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Case Report

Pteye System for Intraoperative Identification of Parathyroid Glands During Thyroidectomy: First Use in A Spoke Center

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Abstract

Thyroid and parathyroid surgery requires meticulous attention to the preservation of parathyroid glands to prevent postoperative complications such as hypoparathyroidism. The identification of parathyroid glands during surgery has traditionally relied on the surgeon's visual assessment; however, the introduction of advanced technologies, such as Near-Infrared Fluorescence (NIR), offers a novel approach [1-4]. In this study, we report the case of a patient who underwent total thyroidectomy and central lymphadenectomy for a TIR 4 nodule, in which the PTeye system was utilized to assist in parathyroid identification. Clinical and technical outcomes are discussed in light of recent literature, highlighting the advantages of this technology in enhancing intraoperative safety, reducing the risk of complications, and optimizing clinical outcomes.

Introduction

Complications from thyroid and parathyroid surgery, such as postoperative hypoparathyroidism, represent a significant challenge in clinical practice. Transient hypoparathyroidism can affect up to 30% of patients, while permanent hypoparathyroidism, though less frequent, requires long-term management that is burdensome for both patients and healthcare systems [5,6]. Preservation of the parathyroid glands through accurate identification and maintenance of their vascularization is crucial to mitigating these risks.Traditionally, parathyroid identification has relied on the surgeon's visual assessment, supported by personal experience. However, the introduction of Near-Infrared Fluorescence (NIR) has opened new avenues, enabling more precise differentiation between parathyroid glands and surrounding tissues [1,2,4]. Devices such as the PTeye represent one of the most promising applications of this technology, providing real-time visual and quantitative feedback [7].

Case Presentation

Patient Data

The patient, a 51-year-old woman, presented to our clinic with a diagnosis of Multinodular Goiter (MNG) and an isthmic nodule measuring 1.4 cm, classified as TIR 4 according to the SIAPEC 2014 guidelines.

Her medical history included

- Autoimmune hypothyroidism diagnosed at the age of 17, treated with levothyroxine.
- Arterial hypertension managed with pharmacological treatment.
- No family history of thyroid disorders or radiation exposure.

Preoperative Tests

The preoperative laboratory findings were as follows

- TSH: 2.52 μIU/ml
- FT3: 2.42 pg/ml
- FT4: 0.73 ng/dl
- Anti-thyroid peroxidase antibodies: 0.6 IU/ml
- Anti-thyroglobulin antibodies: 1.2 IU/ml
- Serum calcium: 8.7 mg/dl
- PTH: 43.2 pg/ml

Diagnostic and Surgical Pathway

A diagnosis of TIR 4, confirmed by ultrasound-guided fine-needle aspiration biopsy, indicated the need for total thyroidectomy with central lymphadenectomy. During the surgery, the following technologies were employed:

Intermittent Intraoperative Neuromonitoring (NIM): To preserve the recurrent laryngeal nerves.

PTeye System: To support parathyroid identification through NIR fluorescence [1-4,7]. The PTeye device enabled visual confirmation of suspected parathyroid glands, minimizing the risk of accidental injury or devascularization. It was used immediately after isolating the superior thyroid pole and later after identifying the inferior pole to provide real-time feedback on parathyroid presence [7]. The device proved particularly useful in distinguishing parathyroid glands from lymphatic tissue requiring excision.The auditory feedback provided by the system facilitated immediate confirmation of successful identification of both superior and inferior parathyroid glands bilaterally. Moreover, the system seamlessly integrated with the neuromonitoring setup for both superior and recurrent laryngeal nerves without causing interference or prolonging surgical time [3,7]. The procedure concluded without immediate complications, and the patient experienced an uneventful postoperative course. A precautionary drain was removed the morning after surgery, and the patient was discharged on the first postoperative day.

