Photodiagnosis and Photodynamic Therapy 45 (2024) 103950

Contents lists available at ScienceDirect

Photodiagnosis and Photodynamic Therapy

journal homepage: www.elsevier.com/locate/pdpdt

Changes in macular pigment optical density after full-thickness macular hole closure using inverted flap technique

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A R T I C L E   I N F O

Keywords:
Full-thickness macular hole
Inverted flap technique
Macular pigment optical density
Vitreoretinal surgery
Visual rehabilitation
Multimodal imaging
OCT

A B S T R A C T

Full-thickness macular hole (FTMH) is a debilitating retinal disorder, particularly in its advanced forms, necessitating surgical intervention for vision restoration. This case report details the successful closure of a large FTMH using the inverted flap technique, highlighting the essential role of multimodal imaging, and particularly macular pigment optical density (MPOD) assessment, in preoperative and postoperative evaluation. A 55-year-old patient presented with severe vision loss in one eye due to a large FTMH. Surgery was performed by an expert vitreoretinal surgeon, resulting in significant postoperative improvements in visual acuity and retinal architecture. Multimodal imaging, including MPOD assessment, played a pivotal role in preoperative evaluation and postoperative monitoring. The notable increase in MPOD following successful surgery suggests its potential role as a valuable adjunctive biomarker associated with a good visual prognosis following this type of macular hole surgical interventions.

1. Introduction

Full-thickness macular hole (FTMH) is a sight-threatening retinal disorder characterized by an anatomic defect in the fovea featuring interruption of all neural retinal layers from the internal limiting membrane (ILM) to the retinal pigment epithelium (RPE), potentially leading to a substantial impairment of vision [1].

Specifically, large FTMHs, >400 μm according to OCT-based anatomic classification of The International Vitreomacular Traction Study Group Classification of Vitreomacular Adhesion, Traction, and Macular Hole, represent the most advanced form of this condition, necessitating surgical intervention for visual recovery [1]. Within the repertoire of surgical techniques utilized for managing this condition, the inverted flap technique prominently emerges as an approach that has exhibited notable effectiveness in achieving macular hole (MH) closure, ultimately contributing to the enhancement of visual rehabilitation.

In this case report we present a successful surgical closure of a large FTMH using the inverted flap technique and underscores the pivotal role of macular pigment optical density (MPOD) changes following surgery, highlighting its potential as a valuable adjunctive tool in assessing postoperative outcomes.

2. Case

A 55-year-old woman was referred to the Eye Clinic of Federico II University of Naples for a clinical assessment, complaining of decreased progressive visual loss in her right eye (RE) for 3 months.

Visual acuity was 1/60 (-1.0 LogMAR) in her RE and 10/10 (0.0 LogMAR) in her left eye (LE). Intraocular pressure (IOP) was 12 mmHg in RE and 14 mmHg in her LE. Anterior segment examination revealed clear corneas, normally reacting pupils, and mild corticonuclear cataract in her RE, with a clear lens in her LE. Fundus examination demonstrated a large full-thickness macular hole in her RE, while her LE exhibited normal findings. Multimodal imaging was performed including multicolor image and autofluorescence (AF) (Fig. 1A and B). Macular pigment optical density (MPOD) was evaluated using the one-wavelength reflectometry method (Visucam 200, CarlZeiss Meditec) (Fig. 1C).

Optical Coherence tomography (OCT) (Spectralis,Heidelberg Engineering, Heidelberg, Germany) was performed and confirmed the diagnosis of a full-thickness macular hole with basal diameter of 1220 μ located at the foveal center, without evidence of persistent vitreomacular traction, and with mild retinal schisis in the area surrounding the macular hole (Fig. 1D). Due to the patient's clinical conditions, surgical intervention became imperative.

