Indian Journal of Surgery (December 2021) 83(6):1444–1450
https://doi.org/10.1007/s12262-020-02703-z

ORIGINAL ARTICLE

A Clinical Audit of Hemithyroidectomy for Differentiated Thyroid Cancer—Experience from a Tertiary Cancer Center

Nithyanand Chidambaranathan[1] · Shivakumar Thiagarajan[1] · Nandini Menon[1] · Adhara Chakraborthy[1] · Richa Vaish[1] · Devendra Chaukar[1]

Received: 1 December 2020 / Accepted: 11 December 2020 / Published online: 13 January 2021

Abstract

Existing guidelines recommend lobectomy/hemithyroidectomy (HT) for low-risk thyroid cancer. They are considered safer with lesser complications compared to total thyroidectomy. However, HT is also associated with certain complications. We conducted this retrospective clinical audit of all patients who underwent HT for DTC in our institute from January 2012 to December 2018. The aim of the study was to assess the complications following HT and the follow-up of these patients subsequently. A total of 128 patients satisfied the eligibility criteria. The majority of the patients were women ($n = 103$, 80.5%). The median age of the patients was 36.5 years (range: 19–77 years). Neck swelling was the most common presentation. All patients underwent conventional open hemithyroidectomy. Five patients had 1–2 metastatic nodes in the central compartment; however, none had metastatic nodes in the lateral neck. Biochemical hypocalcemia ($n = 16$, 12.5%) was the most common postoperative complication followed by recurrent laryngeal nerve palsy ($n = 5$, 3.9%). Twenty-six patients developed hypothyroidism at a median duration of 6.5 months following HT necessitating replacement therapy. None of the patients developed recurrence during follow-up (median of 27.5 months). HT is a feasible treatment option for patients with carefully selected cases of DTC. However, HT is also associated with certain complications that should be kept in mind, and patients should be counseled accordingly.

Keywords Differentiated thyroid cancer · Hemithyroidectomy · Clinical audit

Introduction

The incidence of differentiated thyroid cancer (DTC) has increased manifold in the last few decades. The reasons for this could be many, one of them being overdiagnosis due to aggressive screening [1, 2]. DTC includes papillary, follicular, and Hurthle cell subtypes. The vast majority of the diagnosed DTC are small intrathyroidal papillary thyroid carcinoma. Surgery remains the main treatment modality; however, the extent of surgery has been controversial. Hemithyroidectomy (HT) (lobectomy + isthmusectomy) is an accepted treatment option for up to 4-cm-sized low-risk DTC as per the existing guidelines [3]. AJCC staging system helps predict mortality as per the stage of the patients, and ATA 2015 guidelines help risk-stratify as per the risk of recurrences [3, 4]. The treatment and subsequent follow-up can be done as per these guidelines based on the stage and expected risk of recurrence as per the risk stratification. HT is expected to be associated with lesser complications; however, complications such as recurrent laryngeal nerve (RLN) palsy, hypocalcemia, and hypothyroidism are

✉ Shivakumar Thiagarajan
drshiva78in@gmail.com

Nithyanand Chidambaranathan
nithyanandc88@gmail.com

Nandini Menon
menonnandini1602@gmail.com

Adhara Chakraborthy
adharac90@gmail.com

Richa Vaish
drvaishricha@gmail.com

Devendra Chaukar
dchaukar@gmail.com

[1] Department of Head & Neck Surgical Oncology, Tata Memorial Hospital, Homi Bhabha National Institute, Mumbai 400012, India

known to occur following HT [5]. Preserving the opposite thyroid lobe would ensure an endogenous source of thyroid hormone without the need for replacement. However, a sizable number of patients (5.6–64.2%) tend to develop hypothyroidism subsequently necessitating levothyroxine (LT4) supplementation [6–8]. There is limited data reported from South-East Asian countries, especially India, regarding HT for DTC in terms of its safety concerning postoperative complications and recurrences subsequently. This study was done to assess the complications following HT and the follow-up of patients undergoing HT for DTC.

