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Parathyroid Preservation in Open Thyroid Surgery

Lei Tang[1,2], Chuanchang Yin[1*]

[1]The First Affiliated Hospital of Yangtze University, Jingzhou, China
[2]Graduate School, Yangtze University, Jingzhou, China
Email: 841029418@qq.com, *yinchuanchang@yangtzeu.edu.cn

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Abstract

Parathyroid dysfunction after thyroidectomy can occur even when the glands have been left in place, because dissection may interrupt their blood supply. This narrative review considers how that risk can be reduced during adult open thyroid surgery, particularly total and completion thyroidectomy. It covers relevant anatomy, operative technique, imaging, autotransplantation, and postoperative care. Capsular dissection allows thyroidal branches to be divided while parathyroid vessels are retained. Anatomical and observational evidence supports this approach, although direct trials of its long-term functional benefit are scarce. The need for bilateral resection or central neck dissection should be established before exposing additional glands to injury. Near-infrared autofluorescence can help identify parathyroid tissue; indocyanine green angiography provides information about perfusion. Neither measures hormone secretion. Trials of autofluorescence have yielded inconsistent functional results, despite pooled evidence of less early hypocalcemia and fewer inadvertently excised glands. Selective autotransplantation offers a means of salvaging benign tissue that has been removed or clearly devascularized. The benefit of routinely transplanting an otherwise viable gland remains uncertain. After surgery, early parathyroid hormone measurements help guide supplementation and the intensity of follow-up. Low early values often require treatment and surveillance, but chronic postsurgical hypoparathyroidism is defined by persistence beyond 12 months. Assessment of recovery, including supervised adjustment of supplements, is therefore part of care. Preserving circulation during surgery and documenting subsequent function remain the basis for judging whether a preservation technique benefits patients.

Keywords

Thyroidectomy, Parathyroid Preservation, Hypoparathyroidism, Hypocalcemia,

Near-Infrared Autofluorescence, Indocyanine Green, Autotransplantation

1. Introduction

Perioral tingling, paresthesia, or muscle cramps may be the first sign of hypocalcemia after thyroidectomy. Severe cases require urgent treatment. For patients whose parathyroid function does not recover, the consequences extend well beyond the postoperative admission: medication and biochemical monitoring continue, and renal or other complications may develop [1] [2]. Total and completion thyroidectomy deserve particular attention because they may affect the patient's entire remaining parathyroid reserve.

The surgeon must preserve functioning parathyroid tissue while completing the operation required for the thyroid disease. Recognition of a gland is only the first step; its arterial supply and venous drainage also need protection. If injury occurs, a decision must be made about whether the gland can remain *in situ*. Imaging can assist these judgments, although tissue identification and visible perfusion do not establish sustained hormone secretion. We examine these issues in adults undergoing conventional open thyroid surgery. Operations for primary or renal hyperparathyroidism fall outside this review because their purpose includes deliberate parathyroid resection.

2. Review Scope and Literature Selection

This review addresses the measures used before, during, and after adult open thyroid surgery to preserve parathyroid function, together with the outcomes used to assess them. PubMed/MEDLINE was searched from inception to September 9, 2026, using combinations of "parathyroid preservation," "thyroidectomy," "completion thyroidectomy," "capsular dissection," "hypoparathyroidism," "hypocalcemia," "near-infrared autofluorescence," "indocyanine green," "carbon nanoparticles," "autotransplantation," and "postoperative parathyroid hormone." Reference lists in major guidelines, trials, and reviews were also checked. Publication details were verified against journal or DOI records.

English-language guidelines, anatomical studies, comparative clinical studies, randomized trials, systematic reviews, and meta-analyses were eligible when their findings applied to adult open thyroidectomy, completion thyroidectomy, or central neck dissection. We excluded reports limited to children, parathyroidectomy for primary or renal hyperparathyroidism, and remote-access or robotic procedures without findings directly applicable to open surgery. Case reports and small technical series were not used as evidence of comparative effectiveness.

