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Minimally Invasive Thyroid Surgery for Single Nodules: An Evidence-based Review of the Lateral Mini-incision Technique

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Abstract
Background Minimally invasive thyroidectomy techniques are being developed in an effort to minimize pain, shorten the length of hospital stay, and improve cosmesis. Various minimally invasive thyroid surgery (MITS) techniques have been shown to be safe and feasible with some benefits in terms of cosmesis and pain outcomes; however, no single technique has been broadly accepted. This study was designed to review the evidence in relation to MITS and our experience with the direct lateral mini-incision technique.
Methods A review of literature published until December 2007 on minimally invasive thyroidectomy techniques was undertaken. Three issues were addressed: 1) Does MITS provide any benefit compared with conventional open thyroidectomy? 2) Is there any advantage to the use of endoscopic or video-assisted techniques compared with the direct mini-incision technique? 3) Is the lateral mini-incision technique safe and efficacious? Additional data in relation to the above issues was derived from a retrospective cohort study of patients undergoing mini-incision thyroid surgery within our unit.
Results Issue 1: Five prospective randomized studies and eight studies at a lower level of evidence have demonstrated consistent advantages of MITS compared with open thyroid surgery in terms of reduced pain and improved cosmesis with equivalent operative safety. Issue 2: In compiling four level III and IV studies that compared open and video-assisted minimally invasive surgery, there do not seem to be significant differences in patient satisfaction with the incision. The video-assisted approaches require significantly longer operative times but also seem to be less painful. Issue 3: Three cohort studies (level IV) have demonstrated that the lateral mini-incision technique is both safe and efficacious compared with open surgery for hemi-thyroidectomy. Data from our cohort study of 1281 patients (open hemi-thyroidectomy 1054 vs. MITS 227) confirmed MITS to be a safe and effective procedure. The rate of postoperative hematoma formation and wound infection was equivalent between groups. The rate of permanent recurrent laryngeal nerve injury was 0.4% for MITS and 0.3% for CHT and not significantly different ($p = 0.7$).
Conclusions MITS has demonstrated advantages over conventional open approaches for both hemi- and total thyroidectomy and the benefits do not depend on the open or video-assisted approach. For thyroid lobectomies, the lateral mini-incision approach can be performed with an operative time and postoperative complication profile equivalent to conventional hemi-thyroidectomy while providing excellent cosmesis with a 2–3 cm scar.

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Introduction

As a result of the appalling results of thyroidectomy procedures during the late 19th century, the French Academy of Medicine moved to ban the operation in 1850 [1]. After this, through an emphasis on precise dissection and antisepsis, Theodore Kocher was able to greatly reduce the mortality rate associated with the procedure. The early 20th century was witness to marked improvements in mortality

and morbidity related to thyroid surgery with Thomas Dunhill (Melbourne), William Halsted (Baltimore), Charles Mayo (Rochester), and George Crile (Cleveland) all making considerable contributions to the field [2, 3]. Today in the early 21st century, the mortality of thyroid surgery approaches zero and the morbidity in high volume units is reported to be <1%. The frontiers of thyroid surgery in the current era are focused on techniques that minimize pain, shorten hospital length of stay, and improve cosmesis. These goals are being pursued through the development of minimally invasive thyroid surgery (MITS).

At this point, no one technique for MITS has gained general acceptance; in fact the definition of what comprises a minimally invasive procedure remains controversial. The term itself has been applied to open operations with midline and lateral approaches, as well as video-assisted and endoscopic thyroidectomy, which can employ a cervical or extracervical incision [4–8]. Even among seemingly similar approaches, the definition of minimal in terms of skin incision length can vary from 1.5 to 5 cm. As suggested in a recent editorial, the extracervical endoscopic approaches, whilst they have the advantage of avoiding a cervical incision, require extensive dissection that exceeds that of conventional surgery, and in this regard cannot be considered minimally invasive [7]. The cervical approaches, which may or may not utilize video assistance, have been described by many different centers and seem to be safe and feasible for both hemi- and total thyroidectomy [4, 7].

