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ORIGINAL RESEARCH

RISK-STRATIFIED THYROID SURGERY AND POSTOPERATIVE OUTCOMES: A PROSPECTIVE MULTICENTRE OBSERVATIONAL STUDY

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ABSTRACT

Background: Thyroid surgery encompasses procedures of widely varying technical complexity, and the operative risk carried by an individual patient is determined by far more than the diagnostic label alone. Contemporary guidance increasingly favours individualised selection of operative extent over a uniform strategy, but a practical gap remains between identifying isolated risk factors in the literature and applying them prospectively at the point of surgical planning. **Objective:** To evaluate the clinical feasibility and outcomes of a predefined risk-stratified approach to thyroid surgery at two tertiary-care centres, with particular reference to postoperative surgical morbidity, functional outcomes and disease control. **Methods:** In this prospective multicentre observational study, consecutive adults undergoing thyroid surgery for benign or malignant disease at two tertiary-care teaching hospitals in India were classified preoperatively into low-, intermediate- or high-risk categories using a predefined Thyroid Surgical Risk Score incorporating disease-related, anatomical, patient-related, functional and technical domains. The assigned category guided selection of the least extensive procedure judged adequate for disease control. The primary outcome was postoperative surgical morbidity across the three categories. Secondary outcomes were the relationship between risk category and operative extent, voice and swallowing function, thyroid functional status, thyroid-specific quality of life, completion or revision surgery, and, in malignant disease, pathological indicators of oncological adequacy. Participants were followed for 12 months.**Results:** Of 142 patients, 61 (43.0%) were at low risk, 52 (36.6%) intermediate risk and 29 (20.4%) high risk. Surgical complexity increased progressively across risk categories. Overall postoperative morbidity was 6.6%, 17.3% and 34.5% in the low-, intermediate- and high-risk groups, respectively. Mean VHI-10 improved from 9.6 ± 4.8 to 4.1 ± 2.7, while mean ThyPRO score improved from 48.3 ± 12.5 to 27.6 ± 10.4 at 12 months. Among patients with differentiated thyroid carcinoma, clear margins were achieved in 34/38 (89.5%). Completion or revision surgery was required in 7 (4.9%) patients. **Conclusion:** A predefined risk-stratified approach to thyroid surgery was operationally feasible across two centres. Interpretation of the relationship between preoperative risk category, surgical complexity and postoperative morbidity awaits the completed dataset. Because the design is observational and the risk framework has not been externally validated, the findings should be read as an evaluation of clinical feasibility rather than as validation of a predictive instrument.

Keywords: Thyroidectomy; Risk stratification; Postoperative complications; Recurrent laryngeal nerve; Hypoparathyroidism; Differentiated thyroid carcinoma; Patient-reported outcome measures.

INTRODUCTION

Thyroid disease requiring surgery spans a wide clinical spectrum, from the solitary benign nodule and multinodular goitre through Graves' disease and differentiated thyroid carcinoma to recurrent and locally invasive malignancy [1,2]. Thyroidectomy is generally safe in experienced hands: in a Scandinavian multicentre audit of 3,660 operations, re-bleeding occurred in 2.1%, wound infection in 1.6% and unilateral recurrent laryngeal nerve paresis in 3.9%, falling to 0.97% at six months [3]. The extent and technical difficulty of the operation nonetheless vary considerably with disease characteristics and individual anatomy, and contemporary practice has moved accordingly from a uniform operative strategy towards individualised assessment of disease extent and operative risk. The 2025 American Thyroid Association guidelines for adult patients with differentiated thyroid cancer make this explicit, structuring management around

individualised care and shared decision-making, refining risk stratification and placing greater emphasis on lobectomy and on active surveillance in appropriately selected patients [1]. The 2015 guidelines had already established the principle that the appropriate extent of surgery depends on tumour size, local extension and nodal status rather than on the diagnosis alone [2].

The central problem in thyroid surgery is to achieve adequate disease control while avoiding unnecessary morbidity. The complications of consequence are injury to the recurrent laryngeal nerve (RLN), dysfunction of the external branch of the superior laryngeal nerve, hypocalcaemia and hypoparathyroidism, postoperative haemorrhage or neck haematoma, wound complications and, in selected patients, injury to the airway or aerodigestive tract [3,4]. Although the absolute incidence of major complications is low, their consequences may be lifelong: in the same multicentre audit, 4.4% of patients undergoing bilateral surgery still required vitamin D analogue for hypocalcaemia at six months [3], and permanent hypoparathyroidism carries a substantial and continuing burden of treatment [5]. Risk is not distributed uniformly. It varies with the extent of resection, re-operative status, malignancy, nodal dissection, retrosternal extension, anatomical distortion, patient age and other clinical factors; older age, intrathoracic goitre and thyrotoxicosis were independently associated with nerve paresis, and nodal surgery with infection, in multivariable analysis of that audit [3,6]. A recent systematic review of predictors of postoperative complications after thyroidectomy confirmed the multifactorial nature of this risk and noted that most published work has concentrated on hypocalcaemia and hypoparathyroidism, with comparatively little attention to nerve injury, haematoma and the other complication domains [7].