Histological Examination

- Papillary thyroid carcinoma, 1.4 cm in greatest dimension, encapsulated follicular variant with minimal invasion, in a simple goiter (IEFVPTC - WHO 2022).
- No evidence of necrosis or angioinvasion; no mitotic activity observed.
- Proliferative activity index (Ki-67): <5% (approximately 3%).
- Pathological staging (UICC 2017, 8th edition): pT1b, pN0.
- Central compartment lymph nodes: negative for malignancy (13/13 small isolated lymph nodes).

These findings confirmed the indication for surgery and the usefulness of advanced intraoperative technologies for parathyroid preservation [1-4,7].

Postoperative Tests

- The postoperative course was uneventful. Laboratory values on the first postoperative day were:
- PTH: 39.4 pg/ml
- Serum calcium: 9.1 mg/dl
- Biochemical stability further supported the role of PTeye in minimizing the risk of postoperative hypoparathyroidism [2-4,7].

Pre- and Postoperative RFLS Examination

The pre- and postoperative RFLS (Recurrent Laryngeal Functional Status) examination showed normal results, with regular vocal cord mobility, confirming the combined effectiveness of neuromonitoring and NIR-based parathyroid identification [3,7].

Follow-Up and Postoperative Management

The patient underwent endocrinological and oncological consultation upon receipt of the definitive histological report. A follow-up appointment was scheduled 30 days post-surgery to evaluate the need for additional therapy.

The postoperative management reflected current recommendations for endocrine surgery, emphasizing the relevance of advanced imaging and intraoperative fluorescence guidance for improving patient outcomes [1-4,7].

Discussion

Practical Benefits of Autofluorescence

Earlyand Accurate Parathyroid Identification: According to Barbieri et al. [1], NIR-based devices, such as the PTeye, enable reliable intraoperative identification of parathyroid glands. This approach minimizes the risk of accidental injury, which is particularly valuable in cases of complex anatomy. A comparison between traditional surgery and NIR-assisted techniques demonstrated a significant reduction in transient complications and improved preservation of parathyroid function [1,4].

Reduction of Transient Hypoparathyroidism: As highlighted in Wendelin et al.'s study [4], NIR fluorescence devices decrease

the incidence of postoperative hypoparathyroidism, especially in patients with ectopic or atypically located parathyroid glands. Furthermore, this technology reduces the need for additional procedures, such as autotransplantation of accidentally removed glands [2,4].

Integration with Advanced Surgical Techniques: Devices like the PTeye seamlessly integrate with other intraoperative technologies, such as intermittent Neuromonitoring (NIM). This synergy enhances surgical precision, supporting both experienced surgeons and those in training. Makovac et al. [3] demonstrated that feedback provided by the PTeye shortens operative time and increases safety, even in the most complex cases [3,7].

Supportin Complex Cases: NIR autofluorescence proves particularly beneficial in challenging scenarios, such as parathyroid glands covered by adipose tissue or located in atypical positions. Makovac et al. [3] reported that 15% of visually undetectable parathyroid glands were successfully located using NIR technology, significantly reducing the risks of erroneous resection.

Benefits of the PTeye System

The adoption of the PTeye system in endocrine surgery offers numerous practical and clinical advantages, demonstrating its utility in both routine practice and complex cases [2,3,7].

Enhanced Safety and Surgical Effectiveness: The use of the system helps reduce surgical complications, such as postoperative hypoparathyroidism, which can result from damage to or accidental removal of parathyroid glands [1,3,4]. This technology minimizes the need for corrective interventions, improving long-term outcomes for patients.

Speedand Accuracy in Identification: NIR fluorescence technology provides immediate and precise feedback, making it easier to distinguish parathyroid glands from surrounding tissues [2,3,7] .This reduces the risk of intraoperative errors, ensuring safer outcomes.

Real-Time Objective Assessment: The device offers quantitative data on detected fluorescence, enabling surgeons to confidently identify parathyroid glands and map surrounding tissues. This controlled approach enhances management during the procedure [7].

