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Intraoperative Indocyanine Green Fluorescence Imaging in Thyroid Surgery: Technical Protocol, Evaluation Window and Interpretation Pitfalls — Single-Centre Experience in a Prospective Series of 42 Cases

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Rezumat

Colorația intravitală cu verde de indocianină în chirurgia tiroidiană: protocol tehnic, fereastră de evaluare și capcane de interpretare - experiența unui centru terțiar într-o serie prospectivă de 42 de cazuri

Introducere: Hipoparatiroidismul postoperator rămâne cea mai frecventă complicație a tiroidectomiei totale (20-40% tranzitoriu, 1-4% permanent). Imagistica intraoperatorie NIR cu verde de indocianină (ICG) este validată pentru evaluarea perfuziei glandelor paratiroide — recunoscută în consensul EAES 2023 —, însă datele privind implementarea practică, parametrii temporali şi capcanele de interpretare rămân limitate. *Scop:* Descrierea protocolului tehnic ICG cu sistemul Karl Storz IMAGE1 S™ Rubina®, cuantificarea ferestrei de evaluare (tev) şi sistematizarea capcanelor de interpretare întâlnite.
Material şi Metodă: Studiu prospectiv observațional, monocentric (analiză retrospectivă a datelor colectate prospectiv; includere dependentă de disponibilitatea intraoperatorie a preparatului ICG, deci nu strict consecutivă), incluzând 42 de cazuri la care s-a utilizat ICG intraoperator în cadrul intervențiilor tiroidiene (37 femei, 5 bărbați; vârstă medie 52,6 ani; IMC 27,5 kg/m²), efectuate în perioada februarie 2024 – februarie 2025. Protocol uniform: 5 mg ICG IV (2,5 mg/mL) la aproximativ 66% din durata estimată skin-to-skin; scor Vidal Fortuny (0/1/2). Parametri: momentul injectării (tinj), onsetul fluorescenței (tf) şi fereastra de evaluare ICG (tev).
Rezultate: Durată operatorie (tOR): 88,6 ± 30,2 min. Onset fluorescență (tf): 37,5 ± 5,2 sec. Fereastră evaluare ICG (tev): 6,4 ± 2,3 min global; 5,2 ± 1,8 min cazuri standard vs 7,8 ± 2,0 min cazuri complexe ($p<0,05$). Primele vs ultimele 21 cazuri: tev 7,7 vs 5,1 min ($\Delta = -2,6$ min; $p<0,05$). Reinjectare în 8/42 (19,0%). Scoruri de perfuzie: 64,3% scor 2, 32,1% scor 1, 3,6% scor 0. Zero reacții adverse, zero pareze recurențiale permanente.
Concluzii. În această serie, imagistica NIR/ICG cu sistemul Karl Storz IMAGE1 S™ Rubina® s-a dovedit fezabilă şi sigură. Parametrul tev (6,4 min mediu) cuantifică obiectiv eficiența evaluării şi reflectă consolidarea tehnicii operatorului după 15–20 de

cazuri. Cele patru capcane de interpretare documentate şi protocolul de reinjectare (19,0%) pot oferi un cadru tehnic replicabil pentru centrele care implementează această tehnologie.

Cuvinte-cheie: verde de indocianină, imagistică NIR, chirurgie tiroidiană, Karl Storz Rubina, protocol tehnic, fereastră evaluare ICG, capcane de interpretare