The surgical intervention was conducted by an expert vitreoretinal

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https://doi.org/10.1016/j.pdpdt.2023.103950
Received 24 October 2023; Received in revised form 20 December 2023; Accepted 22 December 2023
Available online 23 December 2023

surgeon (M.R.) using the Inverted internal limiting membrane (ILM) flap technique. After removing the epiretinal membrane, ILM was grasped with ILM forceps and peeled circularly, encompassing an area spanning approximately 2-disc diameters encircling the macular hole. The edges of the ILM were trimmed with a cutter and the remnant was inverted to cover the macular hole, according to the method described by Michalewska et al. [2]. The globe was left tamponaded with air, and the patient was instructed to maintain a prone face position for 6 days, 7 h/day.

The patient was closely monitored postoperatively, with scheduled follow-up visits at one day, one week, and one month, including visual acuity, intraocular pressure, anterior segment evaluation, fundus examination, and fundus multimodal imaging.

One month after surgery, the patient showed a significant improvement compared to the preoperative state, with a VA of 1/10 (1.0 LogMAR) in her RE he BCVA ($P < 0.0006$) and IOP of 14 mmHg, clear cornea, and well-centred IOL. The fundus examination revealed a significant restoration of the architectural integrity of the macula, confirmed with multimodal imaging, and autofluorescence image showed an increase in autofluorescence (Fig. 2A and B). MPOD area and MPOD volume highlighted a significant improvement after surgery ($P < 0.0016$) (Fig. 2C). We found a significant correlation between mean postoperative MPOD and VA ($r = 0.739$ $P = 0.002$). Finally, the OCT imaging confirmed the complete closure of the macular hole, with regular retinal contour, and recovery of central foveal depression and anatomical continuity of the inner retinal layers (Fig. 2D).

3. Discussion

This case illustrates the efficacy of this inverted flap technique approach in achieving a robust closure of the macular hole [3], leading to remarkable improvements in retinal architecture and visual function.

Multimodal imaging played a pivotal role in the preoperative assessment, intraoperative guidance, and postoperative evaluation of this case. One of the most noteworthy contributions to this case is the inclusion of MPOD assessment. The method employed for this analysis was the one-wavelength fundus reflectance technique. The retinal camera captures reflected light from the posterior segment of the eye using narrow-band wavelength reflectance to evaluate macular pigment. By observing the fovea in a blue-reflected image, the level of darkening indicates the concentration of the macular pigment. Subsequently, these variations are converted into a color scale to visually depict the density of the macular pigment in the image [4,5]. This measurement revealed a lower-than-average density, possibly emphasizing the weakened macular health related to the FTMH.

The effectiveness of the surgical closure and the possible improvement in photoreceptor function and visual recovery were suggested postoperatively by a striking increase in MPOD.

MPOD is a measurement of the attenuation of blue light by Macular Pigment and is linearly related to the amount (concentration × path length × area) of lutein and zeaxanthin in the macula if incorporated over the region where Macular Pigment is deposited and resulting decreased in pathological retinal conditions such as MH, epiretinal membrane (ERM), and type 1 diabetes mellitus [5–7].

Although it remains a relatively unexplored technique, MPOD's possible correlation with the anatomical integrity of the macula restoration and the visual prognosis following vitreoretinal surgery has already been postulated [5,7].

In Previous studies, Obana et al. measured MPOD in eyes with MH using the two-wavelength fundus autofluorescence technique, finding

