M, Sherman SI (2009) Revised American Thyroid Association management

guidelines for patients with thyroid nodules and differentiated thyroid cancer: the American Thyroid Association (ATA) guidelines taskforce on thyroid nodules and differentiated thyroid cancer. Thyroid 19(11):1167–1214
13. Bilimoria KY, Bentrem DJ, Ko CY, Stewart AK, Winchester DP, Talamonti MS, Sturgeon C (2007) Extent of surgery affects survival for papillary thyroid cancer. Ann Surg 246(3):375–381
14. Macedo FI, Mittal VK (2015) Total thyroidectomy versus lobectomy as initial operation for small unilateral papillary thyroid carcinoma: a meta-analysis. SurgOncol 24(2):117–122
15. Pacini F, Elisei R, Capezzone M, Miccoli P, Molinaro E, Basolo F, Agate L, Bottici V, Raffaelli M, Pinchera A (2001) Contralateral papillary thyroid cancer is frequent at completion thyroidectomy with no difference in low- and high-risk patients. Thyroid 11(9): 877–881
16. Pitt SC, Sippel RS, Chen H (2009) Contralateral papillarythyroid cancer: does size matter? Am J Surg 197(3):342–347
17. Grigsby PW, Reddy RM, Moley JF, Hall BL (2006) Contralateral papillary thyroid cancer at completion thyroidectomy has no impact on recurrence or survival after radioiodine treatment. Surgery 140(6):1043–1047
18. Kluijfhout WP, Pasternak JD, Lim J, Kwon JS, Vriens MR, Clark OH, Shen WT, Gosnell JE, Suh I, Duh Q (2016) Frequency of high-risk characteristics requiring Total thyroidectomy for 1-4 cm well-differentiated thyroid. Cancer Thyroid 26(6):820–824
19. Cady B, Sedgwick CE, Meissner WA, Bookwalter JR, Romagosa V, Werber J (1976) Changing clinical, pathologic, therapeutic, and survival patterns in differentiated thyroid carcinoma. Ann Surg 184(5):541–553
20. Hay ID, Grant CS, Taylor WF, McConahey WM (1987) Surgery. Ipsilateral lobectomy versus bilateral lobar resection in papillary thyroid carcinoma: a retrospective analysis of surgical outcome using a novel prognostic scoring system. Surgery 102(6):1088–1095
21. Shah JP, Loree TR, Dharker D, Strong EW (1993) Lobectomy versus total thyroidectomy for differentiated carcinoma of the thyroid: a matched-pair analysis. Am J Surg 166(4):331–335
22. Mendelsohn AH, Elashoff DA, Abemayor E, St John MA (2010) Surgery for papillary thyroid carcinoma: is lobectomy enough? Arch Otolaryngol Head Neck Surg. 136(11):1055–1061
23. 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. Ann Surg 260(4):601–605
24. Nixon IJ, Ganly I, Patel SG, Palmer FL, Whitcher MM, Tuttle RM, Shaha A, Shah JP (2012) Thyroid lobectomy for treatment of well differentiated intra thyroid malignancy. Surgery 151(4):571–579
25. Matsuzu K, Sugino K, Masudo K, Nagahama M, Kitagawa W, Shibuya H, Ohkuwa K, Uruno T, Suzuki A, Magoshi S, Akaishi J, Masaki C, Kawano M, Suganuma N, Rino Y, Masuda M, Kameyama K, Takami H, Ito K (2014) Thyroid lobectomy for papillary thyroid cancer: long-term follow-up study of 1,088 cases. World J Surg 38(1):68–79
26. Haugen BR, Alexander EK, Bible KC, Doherty GM, Mandel SJ, Nikiforov YE, Pacini F, Randolph GW, Sawka AM, Schulumberger M, Schuff KG, Sherman SI, Sosa JA, Sterward DL, Tuttle RM, Wartofsky L (2016) 2015 American Thyriod Association management guidelines for adult patients with thyroid nodules and differentiated thyroid cancer: the American Thyroid Association guidelines for adult patients and differentiated thyroid cancer. Thyroid 26(1):124–148
27. Jonklaas J, Sarlis NJ, Litofsky D, Ain KB, Bigos ST, Brierley JD, Cooper DS, Haugen BR, Ladenson PW, Magner J, Robbins J, Ross DS, Skarulis M, Maxon HR, Sherman SI (2006) Outcomes of patients with differentiated thyroid carcinoma following initial therapy. Thyroid 16:1229–1242
