Advances in surgical therapy for thyroid cancer

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Abstract | Thyroid cancer is the most common malignancy of the endocrine system and its incidence has dramatically increased over the past three decades. Well-differentiated thyroid cancers (DTCs) are the main focus of this article, as they represent >90% of thyroid malignancies. This Review provides an overview of the controversies surrounding the optimal choice of surgery and extent of resection for patients with low-risk DTC or with papillary thyroid microcarcinoma, and the role of prophylactic central lymph node dissection. This Review also outlines the current surgical management of DTC and presents updated results for these techniques, along with important advances and current dilemmas in surgical approaches to treatment of these cancers. For example, endoscopic and robotic thyroidectomy are the two most recent innovations to present technical and other challenges to the endocrine surgeon; in addition, the risks as well as the advantages of same-day thyroid surgery, which has gained some acceptance, are detailed. Arguments for and against each approach are presented, along with supporting evidence. The authors' personal opinions are also provided for each topic.

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Introduction

Thyroid cancer is the most common malignancy of the endocrine system and it accounts for ~2% of all new cancer diagnoses.[1] More than 44,000 people are expected to be diagnosed with thyroid cancer in the USA in 2011. During the past three decades, the incidence of well-differentiated thyroid cancer (DTC) has dramatically increased worldwide.[2] In the USA alone, epidemiological data have shown a 2.4-fold increase in the incidence of DTC between 1973 and 2002, and in over 50% of these cases the identified tumors were <2 cm in diameter.[3] The increase in incidence is, therefore, almost certainly related to improvements in imaging modalities. Imaging studies are now widely used for various indications, and can detect clinically occult thyroid nodules, as well as large tumors.[3]

DTCs represent >90% of thyroid cancers and comprise two major histological types: papillary and follicular. Papillary cancers account for ≤85% of thyroid malignancies, and follicular and Hürthle cell carcinomas comprise another 13%.[4] Despite a number of important clinical and pathological differences, the two DTC subtypes (papillary and follicular) are similar in terms of the recommended surgical approach and their overall favorable prognosis: both have a 5-year survival of >97%.[5]

Thyroid surgery has advanced over the past three decades as the numbers of qualified endocrine surgeons have increased worldwide. Several groups have attempted to develop evidence-based guidelines for the surgical management of thyroid cancer. For example, the American Thyroid Association (ATA) published guidelines in 2009 that were endorsed by multiple endocrinology and endocrine surgery associations and societies.[6] However, controversy persists over which surgical approach is optimal for specific subtypes and stages of thyroid cancers.

This Review outlines the surgical approach to DTC, elaborates the controversies surrounding the surgical treatment of small, low-risk cancers and papillary thyroid microcarcinomas (PTMCs), and discusses the role of prophylactic central lymph node dissection. Important advances in thyroid surgery, such as endoscopic or robot-assisted thyroid procedures and same-day surgery, are also presented.

Guidelines for surgical therapy

When DTC is first identified preoperatively, near-total or total thyroidectomy is recommended for patients who either have a primary thyroid carcinoma of >1 cm in diameter,[7] or have other risk factors, such as contralateral thyroid nodules, regional or distant metastases, a history of radiation therapy to the head and neck, or a first-degree family history of DTC.[6] As patients aged >45 years have an increased risk of recurrence of DTC,[6] individuals in this age-group might also be recommended for near-total or total thyroidectomy even if their tumors are <1 cm in size. These treatment recommendations are based upon improved survival and recurrence rates versus an acceptable rate of complications associated with total thyroidectomy.[8–10]

Several studies showed that when performed by experienced surgeons (defined by the American Association of Endocrine Surgeons as surgeons who perform >50 thyroid surgeries per year[11]), total thyroidectomy has a low complication rate.[12,13] However, thyroid surgery, specifically total thyroidectomy, is associated with

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Key points

- Thyroid cancer is the most common malignancy of the endocrine system and its incidence is increasing
- The optimal therapy for papillary thyroid microcarcinoma is currently unclear, and is a controversial issue; suggested management strategies range from regular observation to total thyroidectomy
- Prophylactic central lymph node dissection might identify high rates of lymph node involvement without providing long-term benefits; therefore, its routine use is currently unwarranted
- Same-day thyroid surgery is gaining acceptance and can be safely performed in the majority of patients as long as an appropriate support system is present

several serious postoperative complications, among which recurrent nerve injury and hypoparathyroidism are the most serious long-term sequelae, although postoperative neck hematomas also occur and can be immediately life-threatening. These risks are further reduced in thyroid lobectomy, which exposes only two parathyroid glands and one recurrent laryngeal nerve to the risk of injury. Permanent recurrent laryngeal nerve dysfunction is also uncommon, occurring in ≤1.5% of patients after a total thyroidectomy performed by an experienced surgeon.[12,13]

