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Efficiency of Telemedicine in Assessing the Detection of Primary Open-Angle Glaucoma

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Abstract Objective: To evaluate the effectiveness of telemedicine in the primary detection of primary open-angle glaucoma (POAG). Methods: The study aimed to assess the effectiveness of telemedicine in diagnosing and treating POAG. The research design was based on comparing the results of teleconsultations and in-person ophthalmological examinations in the same sample of patients with suspected or confirmed POAG. The comparison of both types of examinations was conducted, and specific statistical indicators were calculated. Results: In detecting confirmed cases of POAG, sensitivity was 100%, specificity was 83.3%, positive predictive value was 97.4%, negative predictive value was 100%, positive likelihood ratio was 6, negative likelihood ratio was 0, and accuracy was 97.7%. Conclusion: The high sensitivity and specificity of remote consultations allow for the effective identification of patients with this disease and taking appropriate measures for further treatment and monitoring.

Keywords Glaucoma, Primary open-angle glaucoma, Telemedicine

1. Introduction

Glaucoma requires early detection, careful monitoring of intraocular pressure, assessment of the optic nerve condition and visual fields, and control and correction of medication therapy [1,4,5]. One of the key obstacles for patients with glaucoma can be the lack or remoteness of specialized ophthalmological facilities and qualified specialists [2,3,7]. Telemedicine for glaucoma screening offers many potential benefits. In developed countries, where the number of patients is high and there is a shortage of qualified glaucoma specialists, telemedicine can significantly reduce the number of unnecessary doctor visits [1,6,8,9]. Studies evaluating the effectiveness of remote interactions between local optometrists and ophthalmologists based on remote visualization of the optic nerve disc and assessment of visual fields confirm that screening patients at risk for glaucoma can reduce the rate of false referrals to specialists [2,10,11]. Thus, telemedicine is an effective solution to this problem.

Objective. To study the effectiveness of telemedicine in the primary detection of primary open-angle glaucoma (POAG).

2. Materials and Methods

The study was conducted from 2021 to 2023 at the Republican Specialized Scientific and Practical Medical Center of Eye Microsurgery and its regional branches. To achieve the study's objective, it was necessary to assess the effectiveness of using telemedicine in diagnosing and treating POAG. The main study design was based on comparing the results of teleconsultations and in-person ophthalmological examinations in the same sample of patients with suspected or confirmed POAG. The comparison involved evaluating the results of both types of examinations and calculating specific statistical indicators.

The study included two main stages: the stage of assessing the effectiveness of telemedicine in POAG screening and the stage of assessing the effectiveness of telemedicine in POAG monitoring. In the first stage, a study of suspected glaucoma cases was conducted, where patients with initially detected signs of increased intraocular pressure and glaucomatous changes in the optic nerve head underwent two types of ophthalmological examinations: teleconsultation and in-person examination. In the second stage, the effectiveness of the two examination methods in monitoring glaucoma was compared, assessing POAG progression, criteria for changing medication therapy, indications for laser treatment, indications for surgery, and the effectiveness of surgery.

The study included clinical cases of suspected POAG, involving individuals over 40 years old with increased intraocular pressure and/or glaucomatous changes in the optic nerve head. Another inclusion criterion was the patient's informed consent to participate in the study. Age and gender distribution of patients in the first and second stages of the study are presented in Table 1.

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Table 1. Distribution of Patients with Suspected POAG in the First Stage of the Study by Gender and Age

Age Group (years)	25-44 years		45-60 years		61-74 years		older 75 years		Total	
	n	%	n	%	n	%	n	%	n	%
Male	5	5,3	28	29,5	17	17,9	3	3,2	53	55,8
Female	3	3,2	22	23,2	13	13,7	4	4,2	52	54,7
Total	8	8,4	50	52,6	37	38,9	7	7,4	95	100,0

3. Results

Table 2. Results of Glaucoma Suspect Evaluation Using Remote and In-Person Consultations

	Remote Consultation Results		In-Person Consultation Results	
	абс	%	абс	%
Ocular hypertension	32	33,7	30	31,6
Suspected glaucoma	21	22,1	22	23,2
POAG	38	40,0	37	38,9
Normal	4	4,2	6	6,3