Patients and Methods

This case series analysis is a clinical audit of the HT done for DTC at our institute, a tertiary cancer center. Approval from our institute's ethics committee was obtained for this. All patients with DTC (all variants) as documented in the final histopathology report (HPR), > 18 years of age, who underwent hemithyroidectomy between 2012 and 2018 at our institute, were included in the study. Patients who underwent hemithyroidectomy for benign histology (as documented in the final HPR) were excluded. Hemithyroidectomy was performed in a select few patients at the discretion of the treating surgeon. Following hemithyroidectomy and central compartment inspection, frozen section (FS) of any suspicious node of the ipsilateral central compartment was done. Further surgery was based on the findings of the FS. At our institute, central compartment procedures are divided as inspection, sampling, and clearance [9]. Central compartment clearance includes removal of paratracheal, pretracheal, and prelaryngeal group of lymph nodes. The policy for addressing the lateral neck in a N0 neck is in the presence of a positive central compartment neck node and/or the presence of a suspicious clinicoradiological lateral neck node. The extent of lateral neck dissection is tailored according to the presence or absence of metastatic disease.

All the demographic, clinical, treatment (including histopathology), and follow-up-related data were collected from the hospital's electronic medical record (EMR). Details regarding the following variables were collected, such as age, gender, initial presentation, investigations (FNAC, imaging, thyroid function tests—both at presentation and during follow-up), surgery for the central and lateral compartment (if any) including complications (postoperative vocal cord palsy and hypocalcemia), duration of hospital stay, histopathology details (the type of DTC, focality, size and location of the nodule, extrathyroidal extension, lymphatic and vascular invasion), the T-stage and N-stage (clinical and pathological), ATA stratification, recurrences (if any), the status at last follow-up, and investigations done during follow-up.

The statistical analysis was done using SPSS 24, IBM New York. Descriptive analysis and quantitative analysis were done. Also, the χ^2 test was done to understand the significance of certain clinical findings. A p value of ≤ 0.05 was considered statistically significant.

Results

Patient's Demography and Clinical Details (Table 1)

Out of 1762 surgeries that were performed for DTC between 2012 and 2018, 128 patients (7.5%) underwent hemithyroidectomy and satisfied the eligibility criteria to be included in the study for analysis (Fig. 1). The majority of the patients in the cohort were women ($n = 103$, 80.5%) with the median age of 36.5 years. Most of the patients did not have any comorbidities ($n = 110$, 85.9%). Diabetes and hypertension were the common comorbidities when present. Neck swelling was the most common clinical presentation ($n = 121$, 94.5%), and patients were largely euthyroid at presentation ($n = 126$, 98.4). FNA was done in all except 2 patients, and majority were confirmed malignant (Bethesda VI). Ultrasonography was done in all patients preoperatively. The Thyroid Imaging Reporting and Data System (TIRADS) however was available only in 59 patients. This is because the TIRADS system of reporting was available after 2016, probably because it was used in routine practice after that year (Table 1). The majority of the thyroid carcinoma in our cohort belonged to the cT1/T2 stage except for 4 which were cT3.

Treatment-Related Details (Table 2)

All patients in the present cohort underwent conventional open hemithyroidectomy. All resections were R0. No nerves were sacrificed. There was no gross extrathyroidal extension noticed intraoperatively in any of the cases. Central compartment inspection was done in 81 patients (63.3%), sampling in 40 patients (31.3%), and clearance in 7 patients (5.5%). In the present series, 12 patients underwent lateral neck dissection and 2 patients only level II sampling for either of the two reasons mentioned above.