Transient nerve dysfunction is, however, more common after thyroidectomy than after lobectomy (occurring in 4–13% of patients).[12] In addition, permanent hypoparathyroidism occurs in 0.6–5.0% of patients after thyroidectomy, whereas transient postoperative hypocalcemia is much more common, occurring in 10–20% of patients.[11,13] Although hemorrhage can cause life-threatening complications, it is rare after thyroidectomy, occurring in <1% of patients.[14]

Both survival and local recurrence rates have a pivotal influence upon recommendations on the extent of thyroid surgery (lobectomy versus total thyroidectomy) for DTC. In this regard, one study conducted in >50,000 patients with papillary thyroid cancer (PTC) showed that total thyroidectomy was associated with significantly improved survival and recurrence rates only in patients whose tumors were >1 cm in diameter.[7] The same study also showed that lobectomy was associated with a 57% higher risk of recurrence and a 21% higher risk of death than total thyroidectomy ($P=0.001$ and $P=0.027$, respectively). Despite their methodological drawbacks, such as reliance on medical record databases, low usage of radioactive iodine treatment after surgery and missing data on pertinent aspects, several other studies that retrospectively analyzed medical data on patients who underwent surgical treatment for DTC consistently showed reduced recurrence rates associated with total thyroidectomy.[9,16,17] As a result, the current ATA recommendations state that for patients with thyroid cancers >1 cm in diameter, the initial surgical procedure should be near-total or total thyroidectomy.[6] Therapeutic central-compartment and lateral-compartment lymph node dissection are recommended for patients with clinical evidence of and biopsy-proven lymph node involvement, respectively.[6] Prophylactic central-compartment neck dissection (ipsilateral or bilateral) can be performed in patients with PTC who have no clinical evidence of central neck lymph node involvement, especially if these patients have advanced primary tumors (T3 or T4).[6]

These guidelines have been challenged, at least with regard to some subgroups of patients, by the publication of evidence in the literature. Moreover, controversy persists with regard to the extent of surgery required for low-risk patients or those with PTMC. As discussed below, the role of prophylactic central lymph node dissection is a matter of ongoing debate.

Controversies

Treatment of low-risk DTC

The extent of surgery recommended for patients with DTC is a hotly debated topic.[5–7,18] Some of the arguments in support of total thyroidectomy are based on the fact that this procedure involves a minimal risk of postoperative complications and has an excellent outcome when performed by experienced surgeons. Furthermore, total thyroidectomy also removes any undiagnosed microscopic or macroscopic tumor in the contralateral lobe. The incidence of contralateral multifocal disease is 13–56%, and occurs at high rates even when the primary tumor is <1 cm in size.[19,20] Total thyroidectomy can also be combined with adjuvant therapy, such as radioactive iodine, and thyroglobulin levels can be evaluated as a marker for disease recurrence during follow-up. By contrast, a limited procedure that includes an ipsilateral thyroid lobectomy and isthmusectomy offers the clear advantage of avoiding any risk of injury to the nerves or the parathyroid glands on the contralateral side. Moreover, the presence of the remaining thyroid lobe might attenuate the need for thyroid hormone replacement therapy in some patients, whereas patients aged >45 years, or patients with nodular, cystic, or fibrotic lobe might require hormone replacement therapy.

