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Minimally invasive video-assisted thyroidectomy: experience of 300 cases

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Abstract

Background We report on patients selected for minimally invasive video-assisted thyroidectomy (MIVAT) over a 3-year period and evaluate the feasibility and effects of this procedure.

Methods Between March 2005 and August 2008, 300 patients (36 male, 264 female; mean age = 54.6 years) underwent MIVAT using a single central incision with an average length of 2 cm (range = 1.5–3 cm), about 2 cm above the sternal notch. Small conventional retractors and dissectors, ultrasonic scalpel, 5-mm laparoscope, and a video screen were the instruments used.

Results General anesthesia was used in 295 patients and regional block anesthesia in 5. MIVAT was performed successfully in 280 patients (93.3%). Conversion to open thyroidectomy with a 4-cm-long incision was required to achieve selective lymphadenectomy in 18 patients after frozen sections demonstrated differentiated thyroid carcinoma. Only two patients with benign thyroid nodules were converted because of large volume or massive hemorrhage from the upper pole vessels. Mean operative time was 35 min (range = 20–70 min) for unilateral lobectomy and 58 min (35–90 min) for bilateral thyroidectomy. No patients had wound infections, postoperative bleeding that required reoperation, permanent hypoparathyroidism, or bilateral recurrent laryngeal nerve palsy. However, permanent unilateral recurrent laryngeal nerve palsy appeared in five cases (1.7%), transient unilateral recurrent laryngeal nerve palsy in seven (2.3%), superior laryngeal nerve injury in five (1.7%), transient hypocalcemia in nine (3.0%), and mild skin burn from the ultrasonic scalpel in five (1.7%). Postoperative pain was minimal and better cosmetic results were obtained than conventional open thyroidectomy. Postoperative stay was shorter than with conventional open thyroidectomy.

Conclusions MIVAT appears to be safe and feasible in patients with benign thyroid nodules, with minimal injury and excellent cosmetic results. Furthermore, after properly lengthening the skin incision, MIVAT can be used for patients with large benign thyroid nodules or even early–stage differentiated thyroid carcinoma.

Keywords Minimally invasive surgery · Thyroidectomy · Video-assisted thyroid surgery

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Conventional open thyroidectomy is an effective, well-tolerated, and safe procedure. However, the procedure usually requires a 6–10-cm long transverse cervical incision. Scars in the front neck region are sometimes prominent and may even result in discomfort when swallowing. Nowadays, postoperative cosmetic appearance has become increasingly important in thyroid surgery, especially for young female patients. It therefore is necessary to develop endoscopic or minimally invasive techniques for operating on the thyroid. A reduction in the length or even the absence of the cervical incision is particularly appealing.

The first endoscopic parathyroidectomy was performed by Gagner in 1996 [1] and good clinical and cosmetic results were achieved. Since then, several surgeons have reported their experiences with endoscopic techniques in thyroid surgery, including minimally invasive video-assisted thyroidectomy (MIVAT) [2] using breast [3–5], anterior chest [6–9], and axillary [10–15] approaches. More recently, a transoral access approach has been proposed and tested successfully in human cadavers and live pigs [16]. Nevertheless, among the novel surgical approaches that have been described over the past decade, MIVAT has proved to be one of the most widely used techniques in Europe and Asia. As thyroid disease is more common in younger women, a smaller incision also has obvious cosmetic appeal.

Several authors have demonstrated that MIVAT is a safe and feasible procedure with additional advantages with respect to cosmetic results, hospitalization, and postoperative outcome. In our department, MIVAT was developed in 2004 and since then about 300 operations have been performed. The primary objective of this study was to summarize the safety and feasibility of MIVAT performed in our hospital.

Materials and methods

Patients

From February 2005 to August 2008, 300 patients (36 male, 264 female; mean age = 54.6 years, range = 23–71 years) were selected for MIVAT. Eligibility criteria were a thyroid nodule with a maximum diameter of 35 mm, ultrasound-estimated thyroid volume less than 30 ml, absence of radiation in the cervical area, and absence of suspected metastatic enlargement of cervical lymph nodes on ultrasound scanning. After an adequate learning curve (first 50 cases), a properly skin incision length broadens the selection criteria significantly. This means that the following conditions are no longer absolute contraindications for MIVAT (Table 1): thyroiditis, previous thyroid surgery, large benign nodules up to 6 cm in diameter, and small (<2 cm) papillary thyroid carcinoma (PTC) without enlarged lymph nodes, all demonstrated preoperatively.