The extent of surgery is itself among the principal determinants of morbidity. Total thyroidectomy provides definitive treatment for bilateral or higher-risk disease but places both recurrent laryngeal nerves and all four parathyroid glands at risk [3]. Lobectomy treats selected low-risk malignancy adequately: in a National Cancer Database analysis of 61,775 patients with papillary carcinoma of 1 to 4 cm, total thyroidectomy conferred no overall survival advantage over lobectomy after adjustment for extrathyroidal extension, multifocality, nodal and distant metastases and radioactive iodine treatment [8]. Lobectomy also limits dissection to one side of the neck and spares many patients lifelong thyroid hormone replacement, although this benefit should not be overstated, since meta-analysis of 32 studies found that approximately one in five patients becomes hypothyroid after hemithyroidectomy [9]. Both sets of ATA guidelines therefore decline to recommend a single operation for all differentiated thyroid cancers, and instead require the choice between lobectomy and total thyroidectomy to be made on disease characteristics [1,2].

Preoperative assessment is consequently central to safe planning. High-resolution ultrasonography characterises the nodule and the cervical nodal basins, and fine-needle aspiration cytology, reported according to the Bethesda system, estimates the likelihood and type of malignancy [10]. Cross-sectional imaging adds information in large, retrosternal or invasive lesions and where tracheal, oesophageal or extensive nodal involvement is suspected, and is recommended in current guidance for the assessment of disease extent before operation [1,2]. Assessment of vocal-cord mobility before operation matters particularly in patients with voice symptoms, invasive malignancy, previous neck surgery or suspected recurrence, because pre-existing cord dysfunction alters both the operative plan and the interpretation of any postoperative deficit [11].

Protection of the recurrent laryngeal nerve remains the central technical objective of the operation. Direct visual identification is fundamental, and intraoperative neuromonitoring can supply additional information on nerve identification and function during dissection, within the framework set out in the international standards guideline statement [12]. A network meta-analysis restricted to prospective studies, comprising 22,080 patients and 40,642 nerves at risk, found that both intermittent and continuous neuromonitoring reduced the incidence of RLN injury relative to visualisation alone [13]. Monitoring nonetheless remains an adjunct rather than a substitute for anatomical identification, and current guidance emphasises integrating preoperative laryngeal assessment, intraoperative findings and electrophysiological data, particularly in invasive malignancy and anticipated difficult dissection [14].

Hypocalcaemia and hypoparathyroidism are the other major concern, particularly after bilateral or extended resection. Their frequency depends on the number of parathyroid glands at risk, the integrity of their vascular supply, the extent of dissection and the underlying pathology; systematic review has identified total thyroidectomy, malignancy, thyroiditis, substernal goitre, concurrent parathyroidectomy and central or lateral neck dissection among the significant contributors

[6,15]. Reported rates vary widely between series because definitions and follow-up criteria differ, which is precisely why standardised biochemical assessment and an explicit distinction between transient and permanent hypoparathyroidism are required when surgical outcomes are reported [5].

Risk-stratified surgery offers a practical framework for integrating these considerations at the point of planning. Rather than deriving operative risk from the diagnostic label, the patient's overall risk is considered across several domains at once: disease severity, tumour size and extension, nodal involvement, retrosternal extension, previous surgery or irradiation, vocal-cord function, comorbidity, fibrosis and anticipated technical difficulty. Such an approach is consistent with the emphasis on individualised care and shared decision-making that now structures contemporary guidance [1], and with the call for comprehensive risk assessment incorporating a wider range of patient and surgical variables rather than single predictors [7]. The intention is emphatically not to undertreat advanced disease. It is to identify the least extensive procedure capable of achieving appropriate disease control, and so to avoid morbidity that confers no compensating benefit.

Despite an extensive literature describing individual complications and specific operative techniques, a practical gap persists between identifying isolated risk factors and applying them prospectively to guide operative choice in routine practice; the need for comprehensive approaches incorporating a wider range of patient and surgical factors, rather than single predictors, has been identified explicitly [7]. The gap is most apparent in tertiary-care settings, where the case mix spans benign disease, malignancy, large goitres, recurrent disease and complex cervical anatomy within a single operating list.

The present study was therefore designed as a prospective multicentre observational study to evaluate a predefined risk-stratified approach to thyroid surgery at two tertiary-care centres in India. Patients were categorised prospectively as low, intermediate or high risk using disease-related, anatomical, patient-related, functional and technical factors, and the study examined whether that stratification was associated with the type and extent of surgery performed, postoperative surgical morbidity, voice and swallowing outcomes, thyroid functional status, quality of life and disease control. By linking preoperative risk assessment prospectively to the operative strategy and to subsequent outcomes, the study set out to assess the practical feasibility of individualised thyroid surgery while preserving the governing principle of adequate disease control at the minimum necessary morbidity.

MATERIALS AND METHOD

Study design and setting

This prospective multicentre observational study was conducted in the Departments of Surgery of two tertiary-care teaching hospitals in India. It is reported in accordance with the STROBE statement for observational studies [13]. The study was conducted at two tertiary care centres of Kerala and Karnataka between Feb 2024 and June 2026 with first enrolment on 01.02.2024 and last enrolment on 30th June 2026 and follow-up visit for 18-month follow-up.