Some studies suggest that up to 80% of patients with DTC could be cured of the disease by thyroid lobectomy alone and would, therefore, benefit from the above-mentioned advantages of limited resection.[21–23] Consequently, risk-stratification models have been proposed to identify high-risk patients who should be offered a total thyroidectomy as the first line of treatment. Such models differ between institutions, however, and the risk groups include patients with various ages, tumor grades and sizes, as well as differing in whether extrathyroidal extension, completeness of resection, distant metastases, and DNA ploidy are considered (Table 1).[8,24–27]

Some evidence suggests that patients with low-risk DTC who are treated with lobectomy and isthmusectomy have similar long-term outcomes to those treated with total thyroidectomy, and that low-risk patients treated with total thyroidectomy do not benefit from the addition of radioactive iodine ablation.[7,22,23] Despite attempts to improve these risk-stratification models, the current ATA recommendations suggest total or near-total thyroidectomy for all patients with DTCs >1 cm in size.[6] As mentioned above, these recommendations are supported by data that demonstrate improved recurrence and survival for these patients. Obviously, an aggressive approach is warranted in patients with additional risk factors, such as the presence of contralateral thyroid nodules, or regional or distant metastases. Patients with a history of head and neck radiation, or a first-degree family history of DTC, should also be treated with total or near-total thyroidectomy.

The final decision on the extent of surgery depends on the preferences of the patient, the endocrinologist, and the surgeon. At the University of Wisconsin, WI, USA, we follow the ATA recommendations and offer total thyroidectomy to all patients with DTCs >1 cm in size.

Papillary thyroid microcarcinoma

PTMC is defined by the WHO as a papillary thyroid cancer of ≤10 mm in diameter.[28] These tumors may be solitary or multifocal. PTMC is estimated to account for up to 30–40% of all PTCs and its incidence has increased by 50% in the past 10 years.[29] Improved histopathological and imaging techniques are thought to account, at least, in part, for this increase in incidence, as most PTMCs are asymptomatic.[29] These tumors tend to be identified either as an incidental finding at surgery, on radiographic or other imaging procedures, or during specimen examination by pathology. Multifocal disease is present in 15–43% and bilateral disease in up to 41% of patients with PTMC.[19,20] Cervical lymphadenopathy is discovered in 13–64% of patients with this cancer when cervical neck lymph node dissection is performed. Extrathyroidal tumor extension, which is primarily microscopic in nature, is noted in about 15–21% of patients with PTMC, whereas vascular invasion is present in approximately 3.5% of such individuals. Distant metastases occur infrequently, at a rate of 1.0–2.8%.[31] Patients with PTMC have low rates of disease recurrence and mortality, with one study indicating an expected 10-year survival of 100%, a locoregional-recurrence-free survival of 92%, and a distant-metastasis-free survival of 97%.[32]

The relatively high rates of bilateral multifocality and lymph node involvement, as opposed to excellent recurrence-free rates and overall survival, have led to controversy over the optimal management of these tumors. Recommendations range from conservative treatment to aggressive approaches.[33,34] Proponents of nonsurgical approaches to management of patients with PTMC claim that in the majority of these patients thyroidectomy is not necessary. Those who adhere to these views suggest that observation is warranted unless the tumor has one of the following features: position adjacent to the trachea or nerves, compression symptoms (such as hoarseness), evidence of lymph-node involvement obtained by palpation or imaging, high-grade malignancy on fine-needle aspiration (FNA) cytology, and enlargement during follow-up.[34] Capsular invasion is also associated with local recurrence and distant metastasis and is, therefore, suggested as another indication for an aggressive surgical treatment.[33,35] Close follow-up using ultrasonography is recommended in patients who choose not to undergo surgery, and enlargement of PTMC or new evidence of lymph node involvement are indications for surgical intervention in these patients. In one study, tumor growth

Table 1 | Prognostic scoring systems for papillary thyroid cancer

Center where the system was developed	Scoring system	Year of publication
MSKCC	GAMES: grade, age, distant metastasis, extrathyroidal extension, size	1992
Mayo Clinic	AGES: age, grade, extrathyroidal extension, size MACIS: distant metastasis, age, completeness of resection, invasion, size	1987 1993
Lahey Clinic	AMES: age, distant metastasis, extrathyroidal extension, size	1988
Karolinska Hospital and Institute	DAMES: DNA ploidy, age, distant metastasis, extrathyroidal extension, size	1992

Abbreviation: MSKCC, Memorial Sloan–Kettering Cancer Center.

of 2 mm was detected in 30% of patients who underwent observation alone, and more than one-third (56 of 162) of all patients assigned to observation required surgical excision after 19–56 months of observation. Moreover, lymph node metastases developed in 12% of all patients who underwent observation.[34]