Table 1 Indications and contraindications for our MIVAT

Indications	Contraindications	
	Absolute	Relative
Thyroid nodule largest diameter <3.5 cm	Medullary or previous thyroid surgery undifferentiated carcinoma	
Thyroid estimated volume <30 ml	Lymph node metastases	Thyroiditis
Low-risk differentiated carcinoma	Previous neck irradiation	Thyroid nodule largest diameter <6.0 cm

MIVAT minimally invasive video-assisted thyroidectomy

All our patients were investigated with ultrasonography for the localization of thyroid lesions before surgery. Preoperative informed consent was obtained from all patients. All patients, with a lesion that was greater than 4 cm in diameter or suspected malignant nodules, underwent preoperative evaluation which included measurement of hormone serum levels, computed tomography (CT), and fine-needle aspiration cytology (FNAC). If the results of two ultrasonography examinations by different senior ultrasound physicians were not consistent, cervical CT was performed. After surgery, all patients underwent laryngoscopy, to assess the mobility of the vocal chords, and cervical ultrasound scanning. Patients who underwent bilateral thyroidectomy were given tests for blood calcium and parathyroid hormone levels on the first and second postoperative day, and patients with abnormal results were reexamined 1, 3, and 6 months later.

Cosmetic results were evaluated by all the patients using both a numerical and a verbal response scale. The numeric scale ranged from 0 (worst) to 10 (best). The verbal response scale had four options: 1 (poor), 2 (acceptable), 3 (good), and 4 (excellent). All the patients were asked to grade the cosmetic appearance of their wound and complaints about the neck region 1 month after surgery.

Surgical technique

The procedure typically was performed under general anesthesia with endotracheal intubation, but it can also be performed under regional cervical block anesthesia if the patient desires. Three or four surgeons are involved: an operator, one surgeon holding the endoscope, and one or two assistants holding the retractors. All procedures were performed by the same surgeon.

All patients were placed in the supine position with the neck slightly extended. The skin was protected by means of a sterile film (Fig. 1). MIVAT was accomplished by means of a median single incision of 1.5–3.0 cm on an obvious or

Fig. 1 Skin protected by means of a sterile film

Fig. 2 Surgical instruments and ultrasonic scalpel

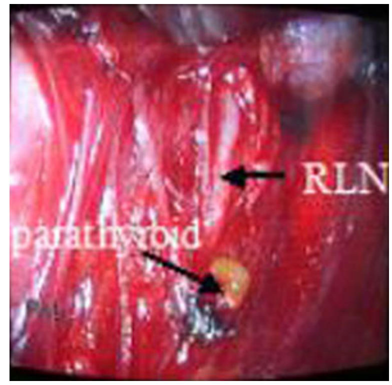

Fig. 4 Magnified view of parathyroid gland and RLN on video screen

occult skin crease, across the anterior neck, about 2 cm above the sternal notch. The incision site could be changed according to the length of the neck and the location of the thyroid lesions. Because of the limitation of the surgical space, the technique was performed with small instruments and an ultrasonic scalpel (Ethicon Endo-Surgery Inc., Cincinnati, OH, USA) (Fig. 2). Video assistance was obtained using a 5-mm 30° endoscope.

At the first stage of this surgical technique, after the platysma was separated and the cervical linea alba was cut longitudinally for about 3 cm, the thyroid lobe was dissected carefully from the strap muscles under endoscopic visualization. Gas insufflation was not needed; the operative space was maintained by tiny retractors that were used to retract the thyroid medially and the strap muscles laterally. A 5-mm 30° endoscope and the surgical instruments were inserted through the single skin incision. With endoscopic lighting, magnification, and on-screen monitoring, tiny dissection clamps and an ultrasonic scalpel were used to operate. Endoscopic magnification made it easier to identify clearly the thyroid lesions, trachea, carotid artery, jugular vein, laryngeal nerves, parathyroid glands (Figs. 3 and 4), and the esophagus.