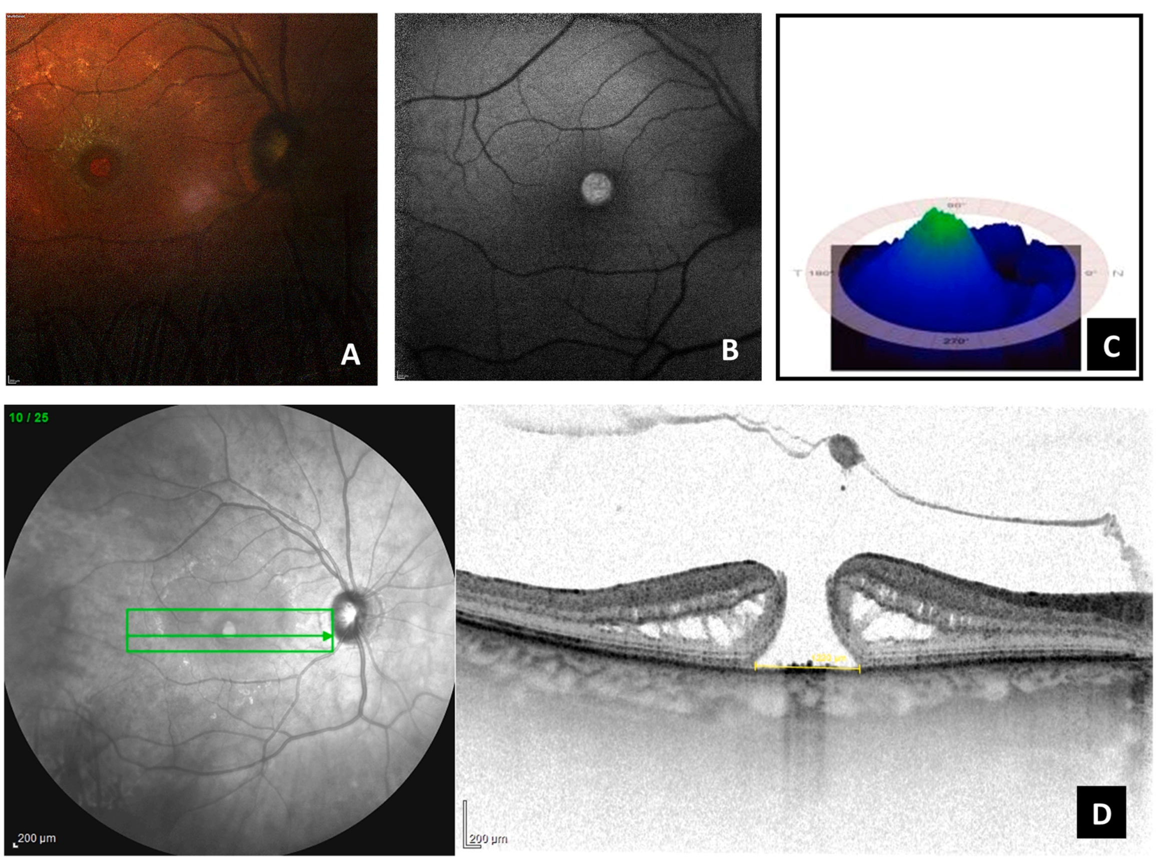

Fig. 1. (A) Multicolor image demonstrates a FTMH in the foveal area; (B) The autofluorescence imaging reveals iperautofluorescence in macular region; (C) MPOD values appear significantly reduced; (D) OCT imaging of the macula reveals 1220 µ FTMH with marked disruption of all the retinal layers, without vitreomacular traction, and with mild retinal schisis.