The incidence of postoperative complications was 14.1% ($n = 18/128$). Postoperative biochemical (temporary) hypocalcemia was the commonest complication. Serum calcium levels were measured 48–72 h post-surgery. Patients with serum calcium levels < 8.5 mg/dl without clinical symptoms were considered biochemical hypocalcemia. Except for two patients who had symptomatic hypocalcemia (both with serum calcium levels below 8 mg/dl), the other 14 patients had biochemical hypocalcemia only. The range of the postoperative serum calcium measurements was between 7.6 and 8.4 mg/dl. Patients underwent indirect laryngoscopy at

Table 1 Demographic, clinical, and treatment-related details

Variables	Numbers (%)
Age	Median: 36.5 years (19–77)
	≤ 55 years:121 (94.5)
	> 55 years:7 (5.5)
Gender	Men: 25 (19.5)
	Women: 103 (80.5)
Comorbidities	Yes: 18 (14.1)
	No: 110 (85.9)
Clinical presentation	Incidentaloma: 4 (3.1)
	Neck swelling: 121 (94.5)
	Others: 3 (2.4)
Preoperative TSH	Euthyroid: 126 (98.4)
	Hypothyroid: 2 (1.6)
FNAC	Not done: 2 (1.6)
	Bethesda category II: 1 (0.8)
	Bethesda category III: 5 (3.9)
	Bethesda category IV: 34 (26.6)
	Bethesda category V: 20 (15.6)
	Bethesda category VI: 66 (51.6)
USG-neck	TIRADS 2: 3 (2.3)
	TIRADS 3: 6 (4.7)
	TIRADS 4a: 15 (11.7%)
	TIRADS 4b: 12 (9.4)
	TIRADS 4c: 12 (9.4)
	TIRADS 5: 9 (7)
	TIRADS 6: 2 (1.6)
	Not Available: 69 (53.9)
Opposite thyroid lobe findings on USG-neck	Normal: 103 (80.5)
	Benign nodule: 25 (19.5)
	Suspicious nodules: 0
Clinical T-stage*	T1a: 16 (18)
	T1b: 35 (35.2)
	T2: 31 (40.6)
	T3: 4 (6.3)
Clinical N-stage*	N0:81 (93.8)
	N+: 5 (6.2)

*Staging done for Bethesda 5 and 6 category patients only. *TIRADS* Thyroid Imaging Reporting and Data System

discharge or within 30 days from the surgery for assessment of vocal cord mobility. Five patients had postoperative vocal cord palsy (3.9%). Three patients in the cohort had both vocal cord palsy and biochemical hypocalcemia. The patients with hypocalcemia were managed with oral supplementation of calcium in the postoperative period. None of the patients had documented permanent hypocalcemia requiring calcium supplementation in the long term. The mean hospital stay duration was 2.5 days (range: 0–6 days). None of the patients required readmission subsequently.

Histopathology Details (Table 3)

The median size of the thyroid nodule was 2.2 cm (0.4–6.5 cm). The classical variant of papillary thyroid carcinoma (PTC) was the most common type followed by the follicular variant of PTC. The malignancy was unifocal in the majority ($n = 115$, 89.8%). The microscopic (minimal) extrathyroidal extension (ETE) was reported in 17 patients (13.3%). Vascular and lymphatic invasions were reported in 12 (9.4%) and 10 (7.8%) patients, respectively. Central compartment nodes were positive in only 5 patients. There was only a single metastatic node in the central compartment in 4 out of the 5 patients, one patient had two metastatic nodes. All the nodes were < 3 cm in size. None of the lateral compartment nodes dissected harbored metastasis. Based on the ATA risk stratification, the majority of the patients were low risk ($n = 108$, 84.3%); 20 patients belonged to intermediate risk. Eight out of the 20 patients with intermediate risk had more than one factor that categorized them into the intermediate strata. Completion thyroidectomy was advised in 5 patients out of these 8 patients. Three of the 5 patients refused completion surgery, and the other two were lost to follow-up.