The middle thyroid vein and the upper and lower pole vessels were dissected with the ultrasonic scalpel. The external branch of the superior laryngeal nerve (SLN) was identified if possible and avoided before dividing the superior pole vessels. The ultrasonic scalpel maintained adequate tension and clamp force when dissecting the vessels and tissues. Then, the traction of the lobe was oriented medially to expose the tracheal-esophageal groove. The recurrent laryngeal nerve (RLN) usually is visualized and dissected where it crosses the inferior thyroid artery and then pushed away from the thyroid lobe under video-endoscopic magnification (Figs. 3 and 4). The inactive blade of the ultrasonic scalpel should be kept at a distance of at least 3 cm from the RLNs. In the case of partial or subtotal lobectomy, the RLNs need not be exposed routinely.

In the second stage, the freed thyroid lobe was extracted through the skin incision (Fig. 5). Under direct vision, the back of the thyroid lobe was dissected completely with the ultrasonic scalpel (Fig. 6). If subtotal lobectomy was performed, the stump of the thyroid usually could not be sutured with resorbable stitches. This procedure was repeated on the contralateral side if bilateral thyroidectomy

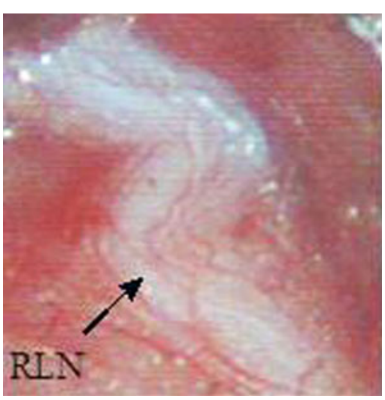

Fig. 3 Magnified view of RLN on video screen

Fig. 5 Thyroid lobe extracted through the skin incision

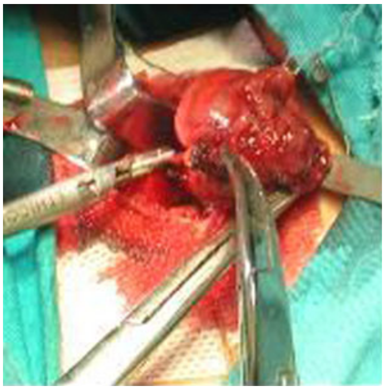

Fig. 6 Resection of thyroid lesion with ultrasonic scalpel

was indicated. Resected specimens were sent for intraoperative quick frozen-section examination. If this showed that the lesion was benign, the thyroid bed was irrigated with normal sodium chlorine solution to check for any bleeding. If blood was still oozing from the residual thyroid tissues, ultrasonic scalpel or resorbable stitches were used for hemostasis. After confirming the hemostasis, the cervical linea alba and the platysma were sutured in an interrupted manner with resorbable sutures, and the skin was closed by subcuticular suturing or skin sealant. Drainage was usually used for patients who underwent bilateral thyroidectomy. The drains were removed 24–48 h after surgery.

Results

General anesthesia was used in 295 patients and regional block anesthesia in five. The procedure was successful in 280 patients (93.3%), and only 2 patients (0.7%) with benign thyroid nodules were converted to open surgery. The nodules proved to be too large for the endoscopic technique in one case, and there was massive hemorrhage from the vessels of the upper peduncle in another case. Conversion to open thyroidectomy with a 4-cm-long incision was required for selective lymphadenectomy in 18 cases (6.0%) after frozen sections revealed differentiated thyroid carcinoma. One hundred eighteen patients underwent bilateral thyroidectomy and 182 underwent lobectomy. Mean operative time was 35 min (range = 20–70 min) for unilateral lobectomy and 58 min (35–90 min) for bilateral thyroidectomy.

Thyroid nodules ranged from 0.5 to 6.0 cm in diameter. Mean thyroid nodule size was 2.5 cm in diameter. Pathology revealed the following: benign multinodular goiter (33.3%), follicular adenoma (54.7%), carcinoma (6.0%), Hashimoto's thyroiditis (1.7%), subacute thyroiditis (2%), diffuse hyperplasia (1.7%) and others (0.9%). None of the patients had wound infections, postoperative bleeding that required reoperation, permanent hypoparathyroidism, or bilateral RLN palsy. However, operative complications included permanent unilateral RLN palsy in five cases (1.7%), transient unilateral RLN palsy in seven (2.3%), SLN injury in five (1.7%), transient hypoparathyroidism in nine (3.0%), and mild skin burn from the ultrasonic scalpel in five (1.7%) (Table 2). Postoperative pain was minimal in all patients who underwent MIVAT. In patients with PTC, no metastases were found at final histological examination. No evidence of recurrence was found at follow-up. Most patients considered the cosmetic outcome excellent, and five patients considered it acceptable because of mild skin burn. The mean postoperative stay was 2.5 days (range = 1–5 days), which was significantly shorter than that of conventional open thyroidectomy (mean = 3–5 days) in our country. Mean follow-up was 12 months