Intuitive Designand Ease of Use: The system's simplicity facilitates integration into the surgical workflow without requiring significant adjustments, such as changes to operating room lighting. Its compact structure and intuitive configuration allow the surgical team to operate the device seamlessly and without disruptions [7].

Reduced Operative Time: By providing immediate feedback, the system supports rapid identification of parathyroid glands, helping to accelerate the procedure without compromising safety [3,7].

Suitability for Minimally Invasive Procedures: The small size of the probe makes it particularly well-suited for minimally invasive thyroidectomy and parathyroidectomy procedures, expanding its applications in diverse surgical scenarios [3,7].

Educational Tool for Surgical Training: The PTeye system is a valuable resource for teaching surgeons in training, offering technological assistance during parathyroid identification procedures [7]. This feature makes it especially beneficial in academic and advanced training settings.

Clinical Impact and Limitations of the Technology

Despite its benefits, NIR autofluorescence has certain limitations that warrant consideration for optimal clinical integration [1,3,4].

NIR Light Penetration: The penetration capacity of fluorescence through tissues is limited, making it challenging to identify parathyroid glands covered by adipose tissue or blood. This issue, highlighted by Wendelin et al. [4], can be addressed by using complementary technologies such as angiography [3].

Technological Integration: The effectiveness of autofluorescence can be enhanced by combining it with Indocyanine Green (ICG) angiography, which provides valuable information on gland perfusion and viability.Makovac et al. [3] demonstrated that this combination is particularly effective in preventing parathyroid damage and improving postoperative outcomes.

Conclusions

The use of Near-Infrared Fluorescence (NIR) technology with devices such as PTeye represents a significant advancement in thyroid and parathyroid surgery [1-4,7]. In the described clinical case, this innovation enabled precise identification of parathyroid glands, minimizing the risk of postoperative hypoparathyroidism and enhancing intraoperative safety.Evidence from the literature supports the benefits of this technology, including:

Reduction of complications: Lower incidence of transient and permanent hypocalcemia [1,4].

Enhanced Surgical Safety: Early and reliable identification of parathyroid glands [1,3,4,7].

Ease of Use: Seamless integration into the surgical workflow without additional complexities [7].

Educational Support: An ideal tool for training new surgeons, improving intraoperative learning [7]. Despite its promising results, some technical limitations remain, such as the reduced penetration of NIR light through dense tissues [4]. However,integration with complementary technologies, such as Indocyanine Green (ICG)

angiography, could overcome these challenges [3]. The adoption of NIR fluorescence in endocrine surgery marks a step forward toward safer and more effective procedures, with a positive impact on postoperative complication management and patient care quality. Further multicenter studies will be essential to validate and optimize the use of this technology in daily clinical practice [1-4]. Traditionally, parathyroid identification relies on the surgeon's visual experience, a method that can be challenging, especially in cases with complex anatomy. The introduction of PTeye provides technological support that simplifies this process, offering real-time feedback on the presence of parathyroid glands through a fiber optic probe that detects their natural autofluorescence [2,7]. The use of PTeye in a Spoke center represents a significant step toward the dissemination of advanced technologies in peripheral facilities. This approach raises surgical standards, offering high-quality treatments to patients regardless of the center's location. Additionally, adopting such technologies in Spoke centers promotes greater uniformity in surgical procedures and clinical outcomes, contributing to a more integrated and efficient healthcare network [7]. It is important to note that implementing PTeye requires adequate training of surgical staff to maximize its benefits. Clinical studies have shown that the use of PTeye can improve accuracy in identifying parathyroid glands, reducing the risk of accidental injury and improving postoperative outcomes [3,7]. In conclusion, the integration of the PTeye system in Spoke centers represents a positive evolution in endocrine surgery, promoting the adoption of innovative technologies that enhance the safety and effectiveness of surgical procedures [1-4,7].

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