The review is narrative. There was no registration, independent duplicate screening, formal risk-of-bias assessment, or new meta-analysis. In comparing studies, we considered the patients and procedures included, the comparator, the outcome definition, and the length of follow-up. Results concerning identification or per-

fusion were considered separately from biochemical dysfunction, symptoms, supplement use, and chronic hormone deficiency.

3. Defining the Outcome before Comparing Techniques

A low calcium concentration after thyroidectomy is not, by itself, the same outcome as hypoparathyroidism. Here, early biochemical hypoparathyroidism means that parathyroid hormone (PTH) falls below the assay's lower reference limit, or the threshold chosen by the study, within 24 hours of total, completion, or another bilateral thyroid operation. This definition does not require symptoms and does not predict whether the disturbance will persist. Corrected or ionized calcium is reported separately. Calcium and activated vitamin D given prophylactically or as treatment must also be considered when interpreting results. Where a study used a different sampling time or threshold, we retain its definition [2] [3].

We use chronic postsurgical hypoparathyroidism for biochemical abnormalities and dependence on treatment that persist beyond 12 months, following international guidance [2] [4]. Older studies often assessed "permanent hypoparathyroidism" at 6 months. Their results are described here as study-defined 6-month outcomes, and "permanent hypocalcemia" is retained when that was the original endpoint. Recovery requires more than a review of prescriptions: calcium and PTH should be measured, with supervised reduction of supplements when appropriate. Some patients recover even after a prolonged interval. Continued supplementation, without an attempt to assess endogenous function, can consequently overstate the frequency of persistent gland failure.

How patients are followed also affects the apparent incidence. A Swedish nationwide cohort found more patients on long-term treatment when operative records were linked to prescription data than when reported complications alone were counted [5]. Prescription records have limitations of their own, but this discrepancy makes a single incidence range difficult to interpret. Meaningful comparisons need to account for the type of operation, nodal dissection, completeness of follow-up, and criteria for persistent disease.

4. Anatomy and Preoperative Planning

Gland location and vascular vulnerability

Four glands are usual, but neither their number nor their position is constant. Akerström and colleagues examined 503 individuals at autopsy and found four parathyroid glands in 84% and supernumerary glands in 13%. The superior glands commonly lay near the crossing of the recurrent laryngeal nerve and inferior thyroid artery. Inferior glands were more often associated with the lower thyroid pole, upper thymus, or thyrothymic ligament [6]. These landmarks help the surgeon recognize tissue encountered during dissection. They do not justify exploring every possible ectopic site; a gland beyond the required operative field may be best protected by leaving that area undisturbed.

Vascular anatomy explains some failures of apparently successful preservation. Although the inferior thyroid artery supplies many glands, branches of the superior thyroid artery and variable anastomoses also contribute [7]. A 2025 cadaveric study examined 110 glands from 30 specimens. Most had a single terminal arterial vessel, and some arteries supplying inferior glands traversed thyroid parenchyma [8]. Separation from the thyroid can therefore leave a gland anatomically intact but ischemic. Cadaveric findings cannot establish viability during an operation, yet they give reason to protect the principal pedicle rather than assume that collateral vessels will compensate for its loss.

Risk assessment and the intended operation

Planning begins with the extent of surgery the disease requires: lobectomy, a bilateral procedure, completion thyroidectomy, or nodal dissection. The history should identify previous neck operations, autoimmune thyroid disease, large or substernal goiter, and relevant conditions such as malabsorption or vitamin D deficiency [1]. Baseline calcium and renal function help interpret later biochemical changes. PTH and magnesium can be added when the history or initial results suggest a pre-existing disorder. Vitamin D deficiency should be corrected where present, alongside attention to the operative factors that threaten perfusion.

For a patient returning to surgery, the earlier operative note and pathology report may indicate how much parathyroid reserve remains. Preoperative imaging serves primarily to define thyroid disease, nodal involvement, and substernal extension, rather than to localize normal parathyroid glands. Complex bilateral operations and reoperations require suitable surgical expertise and a plan for postoperative monitoring [9]. Before surgery, patients should understand the early symptoms of hypocalcemia and the possibility that treatment may need to continue for a prolonged period.