Table 2 Patient and thyroid disease characteristics

Characteristic	No.	%
Age (years)		
Mean age	54.6	
Range	23-71	
Sex		
Male	36	12
Female	264	88
Anesthesia		
General	295	98.3
Regional block	5	1.7
MIVAT procedure		
Unilateral lobectomy	182	60.7
Mean operative time (min)	35 (range = 20-70)	
Bilateral thyroidectomy	118	
Mean operative time (min)	58 (range = 35-90)	
Selective lymphadenectomy	18	6
Conversion to open thyroidectomy	2	0.7
Thyroid pathology		
Benign	282	94
Malignant	18	6
Complications		
Postoperative bleeding	None	0
Wound infections	None	0
Permanent	None	0
Hypoparathyroidism		
Transient hypoparathyroidism	9	3.0
Permanent bilateral RLN palsy	5	1.7
Transient unilateral RLN palsy	7	2.3
Transient SLN palsy	5	1.7
A slight skin burn	5	1.7

RLN recurrent laryngeal nerve, *SLN* superior laryngeal nerve

Fig. 7 Cervical incision on postoperative day 3

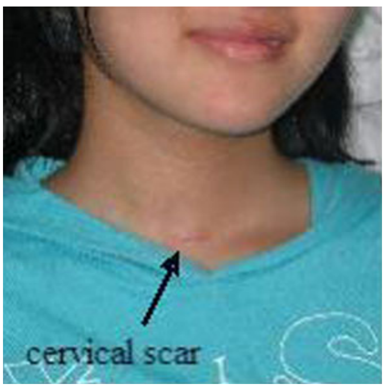

Fig. 8 Cervical scar 1 month later

(range = 6–36 months). Patients who underwent MIVAT were more satisfied with the cosmetic results (Figs. 7 and 8).

Discussion

Conventional thyroid surgical techniques, introduced 100 years ago, continue to be applied widely in endocrine surgery. A significant improvement in endoscopic instrumentation has allowed for the development of minimally invasive operations. The MIVAT technique, however, was originally introduced by Miccoli et al. in 1998, and then increasingly adopted by several other centers worldwide, especially in Europe [17–19].

Interest in the application of the MIVAT procedure in thyroid surgery has increased greatly in recent years. However, postoperative morbidity is still a major concern in modern thyroid surgery. Bleeding, hypoparathyroidism, and laryngeal nerve damage are the complications most feared by patients and surgeons. However, large series of clinical comparative studies have demonstrated that this technique is safe and feasible, with an incidence of postoperative complications similar to that of conventional surgery [20–22]. With endoscopic visualization and magnification, important structures are easily identified through a small incision. The rate of complications was lower than conventional open thyroidectomy in our department. Definite unilateral RLN palsy was observed in only five cases.

After an adequate learning period, the selection criteria can be broadened [23]. It is well known that contraindications for MIVAT include thyroiditis, previous thyroid surgery, or large nodules, but we have been able to perform the MIVAT procedure smoothly on patients with thyroiditis ($n = 11$) and previous thyroid surgery ($n = 7$).

Obviously, thyroid nodule size and thyroid volume are the most important limiting factors for MIVAT because the surgical working space of by the technique is rather limited. So far, the procedure generally is selected for patients with a thyroid volume less than 25 ml [24, 25] or less than 30 ml [26–28], with a skin incision up to a maximum of 30 mm. Ruggieri et al. [29] have reported that the procedure also can be performed smoothly in patients with a thyroid nodule of 25–50 ml in volume. As our experience with MIVAT increases, an expanded set of indications makes this procedure available to a broader population of patients. In our department, this technique is used almost routinely for benign thyroid tumors 40 mm or smaller in diameter. For patients with a large thyroid cystic nodule, liquid is first extracted with a syringe to reduce the volume, and then lesions are conveniently dissected and resected. If the thyroid solid nodule is larger than 40 mm in maximum diameter, FNAC is used. If FNAC reveals a large benign nodule, we may resect the lesions by divided blocks (range = 2–4) through MIVAT. One or two parts of the large thyroid nodule are resected easily with the ultrasonic scalpel, and an adequate working space can be achieved for the complete removal of the remaining thyroid lesion.