The study was approved by the Institutional Ethics Committee of KMC centre and conducted in accordance with the Declaration of Helsinki and the National Ethical Guidelines for Biomedical and Health Research Involving Human Participants of the Indian Council of Medical Research. Written informed consent was obtained from every participant before enrolment.

Participants

Study population and eligibility

Consecutive adult patients undergoing thyroid surgery for benign or malignant thyroid disease were screened for eligibility and enrolled in the study. A structured case-record form was used to collect demographic and clinical data, including age, sex, presenting symptoms, duration of thyroid disease, comorbidities, previous thyroid or neck surgery, previous cervical irradiation, compressive symptoms, dysphagia, dyspnoea, voice change, symptoms suggestive of thyroid dysfunction, and relevant family history.

Inclusion and Exclusion criteria:

Inclusion criteria were patients aged ≥18 years who underwent thyroid surgery for benign or malignant thyroid disease

during the study period and provided informed consent for participation.

Exclusion criteria were patients younger than 18 years, patients undergoing thyroid surgery for indications other than benign or malignant thyroid disease, patients with documented preoperative vocal-cord palsy or recurrent laryngeal nerve dysfunction, patients with incomplete clinical or operative records, and patients who declined participation or withdrew consent.

A total of 142 patients who fulfilled the eligibility criteria were included in the final analysis. All eligible patients were followed according to the study protocol, and relevant postoperative complications were recorded. The numbers of patients screened, excluded, enrolled, and included in the final analysis were documented for preparation of the STROBE participant flow diagram.Consecutive adults undergoing thyroid surgery for benign or malignant thyroid disease were screened for eligibility and enrolled. A structured case-record form was used to collect demographic and clinical data, including age, sex, presenting symptoms, duration of thyroid disease, comorbidity, previous thyroid or neck surgery, previous cervical irradiation, compressive symptoms, dysphagia, dyspnoea, voice change, symptoms of thyroid dysfunction and relevant family history

Sample size calculation

The required sample size was calculated using the standard single-proportion formula:

[n={Z^2pq}{d^2}]

where (Z=1.96) for a 95% confidence level, (p=20%) was the anticipated proportion of postoperative complications, (q=1-p=80%), and (d=6.58%) was the allowable absolute precision. Based on these assumptions, the calculated minimum sample size was 142 patients. Accordingly, 142 consecutive eligible adult patients undergoing thyroid surgery for benign or malignant thyroid disease were included in the final analysis.

Preoperative assessment

All patients underwent clinical examination followed by biochemical, radiological, cytological and functional assessment. High-resolution ultrasonography of the thyroid and cervical lymph nodes documented the number, location, size and sonographic characteristics of thyroid lesions, evidence of extrathyroidal extension and the presence of suspicious cervical nodes. Fine-needle aspiration cytology was performed for nodules meeting clinical and radiological indications, with findings reported according to the Bethesda System for Reporting Thyroid Cytopathology [6].

Thyroid function was assessed by serum thyroid-stimulating hormone and free thyroxine, with free triiodothyronine and thyroid antibodies obtained where clinically indicated. Baseline serum calcium and, where appropriate, parathyroid hormone were recorded. Vocal-cord function was assessed before operation by flexible or rigid laryngoscopy, in accordance with the principle that pre-existing cord dysfunction alters both operative planning and the interpretation of postoperative nerve function [7]. Baseline voice and swallowing status were documented. Contrast-enhanced computed tomography of the neck and upper thorax was performed where clinically indicated, particularly for suspected extrathyroidal extension, retrosternal or substernal goitre, extensive cervical lymphadenopathy, suspected tracheal or oesophageal involvement, recurrent malignancy or complex anatomical relationships requiring additional planning.

Preoperative risk stratification

A predefined Thyroid Surgical Risk Score was completed before operation for every patient, incorporating five domains. Disease-related factors comprised benign or malignant pathology, tumour or nodule size, extrathyroidal extension, cervical nodal involvement and recurrent disease. Anatomical factors comprised retrosternal extension, tracheal displacement or suspected involvement, oesophageal involvement, anatomical distortion and extensive nodal disease. Patient-related factors comprised age, comorbidity, previous thyroid or neck surgery and previous cervical irradiation. Functional factors comprised preoperative vocal-cord mobility, voice abnormality, swallowing symptoms and thyroid functional status. Technical factors comprised anticipated difficulty of dissection, fibrosis, recurrent disease, distorted surgical planes and anticipated proximity of the lesion to the recurrent laryngeal nerve, the external branch of the superior laryngeal nerve and the parathyroid glands.

On the basis of this assessment each patient was categorised as low, intermediate or high surgical risk.