Advocates of the surgical approach base their recommendations on the high rates of tumor multifocality and lymph node involvement in patients with PTMC. No randomized controlled trials on the relative merits of different surgical approaches are available; thus, the ATA guidelines conclude that thyroid lobectomy alone might be sufficient treatment for low-risk, isolated, intrathyroidal PTMCs in the absence of prior head and neck irradiation, radiological or clinical evidence of involvement, or metastases in the cervical lymph nodes.[6]

Prophylactic central lymph node dissection is not recommended for T1 tumors in the ATA guidelines. By contrast, other individuals suggest that prophylactic central lymph node dissection is indicated, owing to the high rate of involved lymph nodes at presentation, the inaccuracy of ultrasonography with regard to detection of lymph node involvement (especially in the central neck area), and the high complication rate in patients who require reoperation to treat local recurrence.[36] Nevertheless, although metastasis in the central lymph nodes predicted worse disease-free survival in patients with large papillary carcinomas, this feature had no prognostic value in a series of patients with PTMC.[37]

Several attempts have been made to identify tumor characteristics that could stratify patients' risk of local recurrence. Some groups aimed to identify a cut-off size above which the risk of PTMC recurrence is substantial, and thus warrants an aggressive surgical approach, with variable success; a few studies reported that tumors <5 mm were less likely to metastasize than tumors above this diameter, whereas other studies failed to confirm these findings.[38,39] Another avenue of research investigated whether PTMCs identified on intentional FNA biopsy might differ in multifocality, lymph node involvement and metastatic potential from truly incidental PTMCs identified on histopathology after resection of a thyroid lobe or the whole gland for unrelated etiologies.[39] Several studies demonstrated that true incidental

PTMC tumors were associated with decreased recurrence rates. Such tumors were also smaller and were less likely to be multifocal or to have extrathyroidal invasion than PTMCs identified on intentional FNA biopsy.[38,41] A large multivariate study of 18,445 patients showed that age >45 years and the presence of distant metastases were both associated with decreased disease-specific survival (odds ratios of 6.2 and 3.8, respectively, versus age <45 years and no distant metastases).[42]

We believe that, in the future, molecular and improved imaging techniques will help to differentiate between PTMCs that can be managed by observation alone and those that require surgery. Currently, however, we perform total thyroidectomy for all patients with PTMCs that are identified before surgery. We do not recommend completion thyroidectomy for patients with true incidental tumors identified on histopathology, unless worrisome features (such as high-grade tumor, capsular invasion, multifocality or lymph node involvement) are present.

Prophylactic central lymph node dissection

Lymph-node involvement is very common in patients with DTC. During the initial surgery, lymphatic metastases have been detected in 22–90% of patients with PTC,[43,44] whereas the rate of lymph node involvement in follicular thyroid cancer (FTC) is substantially lower (2%). Despite the high rate of nodal involvement in patients with PTC, the effect of microscopic disease on both recurrence and survival is unclear.

Most clinicians agree that if positive lymph nodes are identified on physical examination of a patient with PTC and involvement is confirmed by ultrasonography or FNA cytology, the patient should undergo lymph node dissection of the appropriate compartment (central or lateral). Such therapeutic dissections decrease the incidence of locoregional recurrence, prevent serious sequelae (such as invasion or compression of adjacent structures) and possibly improve survival.[45,46] However, the role of elective prophylactic central compartment lymph node dissection in the absence of overt nodal metastases remains a matter of debate.[21,46] Owing to their proximity to the trachea and their inferior location, involvement of the central lymph nodes is difficult to identify preoperatively. Unanticipated metastases are identified in 38–45% of patients undergoing prophylactic central lymph node dissection;[47,48] nevertheless, to date, no randomized, controlled studies have assessed the complications associated with prophylactic central lymph node dissection, or its effect on recurrence and survival of patients with PTC. In evaluations of the utility of prophylactic central lymph node dissection, surgeons should consider the additional morbidity associated with the procedure, as well as the possible improvement in recurrence and survival. Although performing a central lymph node dissection in addition to total thyroidectomy (even by experienced surgeons) has resulted in an increased rate of transient hypoparathyroidism in some studies,[49–51] most reported series found no difference in the rates of permanent hypoparathyroidism or nerve injury.[45,52,53] A crucial consideration in such analyses, however, is that prophylactic central lymph dissection might also result in a decreased rate of reoperation for recurrent disease, which is associated with increased complication rates.[53]