Completion thyroidectomy

Completion thyroidectomy exposes glands on the previously unoperated side in a patient who may already have lost part of their functional reserve. The first operation should therefore be reviewed in detail. Which glands were identified, removed, or autotransplanted? Was hypocalcemia recorded afterwards, and did the specimen contain parathyroid tissue? Missing documentation leaves uncertainty about function. The indication for the second procedure and its extent should also be reassessed against the disease-specific criteria used for primary surgery [9].

Corrected or ionized calcium and PTH provide a useful biochemical baseline before completion surgery. Magnesium, renal function, and 25-hydroxyvitamin D are checked when indicated. Although the second operation is anatomically unilateral, the resulting risk to parathyroid function resembles that of a bilateral procedure. Early postoperative PTH and calcium testing should therefore be planned in advance. Low PTH calls for closer surveillance of symptoms and biochemistry, followed by assessment of recovery before the condition is regarded as chronic [1] [2].

5. Preserving Glands and Their Circulation

Capsular dissection and limited exposure

During capsular dissection, thyroidal vessels are controlled close to the thyroid as it is separated from adjacent structures. Delbridge and colleagues described dividing small terminal branches while retaining parathyroid pedicles and limiting dissection around the recurrent laryngeal nerve [10]. This selective approach leaves supporting tissue around the gland and avoids unnecessary skeletonization of the inferior thyroid artery. Traction and handling should be directed through surrounding tissue where possible, sparing the gland itself from forceps pressure. The rationale is well grounded in vascular anatomy and operative experience, with support from observational studies. Direct comparative evidence for long-term parathyroid outcomes remains limited [7] [10].

Separation becomes more difficult when a parathyroid lies tightly against the thyroid or receives an artery with a short, partly intrathyroidal course [8]. Dissection should proceed only as far as needed for the planned resection, with attention to the gland and pedicle together. Leaving the gland in situ achieves little if its sole supply has been divided. Retaining adjacent thyroid tissue may alter the intended operation, so this decision must be based on the anatomy encountered and the oncological requirements; it is not a routine measure for every gland.

The association between tissue retained in situ and postoperative function was examined prospectively in 657 patients having a first total thyroidectomy [11]. Outcomes worsened as fewer glands remained. The investigators' parathyroid glands remaining in situ (PGRIS) score subtracted autografted glands and those found in the specimen from an assumed total of four. It offers a useful record of tissue loss, but it neither measures perfusion nor fully accommodates variation in gland number. Seeking additional glands solely to complete a count can itself add dissection. An operative note should instead record the glands actually encountered, their apparent vascular condition, and any removal or transplantation.

Hemostasis and difficult dissection

Selective hemostasis depends on being able to see the bleeding point. Clamping an unidentified bundle behind the thyroid can injure a gland or its supply. The same concern applies to traction on a short pedicle and to energy activation beside small feeding vessels. Thermal spread and residual instrument heat depend on the device and how it is used, so no single separation distance guarantees safety. Where space is restricted, a tie, clip, or cold dissection may be easier to control [12]. Adequate exposure remains necessary whichever method is chosen.

A large goiter may displace familiar landmarks, while thyroiditis or scarring from earlier surgery may obscure the tissue planes. In these cases, enlarging the exposure and beginning in an accessible, less scarred area can help define the anatomy. The safest direction of dissection varies with the operation. A substernal component should not be delivered blindly, because attached vessels may be avulsed. Nor should a suspected tumor routinely be opened merely to make mobilization easier. Difficulty at this stage warrants reconsideration of exposure and the planned

resection, with specialist support when needed [9].

Central neck dissection

Avoiding unnecessary central neck dissection reduces the tissue and vessels exposed to injury. The 2025 American Thyroid Association (ATA) guidelines advise against prophylactic central dissection for most small, noninvasive, clinically node-negative papillary cancers and recommend therapeutic clearance when central nodes are clinically involved [13]. When clearance is indicated, the surgeon must preserve parathyroid tissue within the requirements of an adequate compartmental operation. A fixed plane assumed to lie above the glands will not meet both aims in every patient. Inferior glands and their thyrothymic attachments deserve careful assessment, including whether a retained attachment still carries a viable vascular connection. If the first side has sustained substantial functional injury, the need for optional contralateral dissection should be reconsidered.

