

Macular Holes Scan With OCT, Radial or Horizontal Scan?

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Research Article

Keywords: macular hole, optical coherence tomography, horizontal scanning, radial scanning, minimum line diameter (MLD), base diameter (BD)

Posted Date: March 11th, 2022

DOI: <https://doi.org/10.21203/rs.3.rs-1423725/v1>

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Abstract

PURPOSE: Most macular holes was not circular but rather somewhat oval, and thus simple horizontal scans may not accurately capture their dimensions. In this study, we measured the MH with radial and horizontal images to explore the impact of the two scanning modes on the measurement of MH.

METHODS: The macular hole was scanned with 12 radial and 49 horizontal lines scan, respectively. The aperture size including minimum linear dimension (MLD) and base diameters (BD) was measured using the OCT caliper function.

RESULTS: A total of 40 idiopathic MH in 38 patients were included in the study. The average maximum MLD of radial scan was $576.40 \pm 220.86 \mu\text{m}$, and the average maximum MLD of horizontal scan was $552.38 \pm 217.65 \mu\text{m}$ ($t = -6.919$, $P < 0.0001$). Moreover, the average maximum BD of radial scan was $1026.18 \pm 337.85 \mu\text{m}$, and the average maximum BD of horizontal scan was $997.35 \pm 339.51 \mu\text{m}$ ($t = -4.375$, $P = 0.0001$). Only 9 cases (22.5%) of 40 macular holes had the largest MLD on the horizontal scan line, and only 12 cases (30%) had the largest BD hole on the horizontal scan line. We also found that with radial scan image, 3 eyes (7.5%) of 40 eyes had macular hole upgrade from medium to large size .

CONCLUSIONS: Our study confirmed that macular hole was not the standard circle of geometry, and OCT radial scan could find the maximum longitude of macular hole more effectively than horizontal scan without changing the equipment and measuring habits, which was undoubtedly of great significance for standardizing and grading macular hole.

Introduction

A full-thickness macular hole (MH) can be defined as an anatomical defect in the fovea with interruption of all neural retinal layers from the internal limiting membrane to the retinal pigment epithelium. Idiopathic macular hole is one of the most common forms of macular holes, which occurs in the macular area of a healthy eye, usually in patients over 50 years old and could cause marked reduction in vision.^{1,2} Whether it is the most common idiopathic MH or secondary MH, pars plana vitrectomy intervention is the consensus of ophthalmology.^{2,3,4,5}

The MH size influences the therapeutic approach and it is also a prognostic factor for both anatomical and functional outcomes.^{2,3,6,7} The introduction of optical coherence tomography (OCT) makes the quantitative study of MH size more accurate and objective. The classification and staging of vitreomacular interface diseases by OCT are undoubtedly essential for macular hole diagnosis, classification and vitreoretinal surgery. Perhaps due to technical limitations at the initial stage of using OCT, the diameter of MH is only obtained by horizontal scanning and was used worldwide.

Obtaining the maximum diameter of macular holes with OCT is undoubtedly our ultimate goal. However, since the vast majority of macular holes are not standard geometric circles, it may be difficult to obtain the maximum diameter of MH only by horizontal OCT scanning. Based on this, we propose that the same batch of MH be scanned both radially and horizontally focusing on the hole, to explore whether there is a difference in the measurement of idiopathic MH size between the two OCT scanning modes.

Methods

Subjects

This study was approved by the ethical review committee of Weifang Eye Hospital and conducted in accordance with the tenets of Helsinki Declaration. Written informed consent was obtained from each subject. Patients who with idiopathic MH had been imaged with the Heidelberg Spectralis HRA (Heidelberg, Germany) were included. Preoperative best-corrected VA assessment with the Snellen VA chart, slit lamp examination of the anterior segment, IOP measurement, and a dilated fundus examination were performed. We excluded patients with history of trauma, high myopia (spherical equivalent ≥ 6.00 diopters or axial length 26 mm), and other vitreoretinal diseases. All patients had no history of ocular surgery or fundus laser.

Measurements

The SD-OCT scans were obtained after dilatation of pupil with 1% tropicamide and 10% phenylephrine eye drops. The scan protocol used for imaging in this study is 12 radial line (15 °interval between two lines) and 49 horizontal lines (60um between two lines). The OCT minimum linear diameter and basal hole diameter were manually measured by using the caliper function by the same retina specialist (Liu XH). The minimum linear diameter (MLD) was defined as the shortest hole diameter at the level of the mid-retina and the base diameter (BD) was defined as the hole diameter at retinal pigment epithelium level (Fig. 1). Only scans with a signal strength of greater than or equal to 16 with good central fixation were used for analysis. The MLD and BD of the largest macular hole obtained by the two scanning methods were measured and the orientation of the diameter of the largest hole is also recorded (both eyes starting from the temporal level 0 °).