Follow-up Details (Table 4)

At a median follow-up of 27.5 months (range: 0–96 months), none of the patients in our series developed any recurrences. The first thyroid function test (TFT) was done on most occasions at around 3–6 months, and subsequently thereafter, it was repeated every 6–12 months. The TFT reports were available for analysis in only 95 patients; in 6 patients though the TSH values were not available for analysis, the euthyroid/hypothyroid status was documented in the EMR. The median TSH value was 2.90 uIU/L (range: 0.24–11.73 uIU/L) at the last follow-up. Twenty-six (20.3%) patients developed hypothyroidism during follow-up. The mean TSH level in patients with hypothyroidism was 9.44 mIU/L (range: 5.12–31.60 mIU/L) at the first instance of raise in TSH during follow-up. The median duration to develop hypothyroidism was 6.5 months. It was seen more among women than among men (20 women and 6 men) though this was not statistically significant. Most of them had subclinical hypothyroidism (< 10 mIU/L). Fifteen out of the 26 patients who developed hypothyroidism were on documented replacement therapy. Patients in whom central compartment sampling/clearance was done ($p = 0.006$) and in those with metastatic central compartment nodes ($p = 0.005$) were predisposed to develop hypothyroidism. The desired levels of TSH as per the ATA recommendation were seen in 26 (27.3%) patients only out of the 95 patients for whom the reports were available. There were two patients with raised serum TSH preoperatively. Both of them became hypothyroid subsequently ($p = 0.02$). During follow-up, ultrasound (USG) picked up suspicious lesions in

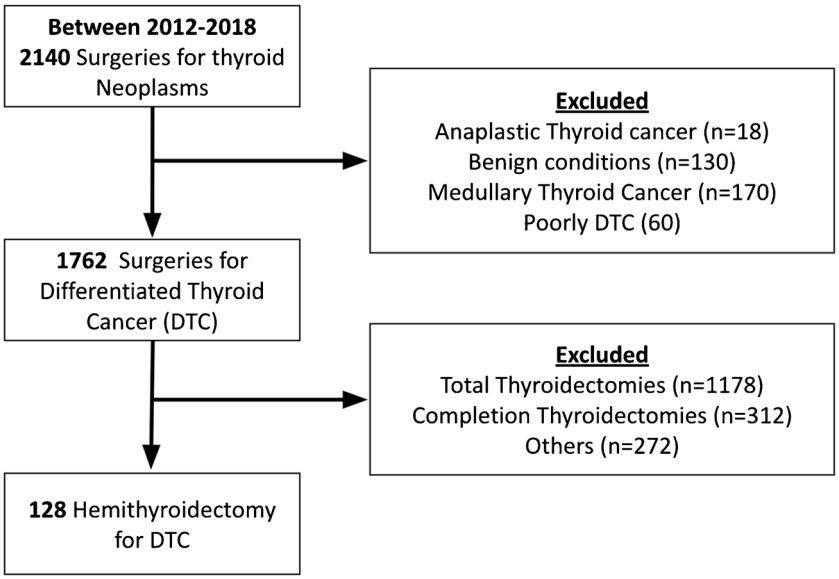

Fig. 1 Flow chart depicting the inclusion of the 128 patients who underwent hemithyroidectomy out of the 2140 surgeries that were done between 2012 and 2018 for thyroid neoplasms

32 (25%) patients necessitating a guided FNA to rule out recurrence. The most common finding on USG-neck was a suspicious neck node in the lateral neck followed by a suspicious nodule in the opposite thyroid lobe. None of the patients who necessitated a guided FNA had proven structural recurrence.

Discussion

The American Thyroid Association (ATA) recommends a lobectomy/hemithyroidectomy for low-risk DTC of up to 4 cm [3]. Lobectomy/hemithyroidectomy should be the minimum operation for a low risk of thyroid carcinoma. A partial lobectomy or nodulectomy puts the ipsilateral recurrent laryngeal nerve at increased risk, especially if a redo surgery is necessitated; hence, this procedure should be highly discouraged and abandoned [10]. The definition of low-risk thyroid cancers has been evolving over the years; they are essentially those with tumor size < 4 cm, intrathyroidal, unifocal, N0 neck, no family history, or history of radiation, which are unlikely to recur, causing morbidity and mortality. They also do not necessitate radioactive iodine therapy subsequently nor an intense follow-up [11].