6. Identification and Perfusion Assessment

Near infrared autofluorescence

Near-infrared autofluorescence uses the gland's intrinsic optical signal and does not require a dye. It can help distinguish a small parathyroid from fat or a lymph node and can identify tissue on a removed specimen. Signal persistence after excision is also a limitation. Wang and colleagues found fluorescence in excised and archived paraffin-embedded tissue, as well as interference from brown fat and eschar [14]. A fluorescent focus must therefore be interpreted with the anatomy; it gives no assurance of an intact circulation. Camera systems display a field image, whereas fiber-based probes assess individual points, a distinction that matters when comparing clinical studies.

In the PARAFLUO trial, 245 adults scheduled for total thyroidectomy were randomized and 241 were analyzed. Camera-based autofluorescence was compared with conventional visual surgery. Corrected calcium below 8.0 mg/dL (2.0 mmol/L) on postoperative day 1 or 2 was the primary endpoint; no preoperative calcium or calcitriol prophylaxis was given. Hypocalcemia occurred in 11 of 121 patients (9.1%) in the imaging group and 26 of 120 (21.7%) in the control group. Inadvertent excision was also less frequent (2.5% versus 11.7%), as was autotransplantation (3.3% versus 13.3%). Patients who became hypocalcemic were followed for 6 months. At that point, the reported permanent hypocalcemia outcome occurred in no imaging patients and two controls, without a statistically significant difference [15].

A later multicenter trial by Bergenfelz and colleagues analyzed 486 patients undergoing planned total thyroidectomy [16]. Its primary outcome was low PTH relative to the local assay range on postoperative day 1. With camera-based autofluorescence, this occurred in 64 of 246 patients (26.0%); with conventional surgery, it occurred in 77 of 240 (32.1%). The overall difference was not significant. Rates in the prespecified central neck dissection subgroup were 18.3% and 33.7%, respectively. Treatment continued at 6 months in six imaging patients and 10 con-

trols. Although the trial termed this "permanent hypoparathyroidism," the duration supports a 6-month outcome under the definitions used here.

Cousart and colleagues used a fiber-based system in a multicenter randomized trial whose thyroidectomy cohort comprised 354 patients undergoing total or completion surgery [17]. The primary outcome, the mean number of glands identified, increased from 2.8 with conventional identification to 3.3 with autofluorescence. Functional outcomes were secondary. Neither transient hypoparathyroidism (27.8% versus 26.0%) nor hypoparathyroidism at the last visit (1.7% versus 3.4%) differed significantly between the imaging and control groups. The follow-up protocol covered 6 months, and all thyroidectomy patients attended at least one visit. Only 17.2% were followed beyond 6 months, leaving uncertainty about chronic outcomes.

Pooled results are more favorable to camera-based autofluorescence. A meta-analysis of seven randomized trials with 1,437 patients found lower risks of early postoperative hypocalcemia and inadvertent gland removal [18]. It also found fewer events classified as permanent, although that estimate was imprecise and combined different definitions and follow-up intervals. Whether an imaging system is useful in a particular unit will depend on baseline complication rates, surgeon experience, and the device being used. Its timing is equally relevant: recognizing a gland before a vessel is divided offers an opportunity for preservation that recognition afterwards cannot provide.

Indocyanine green angiography

Indocyanine green (ICG) angiography shows dye arriving through the circulation after intravenous injection. Once a structure has been recognized as parathyroid, this provides information about its perfusion. Enhancement also occurs in surrounding tissues. Injection timing, hemodynamics, camera settings, and the scoring system can all affect the appearance, so a visual score is a semiquantitative assessment to be considered with the pedicle anatomy and the preceding dissection [7].

The randomized study by Vidal Fortuny and colleagues examined postoperative care after a reassuring ICG result [19]. All 196 patients underwent angiography. The 146 with at least one well-perfused gland were then assigned either to standard care, including day-1 calcium and PTH tests and routine calcium and vitamin D, or to omission of those tests and supplements. Calcium and PTH were measured in both groups at 10 - 15 days, with hypocalcemia at that visit as the primary endpoint. No randomized patient developed hypoparathyroidism. Of the 50 patients without a well-perfused gland, who were excluded from randomization, 11 had hypoparathyroidism on day 1 and six at 10 - 15 days. This design supports interpretation of the angiogram for subsequent management. It does not establish whether using ICG during dissection improves outcomes compared with surgery without ICG.