In our department, 90% of thyroidectomies for benign nodules are accomplished by the MIVAT technique performed by the same experienced surgeon. Furthermore, the MIVAT technique is also suitable for more demanding operations such as total thyroidectomy for low-risk thyroid carcinoma [30, 31]. However, the use MIVAT for thyroid malignancy is still somewhat controversial with respect to whether the thyroid resection is as complete as that of a conventional open approach. Some surgeons feel that thyroid malignancy is a contraindication for this technique because of concern with potential tumor spillage [32]. However, Lombardi et al. [33] confirmed recently MIVAT is safe, with no additional risk of thyroid capsule rupture and thyroid cell seeding, when performed correctly. Miccoli et al. [34] have shown that thyroglobulin serum levels and radioactive iodine uptake after video-assisted thyroidectomy are not significantly different from those in patients treated by open surgery, and they regard that thyroid resection for PTC with MIVAT is complete. If fast frozen-section examination revealed differentiated thyroid carcinoma, the procedure can be converted to open thyroidectomy with a 4-cm-long incision.

Complete lymph node dissection of the central compartment can be performed easily under direct vision. Recently, minimally invasive video-assisted lateral lymphadenectomy (MIVALL) has been reported on by Miccoli et al. [35]. The MIVALL technique is based on two access routes. The first main access, the same as that used for MIVAT, is for dissecting under deep specially-made retractors. The second incision (5–7 mm long), for insertion of the endoscope, is made along the posterior border of the sternocleidomastoid muscle at the median level.

The potential advantage of endoscopic techniques is the better surgical image provided by the endoscope. The endoscope offers not only perfect lighting in a confined space, but also a magnified anatomical view of the tissues. We should pay close attention to the security of the RLN. The RLN need not be exposed in subtotal lobectomy, whereas routine identification of the nerve is necessary in total lobectomy. Canbaz et al. [36] have reported that routine identification of the RLN in total thyroidectomy reduces the rate of injury to the RLN. In our MIVAT series, only five patients suffered from permanent unilateral RLN palsy and seven from transient palsy. The low incidence of RLN injury may have been the result of avoiding the spread of heat produced by the ultrasonic scalpel when dissecting and cutting. Some surgeons have reported that thermal spread is limited to 2.2 mm beyond the tissue grasped within the forceps of the ultrasonic scalpel [37, 38]. Therefore, we propose that some maneuvers help to reduce the incidence of thermal nerve injury. It is always preferable to keep the active blade of the ultrasonic scalpel facing the RLN. The forceps of the ultrasonic scalpel should deviate from the RLN by at least 3 mm. The blades of the ultrasonic scalpel should be frequently washed with cool water or scrubbed with a wet pledget.

The thyroid gland has one of the richest blood supplies among the organs. As a result of its complex anatomy, adequate hemostasis and keeping the operative field dry is of great importance to avoid damage to the SLN and RLN and parathyroid glands in the vicinity of the thyroid gland. Intraoperative blood loss usually is minimal because the ultrasonic scalpel emits high-frequency mechanical energy and causes proteins to denature, which allows complete hemostasis of the thyroid tissue or vessels, obviating knot tying or suturing in the limited surgical space. Therefore, utilization of the ultrasonic scalpel has simplified the operative procedure.

The forceps of the ultrasonic scalpel should not be held with too much tension and clamp force when dissecting tissues or vessels. For the transection of the vessels of the superior or inferior poles of the thyroid, we first expose the vessels carefully by bluntly dissecting the surrounding tissue. The proximal parts of the vessels are coagulated by the ultrasonic scalpel. The distal part, after coagulation, also should be cut completely by the ultrasonic scalpel. The incompletely dissected vessel may cause massive hemorrhage. Although there is some concern about using the ultrasonic scalpel for the thyroid artery, many studies have demonstrated its safe and efficient use for this vessel [39, 40]. In the initial period of our study, only one MIVAT procedure was converted to open surgery because of massive hemorrhage from the vessels of the upper peduncles. None of our patients had postoperative bleeding that required reoperation. This was the result of the correct application of the ultrasonic scalpel, with on-screen monitoring by the endoscope.