Abstract

Background: Postoperative hypoparathyroidism remains the most frequent complication of total thyroidectomy (20-40% transient, 1-4% permanent). Intraoperative NIR imaging with indocyanine green (ICG) is validated for parathyroid gland (PG) perfusion assessment - recognized in the EAES 2023 consensus - but data on practical implementation, temporal parameters and interpretation pitfalls remain limited. *Aim:* To describe the ICG technical protocol with the Karl Storz IMAGE1 S™ Rubina® system, to quantify the evaluation window (tev) and to systematize the interpretation pitfalls encountered.
Materials and methods: Prospective, observational, single-centre study (retrospective analysis of prospectively collected data; enrolment dependent on the intraoperative availability of the ICG preparation, therefore not strictly consecutive), including 42 cases in which intraoperative ICG was used during thyroid surgery (37 women, 5 men; mean age 52.6 years; BMI 27.5 kg/m²), performed between February 2024 and February 2025. Uniform protocol: 5 mg ICG IV (2.5 mg/mL) at approximately 66% of the estimated skin-to-skin time; Vidal Fortuny score (0/1/2). Parameters: time of injection (tinj), fluorescence onset (tf) and ICG evaluation window (tev, from injection to score notation and resumption of surgery).
Results: Operative time (tOR): 88.6 ± 30.2 min. Fluorescence onset (tf): 37.5 ± 5.2 sec. ICG evaluation window (tev): 6.4 ± 2.3 min overall; 5.2 ± 1.8 min in standard cases vs 7.8 ± 2.0 min in complex cases ($p<0.05$). First 21 vs last 21 cases: tev 7.7 vs 5.1 min ($\Delta = -2.6$ min; $p<0.05$). Re-injection in 8/42 cases (19.0%). Perfusion scores: 64.3% score 2, 32.1% score 1, 3.6% score 0. Zero adverse reactions, zero permanent recurrent laryngeal nerve palsy.
Conclusions: In this series, NIR/ICG imaging with the Karl Storz IMAGE1 S™ Rubina® system proved feasible and safe. The tev parameter (mean 6.4 min) objectively quantifies the efficiency of the assessment and reflects consolidation of the operator's technique after 15–20 cases. The four documented interpretation pitfalls and the re-injection protocol (19.0%) may provide a replicable technical framework for centres implementing this technology.

Keywords: indocyanine green, near-infrared imaging, thyroid surgery, Karl Storz Rubina, technical protocol, ICG evaluation window, interpretation pitfalls

Introduction

Total thyroidectomy is among the most frequently performed interventions in endocrine surgery, with an upward trend in operative volume across Europe, also reflecting the broadening of indications towards malignant thyroid pathology (1). The principal specific complication remains postoperative hypoparathyroidism (HypoPT) - 20-40% transient, 1-4% permanent - with significant impact on quality of life and a potential for cardiovascular, renal and neuropsychiatric long-term morbidity (1-4). The main mechanism is devascularization or inadvertent resection of one or several parathyroid glands (PG) during thyroid dissection (5,6).

PG identification and preservation represent one of the essential technical challenges of thyroid surgery. Marked anatomical variability - number (2-6 glands), position, size (3-12 mm) and macroscopic appearance - makes white-light visual identification difficult even for experienced surgeons (7). Hypervascular operative fields (Graves' disease with hypervascular thyroid), fibrotic fields (reoperations) or ectopic glands (intrathyroidal, mediastinal) increase the risk of iatrogenic devascularization (7).

Indocyanine green (ICG) is a hydrophilic fluorescent dye, FDA-approved since 1959 and CE-certified for intraoperative use, with a well-documented excellent safety profile - the rate of severe adverse reactions is below 0.01%, and the reported toxicity threshold (0.2-0.5 mg/kg) far exceeds the clinical doses used (5-10 mg total) (8). After intravenous injection, ICG binds to plasma proteins and circulates within the vascular system, absorbing NIR light at 780 nm and emitting fluorescence at 820 nm, detectable using specialized NIR cameras. The mechanism for PG visualization is based on active vascular perfusion: well-vascularized glands accumulate ICG and light up intensely on the

NIR image, while devascularized glands remain dark - with a quantifiable real-time signal-to-background ratio (SBR) (8,9).

The Karl Storz IMAGE1 S™ Rubina® system combines the white-light image with real-time NIR superimposition (Overlay module), enabling PG perfusion assessment without loss of anatomical orientation of the operative field (9). The EAES 2023 consensus recognizes ICG imaging as a useful tool for PG assessment in thyroid surgery (10), and recent systematic reviews and meta-analyses support the value of the ICG perfusion score in predicting postoperative parathyroid function (11-13). Compared with autofluorescence (NIRAF) - which anatomically identifies PG but does not assess perfusion - ICG provides the dynamic information of vascularization, essential for the autotransplantation decision (14,15).

