Intraoperative Detection of Parathyroid Glands: A Systematic Review and Novel Low-Tech Alternative

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ABSTRACT

Objectives: Perform systematic review of the literature discussing methods of intraoperative detection of parathyroid glands. Determine the feasibility of a low-cost visual identification method utilizing Smartphone camera and hobby-level photographic color analysis.

Methods: A systematic review of the literature was undertaken to characterize experimental and existing techniques for real-time, intraoperative detection of parathyroid glands, a quest meant to reduce the incidence of post-thyroidectomy hypoparathyroidism. As an alternative to published techniques, photographs were taken during thyroid and other central neck surgery, using a variety of cell phone-based cameras, under variable lighting conditions. An app used for red-green-blue (RGB) color analysis was employed to study known parathyroid tissue and surrounding fat and thyroid gland by RGB content.

Results: The majority of published techniques were dependent on specialized, high-tech, and high-cost imaging equipment such as optical coherence tomography, or patient exposure to chemicals such as methylene blue. Red-green-blue (RGB) analysis of Smartphone photographs revealed a consistent pattern of RGB saturation in parathyroid tissue, regardless of lighting conditions or camera type. Using the same app to “subtract” red from the photo visually enhanced the difference between parathyroid and surrounding fat and thyroid, and confirmed the RGB findings.

Conclusions: Photographic RGB analysis used by the amateur photographer at little cost, shows promise as an intraoperative parathyroid detection method. Smartphone photography is universally available and this technique can be employed in a low-resource setting to prevent inadvertent removal of parathyroid tissue.

INTRODUCTION

Hyypoparathyroidism occurs at rates up to 25% transiently, and 1-2% permanently following thyroid surgery. Preserving viable and functional parathyroid glands within the central neck requires experience as well as knowledge of the anatomy. Even with both, however, parathyroid tissue can appear indistinguishable from adjacent fat, lymph tissue, and thyroid gland. The published methods of intraoperative identification of parathyroid glands range from the simple (visual inspection of the thyroid specimen) to the sublime (optical coherence tomography-two articles) and include such disparate techniques as spraying of methylene blue into the wound and intravenous administration of carbon nanoparticles. All described techniques are associated with limitations of cost, risk, efficacy, and/or universality. The senior author has frequently asked her trainees to note subtle color differences in the tissues to supplement the anatomical location of the parathyroid glands. Photographic color analysis used by the hobby photographer via Smartphone-based photographic editing apps offers a method for quantifying color differences in an inexpensive, widely available format. A common method used on the front end (as the photograph is taken) or on the back end (color manipulation of an existing photograph) to enhance or alter color tones is subtractive filtering. This is based on subtractive color mixing which relies on the properties of the subtractive primary colors, cyan, magenta and yellow. Each subtractive primary color absorbs one of the additive primary colors, red, green, and blue (Figures 1 and 2).

METHODS AND MATERIALS

A color analysis app for hobby photography and based on a Smartphone platform was identified that quantifies color saturation within a photograph, and uses subtractive filtering to create special color effects. The RGB Camera App by Victor Chandra, 2013, (Figure 3) was used to systematically analyze existing photographs of the central neck taken during surgery with heterogeneous conditions. Visually identified fat, parathyroid, and thyroid tissue within the photographs were sampled in 3 different locations and RGB quantitative values recorded. Based on the RGB proportion differences between parathyroid, fat, and thyroid tissue, application of a cyan subtractive filter (removing the red) was applied within the RGB app and altered images saved. (Figures 5, 6 and 7).

RESULTS

5 representative photographs from the senior author’s teaching file of the central neck surgical field were chosen for clarity of anatomic structures. Three different areas were randomly selected within each tissue (fat, parathyroid thyroid) for color analysis. Values were averaged within each tissue, as well as among the photographs. The results are summarized in Figure 5.

It was consistently noted that all three tissues were predominantly red saturated. However, parathyroid tissue demonstrated G>B whereas fat and thyroid demonstrated B>G. This observation allowed the selection of a mechanism to “filter out” the red in order to enhance the proportionately greater green saturation of parathyroid. Utilizing a cyan subtractive filter absorbs red light and the resulting photographs highlighted parathyroid tissue by the relative greener tone against a dark blue background. (Figures 6 and 7).

DISCUSSION

This study demonstrates that it is feasible to use visible color to differentiate parathyroid glands from adjacent tissue. This study uses immediately available Smartphone intraoperative photography and color manipulation of the image.

However, true-real time color analysis will necessitate filtration of the image seen by the surgeon, such as could be developed either via an analog/physical alteration of surgeon’s loupes (drop-down cyan-subtraction filter), or via RGB app-based digital manipulation of an image available to the surgeon using a device such as Google Glass.

Tissue color analysis represents a potential low-cost, more universally available method than manipulation of the surgical field (methylene blue, carbon nanoparticles) or acquisition of high-developement cost and limited availability technology.

CONCLUSIONS

1. Visual color differences between tissues in the central neck (parathyroid, fat, and thyroid) are consistently demonstrated with hobby-level photographic color analysis.

2. When this color difference is enhanced by cyan subtraction filtration applied to a photograph of the surgical field, parathyroid tissue is enhanced with a green hue.

REFERENCES


