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Review

Minimally Invasive Video-Assisted Thyroidectomy (MIVAT) in western world: A systematic review from 2015 to 2022

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Abstract. *Background and aim:* Since its first description Minimally Invasive Video-Assisted Thyroidectomy (MIVAT) has spread especially in Western Countries, and it has arisen as a feasible and safe treatment in selected patients undergoing lobectomy or total thyroidectomy. Our review aimed to collect all the studies published in Western Countries (Europe and America) from 2015 to 2022 to evaluate the outcomes and complication rates of the MIVAT technique. *Methods:* The search terms were "mininvasive thyroidectomy", "video-assisted thyroidectomy", "mini-invasive thyroidectomy", "minimally invasive thyroidectomy", "MIVAT", and "endoscopic thyroidectomy". Studies were selected according to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) parameters and enrolled respecting pre-established inclusion and exclusion criteria. *Results:* Out of 552 screened studies, 4 retrospective observational articles and 4 prospective observational studies were considered suitable. The total number of patients was 4489. The complication rate of MIVAT was low and comparable with the complication rate of conventional thyroidectomy described in literature. *Conclusions*: In conclusion, MIVAT is a well-established technique in Continental Europe and North America, with a good safety profile and low invasiveness; further studies are needed to evaluate the subjective aesthetic results of this technique. (www.actabiomedica.it)

Key words: mininvasive thyroidectomy, video-assisted thyroidectomy, MIVAT, endoscopic thyroidectomy

Introduction

Since Miccoli (1) in the late 1990s first proposed an endoscopic minimally invasive approach to small-volume thyroid pathology, MIVAT rapidly gained worldwide acceptance.

This minimally invasive technique offers the advantage of a smaller incision compared to conventional thyroidectomy, alongside a magnified vision provided by the endoscope, that is proven to facilitate the visualization of fundamental anatomic structures, namely the recurrent laryngeal nerve (RLN), the parathyroid glands and the external branch of the superior laryngeal nerve (ESBLN) (2,3)

In addition, a nerve-sparing approach via intraoperative neuro-monitoring can be easily integrated with this procedure (4).

At first, MIVAT was received with some scepticism and limited to the treatment of benign thyroid nodules, but over the years several multicenter studies demonstrated MIVAT's oncologic safety and radicality in low- and intermediate-risk well-differentiated thyroid cancer when selection criteria were met properly (5,6).

Despite the diffusion of remote access techniques, especially in Eastern Countries, where the social burden of neck scars is way higher than in the West, MIVAT still maintains its popularity as it remains a

truly minimally invasive approach with operative time, costs and complications rate comparable to standard open thyroidectomy (7,8).

The limit of MIVAT technique is represented by its strict inclusion criteria, which are often difficult to meet especially in endemic goiter regions. However, some features, such as larger nodule volume and thyroiditis, initially identified as incompatible with a minimally invasive approach are now considered suitable for the MIVAT procedure (7,9,10).

MIVAT safety and feasibility profiles have been extensively investigated in the last 20 years. Our systematic review aims to analyze studies performed from 2015 to 2022 to gain a more recent view of MIVAT evolution, after the learning curve phase. We also selected articles published in the Western world, where MIVAT remains a well-established and standardized procedure, to obtain more relatable results for our daily practice.

Methodology

Our systematic review was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline.

No institutional ethical board statement was needed.

Search strategy

Two reviewers (FC and FdG) independently consulted the Pubmed database for prospective and retrospective articles published between 2015 and 2022 concerning the results of the MIVAT procedure. The search terms were "mininvasive thyroidectomy", "video-assisted thyroidectomy", "mini-invasive thyroidectomy", "minimally invasive thyroidectomy", "MIVAT", and "endoscopic thyroidectomy". In the case of successive articles from the same author, we included only the article with the largest sample size to avoid an overlap in the patient pool. Boolean logic was used to combine the keywords. Related articles and reference lists were searched to avoid omission.

We decided to perform a systematic review rather than a meta-analysis to avoid biases associated with the heterogeneity of the studies designs and data collection.

Study selection and inclusion criteria

The following inclusion criteria were adopted: Studies concerning MIVAT or comparing MIVAT to conventional open thyroidectomy; studies concerning benign or malignant thyroid pathology; studies published in English, Studies with full texts, randomized clinical trials, controlled clinical trials, retrospective and prospective observational studies, studies developed in Europe and North America.