Nevertheless, data on practical implementation in centres at the start of their experience - step-by-step technical protocol, temporal parameters of the assessment, interpretation pitfalls specific to the Karl Storz Rubina system - remain limited. The present article describes the technical protocol consolidated during the first year of system use, introduces the ICG evaluation window parameter (tev) as a novel objective indicator of intraoperative interpretation efficiency for PG perfusion, and systematizes the interpretation pitfalls encountered. The predictive aspects of the ICG score for HypoPT are beyond the scope of the present article and have been addressed in dedicated meta-analyses (12,13).

Materials and Methods

Study Design and Case Selection

Prospective, observational, single-centre study, conducted at the Department of Endocrine Surgery of the C.I. Parhon National Institute of Endocrinology Bucharest, between February 2024 and February 2025. All cases in which intraoperative NIR/ICG imaging was used during thyroid surgery performed by the same surgeon (D.R.B.) were included, after obtaining standard preoperative informed consent. Data were collected prospectively, within the standardized protocol of the first author's doctoral research project; the present analysis was performed after completion of data collection, as a retrospective analysis of prospectively collected data. Enrolment was not strictly consecutive: the intraoperative use of ICG depended on the availability of the dye preparation (Verdye®) on the day of surgery, a logistical criterion independent of patient or disease characteristics. Exclusion criteria consisted of: documented allergy to iodine, age under 18 years, and cases performed with another imaging system (prior to the study period). The series includes the wide range of thyroid pathology operated at our centre: benign multinodular goitre or with suspicion of malignancy, papillary thyroid carcinoma, Graves' disease - as encountered in the routine practice of a high-volume tertiary centre. For the analysis of temporal parameters, cases were classified as complex in the presence of at least one of the following criteria: associated central neck dissection, Graves' disease, reoperation (completion thyroidectomy in a scarred field) or plunging/retrosternal goitre with major distortion of the regional anatomy; all remaining cases (total thyroidectomy or hemithyroidectomy for uncomplicated multinodular goitre) were classified as standard (22 standard and 20 complex cases).

Ethical Considerations

The study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the Ethics Committee of the Scientific Council of the C.I. Parhon National Institute of Endocrinology, Bucharest (approval no. 20, dated 30.04.2026), within the framework of the first author's doctoral research project. All patients provided written informed consent for the surgical procedure, for the intraoperative use of ICG and for the anonymized use of their clinical data.

NIR Imaging System and Technical Setup

The Karl Storz IMAGE1 S™ Rubina® system was used: POWER LED RUBINA TL 400 light source (780 nm), TC 201 and TC 304 camera control unit modules, Overlay module (simultaneous superimposition of white light + NIR). The NIR gain setting was kept at the system default value throughout the entire series, without individual adjustments, to ensure inter-session comparability of scores.

ICG Protocol - Preparation and Administration

Verdye® (lyophilized ICG, Diagnostic Green GmbH, Aschheim, Germany) was used, reconstituted extemporaneously to 2.5 mg/mL. Standard dose: 5 mg ICG as a peripheral intravenous bolus + 10 mL flush of 0.9% NaCl. Timing of injection (tinj): after completion of the principal thyroid dissection and exposure of the PGs, at 60-70% of the estimated tS2S - 55-60% for standard thyroid interventions, 65-75% for associated central neck dissection (CND), Graves' disease or re-operations. The observed mean: tinj = 45.5 ± 22.9 min (66% of the mean tS2S).

Temporal Parameters - Definitions

(1) tOR: total OR duration (anaesthesia chart). (2) tS2S: estimated skin-to-skin (tOR − 20 min). (3) tf: fluorescence onset (from IV injection to first NIR visualization of a PG, measured in seconds). (4) tev - ICG evaluation window (a parameter introduced by the present study): from injection to score notation of all assessed PGs and resumption of surgery; includes tf, individual visual assessment, necessary repositioning and, where applicable, field lavage and/or ICG re-injection. The tev parameter represents the window with direct practical relevance to the entire anaesthesia-surgical team, defining the time interval „dedicated" to NIR imaging within the operation.