Carbon nanoparticles and tissue PTH testing

Carbon nanoparticles stain thyroid tissue and draining lymph nodes, usually

leaving the parathyroids unstained. The resulting negative contrast may help with recognition, but other tissue can also remain unstained, and the technique does not assess blood flow. In a meta-analysis of 12 studies involving 1870 patients, use of carbon nanoparticles was associated with fewer inadvertent parathyroid excisions and less transient dysfunction than conventional surgery. A significant reduction in the studies' reported permanent hypoparathyroidism outcomes was not demonstrated [20].

In a multicenter randomized trial of 569 patients with papillary thyroid cancer, 283 underwent lobectomy and 286 underwent total thyroidectomy [21]. Carbon nanoparticles were compared with no dye. PTH was measured before and during surgery, on postoperative day 1, and at 1 month. Among patients having total thyroidectomy, the groups had similar PTH on day 1. Mean PTH was higher with carbon nanoparticles at 1 month, but calcium at that visit was similar. The number of glands retained in situ did not differ significantly. These findings describe short-term biochemical changes; the 1-month assessment was too early to determine chronic hypoparathyroidism.

Tissue aspirate or washout PTH testing is useful for a different uncertainty: the identity of the structure being sampled. Zou and colleagues studied 186 samples from 31 patients and found much higher PTH concentrations in parathyroid tissue [22]. This was a small diagnostic study, with no demonstration of improved long-term function. Sampling should therefore be reserved for situations in which confirmation is needed, especially when a gland could otherwise remain intact. Blood collected without a defined tissue source cannot answer the same question. Circulating PTH, meanwhile, indicates aggregate secretion and cannot localize injury to an individual gland.

7. Selective Autotransplantation and Intraoperative Salvage

Once the thyroid or central-compartment specimen has been removed, it should be inspected on the sterile field for parathyroid tissue. The 2025 ATA guidelines recommend frozen-section confirmation of benign parathyroid tissue from a portion of a removed or devascularized gland before implantation into nearby muscle [13]. Confirmation is particularly relevant in cancer surgery, where a node or tumor deposit may resemble a parathyroid and must not be transplanted. An otherwise viable gland left in situ should be spared a routine biopsy solely for identification.

A change in color needs to be interpreted in context. Venous congestion may improve after traction is released or drainage recovers; conversely, loss of an arterial supply may not immediately alter the gland's appearance. The pedicle, the maneuvers just performed, and any available perfusion imaging can help guide reassessment. Repeated puncture, deliberate bleeding, and topical vasodilators have not been established as routine rescue measures. A gland that has been excised or clearly devascularized provides a firmer indication for autotransplantation than color change alone [12].

For autotransplantation, small tissue fragments are placed in vascularized muscle, commonly the sternocleidomastoid, and the site is recorded. Implantation in the forearm creates a separate operative site but allows graft secretion to be assessed by comparing PTH between the arms. Lo and Tam demonstrated such a gradient by postoperative day 28 in a study of seven patients [23]. The finding confirms that grafts can secrete PTH, though this small series cannot provide a general success rate. Calcium management is still required during the interval before the graft becomes functional.

Whether to transplant a gland that could remain viable in situ is less clear. A 2025 meta-analysis included 18 studies and 8,182 patients; autotransplantation was associated with more immediate and transient hypoparathyroidism, without a significant reduction in reported permanent outcomes [24]. These comparisons are affected by the reason for grafting. Patients receiving an autograft often already have injured glands or have undergone more difficult surgery. The results therefore need to be distinguished from the rationale for selective salvage of tissue that would otherwise be lost. Evidence has yet to identify a subgroup that clearly benefits from planned transplantation of a safely preservable gland.