The fact that no one MITS technique has been broadly accepted probably reflects the fact that we are still in the relatively early period of evolution of these procedures and some refining of the approach is yet to occur. The experience of MITS within the University of Sydney Endocrine Surgical Unit has developed directly from the lateral approach utilized in minimally invasive parathyroidectomy [6, 7, 9]. In our setting the MITS technique is used for the surgical management of solitary thyroid nodules with atypical cytology or follicular lesions in which diagnostic hemi-thyroidectomy is indicated. Solitary toxic nodules also may be treated in this way. We use this technique for single nodules <3 cm in maximum diameter. Previous neck surgery, multinodular change, clinical evidence of thyroiditis, and morbid obesity represent relative contraindications for this type of surgery. The lateral mini-incision approach maintains the principles of capsular dissection and visualization of laryngeal nerves and, therefore, is easily incorporated into the armamentarium of the experienced endocrine surgeon. It has the advantage of not requiring complex instrumentation, which simplifies operative setup and minimizes costs. It continues to establish itself as an attractive alternative to conventional thyroidectomy in a select group of patients, and in our experience has proven to be popular with both patients and referring physicians [10].

This study was designed to review the evidence in relation to MITS in its general evolution during the past 10 years. We examined the utility of the direct lateral mini-incision technique for hemi-thyroidectomy and we examined the experience in our own unit with MITS utilizing a direct lateral mini-incision for the management of small solitary thyroid nodules.

Patients and methods

A search of the U.S. National Library of Medicine database PubMed was performed by using a combination of the following MeSH terms: thyroid, thyroidectomy, incision, minimally invasive, and surgery. This revealed 364 possible articles in which 69 encompassed prospective, comparative studies as well as retrospective cohorts and case studies. Reviews were not included in our search. From this body of literature, we selected for discussion studies that compared minimally invasive surgical techniques with conventional thyroid surgery. Publications were assessed in relation to their levels of evidence based on the Heinrich modification of Sackett's classification [11, 12]. All related articles in the English language were reviewed. Three issues were addressed: 1) Does MITS provide any benefit when compared to conventional open techniques? 2) Is there any advantage to the use of endoscopic or video-assisted techniques compared with the direct mini-incision technique? 3) Is the lateral mini-incision technique safe and efficacious? Additional data were obtained from a retrospective cohort study of consecutive patients undergoing hemi-thyroidectomy within the University of Sydney Endocrine Surgery Unit. The study group comprised all patients undergoing MITS from its introduction in March 2002 until October 2007. The control group comprised all patients undergoing conventional hemi-thyroidectomy during the same time period. Data were obtained through a prospectively maintained surgical database. Information gathered included patient demographics, nodule size, pathology findings, incidence of complications, such as postoperative bleeding and RLN palsy. All patients underwent routine fiberoptic laryngoscopy by an independent ENT surgeon before and after surgery. Techniques used were conventional hemi-thyroidectomy through a 4- to 6-cm incision or MITS through a lateral 2.5-cm incision.

The MITS procedure was performed as previously described [9]. It begins with a small (2.5 cm) lateral incision placed directly over the nodule. A subplatysmal space is developed to allow the skin incision to be moved around the neck and over the relevant area of dissection (Fig. 1).

The anterior border of the sternomastoid muscle is dissected to expose the lateral margin of the strap muscles. The strap muscles are retracted medially and the middle thyroid vein is divided. Dissection down to the prevertebral plane is performed as described for minimally invasive parathyroidectomy [13]. Once the strap muscles are dissected from the thyroid lobe by retracting them medially, the lateral surface of the thyroid gland is in full view. The tracheal surface is identified above and below the isthmus, which is then divided to maximize the mobility of the lobe to be resected (Fig. 2).

The skin incision is then moved in a cephalad direction and attention directed to the upper pole, which is retracted laterally to open up the avascular plane. In >90% of cases, this allows the external branch of the superior laryngeal nerve to be identified (Fig. 3). The upper pole vessels are then divided. Mobilization of the lower pole is undertaken by careful capsular dissection with preservation of the inferior parathyroid gland on its vascular pedicle.

At this stage, the thyroid nodule is delivered through the incision, allowing the critical lateral dissection to be undertaken close to the skin surface. In exactly the same manner as described for open thyroidectomy [14], capsular dissection is continued until the RLN is encountered (Fig. 4). The nerve is then preserved by continuing the mobilization of the gland superiorly and the superior parathyroid is gently dissected away from the thyroid capsule on its vascular pedicle. The ligament of Berry is divided and the thyroid lobe is removed through the small incision. The skin incision is closed by using subcuticular absorbable sutures.