Adams et al. in their study in 61,775 patients from the SEER database showed that there was no survival benefit with a total thyroidectomy in tumors between 1 and 4 cm after adjusting for high-risk features such as extrathyroidal extension and nodal or multifocal disease [12]. This result was contrary to the findings published by Bilimoria et al. from the NCDB database of 52,173 patients who suggested that total thyroidectomy is associated with lesser recurrence rates and improved survival [13]. The extent of the initial surgery in low-risk thyroid cancer patients must be decided after accurate assessment and also considering the patient's preferences too. Some of the other factors that would also be considered apart from the ones mentioned in the ATA risk stratification to decide upon the extent of thyroidectomy include age, gender, and focality [14–16]. The underlying theme of the 2015 ATA guidelines is that "less is more" [3]. The most striking change in the 2015 ATA was that lobectomy was also considered the initial surgical approach for follicular cell–derived thyroid cancers from 1 to 4 cm in size. This was probably to decrease morbidity and long-term sequelae associated with total thyroidectomy.

Table 2 Treatment-related details

Variables	Numbers (%)
Central compartment	Inspection: 81 (63.2)
	Sampling: 40 (31.3)
	Clearance: 7 (5.5)
Lateral neck dissection	Not done: 114 (89)
	Ipsilateral SND: 11 (8.6)
	Bilateral SND: 1 (0.8)
	Level II sampling: 2 (1.6)
Resection status	R0: 128 (100)
	R+: 0
Postoperative vocal cord status	Bilaterally mobile: 110 (85.9)
	Unilateral palsy: 5 (3.9)
	Not available: 13 (10.2)
Postoperative hypocalcemia	Present: 16 (12.5)
	Absent: 87 (68)
	Not available: 25 (19.5)
Hospital stay duration	Median:2.5 days (range: 0–6 days)

SND selective neck dissection

Table 3 Histopathology details

Variables	Numbers (%)
Thyroid nodule size (pT-size)	Median: 2.2 cm (0.4–6.5 cm)
Type of DTC	Classical variant PTC: 70 (54.7)
	Follicular variant PTC: 41 (32)
	Oncocytic variant PTC: 5 (3.9)
	Hobnail variant PTC: 1 (0.8)
	Columnar variant PTC: 1 (0.8)
	Tall cell variant PTC: 1 (0.8)
	Hurthle cell carcinoma: 1 (0.8)
	Follicular thyroid carcinoma: 8 (6.3)
Location of nodule	Right lobe: 74 (57.8)
	Left lobe: 42 (32.8)
	Isthmus: 3 (2.4)
	Lobe + isthmus: 9 (7)
Focality	Unifocal: 115 (89.8)
	Multifocal: 13 (10.2)
Microscopic extrathyroidal extension (ETE)	Absent: 111 (86.7)
	Minimal ETE: 17 (13.3)
	Gross ETE: 0
Vascular invasion	Yes: 12 (9.4)
	No: 116 (90.6)
Lymphatic invasion	Yes: 10 (7.8)
	No: 118 (92.2)
Pathological T-stage	T1: 58 (45.4)
	T2: 52 (40.6)
	T3: 18 (14)
Pathological N-stage	N0: 123 (96.1)
	N1a: 5 (3.9)
	N1b: 0

In our series, the majority of the patients (108, 84.3%) who underwent HT were low risk. The remaining 20 patients had intermediate risk due to one or more of the following: minimal ETE, multifocality, vascular involvement in PTC, and aggressive histology. This also included patients with a pT-size of > 4 cm. None of the patients in our series developed any documented recurrence during follow-up (median follow-up of 27.5 months).

Complications Following Hemithyroidectomy

Hemithyroidectomy (HT) is generally considered a safer surgery with lesser complications in comparison to total thyroidectomy. However, HT is also associated with certain complications such as hypocalcemia, recurrent laryngeal nerve (RLN) palsy, and hypothyroidism. In our series, the overall incidence of complications following HT was 14.1% ($n = 18$).