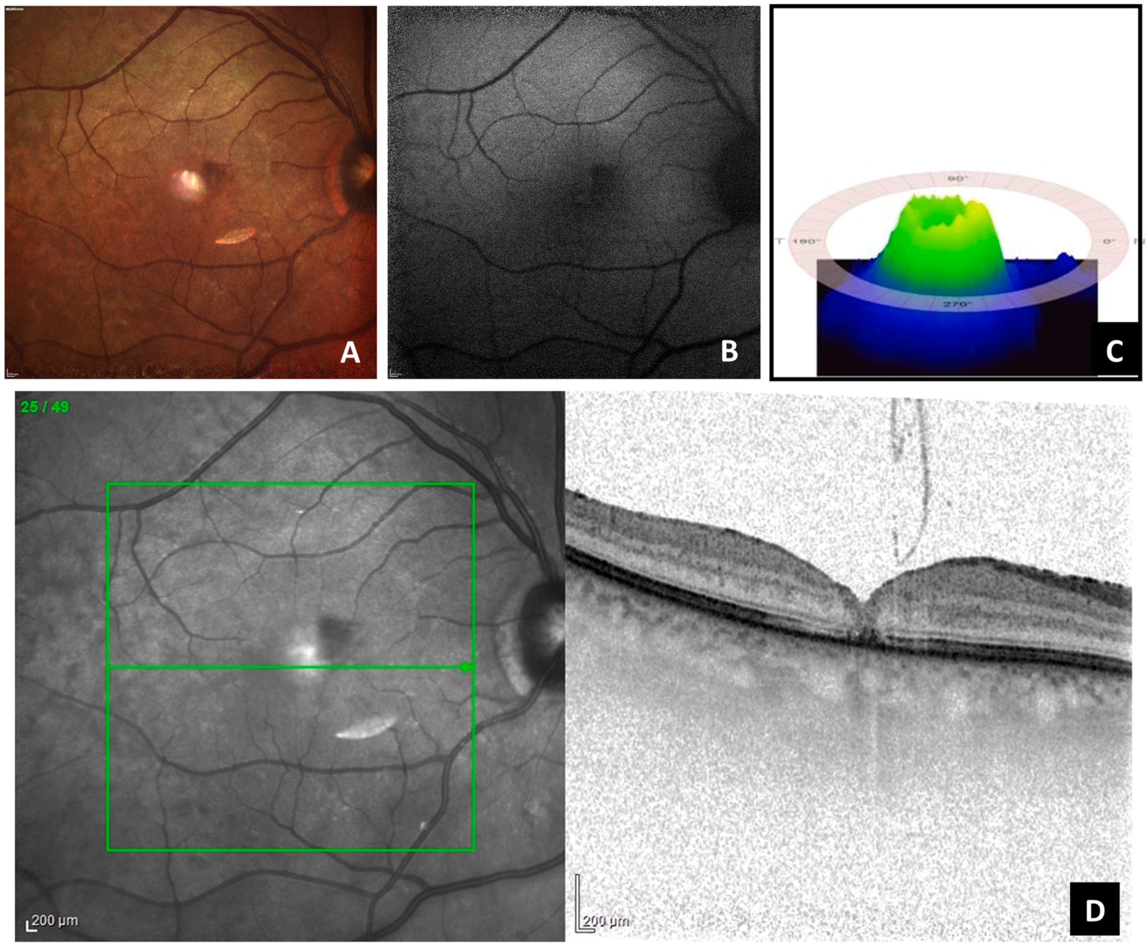

Fig. 2. (A) The multicolor image reveals a well-closed macular hole with no signs of infection; (B) The autofluorescence imaging reveals hypoautofluorescence in the macular region; (C) Post-operative MPOD measurements show improved values; (D) OCT imaging demonstrates regular retinal contour, and recovery of central foveal depression, with successful closure of the macular hole.

that MP was missing at MHs of all stages and recovered after successful surgery [7].

Romano et al. assessed the changes in MPOD in eyes treated with vitrectomy and ERM-ILM peeling and highlighted the relationships between MPOD changes and BCVA and microperimetry, finding a significant correlation between postoperative MPOD and postoperative BCVA [5].

In our case, the effectiveness of the surgical closure and the possible improvement in photoreceptor function and visual recovery were suggested postoperatively by a striking increase in MPOD. We hypothesize that the postoperative increase in mean MPOD could be due to the unfolding and expansion of the fovea, and that postoperative increase in BCVA could be due to the restoration of the integrity of the external photoreceptor layers at the fovea, especially the inner segment/outer segment line.

In conclusion, this case report highlights the successful surgical closure of a large FTMH using the inverted flap technique and emphasizes the crucial role of multimodal imaging, particularly the innovative role of MPOD assessment, in enhancing both diagnostic accuracy and functional prognosis. This surgical case underscores MPOD's potential role as a valuable adjunctive biomarker associated with a good visual prognosis following surgical interventions. However, further research with a larger sample size and longer follow-ups are needed to substantiate these findings.

Compliance with ethical standards

Funding

No Funding was received for this research.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This article does not contain any studies with animals performed by any of the authors.

Informed consent

Informed consent was obtained from all individual participants included in the study.

CRediT authorship contribution statement

Michele Rinaldi: Writing – review & editing, Conceptualization. **Gilda Cennamo:** Writing – original draft, Conceptualization. **Maria Laura Passaro:** Writing – original draft, Data curation. **Ciro Costagliola:** Validation, Conceptualization.

Declaration of Competing Interest

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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