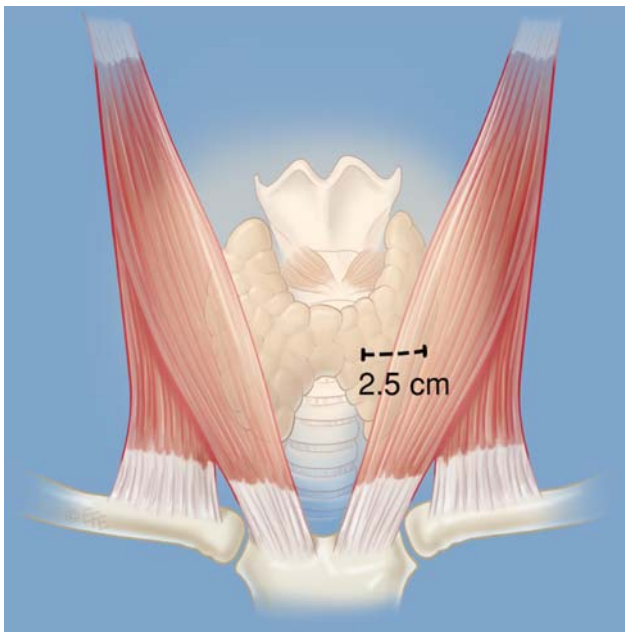

Fig. 1 Positioning of incision for MITS

Data were analyzed by using the STATA 9.0 Statistical Software Program (College Station, TX). Continuous variables were compared by using Student's *t* test. Discreet variables were compared by using Fisher's exact test. The alpha for significance was set at $p < 0.05$.