Exclusion criteria

We excluded from our review: conference presentations, letters to the editor, editorials, commentaries, case reports, publications in other languages apart from English, lack of relevant data or insufficient data, studies concerning lymph node dissection or parathyroidectomy as a primary objective, study population less than 15, studies conducted outside of Europe or America, studies involving pediatric population, studies on cadaver or animal models. Previous reviews and metanalysis were considered during the discussion but not for data extraction.

Data extraction

Data from the included studies were extracted by two reviewers separately (FC and FdG) in predetermined extraction forms. The descriptive data noted were article title, year of publication, nation of publication, study design, and sample size. Quantitative data collected were the number of total thyroidectomies versus lobohystmusectomies, operative time, duration of hospital stay, duration of follow-up, laryngeal nerve palsies (transient and definitive), hypocalcemia (transient and definitive), post-operative hemorrhage, nodule size, gland volume.

Results

We identified 552 studies published between 2015 and 2022 during the initial search. Titles and abstracts screening identified 386 irrelevant studies, 43 reviews and/or metanalysis, and 42 articles published

not in English, that were excluded from our analysis. The remaining 79 articles were selected for full-text assessment. Among these, 36 studies did not include MIVAT technique, 7 studies were not selected because of the absence of data requested by our review and 23 studies didn't meet the selection criteria. 5 studies were excluded to avoid overlapping of patient pool with the selected studies. We finally included 4 retrospective observational studies (11-14) and 4 prospective observational studies (15-18) (Figure 1) (Table 1). There was a total of 4489 patients undergoing MIVAT. The endpoints differ from one study to another, but we mainly focused on the rate of more common complications (hemorrhage, recurrent laryngeal nerve damage and hypoparathyroidism) and secondly on the duration of surgery, duration of hospital stay and nodule size.

Most of the authors performed the MIVAT procedure as originally described by Miccoli, with slight differences in the position of the neck incision (13), or in the choice of ultrasonic devices for dissection. Frank and his colleagues, however, described an extended neck incision of 3.46 +/- 0.69 cm (11). Four studies (12-14,18) included also total thyroidectomies with central neck dissection.

Methods for assessment of laryngeal palsy were quite heterogeneous, from performing laryngoscopy on all thyroidectomy patients in the recovery room (18) to vocal fold examination only in the event of dysphonia.

Transient recurrent laryngeal palsy rates ranged from 1.5% (12) to 9.6% recorded by Frank et. Al. (11), even though in this study only in 7.3% of cases palsy was confirmed by laryngoscopy.

Concerning permanent vocal fold palsy, the highest incidence was registered in the large series published by Miccoli (1.4%), with no mention of transient palsy incidence (14); this result is superimposable to conventional thyroidectomy, and it also considers thyroidectomies with central neck dissection.

Incidence of transient hypoparathyroidism ranged from 2.3% reported by Duke (18) to 29.6% in the