Hypocalcemia is one of the common complications in the postoperative period following total thyroidectomy. It is believed that one to three normal functioning parathyroid is sufficient for normal functioning [17, 18]. Hemithyroidectomy thus theoretically does not pose the risk of hypocalcemia. The possible reason for hypocalcemia could be due to hemodilution with intravenous fluid that was administered during surgery and subsequently in the postoperative period causing increased renal excretion of calcium secondary to diuresis [19]. Baldassarre et al. in their nationwide inpatient sample (NIS) database of 119,567 patients who underwent thyroidectomy from 1998 to 2008 reported a 1.9% incidence of hypocalcemia following thyroid lobectomy [20]. Rosato et al. reported 0.4% of hypocalcemia following thyroid lobectomy, and 0.07% had permanent hypocalcemia [21]. In our series, the incidence was 12.5%; all except two patients had only biochemical (temporary) hypocalcemia. Only two patients out of 16 were symptomatic, the rest of the patients had only biochemical hypocalcemia. None of the patients developed permanent hypocalcemia requiring long-term calcium supplementation.

Recurrent laryngeal nerve (RLN) palsy is another complication that is commonly encountered following thyroid surgery. Theoretically, hemithyroidectomy is a safe procedure in terms of injury to the recurrent laryngeal nerve with lesser nerves at risk; however, Gunn et al. [22] and Rosato et al. [21] reported an RLN palsy rate of 4.3% and 2% (1.4% temporary, 0.6% permanent), respectively, following a thyroid lobectomy. In our series, RLN palsy was 3.9% ($n = 5$).

Another theoretical advantage of HT is the nonrequirement of thyroid supplementation. *Hypothyroidism* is a known complication following hemithyroidectomy. The incidence reported in the literature is between 5.6 and 64.2% [7]. This complication usually goes unnoticed and does not receive the attention that it merits because this complication develops slowly after some months following surgery, and most patients remain asymptomatic (subclinical hypothyroidism). Patients with elevated preoperative TSH values and the presence of Hashimoto's thyroiditis are predisposed to develop hypothyroidism subsequently [6, 8]. Women tend to develop hypothyroidism more often than men. Presentation is often subclinical, and patients tend to develop overt hypothyroidism subsequently if not managed appropriately. Spontaneous recovery of subclinical hypothyroidism may be observed in some patients at a median time period of 14 months of its diagnosis [8]. In the present series, 20.3% ($n = 26$) of the patients developed hypothyroidism during follow-up in a median duration of 6.5 months after HT. Patients with metastatic central compartment nodes necessitating a clearance and those with raised preoperative TSH levels were more predisposed to develop hypothyroidism subsequently.

Role of TSH Suppression and Follow-up Following Hemithyroidectomy

For low-risk thyroid cancer patients, the serum TSH is recommended to be kept between 0.5 and 2 mIU/L. In patients with

Table 4 Follow-up details

Variables	Numbers (%)
ATA risk stratification	Low: 108 (84.3)
	Intermediate: 20 (15.7)
Status at last follow-up	Alive and free of disease: 110 (85.9)
	Alive with disease: 0
	Lost to follow-up: 18 (14.1)
Recurrences	Yes: 0
	No: 128
Follow-up duration	Median: 27.5 months (range: 0–96 months)
Follow-up TSH	Euthyroid: 65 (50.7)
	Hypothyroid: 26 (20.3)
	Median duration: 6.5 months (0–40 months)
	Not available: 37 (29)
USG-guided FNA	Yes: 32 (25%)
	No: 67 (52.3%)
	Not available: 29 (22.7%)
Indications for USG-guided FNA	Suspicious neck node: 20 (15.6)
	Suspicious opposite lobe nodule: 8 (6.3)
	Both: 3 (2.3)
	Others: 1 (0.8)
	Not applicable: 96 (75%)

serum TSH within the recommended range, LT4 replacement therapy is not mandatory [23]. In our series, the median serum TSH value at the last follow-up was 2.9 uIU/L. The desired levels of TSH as per the ATA recommendation were seen in 26 (27.3%) patients only out of the 95 patients for whom the reports were available.

