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Research Article



Comparative analysis of tabular and software methods of quantitative assessment of metamorphopsia

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ABSTRACT

BACKGROUND: Identifying and evaluating the severity of patients complaints of metamorphopsia is an important component of the pre- and postoperative management of patients with vitreomacular interface conditions. To diagnose metamorphopsia, the Amsler grid is used, which allows to detect changes, but does not allow to quantify them. The authors of this article have developed a special software program for quantitative evaluation of metamorphopsia.

AIM: The aim is to comparatively evaluate tabular and programmatic methods of metamorphopsia assessment.

MATERIALS AND METHODS: The study involved 36 patients (36 eyes) divided into two groups: "macular hole" (20 patients, 20 eyes) and "epiretinal fibrosis" (16 patients, 16 eyes). Quantitative assessment of metamorphopsia was performed by two methods: tabular — using printed tables, which are an analog of M-CHARTS, and software — using the developed computer program.

RESULTS: When comparing the integral parameters of the two methods using the Bland–Altman analysis, the results were highly comparable: the mean value of the difference between the PMs determined by the tabular and program methods was only -0.020° ; the 95% confidence interval ranged from 0.277° to 0.235° , with 34 (94.4%) cases out of 36 falling within this range.

CONCLUSIONS: The program and tabular methods of metamorphopsia examination are interchangeable and provide reasonably accurate quantification of metamorphopsia. The developed program is available on-line (https://mntk.ru/specialists/nauka-sotr/diag_meta/) and can be recommended for widespread clinical use.

Keywords: metamorphopsia; macular hole; epiretinal fibrosis; M-CHARTS.

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Научная статья

Сравнительный анализ табличного и программного методов количественной оценки метаморфозий

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АННОТАЦИЯ

Актуальность. Выявление и оценка выраженности жалоб пациентов на искажения (метаморфозии) является важным компонентом до- и послеоперационного ведения пациентов с патологией витреомакулярного интерфейса. Для диагностики метаморфозий используют таблицу Амслера, которая даёт возможность выявить метаморфозии, но не позволяет оценить их количественно. Авторами статьи разработана специальная компьютерная программа для количественной оценки метаморфозий.

Цель — сравнительная оценка табличного и программного методов оценки метаморфозий.

Материалы и методы. В исследовании участвовало 36 пациентов (36 глаз), разделённых на две группы: «макулярный разрыв» (20 человек, 20 глаз) и «эпиретинальный фиброз» (16 человек, 16 глаз). Количественную оценку показателей метаморфозий выполняли двумя методами: с использованием печатных таблиц, являющихся аналогом M-CHARTS, и с помощью разработанной компьютерной программы.

Результаты. При сравнении показателей метаморфозий с использованием анализа Бланда – Алтмана отмечена высокая сопоставимость результатов: среднее значение разности метаморфозий, определяемых табличным и программным методом, составляло всего $-0,020^\circ$; величина 95 % доверительного интервала — от $-0,277$ до $0,235^\circ$, при этом 34 (94,4 %) случая из 36 находились в границах указанного диапазона.

Заключение. Программный и табличный методы исследования метаморфозий являются взаимозаменяемыми и обеспечивают достаточно точную количественную оценку метаморфозий. Разработанная программа представлена в общем доступе (https://mntk.ru/specialists/nauka-sotr/diag_meta/) и может быть рекомендована к широкому клиническому использованию.

Ключевые слова: метаморфозии; макулярный разрыв; эпиретинальный фиброз; M-CHARTS.

Как цитировать

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BACKGROUND

Managing patients with vitreomacular interface conditions (epiretinal fibrosis, macular hole, etc.), special attention is paid to the presence of complaints on metamorphopsia, which commonly manifest as curving of straight lines, distortion of object contours [1]. Detection and assessment of severity of such complaints are necessary to decision-making about surgical treatment. Currently, to detect metamorphopsia the Amsler's chart (grid) is widely used, which gives the possibility to detect metamorphopsia, but does not allow their quantitative assessment. For this purpose, in 1999, special M-CHARTS were elaborated [2], manufactured by Inami & Co., Ltd. (Japan). However, these charts are not supplied to the Russian Federation. For quantitative assessment of metamorphopsia, we elaborated a special software program (Certificate of state registration of a program for ECM No. 2023618455, April 25, 2023).

Aim — the comparative analysis of metamorphopsia assessment methods — using charts or software program.