Whether central lymph node dissection confers a benefit in terms of decreased recurrence or improved survival is not clear. Although some studies indicate that therapeutic central lymph node dissection to remove involved lymph nodes is associated with decreased recurrence rates and reduced thyroglobulin levels,[44,47] no convincing data suggest the same is true for prophylactic dissection of macroscopically uninvolved lymph nodes. Two large cohort studies failed to demonstrate an influence of central lymph node dissection on 20-year survival in patients with DTC.[24,54]

Current data on the genetic alterations present in PTCs, such as point mutations in *BRAF* and *RAS* as well as *RET–PTC* and *PAX8–PPARG* rearrangements suggest that molecular testing for these abnormalities could be used to identify patients at risk of developing aggressive disease.[55,56] Such patients could derive increased benefit from prophylactic central lymph node dissection.[55,56] The utility of such molecular tests has not been evaluated in a prospective randomized trial; nevertheless, *BRAF* is the best-studied thyroid oncogene, and testing for mutations in this gene is routinely conducted in some institutions to guide decision-making for patients with PTC.[57]

The current ATA guidelines suggest that prophylactic central lymph node dissection can be performed in patients with advanced primary thyroid tumors (T3 or T4), as patients with tumors >4 cm in diameter have a 2–6-fold higher risk of central lymph node involvement than patients with tumors ≤4 cm (T1 or T2).[52,58] Patients with smaller tumors (T1 or T2) and those with FTCs are, therefore, treated with total or near-total thyroidectomy alone.[6] The European Thyroid Cancer Task Force recommends performing prophylactic central lymph node dissection only in patients with preoperatively suspected and/or intraoperatively proven lymph node metastases.[58]

In our own institution, we perform *en bloc* prophylactic central lymph node dissection for selected high-risk patients with DTC. We are currently planning a prospective, randomized, controlled study to be conducted at the University of Wisconsin to assess the complications and immediate outcomes of prophylactic central lymph node dissection in patients with DTC.

Recent advances in thyroid surgery

The surgical treatment of thyroid carcinoma has evolved over the past two decades in many aspects. Large numbers of thyroid operations are now being performed at high-volume tertiary referral centers, resulting in the never-ending pursuit of improvements in patient care and outcomes. Two aspects that have advanced greatly are the introduction of same-day thyroidectomy and the use of endoscopic and robotic technology to perform thyroid surgery.

Same-day thyroid surgery

As mentioned above, thyroidectomy is generally a safe procedure that has few complications. Bilateral nerve injury might compromise the airway, by causing closure of the vocal cords leading to the need for tracheostomy, and profound, but usually transient, hypocalcemia resulting from hypoparathyroidism might necessitate intravenous calcium infusions. The most catastrophic complication is a compressive neck hematoma that obstructs the airway, which can develop even beyond 24 h after the procedure and requires correct identification and rapid treatment. For this reason, patients typically remain hospitalized for several days after a thyroidectomy. Nevertheless, in the past two decades a short hospital stay after thyroidectomy has become the most common practice. This trend has been driven in part by efforts to reduce medical costs, and has been supported by the very low rate of complications requiring readmission after the procedure. Most nerve injuries are transient and do not compromise the airway, and hypocalcemia rarely requires intravenous calcium infusion. These complications can almost always be managed in an outpatient setting. Two large studies of post-thyroidectomy hemorrhage show that this complication occurs in only 0.25–1.0% of patients; approximately 40–50% of hemorrhages occur within 6 h of the procedure, 40% occur within 7–24 h, and 10–20% occur >24 h after thyroidectomy.[15,60]

Same-day thyroidectomy was initially described in 1986.[61] In the past decade, several large, single-center trials have been published reporting acceptable results for this procedure.[62–64] The rationale for performing same-day thyroidectomy relies on a combination of factors: firstly, patients and health insurance providers usually prefer short hospital stays, which limit the cost of treatment. The use of improved antiemetic drugs helps to reduce both the discomfort associated with the procedure and the risk of postoperative hematoma. Patients generally feel well after thyroidectomy and experience only mild discomfort; in addition, the rate of complications that necessitate in-hospital treatment is very low.