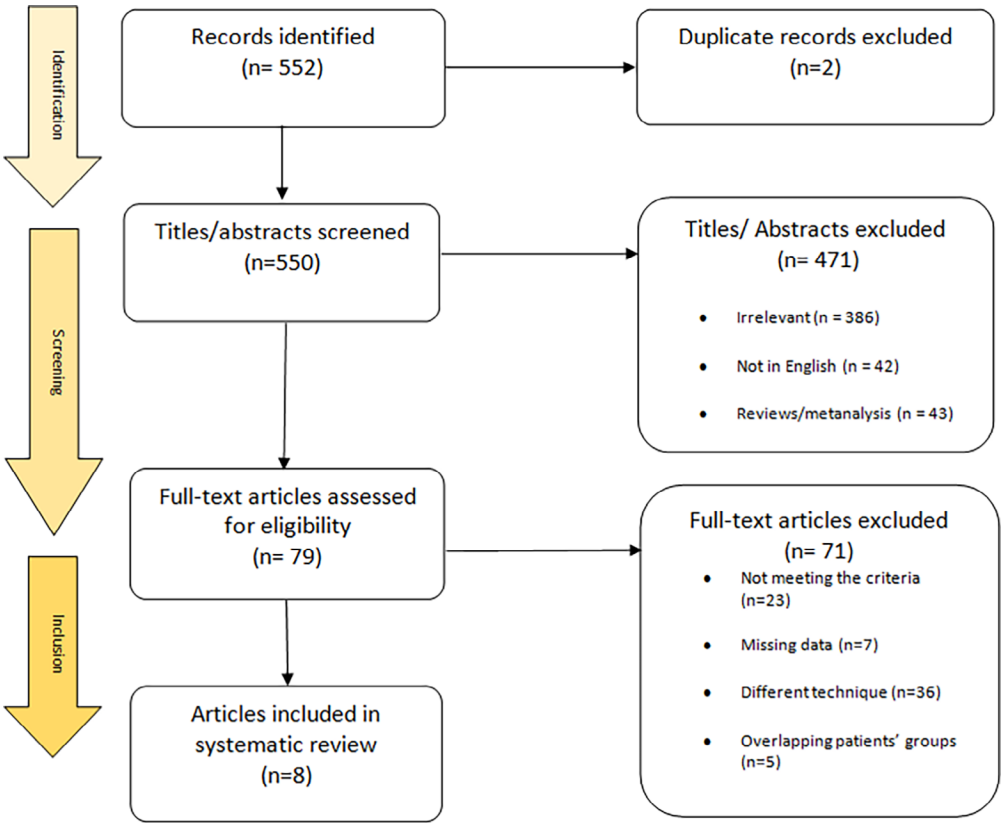

Figure 1. Selection process following PRISMA guidelines.

Table 1. Characteristics of studies included in the review.

Study	Year	Study Design	Sample Size (n)
Del Rio et. Al.	2016	PO	497
Giuli Capponi et. Al.	2015	PO	36
Duke et. Al.	2015	PO	260
Sapalidis et. Al.	2016	PO	48
Frank et. Al.	2016	RO	583
Bellantone et. Al.	2018	RO	257
Miccoli et. Al.	2020	RO	2698
Bellotti et. Al.	2017	RO	110

Abbreviations: PO: prospective observational; RO: retrospective observational.

Table 2. Adverse events following thyroid surgery.

Study	Hemorrhage (n)	Transient RLN Palsy (n)	Permanent RLN Palsy (n)	Transient Hypopara (n)	Definitive Hypopara (n)
Del Rio et. Al. (2016)	1	12	4	124 †	1
Giuli Capponi et. Al. (2015)	0	3	0	2	0
Duke et. Al. (2015)	0	10	0	6	0
Sapalidis et. Al. (2016)	0	0	0	5	0
Frank et. Al. (2016)	0	56	1	59	3
Bellantone et. Al. (2018)	0	4	0	76 †	1
Miccoli et. Al. (2020)	6	-	38	188	12
Bellotti et. Al. (2017)	0	2	1	11 †	4

Abbreviations: RLN: recurrent laryngeal nerve; †: calculated as serum calcium levels <8 mg/dL the day after the procedure.

Bellantone series (12). However, in the first study hypoparathyroidism is defined by hypocalcemia requiring supplementation; on the other hand, Bellantone considered all patients with serum calcium <8 mg/dL the day after the procedure.

Incidence of definitive hypoparathyroidism ranged from 0 to 3.6%; the last result was registered by Bellotti et al. (13) and included thyroidectomies with central node dissection, while incidence of definitive hypocalcemia for thyroidectomy alone was 1.05%.

Duke et al. (18) found that MIVAT was associated with a significantly lower incidence of hypocalcemia and a lower overall complication rate than conventional thyroidectomy.

Post-operative hemorrhage is reported by Miccoli (14) and Del Rio (15) with an incidence of 0.2% in both studies. Giuli Capponi et. Al. (16) mention an intra-operative hemorrhage that led to conversion to conventional thyroidectomy (Table 2).

Conversion to conventional thyroidectomy was necessary in 70 cases overall (14-16): 3 cases were mentioned by Giuli Capponi et. al (2 for difficult identification of RLN, one for intraoperative hemorrhage). Del Rio et. Al. describe 24 cases of conversion to conventional thyroidectomy, 13 for thyroiditis, and 11 for exceeding gland volume. The remaining 43 cases belong to the Miccoli series, even though the reasons for conversion were not clarified.

The mean operative time for minimally invasive total thyroidectomy ranged from 44.1 minutes (14) to 109 minutes (16); the last value was reported by Capponi et. Al. at the beginning of their experience with minimally invasive thyroid surgery and the operation time gradually decreased during the learning curve (Table 3).

Table 3. Operative time described in each study.

Study	Operative Time TT (min)	Operative Time HT (min)
Del Rio et. Al.	48 ± 8.4	-
Giuli Capponi et. Al.	109	-
Duke et. Al.	-	-
Sapalidis et. Al.	71.23 ± 23.81	-
Frank et. Al.	106.8 ± 41.3	78.5 ± 37.0
Bellantone et. Al.	69.1 ± 24.1	77.2 ± 51.5
Miccoli et. Al.	44.1	31.1
Bellotti et. Al.	74 ± 7.2	-

Abbreviations: TT: total thyroidectomy; HT: hemithyroidectomy.