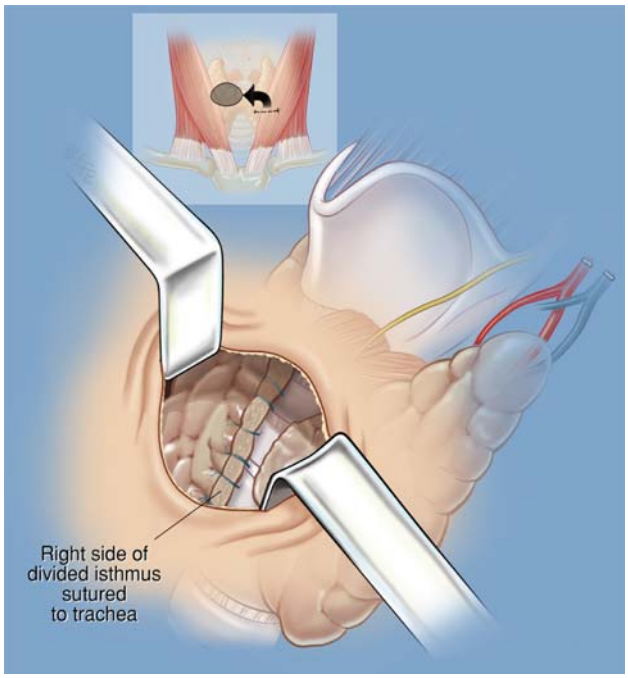

Fig. 2 Division of thyroid isthmus

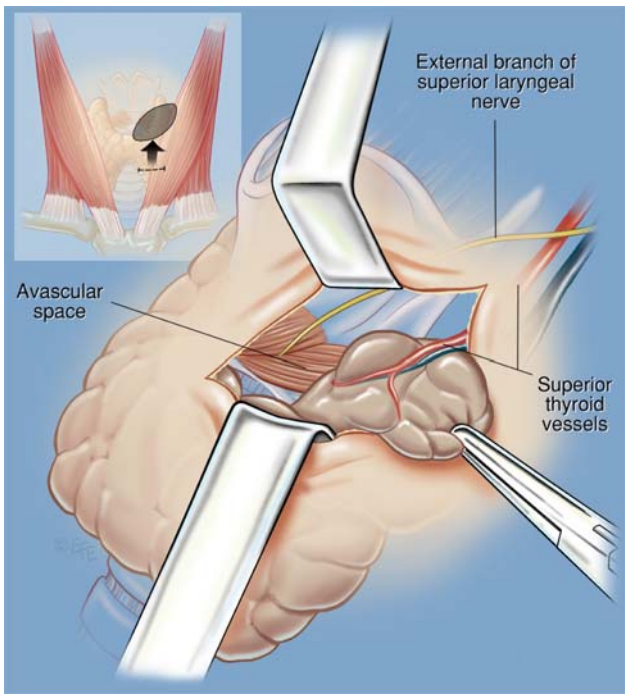

Fig. 3 Dissection of superior thyroid pole and identification of external branch of superior laryngeal nerve

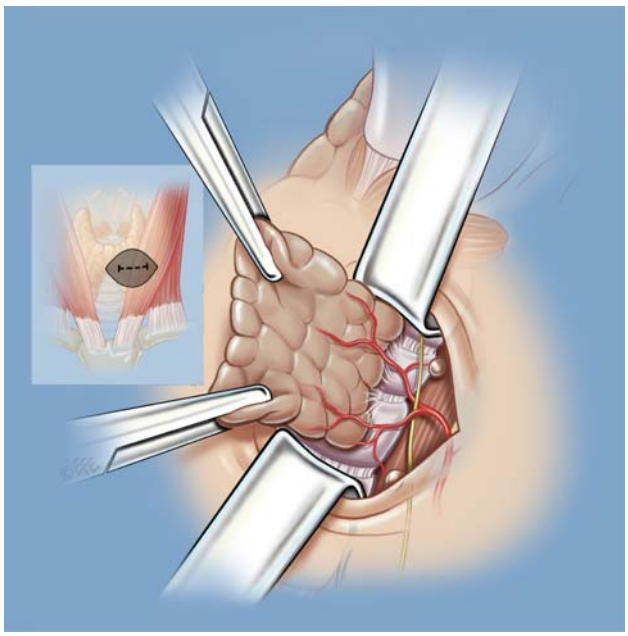

Fig. 4 Lateral dissection and exposure of recurrent laryngeal nerve

Results

Issue 1. Does MITS provide any benefit compared with conventional open hemi-thyroidectomy (YES – RECOMMENDATION B).

Five prospective randomized studies (level II) have directly compared minimally invasive approaches with open thyroid surgery (Table 1). Within the group of randomized studies, all of which used video-assisted techniques and the largest had 111 patients, the outcome measures that were examined included operative complications, length of stay, cosmesis, and pain [15–19]. Both thyroid lobectomy and total extirpation also are included in this group of studies. It was uniformly noted that complications, including recurrent laryngeal nerve injury and postoperative bleeding, were not different between the two techniques. Also commonly noted was that MIVAT patients had significantly less pain and shorter hospital stays than those patients who underwent conventional thyroidectomy [15, 18, 19]. Cosmetic improvements are mentioned in each article; however, we note that there is no consistent measurement given for the length of incision used for conventional thyroidectomy or for the minimally invasive approach. In fact, only one study provided average incision lengths for the MIVAT and conventional thyroidectomy groups at 1.5 vs. 6 cm, respectively. As such it is difficult to draw conclusions between studies. Two of the studies have patient questionnaires that examined cosmesis, both of which significantly favor the shorter incision of the minimally invasive approach. With respect to operative times, there is general agreement that MIVAT was only slightly longer than conventional approaches. Finally, Miccoli et al. [17] and Lombardi et al. [15] assessed the completeness of resection and found it to be similar for open and MIVAT when thyroglobulin and iodine scans were completed.

There were eight nonrandomized studies with prospective or retrospective cohorts that compared MITS or MIVAT to conventional thyroidectomy [10, 20–26]. These range in size from 40 to as many as 957 patients. This group of studies is heterogeneous with some studies examining minimally invasive nonendoscopic thyroiectomy and others comparing video-assisted techniques to conventional thyroidectomy. Regardless of the approach or technology used, the studies agree that minimally invasive approaches do not increase the rate of complications and, generally speaking, there is a decrease in the perception of patient discomfort and quicker recovery times. Although many of the studies comment that the smaller incision is favorable, only one group used a questionnaire to quantify patient perceptions, which indicated that both video-assisted and open minimally invasive approaches were preferred to conventional thyroidectomy [20]. The combined works of all 13 studies suggest that the small investment in operative time with minimally invasive approaches does translate into improved cosmesis, less pain, and quicker recovery without any increase in operative complications. It is important to note that the indications for the use of minimally invasive approaches are overwhelmingly benign in this group of studies and that size restrictions often are applied to MITS that limit its utility in larger nodules or goiters.