The results of assessing suspected glaucoma cases using remote and in-person consultations are presented as absolute values and percentages (Table 2). Remote consultation identified 32 cases (33.7%) of ocular hypertension, compared to 30 cases (31.6%) identified during in-person consultation. Suspected POAG was identified in 21 cases (22.1%) through remote consultation, while 22 cases (23.2%) were identified in in-person consultations. Confirmed POAG cases were found in 38 cases (40.0%) through remote consultation, compared to 37 cases (38.9%) in in-person consultations. Normal findings were confirmed in 4 cases (4.2%) through remote consultation, whereas 6 cases (6.3%) were confirmed during in-person consultations. These data indicate that remote and in-person consultations generally show comparable results in identifying suspected glaucoma cases. The majority of suspected glaucoma cases were confirmed as POAG in both remote and in-person consultations.

Statistical calculations showed that for detecting ocular hypertension, the sensitivity was 96.8%, specificity was 66.7%, positive predictive value was 93.8%, negative predictive value was 80%, positive likelihood ratio was 2.9, negative likelihood ratio was 0, and accuracy was 91.9%.

For suspected glaucoma, sensitivity was 95.5%, specificity was 75%, positive predictive value was 95.5%, negative predictive value was 75%, positive likelihood ratio was 3.8, negative likelihood ratio was 0.1, and accuracy was 92.3%.

In confirmed glaucoma cases, sensitivity was 100%, specificity was 83.3%, positive predictive value was 97.4%, negative predictive value was 100%, positive likelihood ratio was 6, negative likelihood ratio was 0, and accuracy was 97.7%.

The clinical recommendations outlined in the European Glaucoma Society Terminology and Guidelines for Glaucoma, 5th Edition, served as the basis. Table 4 provides a comparison of the content between teleconsultation and in-person examination for glaucoma screening. Overall, the data from the table indicate that teleconsultation, due to its high level of technical capability, can encompass nearly the entire spectrum of diagnostic processes related to glaucoma.

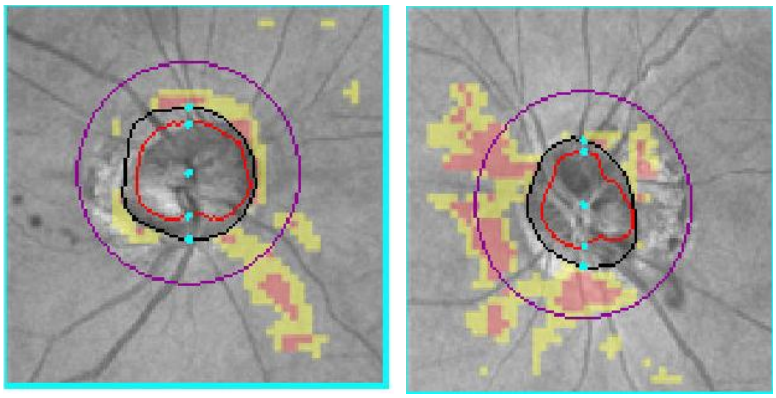
Table 3. Diagnostic Efficiency Assessment of Remote Telemedicine Consultations

	Sensitivity (%)	Specificity (%)	Positive Predictive Value (%)	Negative Predictive Value (%)	Positive Likelihood Ratio	Negative Likelihood Ratio	Accuracy (%)
Ocular hypertension	96,8	66,7	93,8	80	2,9	0	91,9
Suspected glaucoma	95,5	75	95,5	75	3,8	0,1	92,3
Glaucoma	100,0	83,3	97,4	100	6	0	97,7

Table 4. Comparison of Content between Teleconsultation and In-Person Examination for Glaucoma Screening

Content of Ophthalmological Examination in Telemedicine	**In-Person Examination**
1. Transfer of brief patient information including age, family history, and other relevant details. 2. Transmission of results from visual acuity, autorefraction, and correction. 3. Transmission of data from Goldman applanation tonometry, corneal pachymetry, and pachymetry by ultrasound (UBM or anterior OCT in cases of suspicion of angle closure glaucoma). 4. Transmission of video images from slit lamp examination. 5. Analysis of fundus images. 6. Analysis of OCT scans. 7. Analysis of visual field examination results.	1. Gathering patient history. 2. Visual acuity testing, autorefraction, and correction. 3. Goldman applanation tonometry. 4. Corneal pachymetry. 5. A-scan ultrasound (Pachymetry by ultrasound). 6. Biomicroscopy. 7. Gonioscopy (in cases of suspicion of angle closure glaucoma). 8. Ophthalmoscopy. 9. OCT and interpretation of results. 10. Visual field examination and interpretation of results.