Recurrence Following Hemithyroidectomy

The pooled 10-year overall survival following hemithyroidectomy for low-risk DTC is 95.7% which was comparable with the overall survival achieved with total thyroidectomy (95.8%) [6]. However, the recurrence rate in DTC after a hemithyroidectomy is 8–9%, especially in low-risk groups, which is small but significantly higher when compared to total thyroidectomy (5.3%) [24]. While interpreting these results, we also need to keep in mind the heterogeneity of the studies included, as several studies did not provide risk stratification, and quite a few of them included high-risk stratification patients and patients with T3 tumors for hemithyroidectomy. This also probably reiterates the fact that while planning hemithyroidectomy/lobectomy we need to consider various other factors discussed previously to personalize the treatment for these patients, especially those belonging to low-risk groups. None of the patients in our series had a documented structural recurrence (in the thyroid bed or lateral neck) during the follow-up (median follow-up 27.5 months).

Ours is probably the only reported series of hemithyroidectomy exclusively in DTC from India. However, it has some limitations, like its retrospective nature (recording bias and complete records unavailability in some cases) of the study design and small median follow-up time of 27.5 months, and quite a few patients were lost to follow-up; thereby, valuable follow-up information was lost.

Conclusions

Hemithyroidectomy (HT) is an acceptable treatment option in low-risk 1–4 cm DTC. It is important to understand that HT is also associated with certain postoperative complications such as (biochemical) hypocalcemia, hypothyroidism, and RLN palsy subsequently. Hence, it is important to document the vocal cord status before and after surgery and consider to routinely test for serum calcium in the postoperative period and TFT during follow-up for identification and correction when the values are altered. Also, the TFT needs to be monitored to keep the serum TSH within the desired range for low-risk DTC patients.

Authors' Contributions Dr. Nithyanand Chidambaranathan: data collection, manuscript writing and editing
Dr. Shivakumar Thiagarajan: concept, design, analysis and interpretation, manuscript writing and editing
Dr. Nandini Menon: data collection, manuscript writing and editing
Dr. Adhara Chakraborthy: data collection, manuscript writing and editing
Dr. Richa Vaish: manuscript writing and editing
Dr. Devendra Chaukar: manuscript writing and editing

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval A retrospective clinical audit of an existing database. No patient contact was made. All patients received the standard of care for their condition as per the ethical standards. Approval from our institute Ethics Committee was obtained.

Informed Consent No identifying information of the participants is available in the article. However, all patients have given consent for the treatment they have received.