Some randomized studies have demonstrated a significant reduction in the operating time of conventional thyroidectomy using an ultrasonic scalpel instead of the conventional clip–ligature technique [41–44]. As shown in a randomized study [45], the ultrasonic scalpel in the MIVAT procedure is safe and facilitates dissection, which also significantly decreases operative time, and the incidence of postoperative morbidity did not differ significantly between the group in which the ultrasonic scalpel was used and the group in which it was not used. In the initial period, the operative time of MIVAT was probably longer than that of conventional thyroidectomy, but with increasing experience and advances in surgical instruments it is clear that it decreased significantly. Miccoli et al. [46] have reported that the mean operative time for 421 lobectomies was 32.3 min, and for 899 total thyroidectomies it was 44.1 min. The mean operative times of MIVAT for unilateral lobectomy (35 min) and bilateral thyroidectomy (58 min) in our study were shorter than that of conventional thyroidectomy; this is due mainly to quick dissection and complete hemostasis by the ultrasonic scalpel, in addition to the small incision and skin flap.

Compared with conventional thyroidectomy, the potential advantages of this technique include magnification of the cervical anatomy, less postoperative pain correlated with neck position (the neck is not hyperextended on the operating table as in conventional thyroidectomy), less discomfort while swallowing, reduced hospital stay, and improved cosmesis, while the complication rate for MIVAT does not show any increase [22]. Among these factors, the cosmetic concern has been appreciated most widely by patients and doctors. In fact, although the length of the incision has been reduced in conventional surgery, there is still a significant difference between a scar of 2 cm and one of at least 5–6 cm. Injury is not great in conventional thyroidectomy; therefore, we think that MIVAT is a cosmetic rather than a minimally invasive surgical technique. In our study, most young and even old patients who underwent MIVAT were satisfied with their cosmetic outcome, and only five patients considered it acceptable because of a mild skin burn. For the long-term follow-up of MIVAT, the application of minimally invasive techniques for thyroid surgery attempt to improve cosmetic results.

To avoid a cervical scar, the incision has been shifted to the anterior thoracic wall or axilla, which is covered by clothing. Excellent aesthetic appearance thus results from pure endoscopic thyroidectomy. However, demanding endoscopic skills and establishment of an artificial working space are needed for pure endoscopic thyroidectomy. Use of the term minimally invasive in the context of thoracic/breast or axillary access has been controversial. Compared with this pure endoscopic thyroidectomy, the MIVAT technique permits the operator to touch the thyroid lesions directly with his/her fingers and determine the operative range. In addition, there is less postoperative pain as a result of avoiding access trauma caused by extensive subcutaneous dissection to create a working space. Also, with MIVAT one can avoid the complications related to insufflation with CO_2. Most importantly, it is easy to convert to conventional surgery in cases of massive bleeding or malignancy by enlarging the cervical incision. Central or lateral lymphadenectomy is rather difficult to accomplish using thoracic/breast or axillary access; therefore, a suspected malignant thyroid nodule is one of our contraindications for pure endoscopic thyroidectomy. In our department, pure endoscopic thyroidectomy is indicated for young patients (usually younger than 40 years old) with benign thyroid nodules or for patients who demand cervical cosmesis. This is why the number of MIVAT procedures is much higher than that of pure endoscopic thyroidectomy in our department or in other studies. Like conventional thyroidectomy, nevertheless, the MIVAT procedure still produces slight cervical hypoesthesia, paresthesia, and swallowing discomfort, which can be avoided by pure endoscopic thyroidectomy through thoracic/breast or axillary access.

MIVAT depends mainly on the surgeon's experience with conventional open thyroidectomy and some endoscopic skills. Theoretically, MIVAT can be learned easily by skilled endocrine surgeons. Conversely, other endoscopic techniques are more technically demanding and may be more difficult to learn. MIVAT is associated with an initial increase in operating time at the beginning of the learning curve. As our experience has increased, the operative time has diminished.

Conclusions

Our experience demonstrates that the MIVAT technique appears to be safe and feasible to treat patients with benign thyroid nodules, with minimal injury, shorter operative time, lower complications, and significant cosmetic results. A lot of conventional thyroidectomy experience and endoscopy and ultrasonic scalpel skills are needed by surgeons to perform MIVAT. Furthermore, after properly lengthening the cervical skin incision, MIVAT also can be performed in patients with large benign thyroid nodules or even low-risk differentiated thyroid carcinoma.

Disclosure Drs. Y. Fan, B. Guo, S. Guo, J. Kang, B. Wu, P. Zhang, and Q. Zheng have no conflicts of interest or financial ties to disclose.

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