Issue 2. Is there any advantage to the use of endoscopic or video-assisted techniques compared with the direct mini-incision technique? (NO ADVANTAGE – RECOMMENDATION B).

Comparisons directly between nonendoscopic, minimally invasive approaches and video-assisted or true endoscopic thyroidectomy are few, and there is only one study that randomly and prospectively compares these techniques (Table 2) [20, 27–29]. Hegazy et al. [28] in a small, randomized trial compared MIVAT to an open MITS by using the Sofferman technique and demonstrated that the MIVAT group had longer operative times and less pain. Questionnaires on patient satisfaction with the incision indicated no difference between the two approaches. The remaining literature, dominated by the prospective cohort of Perigli et al. [20] of 957 patients, has revealed that both approaches are safe and that the MIVAT approach requires longer operative times. This large study also examined patient satisfaction with a numerical score from 1 to 10, which that revealed no differences between the cosmetic results of MIVAT and MITS groups (average incision sizes, 1.7 and 3.1 cm, respectively). The remaining studies

Table 1 Issue 1: Does MITS provide any benefit compared with conventional open hemi-thyroidectomy?

Reference	n	Technique	Outcome	Level of evidence
Lombardi et al. [15]	20	MIVAT vs. CT	Safe with less pain	II
Chao et al. [16]	111	MIVAT vs. CT	Comparable safety	II
Miccoli et al. [17]	33	MIVAT vs. CT	Both techniques achieve complete resection thyroid gland	II
Bellatone et al. [18]	62	MIVAT vs. CT	Safe and less pain with better cosmesis	II
Miccoli et al. [19]	49	MIVAT vs. CT	Safe with less pain and better cosmesis but longer operative time	II

MIVAT minimally invasive video-assisted thyroidectomy; *MITS* minimally invasive thyroidectomy; *CHT* conventional thyroidectomy

confirm the relatively longer MIVAT operative times with the benefit of less pain compared with MIT. Overall, it seems on the basis of a single, small, randomized trial and a larger prospective cohort that MIT and MIVAT provide similar cosmesis but that MIVAT can decrease postoperative pain with the counterpoint that it does require significantly longer time to complete. It is important to note that the video-assisted and open approaches were applied to somewhat different standards because different authors set different limits on thyroid size for the use of each technique. For example Perigli et al. [20] used video-assisted techniques for thyroid nodules <3.5 cm and MIT for lesions 3.5–5 cm. Thus, outcomes for the different techniques are tailored to the gland morphology and must be considered when attempting to compare techniques.

Issue 3. Is the lateral mini-incision technique safe and efficacious? (YES – RECOMMENDATION C).

The lateral approach is a variation of MITS that represents a safe and feasible alternative to open thyroid surgery in selected cases. It is most useful for diagnostic excision biopsy in patients with thyroid nodules demonstrating an atypical cytology on fine-needle biopsy. This approach has been examined in three studies that represent retrospective cohorts (level IV; Table 3). The largest and most recent, Lundgren et al. [30], reviewed more than 200 cases in which the thyroid nodules, <3 cm in size, were removed through an incision <2.5 cm. The safety profile was similar to that seen for a matched group of conventional hemi-thyroidectomies. Patient cosmesis and pain reports were not assessed.

Further data that support the safety and efficacy of the lateral mini-incision approach are presented based on a retrospective cohort study from our own unit. From March 2002 to October 2007, 1281 patients underwent hemi-thyroidectomy within the University of Sydney Endocrine Surgical Unit. Of these, 227 were performed by MITS through a lateral direct 2.5-cm incision approach. The remaining 1054 patients underwent conventional hemi-thyroidectomy using a traditional 4- to 6-cm cervicotomy.

Patients in the MITS cohort were significantly younger than the CHT group (42 vs. 51 years; $p = 0.001$) and had smaller thyroid nodules as measured on final histological assessment (15 vs. 27 mm; $p = 0.028$). Mean operative times were comparable between the two groups. Patient demographics and operative details are summarized in Table 4.