References

1. Ahn HS, Kim HJ, Welch HG (2014) Korea's thyroid-cancer "epidemic"–screening and overdiagnosis. N Engl J Med 371(19):1765–1767
2. Seib CD, Sosa JA (2019) Evolving understanding of the epidemiology of thyroid cancer. Endocrinol Metab Clin N Am 48:23–35
3. Haugen BR, Alexander EK, Bible KC, Doherty GM, Mandel SJ, Nikiforov YE, Pacini F, Randolph GW, Sawka AM, Schlumberger M, Schuff KG, Sherman SI, Sosa JA, Steward 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 Task Force on thyroid nodules and differentiated thyroid cancer. Thyroid. 26(1):1–133
4. Amin MB, Edge SB, Greene FL, Byrd DR, Brookland RK, Washington MK et al (eds) (2017) AJCC cancer staging manual, 8th edn. Springer-Verlag, New York
5. Chan S, Karamali K, Kolodziejczyk A, Oikonomou G, Watkinson J, Paleri V, Nixon I, Kim D (2020) Systematic review of recurrence rate after hemithyroidectomy for low-risk well-differentiated thyroid ccancer. Eur Thyroid J. 9(2):73–84
6. Ahn D, Sohn JH, Jeon JH (2016) Hypothyroidism following hemithyroidectomy: incidence, risk factors, and clinical characteristics. J Clin Endocrinol Metab 101(4):1429–1436
7. Verloop H, Louwerens M, Schoones JW, Kievit J, Smit JW, Dekkers OM (2012) Risk of hypothyroidism following hemithyroidectomy: systematic review and meta-analysis of prognostic studies. J Clin Endocrinol Metab 97(7):2243–2255
8. Ahn D, Lee GJ, Sohn JH (2019) Levothyroxine supplementation following hemithyroidectomy: incidence, risk factors, and characteristics. Ann Surg Oncol 26(13):4405–4413
9. Pantvaidya G, Katna R, Deshmukh A, Nair D, D'Cruz A (2017) Morbidity of central compartment clearance: comparison of lesser versus complete clearance in patients with thyroid cancer. J Can Res Ther 13:102–106
10. Yip L, Stang MT, Carty SE (2011) Thyroid carcinoma: the surgeon's perspective. Radiol Clin N Am 49(3):463–4vi
11. Iñiguez-Ariza NM, Brito JP (2018) Management of low-risk papillary thyroid cancer. Endocrinol Metab (Seoul) 33(2):185–194
12. 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 260:601–607
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 246:375–384
14. Tran B, Roshan D, Abraham E, Wang L, Garibotto N, Wykes J, Campbell P, Ebrahimi A (2018) The prognostic impact of tumor size in papillary thyroid carcinoma is modified by age. Thyroid. 28(8):991–996
15. Rahbari R, Zhang L, Kebebew E (2010) Thyroid cancer gender disparity. Future Oncol 6(11):1771–1779
16. Wang F, Yu X, Shen X, Zhu G, Huang Y, Liu R, Viola D, Elisei R, Puxeddu E, Fugazzola L, Colombo C, Jarzab B, Czarniecka A, Lam AK, Mian C, Vianello F, Yip L, Riesco-Eizaguirre G, Santisteban P, O'Neill CJ, Sywak MS, Clifton-Bligh R, Bendlova B, Sýkorová V, Wang Y, Liu S, Zhao J, Zhao S, Xing M (2017) The prognostic value of tumor multifocality in clinical outcomes of papillary thyroid cancer. J Clin Endocrinol Metab 102:3241–3250
17. Asson AR, Pingpank JF Jr, Wetherington RW, Hanlon AL, Ridge JA (2001) Incidental parathyroidectomy during thyroid surgery does not cause transient symptomatic hypocalcemia. Arch Otolaryngol Head Neck Surg 127:304–308
18. Attou F, Combemale F, Fabre S, Carnaille B, Decoulx M, Wemeau JL et al (1998) Hypocalcemia following thyroid surgery: incidence and prediction of outcome. World J Surg 22:718–724
19. Sutton RA, Dirks JH (1986) Calcium and magnesium: renal handling and disorders of metabolism. In: Brenner BM, Reector FC (eds) The kidney. WB Saunders, Philadelphia, pp 551–619
20. Baldassarre RL, Chang DC, Brumund KT, Bouvet M (2012) Predictors of hypocalcemia after thyroidectomy: results from the nationwide inpatient sample. ISRN Surgery 2012:1–7
21. 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 patients operated on in Italy over 5 years. World J Surg 28(3):271–276
22. Gunn A, Oyekunle T, Stang M, Kazaure H, Scheri R (2020) Recurrent laryngeal nerve injury after thyroid surgery: an analysis of 11,370 patients. J Surg Res 255:42–49
23. Filetti S, Durante C, Hartl D, Leboulleux S, Locati LD, Newbold K, Papotti MG, Berruti A (2019) Thyroid cancer: ESMO clinical practice guidelines for diagnosis, treatment and follow-up†. Ann Oncol 30(12):1856–1883
24. Chan S, Karamali K, Kolodziejczyk A, Oikonomou G, Watkinson J, Paleri V, Nixon I, Kim D (2020) Systematic review of recurrence rate after hemithyroidectomy for low-risk well-differentiated thyroid cancer. Eur Thyroid J 9(2):73–84