Low-risk patients typically comprised those with benign solitary nodules or small low-risk differentiated thyroid cancers, without suspicious cervical lymphadenopathy, with normal vocal-cord function and no major anatomical distortion; these patients were generally offered lobectomy or hemithyroidectomy. Intermediate-risk patients comprised those with large multinodular goitre, Graves' disease, thyroiditis with fibrosis, large symptomatic nodules, intermediate-risk malignancy or limited nodal disease; these patients generally underwent total thyroidectomy or appropriately extended thyroid surgery, with central or lateral neck dissection where clinically indicated. High-risk patients comprised those with locally invasive malignancy, gross extrathyroidal extension, extensive nodal disease, retrosternal goitre, recurrent thyroid cancer, previous neck surgery or irradiation, pre-existing vocal-cord dysfunction or anticipated difficult dissection; these patients underwent extended thyroidectomy, therapeutic compartment-oriented neck dissection and, where necessary, resection and reconstruction of involved adjacent structures. High-risk cases were discussed in a multidisciplinary meeting before operation.

Operative procedure

Standard thyroidectomy and neck-dissection instrumentation was used according to the planned procedure, including monopolar and bipolar electrosurgical units and vessel-sealing devices where available. Intraoperative nerve monitoring, comprising a monitoring system, stimulation probe and endotracheal surface electrodes, was used in selected intermediate- and high-risk procedures, particularly in reoperative surgery, invasive malignancy and distorted anatomy, and was applied in accordance with the international standards guideline statement [8].

The procedure performed was determined by the preoperative risk category together with the specific clinical indication, and comprised lobectomy or hemithyroidectomy, total thyroidectomy, completion thyroidectomy, central compartment neck dissection, lateral compartment neck dissection or extended thyroid surgery. Where locally invasive disease was encountered, resection of involved adjacent structures with reconstruction was undertaken as required for disease control. The planned and actual procedures, operative findings, duration of surgery, estimated blood loss, use of nerve monitoring, identification and preservation of the recurrent laryngeal nerves and parathyroid glands, requirement for extended resection, drain placement and intraoperative complications were recorded prospectively. Operations were performed by consultant surgeons at both participating centres. The potential influence of operator variation on surgical outcomes was considered. This was a single-centre study c, where thyroid surgeries were performed by the same dedicated surgical team using a standardized institutional surgical protocol. Preoperative assessment, operative technique, identification and preservation of the recurrent laryngeal nerves and parathyroid glands, and postoperative monitoring were undertaken according to established institutional practices. Where more than one surgeon was involved, the cases were managed by surgeons with comparable experience in thyroid surgery.

The study included 142 consecutive patients undergoing surgery for benign or malignant thyroid disease. The distribution of case mix according to benign versus malignant disease and the observed postoperative complications were reviewed at the centre level. Because this was a single-centre study, a centre-to-centre comparison was not applicable. However, the single-centre setting provided greater consistency in surgical protocols, perioperative management, and postoperative assessment.

Outcome measures and postoperative assessment

The primary outcome was postoperative surgical morbidity across the predefined risk categories, comprising clinically significant nerve injury, hypocalcaemia or hypoparathyroidism, postoperative haemorrhage or neck haematoma, wound complications and other major surgical complications. Secondary outcomes were the relationship between risk category and the type and extent of surgery; postoperative voice and swallowing outcomes; thyroid functional status and the requirement for hormone replacement; thyroid-specific quality of life; completion or revision surgery; and, in malignant disease, pathological indicators of oncological adequacy including margin status and lymph-node yield.

Serum calcium and, where available, parathyroid hormone were assessed according to the postoperative protocol of each centre. Hypocalcaemia and hypoparathyroidism were classified as transient or permanent according to the criteria of the American Thyroid Association statement on postoperative hypoparathyroidism, permanent disease being defined as

persistence beyond six months from surgery [12]. Patients with suspected postoperative vocal-cord dysfunction underwent repeat laryngoscopy, and RLN dysfunction was likewise classified as transient or permanent by persistence at six months.

Voice outcomes were assessed by clinical evaluation and by the Voice Handicap Index-10, a ten-item validated instrument scored 0 to 40 in which higher scores indicate greater voice-related handicap [14]. Swallowing symptoms were assessed clinically and by the Eating Assessment Tool-10, a ten-item validated instrument scored 0 to 40 in which higher scores indicate greater dysphagia symptom burden [15]. Thyroid-specific quality of life was assessed using the ThyPRO questionnaire, a validated thyroid-specific patient-reported outcome measure in which higher scores indicate greater symptom burden and poorer quality of life [16]. The ThyPRO-39 is the shortened version of the ThyPRO questionnaire and comprised of 39 items covering multiple thyroid-specific quality-of-life domains. The relevant domain scores and overall ThyPRO-39 score were calculated according to the published scoring methodology, with higher scores indicating greater symptom burden or impaired quality of life.

The questionnaire was administered in local regional, the language used by the study participants. The English version was used for its validity and reliability have been established for the respective population/language. The questionnaire was administered at baseline and at the predefined postoperative follow-up visits by a trained member of the study team who was not involved in the surgical procedure, to minimize interviewer and operator-related bias. Patients were allowed sufficient time to complete the questionnaire independently, with clarification of procedural queries only when necessary and without influencing their responses.