28. Lamartina L, Durante C, Filetti S, Cooper DS (2015) 2015 low-risk differentiated thyroid cancer and radioiodine remnant ablation: a systematic review of the literature. J Clin Endocrinol Metab 100: 1748–1761
29. Meltzer C, Klau M, Gurushanthaiah D, Tsai J, Meng D, Radler L, Sundang A (2016) Surgeon volume in thyroid surgery: surgical efficiency, outcomes, and utilization. Laryngoscope 126(11): 2630–2639
30. Adam MA, Thomas S, Youngwirth L, Hyslop T, Reed SD, Scheri RP, Roman SA, Sosa JA (2017) Is there a minimum number of thyroidectomies a surgeon should perform to optimize patient outcomes? Ann Surg 265(2):402–407
31. Bhattacharyya N, Fried MP (2002) Assessment of the morbidity and complications of total thyroidectomy. Arch Otolaryngol Head Neck Surg 128(4):389–392
32. Bergenfelz A, Jansson S, Kristoffersson A, Mårtensson H, Reihnér E, Wallin G, Lausen I (2008) Complications to thyroid surgery: results as reported in a database from a multicenter audit comprising 3,660 patients. Langenbeck's Arch Surg 393(5):667–673
33. Seo GH, Chai YJ, Choi HJ, Lee KE (2016) Incidence of permanent hypocalcaemia after Total thyroidectomy with or without central neck dissection for thyroid carcinoma: a Nationwide claim study. Clin Endocrinol 85(3):483–487
34. Rosato L, Avenia N, Bernante P, De Palma M, Gulino G, Nasi PG, Pelizzo MR, Pezzullo L (2004) Complications of thyroid surgery: analysis of a multicentric study on 14,934 patientsoperated on in Italy over 5 years. World J Surg 28(3):271–276
35. Grover G, Sadler GP, Mihai R (2013) Morbidity after thyroid surgery: patient perspective. Laryngoscope 123(9):2319–2323
36. Jeannon JP, Orabi AA, Bruch GA, Abdalsalam HA, Simo R (2009) Diagnosis of recurrent laryngeal nerve palsy after thyroidectomy: a systematic review. Int J Clin Pract 63(4):624–629
37. Shrime MG, Goldstein DP, Seaberg RM, Sawka AM, Rotstein L, Freeman JL, Gullane PJ. Cost-effective management of low-risk papillary thyroid carcinoma. Arch Otolaryngol Head Neck Surg 2007;133(12):1245–1253.
38. Hirsch D, Levy S, Tsvetov G, Shimon I, Benbassat C (2014) Total versus hemithyroidectomy for small unilateral papillary thyroid carcinoma. Oncol Lett 7(3):849–853
39. Carling T, Carty SE, Ciarleglio MM, Cooper DS, Doherty GM, Kim LT, Kloos RT, Mazzaferri EL Sr, Peduzzi PN, Roman SA, Sippel RS, Sosa JA, Stack BC Jr, Steward DL, Tufano RP, Tuttle RM, Udelsman R, American Thyroid Association Surgical Affairs Committee (2012) American Thyroid Association (ATA) - design and feasibility of a prospective randomized controlled trial of prophylactic central lymph node dissection for papillary thyroid carcinoma. Thyroid 22(3):237–244
40. Udelsman R, Lakatos E, Ladenson P (1996) Optimal surgery for papillary thyroid carcinoma. World J Surg 20(1):88–93
41. EsnaolaNF CSB, Sherman SI, Lee JE, Evans DB (2001) Optimal treatment strategy in patients with papillary thyroid cancer: a decision analysis. Surgery 130(6):921–930
42. Li YJ, Wang YZ, Yi ZB, Chen LL, Zhou XD (2015) Comparison of completion thyroidectomy and primary Total surgery for differentiated thyroid cancer: a meta-analysis. Oncol Res Treat 38(10):528–531
43. Kiernan CM, Parikh AA, Parks LL, Solórzano CC (2015) Use of radioiodine after thyroid lobectomy in patients with differentiated thyroid cancer: does it change outcomes? J Am Coll Surg 220(4): 617–625
44. Bal C, Singhal T, Kumar R, Verma R, Chandra P, Kumar A, Pant G (2006) Long-term outcome of radioiodine lobar ablation in patients with differentiated thyroid cancer. J Nucl Med 47(suppl 1):324P
45. Santra A, Bal S, Mahargan S, Bal C (2011) Long-term outcome of lobar ablation versus completion thyroidectomy in differentiated thyroid cancer. Nucl Med Commun 32(1):52–58