MATERIALS AND METHODS

The study included 36 patients (36 eyes), divided into two groups: “macular hole” (20 patients, 20 eyes) and “epiretinal fibrosis” (16 patients, 16 eyes). Inclusion criteria for patients with these conditions were: complaints on distortions of lines, letters, object contours, age more than 40 years. Exclusion criteria: serious concomitant ocular or somatic diseases, myopia of more than 6.0 D, astigmatism higher than 3.0 D. For all patients, common diagnostic tests were performed, including autorefractometry, keratometry, visual acuity testing, ophthalmotometry, optical biometry, biomicrophthalmoscopy, as well as optical coherence tomography using Cirrus HD-OCT 5000 (Carl Zeiss Meditec, USA). The quantitative assessment of the metamorphopsia index (MI) was performed using two methods: using printed charts being an analogue to M-CHARTS, and using the designed software program.

Printed charts represented straight dotted lines with an interval between dots within the range from 0.1 to 2.0° spaced 0.1° apart (from 30 cm distance). They were printed on a laser printer with strict conformance of main characteristics, formulated by their authors (Fig. 1) [3]. The tables were shown twice, with lines in horizontal and vertical position. Corresponding metamorphopsia were conventionally called horizontal and vertical ones. In original charts, for patients with central scotoma double lines were also proposed, which were not used in the present study, in order not to complicate the examination procedure. As the result of MI investigation in each direction, the minimal distance between dots (in degrees),

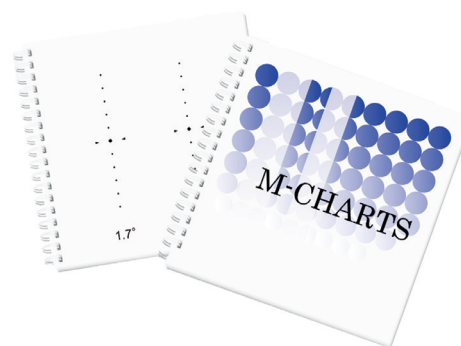


Fig. 1. M-CHARTS (Inami & Co., Ltd, Japan)

Рис. 1. Таблицы M-CHARTS (Inami & Co., Ltd, Япония)

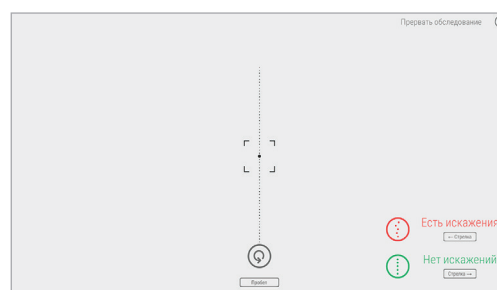


Fig. 2. A software method for evaluating metamorphopsia. Screen view with one of the test images. Further details are explained in the text

Рис. 2. Программный метод оценки метаморфопсий. Вид экрана с одним из тестовых изображений. Пояснения в тексте

at which metamorphopsia were still detectable (that is one step less than the value, at which metamorphopsia were already not detected). Additionally, the mean value of the determined minimal distances for horizontal and vertical lines was calculated, it was considered by convention to be an integral result of the test – integral MI.

The developed software program is the analogue of printed charts, which allows to display on the screen of a computer or tablet same straight dotted lines with an interval between dots within the range from 0.1 to 2.0° spaced 0.1° apart (from 40 cm distance) in vertical and horizontal directions (Fig. 2). The program was different by the demonstration of charts in a random sequence with consideration to previous answers of the study participant and with repeated control presentations, providing better reliability of obtained results. The distance from the screen 40 cm was chosen as more conventional for patients working on the computer.

The tests using charts and computer software were carried out in the same conditions — with customary for the patient correction for reading at the same artificial illumination. The choice of the first examination method (charts or software program) was performed randomly.

The data statistical processing was carried out using application program packages Excel (Microsoft Inc., USA) and Jamovi (The Jamovi project, Australia). To assess the normality of distribution the Shapiro–Wilk test was used. Data with normal distribution are presented as $M \pm \sigma$, where M is an arithmetic mean, σ — a standard deviation. Data with absence of normal distribution are presented as $Me [Q_1; Q_3]$, where Me is a median, Q_1 and Q_3 — first and third quartiles. The relationship between signs was evaluated by Pearson’s correlation analysis. As statistically significant, the $p < 0.05$ level was considered.

When calculating mean values, data obtained using standard (decimal) charts were recalculated for ETDRS charts.