Figure 1. Fundus images of patient. OU: Optic disc: CDR=0.4-0.5; presence of b-zone parapapillary atrophy; no pronounced defects in RNFL are noted



	OD	OS
Average RNFL Thickness	81 µm	73 µm
RNFL Symmetry	85%	
Rim Area	1.18 mm²	1.10 mm²
Disc Area	3.47 mm²	2.72 mm²
Average C/D Ratio	0.80	0.76
Vertical C/D Ratio	0.70	0.74
Cup Volume	0.640 mm³	0.261 mm³

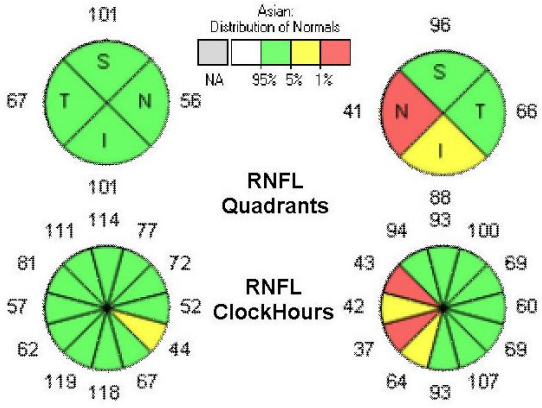


Figure 2. Results of OCT (RNFL analysis). OD: No pronounced zones of RNFL defects are observed; thickness is within normal limits. OS: Limited zones of RNFL defects are noted in the upper and lower nasal sectors with relative thinning