Parathyroid Perfusion Score and Re-Injection

Vidal Fortuny score (16): 0 — absence of fluorescence (devascularization); 1 — faint, delayed or inhomogeneous fluorescence (compromised perfusion); 2 — intense, early, uniform fluorescence (excellent perfusion). Each PG identified intraoperatively received an individual score (P1 — right superior PG, P2 — left superior, P3 — right inferior, P4 — left inferior). Re-injection (a second 5 mg ICG dose) was performed whenever the first assessment was considered technically inadequate: residual bleeding obscuring the PGs (after saline lavage), hypervascular field with insufficient SBR, or identification of parathyroid tissue in the resected specimen — for ex vivo confirmation.

Learning Curve and Statistics

The learning curve was analyzed by comparing the first 21 cases (implementation phase) with the last 21 (consolidated phase); primary endpoint: tev. Data: mean ± SD, median, range. Comparisons: independent Student t-test; $p<0.05$ was considered statistically significant.

Results

Demographic and Histopathological Characteristics

Forty-two cases in which intraoperative ICG was used were included (37 women, 5 men; mean age 52.6 ± 14.2 years, mean BMI 27.5 ± 4.8 kg/m²). Type of intervention: total thyroidectomy — 38 cases (90.5%); completion thyroidectomy — 3 cases (7.1%); hemithyroidectomy — 1 case (2.4%). Associated central neck dissection (level VI) in 8 cases (19.0%). Definitive histopathology revealed: benign multinodular goitre — 28 cases (66.7%); papillary thyroid carcinoma (PTC) — 10 cases (23.8%); Graves' disease — 6 cases (14.3%). Reoperations (completion on prior hemithyroidectomy): 3 cases (7.1%). Inadvertently resected PGs, confirmed histopathologically: 4 glands in 3 cases (9.5%) (*Table 1*).

Temporal Parameters

Total OR duration (tOR): 88.6 ± 30.2 min (median 80 min, range 45-215 min). The wide variability reflects the diversity of the included cases: from simple hemithyroidectomies (45 min) to thyroidectomies with extensive bilateral CND in advanced PTC (215 min). Estimated skin-to-skin duration (tS2S): 68.6 ± 30.2 min. Time of injection (tinj): 45.5 ± 22.9 min from incision (66% of the mean tS2S). Fluorescence onset (tf): 37.5 ± 5.2 sec (range 30–50 sec) — 30 sec in hypervascular fields (Graves' disease), 38 sec in standard cases, 45–50 sec in obese patients or those with low cardiac output (*Table 2*).

ICG Evaluation Window, Re-Injection and Learning Curve

The ICG evaluation window (tev) was significantly greater in complex cases compared with standard cases (7.8 vs 5.2 min; $p<0.05$), reflecting the real differences of the operative field. ICG re-injection was required in 8/42 cases (19.0%): residual bleeding — 3 cases; hypervascular field (Graves' disease with hypervascular thyroid) — 2 cases; ex vivo confirmation of PGs in the resected specimen — 2 cases; combination — 1 case. In these cases, tev ranged between 10 and 15 min. First 21 vs last 21 cases: tev = 7.7 ± 2.1 vs 5.1 ± 1.8 min ($\Delta = -2.6$ min; $p<0.05$), with an inflection point

Table 1. Demographic and clinical characteristics (n=42 cases).

Parameter	Value	Notes
Female sex, n (%)	37 (88.1%)	
Mean age ± SD (years)	52.6 ± 14.2	range 24–73
Mean BMI ± SD (kg/m²)	27.5 ± 4.8	range 19.4–36.7
Total thyroidectomy, n (%)	38 (90.5%)	
Completion thyroidectomy, n (%)	3 (7.1%)	partially scarred field
Hemithyroidectomy, n (%)	1 (2.4%)	
Associated CND level VI, n (%)	8 (19.0%)	bilateral in all cases
Multinodular goitre (benign/suspicious), n (%)	28 (66.7%)	
Histologically confirmed papillary thyroid carcinoma, n (%)	10 (23.8%)	
Graves' disease, n (%)	6 (14.3%)	hypervascularization
Reoperations (completion), n (%)	3 (7.1%)	on prior hemithyroidectomy
Inadvertently resected PGs (histologically confirmed)	4 PGs in 3 cases (9.5%)	

SD = standard deviation; CND = central neck dissection; PG = parathyroid gland. Histopathological categories are not mutually exclusive: some specimens contained more than one lesion type on final pathology (e.g., papillary carcinoma associated with multinodular goitre, or Graves' disease with nodular changes), therefore the sum of the diagnostic categories exceeds n=42.