Table 2 Issue 2: Is there any advantage to the use of endoscopic or video-assisted techniques compared with the direct mini-incision technique?

Reference	n	Technique	Outcome	Level of evidence
Perigli et al. [20]	957	MIVAT vs. MIT vs. CT	All safe, less pain and better cosmesis for both MIVAT and MIT vs. CT	III
Del rio et al. [27]	113	MIVAT vs. MIT	MIVAT less painful	III
Hegazy et al. [28]	68	MIVAT vs. MIT	MIVAT longer to complete, less painful and same cosmesis as MIT	II
Terris et al. [29]	48	MIVAT vs. MIT	Comparable safety, MIVAT smaller incision	IV

Table 3 Issue 3: Is the lateral mini-incision technique safe and efficacious?

Reference	n	Technique	Outcome	Level of evidence
Gosnell et al. [10]	25	MITS (2.5-cm lateral incision)	Safe and feasible	IV
Palazzo et al. [24]	50	MITS	Safe and feasible	IV
Lundgren et al. [30]	203	MITS	Safe and feasible	IV

The indications for surgery and histopathology results are summarized in Table 5. The CHT group had a greater proportion of patients undergoing surgery for compressive symptoms compared with the MITS group. This reflects the larger nodule size in the cohort. The MITS group had a greater proportion subject to surgery due to atypical cytological findings that required hemi-thyroidectomy for definitive histological assessment. The incidence of malignancy at final histology was equivalent between the two groups: 16% for MITS and 17% for CHT.

The postoperative complication profiles of the two groups are shown in Table 6. The rate of postoperative wound infection and hematoma requiring return to the operating room for evacuation were equivalent for the two procedures. The MITS group had a higher incidence of temporary vocal cord dysfunction as seen on routine postoperative laryngoscopy. However, there was no difference in the rate of permanent recurrent laryngeal nerve injury, which was 0.4% for MITS and 0.3% for CHT.

Table 4 Comparison of conventional and minimally invasive thyroiectomy

	CHT (n = 1053)	MITS (n = 227)	*p*
Sex			
Male	172 (16.33)	13 (5.72)	
Female	881 (83.66)	214 (94.92)	
Mean age (yr)	50.9 (47.3–54)	42 (38–46)	0.001
Mean nodule size (mm)	26.9 (23.6–30)	15 (11–18)	0.028
Mean incision length (mm)	24 (23.8–24.4)	61 (58–63)	0.0001
Mean operative time (min)	55 (51–59)	49 (43–54)	0.06

Data are number (%) or mean (95% confidence interval) unless otherwise indicated

Table 5 Indications and histopathology

		CHT	%	MITS	%	*p*
Indications	Atypical cytology	428	40.6	180	79.3	<0.001
	Compressive symptoms	254	24.1	17	7.4	<0.001
	Toxic nodule	71	6.7	11	4.8	0.3
	Other	300	28.5	19	8.3	<0.001
Pathology	Thyroid cancer	176	16.7	36	15.8	0.77
	Benign disease	877	83.2	191	84.1	0.8

MITS minimally invasive thyroidectomy; *CHT* conventional thyroidectomy

Table 6 Postoperative complications

	CHT	%	MITS	%	*p*
Temporary hypocalcemia	10	0.94	2	0.88	0.9
Temporary vocal cord dysfunction	17	1.6	9	3.9	0.02
Permanent RLN palsy	3	0.28	1	0.44	0.7
Wound infection	6	0.56	3	1.32	0.21
Reoperation for bleeding	11	1.04	2	0.88	0.83

MITS minimally invasive thyroidectomy; *CHT* conventional thyroidectomy

Discussion

The role and technique of minimally invasive thyroidectomy in nodular thyroid disease continues to evolve, and the fact that no single technique has established itself as being dominant over all others indicates that further refinement is still needed. In this study, we put forward a safe and effective approach to MITS through a 2.5-cm lateral incision and compare surgical outcomes to those of a group undergoing CHT during the same time period.