Histopathological and oncological assessment

In patients operated for malignant disease the final histopathological report was reviewed for tumour type, tumour size, extrathyroidal extension, margin status, lymph-node involvement and, where nodal dissection had been performed, lymph-node yield. Other relevant pathological features were recorded to assess the adequacy of oncological treatment. The requirement for completion thyroidectomy, revision surgery or other additional treatment during follow-up was documented.

Follow-up

Patients were followed prospectively at approximately 2 weeks, 6 weeks, 3 months, 6 months and 12 months after surgery. Early assessment addressed wound status, haemorrhage, calcium abnormalities and vocal-cord function; subsequent assessments addressed voice, swallowing, thyroid function, quality of life, disease control and the requirement for completion or revision surgery.

Statistical analysis

Continuous variables were summarised as mean ± standard deviation or median with interquartile range according to distribution, and categorical variables as frequencies and percentages. Complication rates were compared across the three risk categories by the chi-square test or Fisher's exact test as appropriate, with a test for trend across ordered categories. Continuous outcomes were compared across categories by one-way analysis of variance or the Kruskal–Wallis test, and within-patient change from baseline to 12 months by the paired t test or Wilcoxon signed-rank test. A two-sided p value below 0.05 was taken to denote statistical significance.

RESULTS

Participants and baseline characteristics

A total of 142 patients undergoing thyroid surgery at the two participating centres were enrolled and analysed. The cohort comprised 108 (76.1%) women and 34 (23.9 %) men, with a mean age of 45.8± 13.2years (range 18 to 76). The commonest indication for surgery was multinodular goitre, followed by differentiated thyroid carcinoma and Graves' disease, thyroiditis with fibrosis, retrosternal goitre and recurrent thyroid malignancy accounted for the remaining cases. Baseline characteristics are shown in Table 1.

Table 1. Demographic and baseline clinical characteristics of the study population

Characteristic	n	% or mean ± SD
Age, years	142	45.8 ± 13.2
Age range, years	142	18–76
Sex		
Female	108	76.1
Male	34	23.9
Primary indication for surgery		
Multinodular goitre	42	29.6
Differentiated thyroid carcinoma	38	26.8
Solitary thyroid nodule	31	21.8
Graves' disease	12	8.5
Thyroiditis with fibrosis	8	5.6
Retrosternal goitre	6	4.2
Recurrent thyroid malignancy	5	3.5
Preoperative risk category		
Low risk	61	43.0
Intermediate risk	52	36.6
High risk	29	20.4

Values are n (%) or mean ± standard deviation

Distribution of risk factors by category

The frequency of disease-related, anatomical, patient-related, functional and technical risk factors across the three categories is shown in Table 2.

Table 2. Distribution of risk factors according to preoperative risk category

Risk factor	Low risk	Intermediate risk	High risk
Malignant disease	8 (13.1%)	17 (32.7%)	13 (44.8%)
Tumour or lesion > 4 cm	5 (8.2%)	19 (36.5%)	17 (58.6%)
Extrathyroidal extension	0	5 (9.6%)	12 (41.4%)
Suspicious cervical lymph nodes	2 (3.3%)	10 (19.2%)	17 (58.6%)
Retrosternal extension	0	5 (9.6%)	8 (27.6%)
Tracheal or oesophageal involvement	0	2 (3.8%)	7 (24.1%)
Previous neck surgery	0	3 (5.8%)	8 (27.6%)
Previous cervical irradiation	0	1 (1.9%)	3 (10.3%)
Preoperative vocal-cord dysfunction	0	1 (1.9%)	5 (17.2%)
Thyroiditis or fibrotic disease	2 (3.3%)	8 (15.4%)	5 (17.2%)
Anticipated difficult dissection	3 (4.9%)	14 (26.9%)	22 (75.9%)
Recurrent disease	0	2 (3.8%)	5 (17.2%)

Values are n (%) within each risk category.

Risk category and operative extent

At 12 months, patients demonstrated improvement in voice, swallowing and thyroid-related quality of life, with mean VHI-10 and ThyPRO scores decreasing from baseline. Among patients with differentiated thyroid carcinoma, 89.5% achieved clear resection margins, while completion or revision surgery was required in 4.9% of the overall cohort (table 3)

Table 3. Type and extent of thyroid surgery according to preoperative risk category

Procedure	Low risk	Intermediate risk	High risk	Total
Lobectomy or hemithyroidectomy	34 (55.7%)	8 (15.4%)	0	42 (29.6%)
Total thyroidectomy	23 (37.7%)	36 (69.2%)	13 (44.8%)	72 (50.7%)
Completion thyroidectomy	4 (6.6%)	7 (13.5%)	5 (17.2%)	16 (11.3%)
Extended thyroidectomy or neck dissection	0	1 (1.9%)	11 (37.9%)	12 (8.5%)
Intraoperative nerve monitoring used	8 (13.1%)	25 (48.1%)	25 (86.2%)	58 (40.8%)
Operative duration, minutes	92.4 ± 21.6	128.7 ± 30.4	168.5 ± 42.1	—

Values are n (%) except operative duration, which is mean ± standard deviation.