Table 2. Temporal parameters of the ICG procedure (n=42).

Parameter	Notation	Mean ± SD	Median	Range
Total OR duration (min)	tOR	88.6 ± 30.2	80	45–215
Estimated skin-to-skin (min)	tS2S	68.6 ± 30.2	60	25–195
Time of ICG injection from incision (min)	tinj	45.5 ± 22.9	40	14–146
Fluorescence onset (sec)	tf	37.5 ± 5.2	38	30–50
ICG evaluation window — overall (min)	tev	6.4 ± 2.3	6.0	3.0–15.0
— standard cases (n=22)	tev(std)	5.2 ± 1.8	5.0	3.0–8.0
— complex cases (n=20)	tev(cx)	7.8 ± 2.0	7.5	5.0–15.0

SD = standard deviation; OR = operating room; tS2S = skin-to-skin time.

around cases 15–20 (*Fig. 1*). The tOR was 81.0 ± 24.6 vs 96.2 ± 33.8 min in the two groups (p=0.08), the difference being explained by the concentration of complex cases in the second half of the series.

Distribution of Parathyroid Perfusion Scores

Of the 168 PGs effectively identified and individually scored intraoperatively: score 2 (excellent perfusion) - 108 PGs (64.3%); score 1 (reduced or delayed perfusion) - 54 PGs (32.1%); score 0 (absence of perfusion) - 6 PGs (3.6%). The clinical contexts associated with score 0 included: completely scarred field (third-time completion thyroidectomy) - 1 PG; severe parathyroid atrophy in Hashimoto thyroiditis with anti-TPO >1000 IU/mL - 1 PG; PG devascularization adjacent to a plunging intrathoracic macronodule - 1 PG; inadvertent parathyroid cyst - 1 PG; inadvertently resected inferior PG, confirmed by ex vivo fluorescence - 1 PG; preoperatively medically uncontrolled Graves' disease, with severe postoperative HypoPT - 1 PG (*Table 3*). The figure of 168 glands corresponds to glands actually identified, counted and scored intraoperatively — in this series, all four PGs were identified and assessed in every case, including the ex vivo evaluation of the inadvertently resected glands — and does not represent a theoretical estimate of four glands per patient.

Interpretation Pitfalls

Retrospective analysis of the series identified four main interpretation pitfalls, present in 18/42 cases (42.9%), documented and classified after data collection was completed (*Table 4*).

Safety and Early Postoperative Outcomes

No adverse reactions to ICG administration were recorded (0/42). No permanent recurrent palsy (0/42);