Two studies, each conducted in >1,000 patients,[63,64] showed that postoperative emergency room visits occurred after 7.8% of same-day thyroidectomies, but only 2.3% of these visits required readmission. The overall complication rate was comparable to that in patients assigned to standard care and, importantly, only 0.2% of patients who underwent same-day thyroidectomy developed neck hematomas, none of which required bedside decompression.[64] In the New York study,[63] 17% of all thyroidectomies were performed as same-day procedures; however, patients who underwent the same-day procedure were mostly white, with private health insurance, and were operated on at high-volume hospitals by experienced surgeons. Rehospitalization rates after same-day thyroidectomy were 1.4%. In both studies,[63,64] patients who underwent same-day thyroidectomy were younger and healthier than those undergoing standard (inpatient) thyroidectomy. The risk factors for postoperative hypocalcemia after both same-day and standard thyroidectomy include bilateral resection, a large gland or tumor, central lymph node dissection, reoperation, and a young age.[65,66]

We perform same-day thyroidectomy in the majority of patients treated at our institution. We consider the patient's age and medical history, the extent of surgery, as well as the patient's and surgeon's preference, when deciding on whether the postoperative complications will be managed in an inpatient or outpatient setting. We believe that same-day thyroidectomy should only be performed at high-volume centers by experienced surgeons and that careful selection of patients for the procedure is of the utmost importance. A support system that enables close follow-up and rapid problem solving is necessary to assure these patients' safety.

Endoscopic and robotic surgery

The open method of thyroid excision initially involved an 8–10 cm transverse skin-crease incision. Over the years, the length of the incision has been greatly reduced and a 3–6 cm incision has become standard.[67] Although the open method is quick, provides adequate access to the tumor, and leaves a scar that is often well-hidden in the skin crease, the possibility of scar hypertrophy and the search for improved cosmesis has resulted in the development of minimally invasive and video-assisted surgical techniques.

Endoscopy offers the possibility of remote port placement and improved visualization and illumination. The first reported endoscopic thyroid surgery was described in 1997.[68] Since then, several endoscopic approaches for thyroid surgery have been described. The technique most commonly used in North America is termed minimally invasive video-assisted thyroidectomy (MIVAT), which was first described in 1999.[68] In this technique, thyroidectomy is performed via a small anterior neck incision, with comparable results to open thyroid surgery.[70] Moreover, MIVAT has similar long-term outcomes in patients with either low-risk or intermediate-risk PTC.[71] The cervical approach to video-assisted thyroidectomy with postauricular port placement has not gained wide acceptance. An initial proof-of-concept study has demonstrated the feasibility of a completely scarless technique, by approaching the thyroid from the oral cavity.[72]

Robotic or endoscopic transaxillary thyroidectomy offers two advantages over conventional neck incisions: excellent cosmesis, as the operation scar is in the axilla, and absence of postoperative hypesthesia and fibrotic contracture in the anterior neck.[73] However, extracervical approaches often lead to increased operative times, greater postoperative pain,[74] and involve a greater amount of dissection versus cervical approaches.

The first single-incision, robot-assisted, transaxillary thyroidectomy was described in 2010 by Chung and colleagues (Figure 1).[75] Compared with conventional endoscopy, robotic surgical systems offer superior visualization and improved maneuverability of the surgical instruments. The robotic camera is stable and delivers a 3D image with ×10 magnification. The seven degrees of freedom that the surgical robot device offers enable easy and precise dissection, which is crucial for preservation