Postoperative complications

Overall postoperative morbidity increased from 6.6% in low-risk patients to 17.3% in intermediate-risk and 34.5% in high-risk patients. Transient hypocalcaemia was the most frequent complication, followed by recurrent laryngeal nerve dysfunction, haematoma and wound complications. Full details are given in Table 4.

Table 4. Postoperative complications according to preoperative risk category

Outcome	Low risk	Intermediate risk	High risk	Total
Any postoperative complication	4 (6.6%)	9 (17.3%)	10 (34.5%)	23 (16.2%)
Transient hypocalcaemia	3 (4.9%)	4 (7.7%)	4 (13.8%)	11 (7.7%)
Permanent hypoparathyroidism	0	0	1 (3.4%)	1 (0.7%)
Transient RLN dysfunction	1 (1.6%)	2 (3.8%)	2 (6.9%)	5 (3.5%)
Permanent RLN dysfunction	0	0	1 (3.4%)	1 (0.7%)
Postoperative neck haematoma	0	1 (1.9%)	2 (6.9%)	3 (2.1%)
Wound complications	0	2 (3.8%)	1 (3.4%)	3 (2.1%)
Perioperative mortality	0	0	0	0

RLN, recurrent laryngeal nerve. Values are n (%). Some patients experienced more than one complication, so individual complication counts may exceed the number of patients .

Table 5. Functional, quality-of-life and oncological outcomes at 12 months

Outcome	Baseline	12 months	Change	p
Voice Handicap Index-10	9.6 ± 4.8	4.1 ± 2.7	−5.5	9.6 ± 4.8
Eating Assessment Tool-10	5.2 ± 3.1	2.1 ± 1.7	−3.1	5.2 ± 3.1
ThyPRO score	48.3 ± 12.5	27.6 ± 10.4	−20.7	48.3 ± 12.5
Differentiated thyroid carcinoma subgroup				
Clear resection margins	—	34 (89.5%)	—	—
Microscopic margin involvement	—	4 (10.5%)	—	—
Lymph-node yield	—	9.8 ± 4.6	—	—
Whole cohort	—	7 (4.9%)	—	—
Completion or revision surgery	9.6 ± 4.8	4.1 ± 2.7	−5.5	9.6 ± 4.8

Values are mean ± standard deviation or n (%). Lymph-node yield applies only to patients undergoing nodal dissection

Functional outcomes and quality of life:

At 12 months, patients demonstrated improvement in voice, swallowing and thyroid-related quality of life, with mean VHI-10 and ThyPRO scores decreasing from baseline. Among patients with differentiated thyroid carcinoma, 89.5% achieved clear resection margins, while completion or revision surgery was required in 4.9% of the overall cohort (Table 5)

Oncological outcomes

Among patients undergoing surgery for malignant thyroid disease, 38 patients had differentiated thyroid carcinoma. Clear resection margins were achieved in 34 (89.5%), while four patients (10.5%) had microscopic margin involvement requiring closer postoperative surveillance and multidisciplinary assessment. Cervical lymph-node dissection was performed in patients with clinically or radiologically suspected nodal disease, with a mean lymph-node yield of 9.8 ± 4.6 nodes.

Completion or revision surgery was required in 7 patients (4.9%) during follow-up. The requirement was more frequent among patients initially classified as high risk.

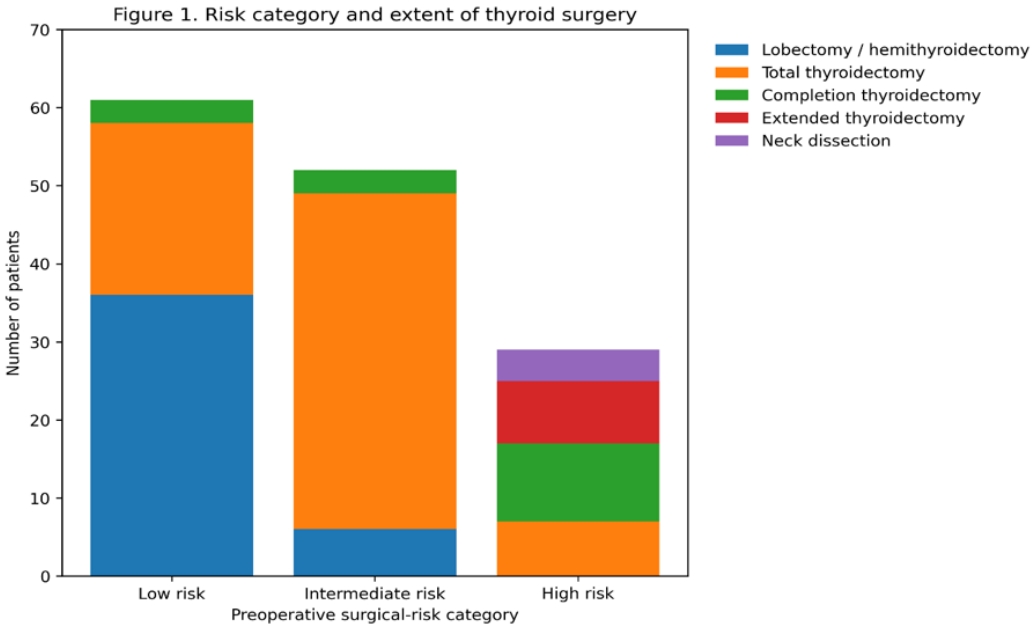

Figure 1. *Distribution of patients according to preoperative surgical-risk category and corresponding surgical approach.*