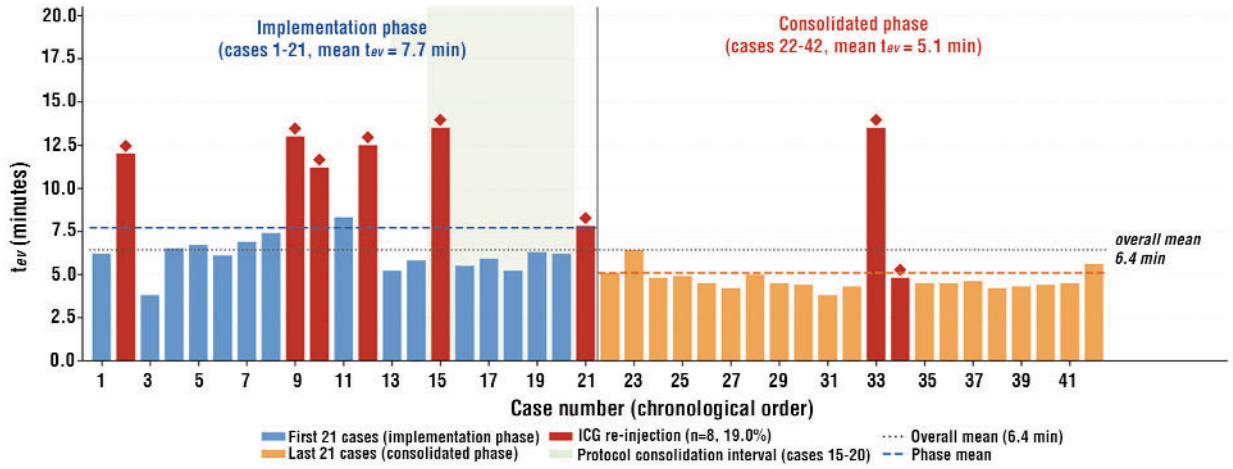

Figure 1. Evolution of the ICG evaluation window (t_{ev}) per case, in chronological order (n=42 cases). Blue bars: first 21 cases (implementation phase, mean t_{ev} = 7.7 min); orange bars: last 21 cases (consolidated phase, mean tev = 5.1 min); red bars: cases requiring ICG re-injection (n=8; 19.0%); shaded area: protocol consolidation interval (cases 15–20); dashed lines: phase means; dotted line: overall mean (6.4 min).

Table 3. Distribution of ICG perfusion scores (n=42, 168 PGs).

Score	Significance	PGs (n)	%	Vidal Fortuny 2018 (16)	Clinical context of score 0
2	Excellent, early, uniform perfusion	108	64.3%	´62%	—
1	Reduced / delayed / inhomogeneous perfusion	54	32.1%	´29%	—
0	Absence of perfusion (devascularization)	6	3.6%	´9%	Scarred field, severe Hashimoto, macronodule, parathyroid cyst, accidental PG, uncontrolled Graves'
Total		168	100%	100%	

PG = parathyroid gland.

Table 4. ICG interpretation pitfalls identified in the series analysis (n=42).

No.	Interpretation pitfall	Mechanism	Intraoperative solution	n
1	Diffuse hypervascularization — Graves' with hypervascular thyroid	Reduced SBR: thyroid and periglandular tissue hyperfluorescent → PGs cannot be discriminated	Adequate preoperative treatment; in residual fields: re-injection after haemostasis	4
2	Residual bleeding obscuring PGs	Blood absorbs NIR at 780 nm → false score 0 (false negative)	Saline field lavage + re-injection	3
3	Coverage by perithymic adipose tissue	Adipose tissue attenuates the NIR signal → false score 1 (falsely low)	Gentle dissection of the adipose tissue before ICG assessment	6
4	Increased latency — obesity / low cardiac output	Prolonged tf (45–50 sec) → premature assessment → false score 1	Wait at least 60 sec before assessment in BMI >35 or heart failure	5

SBR = signal-to-background ratio; PG = parathyroid gland; NIR = near-infrared; BMI = body mass index.

transient vocal cord paresis in 2/42 patients (4.8%), with complete recovery at the 3-month control. Postoperative hypocalcaemia rates fell within the spectrum reported in the literature for centres with a systematic protocol of in situ PG preservation (17).

Discussion

The present series introduces tev as a novel objective indicator of the efficiency of intraoperative PG perfusion interpretation. The mean value of 6.4 min is concordant with literature estimates (14,18) — an interval acceptable from the perspective of operative efficiency. The parameter has practical relevance not only for the surgeon but for the entire anaesthesia-surgical team: the anaesthetist can anticipate the ICG assessment pauses and adjust monitoring accordingly. The stratification of tev by complexity (5.2 vs 7.8 min; $p<0.05$) provides a practical estimate of the procedural overhead according to operative field difficulty.

The significant reduction of tev from 7.7 to 5.1 min ($\Delta = -2.6$ min; $p<0.05$) between the first and last 21 cases confirms the consolidation of the NIR interpretation technique. The inflection point at cases 15–20 is consistent with recent learning-curve data reported in fluorescence-guided thyroid surgery (19) and may be used as a credentialing threshold for autonomous use of ICG. The non-significant difference in overall tOR (81.0 vs 96.2 min; $p=0.08$) does not reflect a technical regression but rather the concentration of cases with extensive CND in the second half of the series — a frequent phenomenon in centres with growing oncological volume (20).