To assess the MI conformity, determined by methods using charts and software program, the Bland–Altman analysis was used [4]. This analysis assumes a graphical presentation of the dependance of obtained data differences from their mean values by horizontal dotted lines on the graph, the mean difference in measurements between the two methods is denoted, as well as upper and lower limits of the 95% confidence interval (CI) for the difference in measurements ($M + 2\sigma$ and $M - 2\sigma$). The Bland–Altman analysis does not provide a statistical comparison of obtained values. Graphic results are assessed in respect to individual objectives of the compared examinations: if both the mean and CI differences are relatively small and, above all, of minor clinical value, the methods are considered to be interchangeable.

RESULTS

Clinical and demographic data of patients of both groups are shown in the table.

Because patients suffered from different conditions, data are shown for reference only, statistical comparison between groups was not performed.

The examination using both software program and charts did not cause any difficulties for patients, it was performed relatively rapidly — during less than 1 min.

When comparing integral MI of the two methods using the Bland–Altman analysis, a high result comparability was noted: the mean value of MI difference determined by the method using charts and that using software program was -0.020° only; the 95% CI value — between -0.277 and 0.235° , moreover 34 cases (94.4%) out of 36 were within this range (Fig. 3).

It is to be noted that two datapoints being beyond the CI, were the first and the third out of the examined patients’ number, and this may be explained by non-significant что могло объясняться незначительными procedure errors during the period of method mastering. In case both these two datapoints were acknowledged as falling out of range ($>M + 3\sigma$ or $<M - 3\sigma$), the mean difference value decreased to 0.004° , and the limits of the 95% CI to -0.151 – 0.160° . Even without the exclusion of falling out values, and especially after their exclusion, the difference between the integral MI of both methods (mean value and 95% CI) appears to be clinically non-significant.

For vertical MI, the mean difference value was minimal (-0.006°), and the 95% CI value was between -0.258 and 0.247° . For horizontal MI, these values were somewhat higher: the mean difference value was -0.036° , and the limits if the 95% CI — between -0.390 and 0.318° . The obtained values both for horizontal and vertical MI appear also to be clinically non-significant.

In comparative analysis of quantitative results of MI assessment for the “epiretinal fibrosis” diagnosis alone, the mean difference value was also minimal (-0.006°), and the limits if the 95% CI were between -0.276 and 0.264° . For the “macular hole” diagnosis, the mean difference value was somewhat higher and made -0.032° , were in the range from -0.281 to 0.216° . The obtained values in this case appear as clinically non-significant for both groups as well.

Table. Clinical and demographic data of patients in groups. $M \pm \sigma$ (min – max)
Таблица. Клинико-демографические данные пациентов в группах. $M \pm \sigma$ (мин. – макс.)

Parameter	Group	
	macular hole	epiretinal fibrosis
Total number of patients (eyes)	20	16
Age, years	64.4 ± 6.0 (53–75)	67.4 ± 6.0 (57–76)
Sex (f/m)	16/4	12/4
Best corrected visual acuity, ETDRS letters, $Me [Q_1; Q_3]$	58.9 [57; 64]	65.0 [59; 70]
Anatomical axis length, mm	23.52 ± 0.81 (22.17–24.93)	23.40 ± 0.67 (22.27–24.36)
Minimal diameter of the macular hole, μm	334 ± 90.3 (107–442)	–
Mean retinal thickness in the foveal area, μm	–	449 ± 57.8 (344–521)

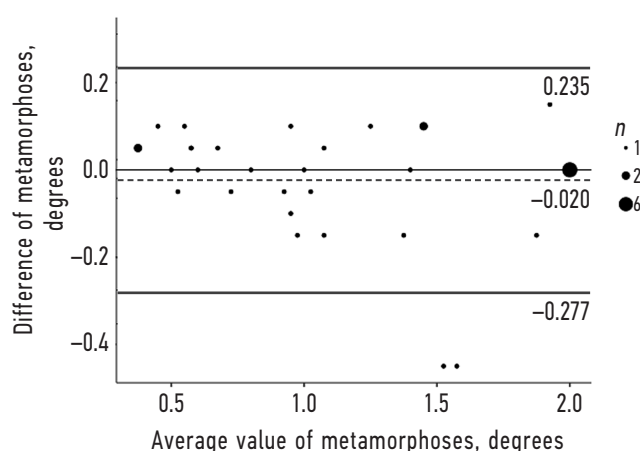


Fig. 3. Bland–Altman analysis for integral parameters of tabular and software methods of metamorphopsia assessment. Dotted line is the mean value of the differences of the integral parameters of metamorphopsia determined by the compared methods. Solid lines are the upper and lower limits of the 95% confidence interval of the differences