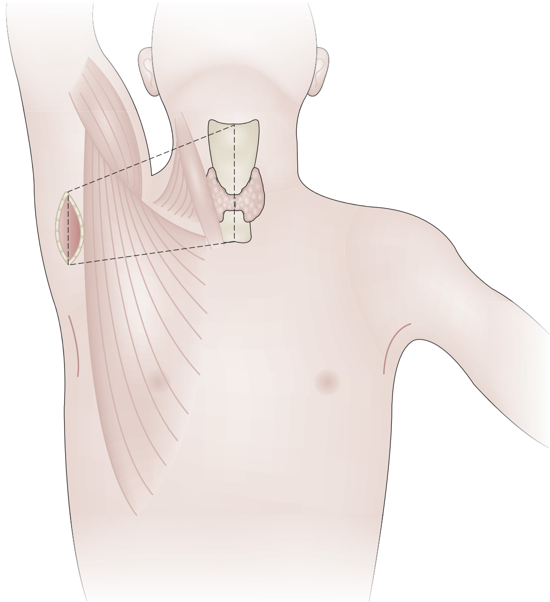

Figure 1 | Incision and dissection plane for transaxillary thyroidectomy. The patient is placed in a supine position with the ipsilateral arm flexed to approximately 160°. A 5–6 cm longitudinal incision is made in the axilla along the outer border of the pectoralis major muscle. Skin flaps are developed superficial to the pectoralis fascia in an avascular plane between the sternal and clavicular heads of the sternocleidomastoid muscle. A bladed thyroid robotic retractor is attached to the contralateral side of the operating table, and deployed to elevate the skin and strap muscles. Dissection is carried out with a camera and three robotic arms. After dissection is completed, a drain may be left within the dissection plane. Patients are discharged from hospital after overnight observation.

of the recurrent laryngeal nerve and parathyroid glands. The robot also diminishes hand tremor.[73,76]

Robotic thyroidectomy is associated with several limitations. First, the operative time is longer than that of open procedures. The largest experience with this procedure has been described by researchers from South Korea who treated >100 patients; in this study, the mean operative time for removal of one thyroid lobe was >2 h.[73] Furthermore, robotic thyroidectomy in general usually requires two skilled surgeons, as opposed to the one needed for the open procedure. Secondly, a much larger dissection is needed to reach the thyroid gland via the axilla than via the cervical approach and the axillary route is associated with complications that have not been reported with open (cervical) surgery: ulnar and brachial plexus injury, as well as the need to convert to conventional surgery owing to bleeding during the operation. Shoulder pain and Horner syndrome have also been described after robotic thyroidectomy. The learning curve for a surgeon to become experienced in robotic thyroidectomy is estimated to be 50–70 cases.[73,77] Thirdly, and most importantly, the very high cost of robotic procedures and of the device itself is the main factor limiting the applicability of robotic thyroid surgery. In addition to the high initial cost of equipment and training, the consumables are also expensive. Various components of the robot need to be replaced after a certain number of uses, regardless of the condition of the instrument. Furthermore, the entire operative team, including nurses, also requires training in the use, set up and maintenance of the robot.[78]

At this point, robotic thyroidectomy seems to be feasible; however, no strong evidence from randomized controlled trials exists to support its routine use. A New Technology Task Force has suggested a framework for the assessment and safe implementation of robotic thyroidectomy,[79] including procedure observation, robotic training, cadaver surgery, and proctored surgery, which should be adopted by surgeons who consider performing such procedures.

Appropriate selection of patients is also of the utmost importance when considering the use of minimally invasive techniques (endoscopic or robotic). Some controversy remains as to the use of minimally invasive endoscopic techniques for the management of thyroid cancers. Although most surgeons would agree that highly malignant or aggressive tumors are not suitable for such techniques, no long-term data are available for the management of DTCs by minimally invasive techniques. Consequently, some researchers propose that such procedures should only be offered to patients with tumors <3 cm in size and total ultrasonographically estimated thyroid volume of <20 ml.[80] Contraindications include previous irradiation to the neck, previous neck surgery, aggressive tumors, extracapsular or nodal spread of the tumor, and previous thyroiditis. Dissection might also be difficult in patients with obesity and those with long necks.

Conclusions

Surgery for thyroid cancer has advanced greatly over the past two decades. Although some treatment guidelines have been widely accepted, debate continues with regard to the optimal extent of surgery in low-risk patients and those with PTMC. No consensus has yet been reached with regard to the role of prophylactic central lymph node dissection, although future randomized, controlled studies might shed light on the indications for this procedure. Important advances in the treatment of DTC include same-day thyroid surgery, minimally invasive procedures and endoscopic or robotic transaxillary thyroidectomy. Surgical approaches to the management of thyroid cancer will, no doubt, continue to evolve in the future.

Review criteria

A literature search was performed in PubMed. The search terms included: “differentiated thyroid cancer”, “PTC”, “PTMC”, “guidelines”, “low risk”, “central lymph nodes”, “thyroid molecular markers”, “same day thyroid surgery”, “endoscopic thyroidectomy” and “robotic thyroidectomy”. The identified articles were full-text, English-language articles published after January 2000. The reference lists of authoritative reviews were also searched to identify further relevant papers.

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Author contributions

H. Mazeh researched the data for the article. Both authors wrote the article, and provided substantial contributions to discussions of the content, as well as to review and/or editing of the manuscript before submission.