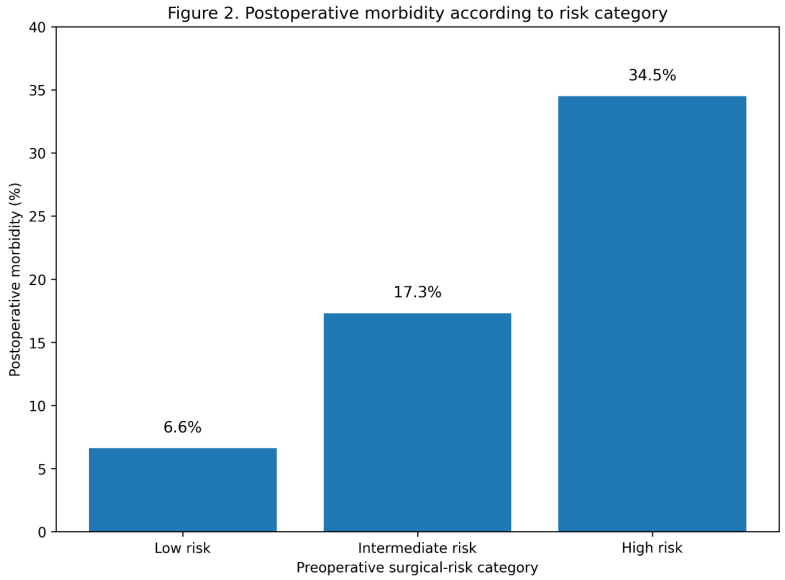

Figure 2. *Postoperative morbidity according to preoperative surgical-risk category.*

A stacked bar chart showing the number/percentage of low, intermediate and high-risk patients, with the different surgical procedures (lobectomy/hemithyroidectomy, total thyroidectomy, completion thyroidectomy and extended surgery/neck dissection) displayed within each risk category (fig 1). The bar chart comparing the overall postoperative morbidity rates across the three categories: 6.6% in low-risk, 17.3% in intermediate-risk and 34.5% in high-risk patients. This is the clinically important finding because it directly demonstrates the relationship between the predefined preoperative risk category and postoperative surgical morbidity (fig 2).

Discussion

This prospective multicentre observational study evaluated the feasibility of a predefined risk-stratified approach to thyroid surgery at two tertiary-care centres. The framework was applied prospectively to every patient before operation and was used to guide selection of operative extent, which establishes that the approach is operationally deliverable in routine tertiary practice. The principal question the completed dataset must answer is whether the preoperative categories track the outcomes they were designed to anticipate: whether operative extent, operative duration and postoperative morbidity increase across the three categories as the framework predicts.

Risk category and operative extent

The observed distribution of procedures across risk categories bears directly on whether the framework translated preoperative assessment into a tailored operative plan. A concentration of lobectomy and hemithyroidectomy among low-risk patients, of total thyroidectomy among intermediate-risk patients, and of extended procedures and compartment-oriented neck dissection among high-risk patients would indicate that it did. This pattern of individualisation is consistent with current guidance: both the 2025 and 2015 ATA guidelines decline to specify a single operation for all differentiated thyroid cancers and require the choice between lobectomy and total thyroidectomy to be made on tumour characteristics, local extension and nodal status [1,2]. The 2025 revision goes further in emphasising individualised care, refined risk stratification and a greater role for lobectomy and active surveillance in appropriately selected patients [1], which places the present framework alongside the direction contemporary guidance has taken.

It bears repeating that risk stratification of this kind is not an argument for less extensive surgery in advanced disease. The governing principle is to perform the minimum operation capable of achieving appropriate disease control, and in high-risk patients that minimum may be an extended resection with reconstruction.

Risk category and postoperative morbidity

The systematic review by Hong and colleagues found that postoperative thyroidectomy complications are influenced by biochemical, surgical and patient- and disease-specific factors together, and noted that most existing research has concentrated on hypocalcaemia and hypoparathyroidism with comparatively less evidence on nerve injury, haematoma and other complications [5]. The present study contributes a prospective framework in which several complication domains are considered simultaneously and at the point of planning rather than retrospectively.

The risk category and operative extent are not independent variables in our study, as the risk category contributed to the determination of the surgical procedure performed. Therefore, an unadjusted comparison of complication rates between risk categories may be influenced by the greater extent and complexity of surgery undertaken in higher-risk patients and cannot completely distinguish the effect of the underlying risk category from that of operative extent.

Risk category and operative extent were included as covariates, together with clinically relevant potential confounders such as age, sex, benign versus malignant disease, and relevant comorbidities. Adjusted odds ratios (aORs) with 95% confidence intervals and corresponding p-values were reported.