Рис. 3. Анализ Бланда – Альтмана для интегральных показателей табличного и программного методов оценки метаморфопсий. Пунктирная линия — полученное в результате исследования среднее значение разностей интегральных показателей метаморфопсий, определяемых сравниваемыми методами. Сплошные линии — верхняя и нижняя границы 95 % доверительного интервала разностей

To assess the visual acuity influence on MI, we explored the dependency of MI, obtained by both methods (both the integral and the vertical and the horizontal ones) from best corrected visual acuity (BCVA, ETDRS letters). No significant correlation was revealed, Pearson correlation coefficient in all the patients' array was not higher than 0.17.

DISCUSSION

The M-CHARTS are successfully used, and proved themselves as sufficiently effective method for qualitative assessment of metamorphopsia in all main vitreomacular interface conditions — epiretinal fibrosis [2, 3, 5], macular hole [5–7], retinal detachment [8], age-related macular degeneration [5, 9]. Most often, the MI is used for the assessment of visual functions after surgical procedures [8–11]. The results of present study correlate with literature data and demonstrate high informational capacity of the developed by authors software program, which is non-inferior to the M-CHARTS informational capacity, in particular in patients with epiretinal fibrosis and macular hole.

Revealed in the present study the absence of BCVA (ETDRS letters) correlation with MI was noted by other authors as well at examination of patients with “epiretinal fibrosis” and “macular hole” diagnoses [3, 7]. The obtained data may suggest that the MI is an individual independent parameter of visual functions' assessment, and this may be related to the involvement of other morpho-functional retinal structures. As a consequence, the MI may be used as an additional, not depending on visual acuity criterion characterizing visual functions and their dynamics.

Some alternatives to M-CHARTS were proposed, in particular, D-CHART [12]. This method consisted in presentation of charts with a grid of squares, situated in a ring shape around the fixation area. This method did not find a wide use: as on August, 2023, in the PubMed database, 13 articles mentioning this method were found, by comparison, M-CHARTS are mentioned in 86 articles.

Taking into account the nonavailability of M-CHARTS in the Russian Federation, an original software program was developed based on this chart. At the same time, there was a concern about the interchangeability of the developed program and M-CHARTS. The results of present study show that these methods are reasonably interchangeable.

The present study has some limitations.

An integral MI was used, while the original chart and the developed program do not foresee its use. However, it is necessary to mention that in some foreign studies, the authors also use the integral index M-SCORE [8, 11]. The use of the integral MI is more convenient in cases, when the detection of the specific metamorphopsia direction (horizontal or vertical) is of no great consequence. The results of the present study demonstrate that integral indices reflected the patterns for vertical and horizontal MIs equally.

The number of patients included in the present study is relatively small. However, this number seems to be fairly sufficient for the evaluation of correlations of the metamorphopsia assessment method using charts with that using software program. And this was the main aim of the study. This work included patients with two types of macular conditions only. The comparison of methods in other conditions will be the objective of further studies.

CONCLUSION

Software program and charts as metamorphopsia investigation methods are interchangeable and assure sufficiently exact qualitative metamorphopsia assessment. The developed program is available in free access (https://mntk.ru/specialists/nauka-sotr/diag_meta/), and may be recommended for wide clinical use.

ADDITIONAL INFORMATION

Authors' contribution. Thereby, all authors made a substantial contribution to the conception of the study, acquisition, analysis, interpretation of data for the work, drafting and revising the article, final approval of the version to be published, and agree

to be accountable for all aspects of the study. Personal contribution of each author: A.A. Shpak — experimental design, data analysis, writing the main part of the text, making final edits; A.S. Zhuravlev — data collection, data analysis, writing the main part of the text; F.A. Avakyan — data collection, writing the main part of the text; A.I. Kolesnik, S.V. Kolesnik — making final edits; A.A. Avakyan — writing the main part of the text.

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Competing interests. The authors declare that they have no competing interests.

Ethics approval. The present study protocol was approved by the local Ethics Committee of the S.N. Fyodorov Eye Microsurgery Federal State Institution (No. 4, 2023 Apr 3). All participants voluntarily signed an informed consent form prior to inclusion in the study.

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