Statistical analysis

The statistical analyses were performed using SPSS version 22.0 (SPSS Inc, Chicago, IL, USA). Two-tailed p values ≤ 0.05 were considered statistically significant. Descriptive statistics are presented as minimum, maximum, and mean \pm standard deviation. Paired sample t-test was used to analyze the MH diameter obtained by radial and horizontal scanning.

Results

A total of 40 eyes of 38 patients fulfilled the inclusion criteria and were included in this study from September 2019 to July 2020 in Weifang Eye Hospital of Zhengming Eye Group. The patient group had a mean age of 64.95 years and included 9 males and 29 females.

1. Comparison of MLD between radial and horizontal scan: The average maximum MLD obtained by radial scan was $576.40 \pm 220.86\mu\text{m}$, and the average maximum MLD obtained by horizontal scan was $552.38 \pm 217.65\mu\text{m}$. A mean absolute difference of $24.03\mu\text{m}$ was observed between the radial and horizontal diameters ($t=-6.919$, $P < 0.0001$).
2. Comparison of BD between radial and horizontal scan: The average maximum BD obtained by radial scan was $1026.18 \pm 337.85\mu\text{m}$, and the average maximum BD obtained by horizontal scan was $997.35 \pm 339.51\mu\text{m}$. A mean absolute difference of $28.83\mu\text{m}$ was observed between the radial and horizontal ($t=-4.375$, $P = 0.0001$).

3. Analysis of distribution of the maximum MLD of radial scanning: If the horizontal diameter of the temporal side of both eyes is taken as zero degree, the maximum MLD is distributed in 25 eyes (62.5%) in the diameter range of 0 °~ 30 °and 150 °~ 180 ° while only 9 eyes (22.5%) were found with maximum MLD with horizontal scan (Table 1).
4. Analysis of distribution of the maximum BD of radial scanning: The maximum BD is distributed in 29 eyes (72.5%) in the diameter range of 0 °~ 30 °and 150 °~ 180 °while only 12 eyes (30%) were found with maximum BD with horizontal scan (Table 2).
5. Effect of scanning mode on macular hole grading: According to IVTS's macular hole grading scheme, we found that 3 eyes (7.5%) of 40 eyes had macular hole upgrade from medium to large size.

Discussion

OCT can provide a detailed cross-sectional image of the macula and enable the non-invasive objective evaluation of the status of the MH, which is especially useful for the quantitative assessment of MH geometry. The importance of the minimum and base diameters as prognostic factors has been widely reported, where accurate or even automatic measurement of macular hole size has always been one of the research hotspots.^{4,8} Whether it is GASS or the latest classification of (IVTSG),⁹ the measurement of macular hole has been based on horizontal scanning, which may be out of the assumption that the macular hole is a standard geometric circle, and horizontal scan through the center of the hole can truly reflect the maximum diameter of the macular hole. However, from both the infrared fundus plane image and the radial scan, it can be confirmed that the macular hole is not a standard geometric circle. As a result, the diameter of the macular hole may be underestimated, resulting in a systematic error. As finding the maximum diameter is undoubtedly one of the most important purposes of macular hole diameter measurement, more options should be considered.

In order to more accurately compare the effects of radial and horizontal scanning on the diameter of macular hole, we used 12-line radial scan and 49-line horizontal scan. It has been found that the macular hole is not a standard geometric circle, and the average values of maximum MLD and maximum BD obtained by radial scanning are larger than those obtained by horizontal scanning. A mean absolute difference of 24.03um for MLD and 28.83um for BD was observed between the radial and horizontal diameters. Among the 40 patients scanned by radiation, only 9 cases (22.5%) had the maximum MLD on the horizontal diameter, while only 12 (30%) cases had the maximum BD on the horizontal line. On the contrary, 62.5% of the maximum MLD and 72.5% of the maximum BD were distributed in the range of 0 °~ 30 °and 150 °~ 180 °.According to IVTS's macular hole grading scheme,⁹ we found that 3 (7.5%) out of 40 eyes had macular hole upgrade from medium to large size, which will undoubtedly affect the homogenization comparison of different studies.

If manual measurement errors are inevitable, systematic errors need to be avoided as much as possible. The effects of radial and horizontal scan on the measurement values cannot be neglected. This study proves that the maximum diameter of macular hole can be found easily by radial scanning rather than horizontal scanning. We observed substantial differences between the values that were derived from the two mode images for the majority of the parameters. Ophthalmologists should keep in mind that our initial intention is to find the maximum diameter of the macular hole as much as possible, but the simple horizontal scanning mode obviously cannot meet today's needs either in theory or in practice. In order to obtain the maximum macular diameter more conveniently and accurately, we suggest using radial scanning of macular hole instead of

horizontal scanning, not only because the radial scan itself covers the horizontal scan, but more importantly, the maximum macular hole diameter can be found easily by a qualified radial scan. And all of this is achieved without changing your OCT equipment, without changing our measurement habits, just by changing the scanning mode.¹⁰

Declarations

Acknowledgements

Not applicable.