MITS has been included in the surgical protocols within our unit for the management of unilateral nodular thyroid disease where the index lesion is $\leq$3 cm in maximum diameter. As such, this technique is particularly useful for the management of atypical thyroid nodules or follicular lesions that require further histological assessment. This technique has its origins in minimally invasive parathyroidectomy in which a similar approach is used for the removal of single parathyroid adenomata. Conceptually for us it represents the next logical step after fine-needle aspiration biopsy for evaluation of the indeterminate thyroid nodule with the potential benefits of improved cosmesis, less postoperative pain, and greater patient satisfaction. Having established the safety of the procedure in initial feasibility studies, its wider application into unit protocols has been embraced by our referring endocrinology colleagues and patients [24].

Conventional hemi-thyroidectomy is a well-established procedure with low complication rates, and any new approach would need to demonstrate a similarly low incidence of postoperative problems. Our cohort study demonstrates a higher incidence of temporary vocal cord dysfunction but no difference in permanent recurrent laryngeal nerve palsy. This temporary difference may be a reflection of a learning curve phenomenon because the cases of temporary dysfunction occurred early in the experience. Nevertheless, the principles of capsular dissection routine encountering and identification of the recurrent laryngeal nerve hold true for the minimally invasive procedure and CHT and seem to translate into equivalent long-term outcomes in terms of nerve function. Similarly, the incidence of wound problems in terms of infection and hematoma formation are equivalent between the techniques.

A range of MITS techniques are currently in evolution and a number of international centers have promoted their favored approaches [5, 10, 25]. The axillary and transmammary approaches are certainly novel and have merit in that they achieve thyroidectomy with no neck scar [5]; however, they do create a more extensive plane of dissection, require more complex instrumentation and set up, and at this point seem to have significantly longer operative times. These approaches will continue to be evaluated by their proponents; however, at this stage it is difficult to recommend them for widespread use.

Video-assisted thyroidectomy has been shown to be feasible and safe in a selected group of patients with superior cosmesis [19]; however, it also suffers from the need for more complex instrumentation and likely has a steeper learning curve due to the significant differences from the traditional open approach. The technique put forward by Terris et al. [23] describes the combination of strap muscle transection and videoendoscopic assistance to achieve a minimally invasive approach. Although the videoendoscopic technique offers some potential advantages in terms of magnification, the incision length of almost 5 cm described by the authors cannot be considered minimally invasive and would be considered a standard incision length in many institutions.

In contrast to the techniques described above, MITS through a lateral 2.5-cm incision offers a direct approach to the thyroid lobe without the need for complex videoendoscopic instrumentation. We use small retractors, headlight illumination, and liberal subplatysmal mobilization of skin flaps to move the incision over the critical part of the operation. Because the principal steps of the procedure mirror those of our approach in open thyroidectomy, we believe this to be a reasonably straight forward technique to learn. Surgeons familiar with the concepts of lobe mobilization and capsular dissection can easily apply the minimally invasive approach with a few modifications. In particular, we have found the early division of the thyroid isthmus to be an important step in increasing the mobility of the thyroid lobe and allow progress to the critical dissection of the recurrent laryngeal nerve and superior parathyroid gland in the region of the ligament of Berry. The incision placed over the thyroid nodule also allows excellent visualization of the upper pole making the identification and preservation of the external branch of the superior laryngeal nerve straight forward. This direct approach has the potential to minimize operative costs and in our hands has resulted in operative times that are comparable between MITS and CHT.

MITS through a lateral incision is now the procedure of choice for thyroid nodules that measure $\leq$3 cm in our unit with atypical cytology on fine-needle biopsy [24]. The technique also is applicable to solitary toxic thyroid nodules and offers an attractive alternative to radioiodine ablation in this setting. Although the benchmark parameters of permanent recurrent laryngeal nerve palsy and postoperative hemorrhage have been shown to be equivalent between CHT and MITS in this nonrandomized cohort, it remains to be seen whether the technique offers real benefits in terms of pain, tissue trauma, and patient satisfaction. These outcomes need to be measured in a randomized trial to avoid the selection bias that is inherent in retrospective studies.

Conclusion

Minimally invasive thyroid surgery using a direct lateral 2.5-cm incision for the management of small thyroid nodules can be performed with an equivalent postoperative complication rate to traditional hemi-thyroidectomy using a standard cervicotomy.

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