The 19.0% re-injection rate reflects both the composition of the series (Graves' disease, reoperations) and fidelity to the protocol: whenever the first NIR image was deemed inadequate for assigning a confident score, lavage and/or re-injection was performed. This approach prevents false-negative score 0 and, consequently, the erroneous decision for autotransplantation. The maximum cumulative dose (10 mg) remains far below the toxicity threshold, confirming the safety of the procedure (8).

The score distribution (64.3% score 2, 32.1% score 1, 3.6% score 0) compares favourably with the Vidal Fortuny 2018 series (16). The lower frequency of score 0 (3.6% vs ~9%) merits a nuanced discussion: in addition to rigorous in situ preservation, this could reflect a performance bias specific to high-volume centres. A surgeon with extensive experience in visual identification of PGs develops dissection patterns that reduce iatrogenic devascularization, independent of ICG. This pre-existing competence, superimposed on the NIR assessment, generates a centre effect that may partially explain the difference relative to early-implementation series. The slightly increased frequency of score 1 (32.1% vs ~29%) remains compatible with the learning curve: in the early phases of ICG use, the operator tends to be more conservative in assigning score 2 in borderline cases.

The four interpretation pitfalls, retrospectively identified in the series analysis, are concordant

with the literature (14,21). Pitfall 1 — diffuse hypervascularization in Graves' disease with hypervascular thyroid — deserves to be specifically emphasized, as it leads to a SBR insufficient for PG discrimination, requiring re-injection after haemostasis and a quieter field. Pitfall 4 (increased latency in obese/heart-failure patients) is subtle and easy to miss: premature assessment at 30 sec — before ICG has saturated the PGs — produces a false score 1, avoidable by simply waiting 60 sec.

The principal disadvantage of ICG compared with autofluorescence (NIRAF) lies precisely in tev — the 5–8 min interval that NIRAF does not impose, since intrinsic fluorescence is immediately detectable (22,23). In contrast, ICG provides the dynamic perfusion information — which NIRAF, by its nature, cannot supply — essential for the critical distinction between an anatomically present PG (NIRAF-positive) but devascularized (ICG-negative, score 0). This distinction has direct therapeutic implications, since it guides the autotransplantation decision. The combination of the two technologies in hybrid NIRAF+ICG protocols — with NIRAF for rapid anatomical identification and ICG for perfusion confirmation — represents a promising direction for future studies (15).

Limitations

Study limitations include: single-centre observational design with a single operator surgeon, limiting generalizability of the learning-curve data to other surgical training contexts; estimation of tS2S through the formula tOR − 20 min instead of direct measurement of incision–suture time, with possible underestimation effect in cases with prolonged anaesthetic induction; retrospective identification of interpretation pitfalls, without prospective intraoperative recording; absence of a contemporary control group for quantification of the impact of ICG on HypoPT rates; and non-consecutive enrolment, dependent on the intraoperative availability of the ICG preparation — a logistical criterion independent of patient characteristics, but one that precludes describing the series as strictly consecutive. These limitations are, however, inherent to any pilot study of technical implementation, and the prospective data collection and the uniform protocol applied throughout the series represent methodological advantages that confer value within the available literature.

Conclusions

NIR/ICG imaging with the Karl Storz IMAGE1 S™ Rubina® system in thyroid surgery proved feasible and safe in this series, with no adverse events recorded. The ICG evaluation window parameter (tev), with a mean of 6.4 min (5.2 min standard, 7.8 min complex), objectively quantifies the time interval dedicated to NIR imaging within the operation and is of practical relevance to the entire anaesthesia-surgical team. The significant reduction of tev from 7.7 to 5.1 min (Δ = −2.6 min; $p<0.05$) between the implementation and consolidation phases suggests a streamlining of interpretation after approximately 15–20 cases — a potential orientation threshold for credentialing programmes. The need for re-injection in 19.0% of cases and the documentation of the four main interpretation pitfalls highlight that mastery of the technology goes beyond mere acquisition of equipment: the lavage, re-injection and adequate-waiting protocol appear to be key elements for the optimal exploitation of the NIR image.

Conflicts of Interest: None.

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