Authors' contributions

Xiuhua Liu and Lifeng Liu performed OCT Scan; Jie Zhang and Xudong Huang contributed significantly to analysis and manuscript preparation; Lei Gao performed the data analyses; Jie Zhang and Lei Gao perform the analysis with constructive discussions. The author(s) read and approved the final manuscript.

Funding

None

Availability of data and materials

All data generated or analysed during this study are included in this published article

Ethics approval and consent to participate

The study was carried out in accordance with the Helsinki Declaration.

Informed consent was obtained from all patients.

This study protocol was reviewed and approved by the Ethics Committee of the Weifang Eye Hospital, approval number No. 2020-02

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Tables

Table 1: Distribution of maximum MLD in radial scan

Radial angle	0°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°
	180°	195°	210°	225°	240°	255°	270°	285°	300°	315°	330°	345°
eyes	9	2	3	1	0	2	5	0	4	3	4	7
%	22.50	5.00	7.50	2.50	0.00	5.00	12.50	0.00	10.00	7.50	10.00	17.50

Table 2: Distribution of maximum BD in radial scan

Radial angle	0°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°
	180°	195°	210°	225°	240°	255°	270°	285°	300°	315°	330°	345°
eyes	12	3	4	1	1	1	3	0	3	2	2	8
%	30.00	7.50	10.00	2.50	2.50	2.50	7.50	0.00	7.50	5.00	5.00	20.00

Figures

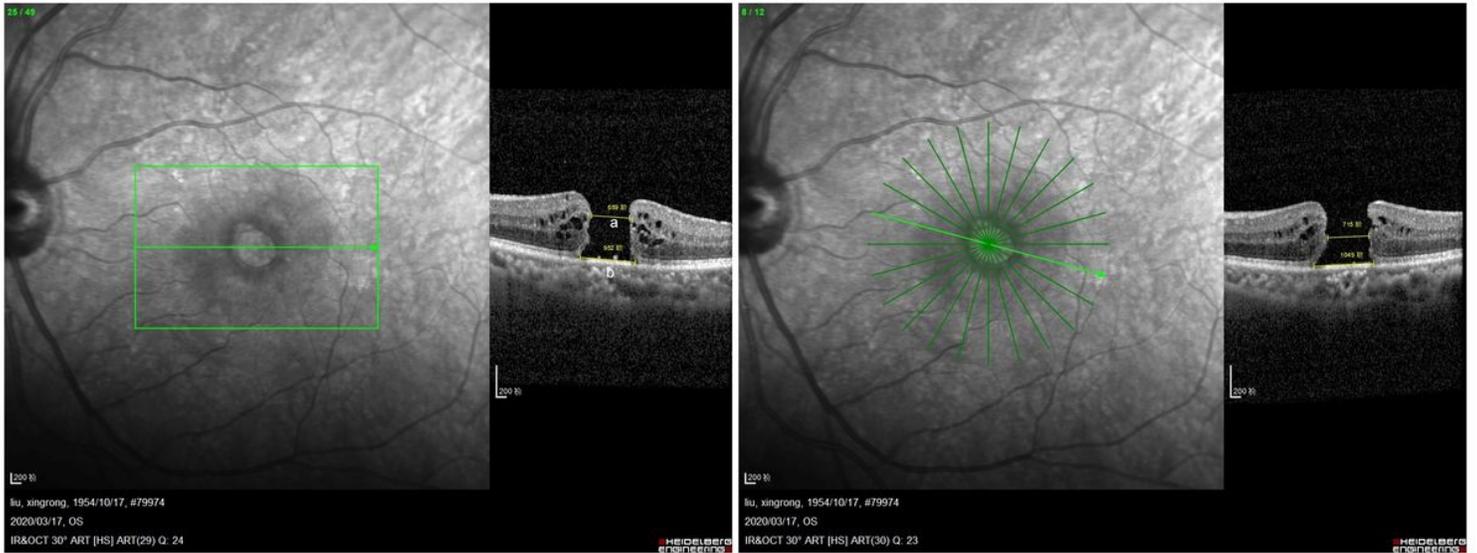


Figure 1

Macular hole diameter measured on horizontal (Left) and radial (Right) SD-OCT B-scans. (a) minimum linear dimension (MLD), (b) basediameter (BD), The maximum horizontal scan MLD and BD is 659um and 952um. The maximum MLD and BD is 715um and 1049um on the 165° radial scan.