8. Postoperative Assessment and Treatment

Early biochemical risk and supplementation

PTH measured soon after bilateral thyroid surgery helps determine the need for closer observation and supplements. The 2022 international guidance considers a value above 10 pg/mL at 12 - 24 hours strongly reassuring against long-term hypoparathyroidism [2]. Values below this threshold can still recover and should not be taken as proof of permanent injury. Interpretation also depends on the assay, sampling time, calcium concentration, renal function, and treatment protocol.

Cayo and colleagues prospectively studied 143 patients after total thyroidectomy [25]. Of the 31 whose first-day PTH was below 10 pg/mL, 15 developed symptoms and five needed intravenous calcium. Most patients with PTH at or above 10 pg/mL managed without routine supplements, although some had transient symptoms treated with oral calcium. These findings support PTH-guided care and also explain why patients with a reassuring result still need advice and follow-up. A favorable intraoperative assessment alone is insufficient grounds for omitting postoperative monitoring.

Units may use a standardized prophylactic regimen or prescribe oral calcium and activated vitamin D selectively. The intensity of treatment should take account of symptoms, trends in calcium and PTH, renal function, and access to repeat testing. Patients should receive clear instructions about tingling, cramps, and circumstances requiring urgent review. As parathyroid function returns, doses need reassessment to avoid rebound hypercalcemia [1].

Severe symptoms and persistent disease

Tetany, seizures, arrhythmia, laryngospasm, or severe biochemical hypocalcemia warrants urgent assessment in a monitored setting. Management may require

intravenous calcium, electrocardiographic monitoring, and repeated calcium measurements, together with correction of magnesium deficiency and other contributing abnormalities [26]. Symptoms must be considered alongside their progression and the biochemical findings: mild isolated tingling and a life-threatening disturbance require different responses. Once the patient is stable, treatment can be transitioned to an appropriate oral regimen.

Follow-up for chronic hypoparathyroidism includes symptoms and measurements of calcium, phosphate, magnesium, and renal function, with urinary calcium assessment as appropriate. Adequate calcium intake and activated vitamin D remain conventional treatment, with doses adjusted to control symptoms while avoiding excessive calcium exposure. The 2025 European guideline also supports PTH replacement in selected patients whose disease remains inadequately controlled despite optimized conventional therapy, according to availability and individual suitability [4]. Counseling should allow for these options and for reassessment of recovery. Continued use of supplements does not establish persistent gland failure if endogenous function has never been reassessed.

9. Priorities for Research and Practice

Studies of preservation techniques need to connect operative findings with the patient's subsequent course. Reporting should include inadvertent excision, glands retained or grafted, early biochemical dysfunction, symptoms requiring treatment, and recovery assessed beyond 12 months. For imaging studies, it matters when the device was used and what the surgeon did in response. An image obtained after devascularization cannot offer the same preventive opportunity as information available before a vessel is divided. Device-specific trials should describe both surgeon experience and the operative decisions prompted by an abnormal finding.

The remaining question is how much an adjunct improves outcomes when added to careful surgery in different settings. Larger studies using consistent definitions would help establish effects on persistent dysfunction. Prospective assessments of workflow and cost could show where the practical benefit justifies adoption. Follow-up should capture treatment burden and renal safety, as well as whether function has recovered, rather than rely on a prescription recorded at a single visit. The recent surgical consensus identifies similar reporting problems [3]. Addressing them would make it easier to judge whether better identification produces a lasting benefit for patients.

10. Conclusion

Successful parathyroid preservation requires glands to retain a working blood supply after the thyroid operation is complete. Selective control of vessels and avoidance of unnecessary resection provide the operative basis. Autofluorescence can assist recognition, ICG can inform assessment of perfusion, and selective autotransplantation can salvage tissue when preservation *in situ* is no longer possi-

ble. Their value should be judged against the specific problem each is intended to address. Postoperative PTH assessment and appropriately adjusted supplementation then support safe recovery. Longer follow-up is needed to establish who regains endogenous function and who continues to require treatment.

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Ethics Approval and Consent to Participate

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Consent for Publication

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Availability of Data and Materials

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Author Contributions

Lei Tang: Conceptualization, methodology, literature review, writing—original draft. Chuanchang Yin: Conceptualization, supervision, writing—review and editing. All authors read and approved the final manuscript.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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