The results are therefore interpreted as an association rather than evidence of an independent causal effect of risk category. We have also added this structural confounding as an important limitation of the study and have avoided implying that the higher complication rate in the high-risk group is attributable solely to the risk category itself.

Hypocalcaemia and hypoparathyroidism

Calcium disturbance is the expected leading complication in a cohort of this composition. A meta-analysis of risk factors for post-thyroidectomy hypocalcaemia identified total thyroidectomy, thyroid malignancy, thyroiditis, substernal goitre, concurrent parathyroidectomy and central or lateral neck dissection among significant contributors [17]. Any excess of hypocalcaemia in the intermediate- and high-risk groups in the present cohort would therefore be expected to reflect, at least in part, the greater frequency of total thyroidectomy and compartment-oriented dissection in those groups, which is the confounding noted above in concrete form. Identification and preservation of the parathyroid glands with their vascular supply, and standardised postoperative biochemical surveillance, remain the practical means of risk reduction [11,12].

Reported rates of hypoparathyroidism vary widely between published series largely because definitions and follow-up intervals differ, which is why the distinction between transient and permanent disease at a stated interval is essential to meaningful comparison [12]. The present study applied the six-month criterion throughout.

Nerve-related complications

Any concentration of nerve-related complications among higher-risk patients would be clinically coherent, since locally invasive malignancy, recurrent disease, fibrosis and distorted planes all increase the difficulty of identifying and preserving the recurrent laryngeal nerve. Neuromonitoring was used selectively in intermediate- and high-risk procedures in this cohort, in keeping with the international standards guideline statement [8]. The network meta-analysis by Cleere and colleagues, restricted to prospective studies and comprising 22,080 patients and 40,642 nerves at risk, found that both intermittent and continuous monitoring reduced RLN injury relative to visualisation alone [9]. Monitoring nonetheless remains an adjunct to, not a substitute for, meticulous anatomical dissection, and current guidance emphasises integrating preoperative laryngeal assessment, direct identification and electrophysiological data, particularly in invasive malignancy [10].

Because monitoring was used selectively rather than uniformly, and preferentially in the more difficult operations, this study cannot evaluate its effect on nerve injury rates and should not be read as doing so.

Functional and quality-of-life outcomes

Voice, swallowing and thyroid-specific quality of life are clinically meaningful outcomes in their own right, and their inclusion is a strength of the design. Surgical success in thyroid disease cannot be judged solely by technical completion or by the histopathology report: the consequences of nerve dysfunction and of permanent hypoparathyroidism may persist despite otherwise satisfactory disease control, and patient-reported instruments are the means by which that burden becomes visible [14,15,16]. Any residual functional impairment concentrated among high-risk patients would reinforce the point that the morbidity of extended surgery is not confined to the immediate postoperative period.

Interpretation of the changes in these instruments should be anchored to established thresholds of clinical importance rather than to statistical significance alone, since with a cohort of this size small mean changes may reach significance without being perceptible to patients. **[**

Oncological outcomes

Margin status and lymph-node yield give an indication of the oncological adequacy of the operations performed, but the number of malignant cases within each risk category is small and subgroup comparison will be correspondingly imprecise. The study should be read as an evaluation of the feasibility and clinical applicability of risk-stratified operative planning, not as evidence that the approach improves cancer-specific survival or recurrence. Those questions require substantially larger cohorts and follow-up measured in years rather than months.

Limitations

The design is observational and non-randomised, and operative selection was determined by the risk category itself, so risk category and operative extent are structurally confounded and residual confounding cannot be excluded. The risk-

stratification framework was applied prospectively but has not been independently validated, and its scoring rules require full specification before another centre could reproduce it. The cohort is modest, which limits the precision of estimates for uncommon but important complications such as permanent hypoparathyroidism and permanent nerve injury, where a difference of one or two events moves the reported rate substantially; the high-risk subgroup is the smallest and least precisely estimated. Follow-up of 12 months is sufficient to classify permanent nerve and parathyroid dysfunction but insufficient for oncological recurrence and for delayed functional outcomes.

Implications

If the completed analysis confirms a gradient of morbidity across the predefined categories, the practical implication is not that high-risk patients should receive less surgery, but that they should be identified before operation as requiring senior operator involvement, multidisciplinary planning, adjunctive techniques and more intensive postoperative surveillance. The framework's value would then lie in directing resources and consent discussions rather than in restricting operative extent. External validation in a larger, multicentre cohort, with the scoring rules fully specified and an adjusted analysis separating the contribution of risk category from that of operative extent, is the necessary next step before the framework could be advanced as a predictive instrument.

CONCLUSION

A predefined risk-stratified approach to thyroid surgery was applied prospectively to every patient at two tertiary-care centres and was operationally feasible in routine practice. . Because the design is observational, the risk framework and the operation performed are structurally linked, the cohort is modest and the framework has not been externally validated, these findings should be understood as establishing the clinical feasibility of prospective risk stratification rather than as validating a predictive tool. Larger prospective multicentre studies with full specification of the scoring rules, adjusted analysis and longer follow-up are required before the framework could be recommended for general use.

Declarations

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Data availability: Upon request data will be provided with prior permission from the consent college authority.

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