Hospital stay was reported by only four of the selected studies (12,15-17) and ranged from 1.14 ± 0.4 days (17) to 2.9 ± 1.4 days (12). However, 90% of MIVAT procedures described in Duke's series were performed in an outpatient surgery setting, even though the duration of clinical observation and the length of hospitalization of inpatients are not specified.

Aesthetic result wasn't considered as an outcome of this review. However, Sapalidis et. al. 17) found an "excellent" satisfaction grade in all the patients questioned about the cosmetic result. Moreover, 78.2% of patients in the Bellotti series (13) and 94.5% of patients in the Giuli Capponi series (16) described their aesthetic result as "excellent". Finally, Del Rio et. Al described an excellent cosmetic outcome in 434 patients, a good result in 55 patients and a sufficient result in only 8 patients (15).

Discussion

A minimally invasive approach to thyroid surgery has developed over the last 20 years to meet the need for a satisfying aesthetic result, especially in young women, a group burdened with a high incidence of benign and malignant thyroid pathology.

Minimally Invasive Video-assisted Thyroidectomy has become a widely spread technique with comparable outcomes and complication rates to conventional thyroidectomy in selected patients.

Our results are consistent with previous reviews and metanalysis (19-20) and confirm the safety and feasibility of MIVAT technique with a comparable complication rate to traditional thyroidectomy.

Over the years this procedure has gained worldwide consensus as it showed several advantages compared to traditional technique and even to emerging remote access approaches.

In the first place, the MIVAT procedure follows the steps of conventional open technique with limited, easily learnable endoscopic steps; for this reason, it can be quite easily acquired even by a low-volume center surgeon skilled in thyroid surgery.

Lombardi et. Al. (21), in a recent study, suggested performing 30 MIVAT procedures allows to master the surgical steps; in addition, the operative time for MIVAT tends to decrease with increasing surgeon's experience.

A large review and meta-analysis published by De Vries in 2021 (20) comparing MIVAT to remote access surgical approaches, suggested that operating times for MIVAT were not significantly different compared to the standard of care, while other techniques showed a longer duration of the procedure. This meta-analysis found no differences in complication rate and hospital stay between MIVAT and conventional thyroidectomy.

Magnified endoscopic vision can be helpful in the identification and preservation of important anatomic structures; in 2010 we observed that the risk of postoperative hypocalcemia and the intraoperative identification of the parathyroid glands are more favourable with MIVAT than with conventional thyroidectomy, with a reduced rate of clinically symptomatic hypocalcemia (22).

Furthermore, MIVAT's minimal invasiveness provides an advantage as it is not only limited to the size of surgical incision but also to minimal tissue manipulation.

Thus, this procedure isn't burdened by complications typical of remote access approaches, such as injuries to the brachial plexus and the great vessels (23).

In addition, it doesn't require incision in the tail of the breast that can interfere with the efficacy of mammograms or sentinel node mapping in a pathology with a marked prevalence in the female sex (24).

A meta-analysis by Zheng et. Al (25) also demonstrated that MIVAT is associated with fewer immune response outcomes than conventional surgery, thus confirming its small impact on global physiology. This underlines the concept that MIVAT invasiveness is minimal not only in a cosmetic setting but also from a biological and anatomical point of view.

This feature is also reflected by the fact that minimally invasive thyroid surgery is associated with reduced neck pain and swallowing symptoms after surgery (8,26-28).

A final consideration of aesthetic results seems mandatory when discussing MIVAT results. There is still scarce agreement about the superiority of MIVAT over conventional thyroidectomy in terms of aesthetic results. While many studies, including those examined in this review, found an excellent cosmetic outcome in most patients, others concluded that there was no significant difference in patient satisfaction between minimally invasive and conventional techniques (13,15-17,29-31).

On the other hand, MIVAT has been proven non-inferior to remote access procedures in terms of patients' satisfaction with cosmetic results (32).

Conclusion

There is broad consensus in the literature about the outcomes and complication rate of MIVAT and their similarity to conventional thyroidectomy in selected patients. Unfortunately, the heterogeneity in inclusion criteria, assessment of hypoparathyroidism and recurrent laryngeal nerve palsy, and evaluation of aesthetic outcome make it challenging to compare different studies and obtain a clear evaluation of MIVAT advantages and pitfalls over conventional technique and emerging not minimally invasive remote access procedures.

Conflict of Interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement, etc.) that might pose a conflict of interest in connection with the submitted article.

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