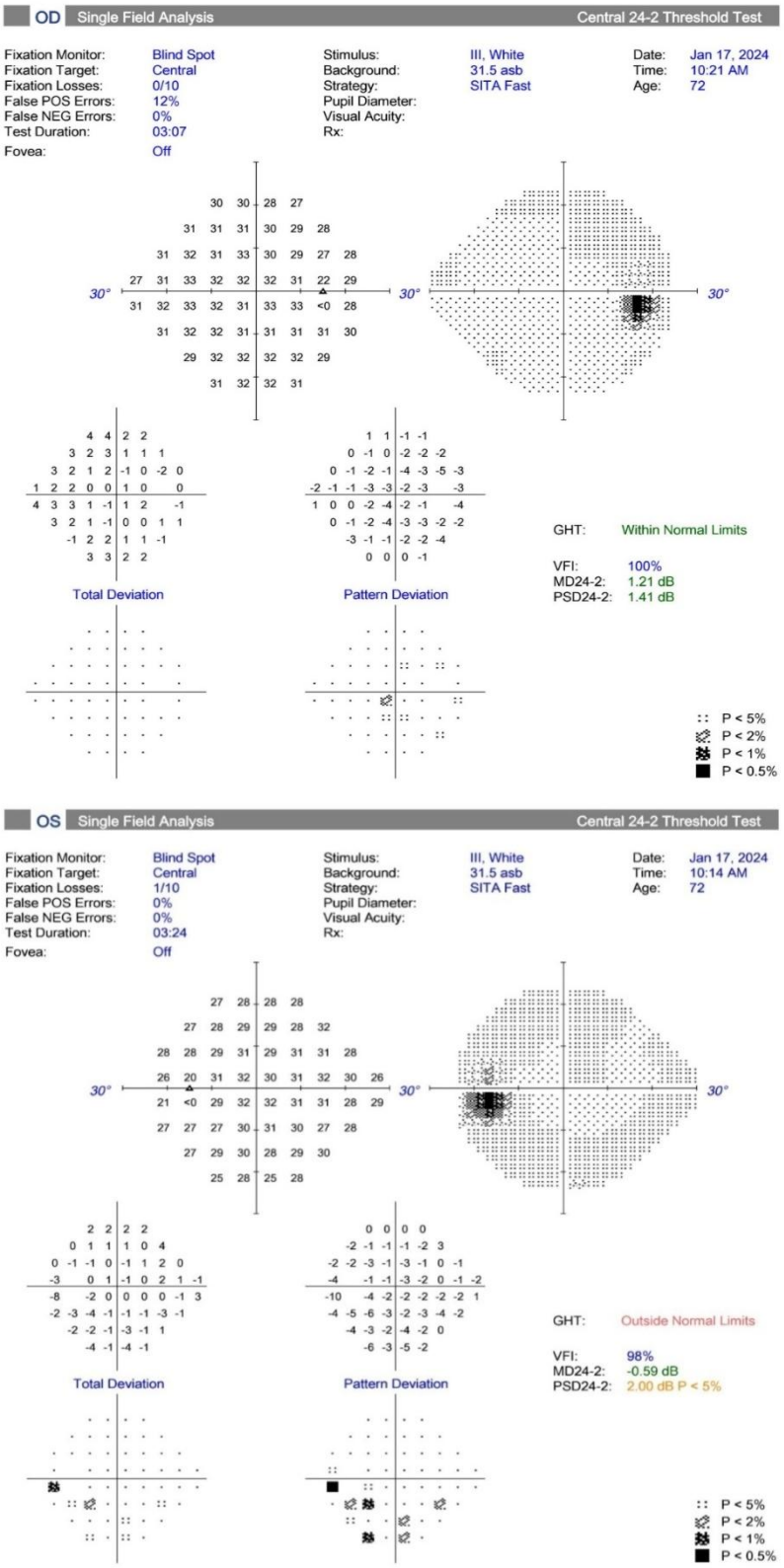


Figure 3. Results of Humphrey visual field test. OD: Within normal limits. OS: Field defects in the lower nasal and lower temporal quadrants with decreased VFI. PSD at the lower limit of normal

4. Discussion

Digitization of Diagnosis Allows for Rapid Transmission of Completed Examination Results to Specialists at the Central Branch of the Center. Moreover, Thanks to the Capability of Receiving High-Quality Fundus Images, There are No

Difficulties Associated with Evaluating the State of the Optic Disc. Furthermore, the Analysis of Color Fundus Photographs in Assessing Glaucoma Patients Abroad is Currently Considered More Effective Than Ophthalmoscopy, as the Monitor Screen Enables Simultaneous Visualization of Fundus Photos and Corresponding OCT Images, Which is Extremely Important in Suspected Glaucoma Cases. Observations Have Shown That Difficulties Were Only Noted in Evaluating the Anterior Segment, as Despite the Presence of Sufficiently High-Quality Equipment for Online Slit Lamp Transmission, Some Aspects Were Still Difficult to Assess Remotely. Specifically, the Resolution and Image Quality Did Not Always Allow for Accurate Determination of Anterior Chamber Depth, Leading to Incorrect Conclusions About Its Depth Reduction and the Need for Gonioscopy, UBM, or Anterior OCT. There Were Also Cases of False Positive Diagnoses of Pseudoexfoliation Syndrome in Patients, Which the In-Person Consultation Excluded. Finally, it was Found That Image Transmission Was Currently Unable to Provide the Capability to Assess the Angle of the Anterior Chamber When Using a Gonioscopy Lens Due to Low Image Detail. Otherwise, the Technical Capabilities of Teleconsultation Did Not Inferior to Those of In-Person Examination.

Below is a Clinical Example of Examination Using Teleconsultation in the Form of Fundus Images, OCT Results, and Computer Perimetry of a Patient Suspected of Glaucoma. The Patient, 62 Years Old, IOP OD/OS=23/21 mmHg (Fig. 1-3).

Based on the examination results, the teleconsultation concludes as follows:

OD: Ocular hypertension.

OS: Suspected primary open-angle glaucoma (POAG).

The teleconsultation conclusion aligns with the findings of the in-person consultation.

This clinical case demonstrates the effectiveness of teleconsultation specifically in remote analysis of specialized examination results, as the diagnosis in this case relied significantly on visualization data and analysis of visual field test results.

5. Conclusions

These results indicate the high diagnostic efficiency of remote telemedicine consultations in detecting ocular hypertension, suspected primary open-angle glaucoma (POAG), and confirmed POAG. The sensitivity and specificity of the remote consultation tests are high, enabling effective identification of patients with these conditions and appropriate measures for further treatment and monitoring.

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