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RESEARCH ARTICLE

Efficacy of teleophthalmology: Experience at the Mexican Institute of Ophthalmology

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ABSTRACT

The COVID-19 pandemic prompted the search for new methods of accessing health services, highlighting teleophthalmology as a promising alternative.

This study aimed to evaluate the concordance between diagnoses made through teleophthalmology and those obtained in high-specialty in-person consultations, with the purpose of determining whether teleophthalmology can be a viable and complementary diagnostic tool to traditional ophthalmology.

Methodology: An observational, descriptive, study was conducted at the Vision Center of the Mexican Institute of Ophthalmology in San Juan del Río, Querétaro, during 2021. Patients attended via teleophthalmology who subsequently visited for an in-person consultation were included.

Results: Of the 2,133 patients assessed through teleophthalmology, 993 (46.55%) were referred to specialized services, of which 696 (70%) attended an in-person consultation. The most frequent diagnoses were cataract (23.5%), glaucoma or suspected glaucoma (12.49%), and ametropia (8.39%). The concordance between the initial diagnosis by teleophthalmology and the final in-person diagnosis was 89.1% ($p < 0.05$), with a correlation coefficient of 88% according to Cohen's Kappa test.

Conclusions: Teleophthalmology demonstrated a high degree of diagnostic accuracy, emerging as an effective solution to expand access to specialized ophthalmological services, especially in areas where in-person care is limited.

Keywords: Ophthalmology, teleophthalmology, optical coherence tomography, telemedicine, remote area

Introduction

Secondary to the epidemiological contingency generated by SARS-COV-2, which caused restrictions in healthcare services, the initiative to find new methods of accessing health services and to promote teleophthalmology as one of the main representatives is considered an area of opportunity with future significance.

The World Health Organization (WHO) estimates that there are 2.2 billion people worldwide with some form of visual impairment, and of these, 1 billion could have been prevented or have not yet been addressed. As indicated by Bourne et al,[1] the most common pathologies are cataracts (65.2 million), glaucoma (6.9 million), corneal opacities (4.2 million), and diabetic retinopathy (3 million). In Mexico, data from Stevens et al, [2] and the Instituto Nacional de Salud Pública,[3] estimated that the prevalence of blindness ranges from 0.4 to 1.5% while visual impairment affects between 2.4% and 7.0% of the population. In Querétaro, a study conducted by López-Star EM et al, [4] in 2018 identified cataracts as the leading cause of blindness, followed by diabetic retinopathy and glaucoma.

In 2010, the WHO defined telemedicine as "the delivery of health care services where distance is a critical factor, by all health professionals using information and communication technologies for the exchange of valid information for diagnosis, evaluation, and treatment of diseases and injuries, research, and continuous education of health care providers, all in the interest of advancing the health of individuals and their communities."

One of the primary advantages of telemedicine is provides access to healthcare and information for both patients and providers, regardless of geographic location. This becomes important considering the geographic distribution of ophthalmologists, which ranges from 29.8 to 52.2 specialists per million population, according to Resnikoff et al, [6] and are as documented by Heinze-Martin et al,[7] specialists are predominantly concentrated in urban areas, leaving rural communities with limited access to eye care professionals. In addition, as demonstrated by Ekeland et al, [8] telemedicine offers significant socioeconomic benefits to patients, families, healthcare professionals, and health systems by reducing unnecessary travel, alleviating the burden on hospital services, and improving access to specialized consultations that enable accurate diagnosis, treatment, and follow-up of various conditions :Newton et al, [9] Sreelatha et al, [10] Wootton et al, [11] Carregal Rañó et al. [12]

Limitations have been categorized by the WHO and the Pan American Health Organization in four major group : economic factors (high implementation costs, insufficient reimbursement models, and limited evidence of cost-effectiveness); human factors (patient and provider resistance to change); technological factors (information system incompatibility and uneven geographic access to technology); and organizational factors (need for strategic planning and professional role restructuring) [13]

In Mexico, until 2024, there is no law regulating the practice of telemedicine at the state or federal level, and it is considered that "telemedicine should be taken into account as an activity integrated into clinical practice, considering that the use of information and communication technologies (ICTs) has become an intrinsic part of medical practice and, therefore, not an additional activity requiring separate regulation from medical procedures. Secretary of the Interior of Mexico. [14]

Teleophthalmology emerges as an innovative solution in the field of ophthalmic medical care, offering a viable and precise alternative for the diagnosis of eye diseases. Among the most recognized and documented teleophthalmology methods is the one used for the screening and follow-up of diabetic retinopathy, which has established itself as a method that simplifies access to high specialty consultations, reduces the care burden, and significantly decreases preventable vision loss by allowing timely referral of patients.

As demonstrated by several studies, [15-21] teleophthalmology consultations have shown comparable effectiveness to traditional in-person consultations. Sensitivity and specificity values from these comparative studies range from 54.0% to 100.0% and 76.6% to 100.0%, respectively. Wang et al, [15] reported highly favorable 6-year results for the SUNDROP telemedicine initiative regarding diagnostic accuracy. Their findings suggest that telemedicine represents a safe, reliable, and cost-effective complement to ROP specialists' efforts, potentially expanding screening access while allowing the ophthalmic community to focus resources on infants with vision-threatening conditions. In terms of glaucoma progression assessment, Odden et al, [16] found that agreement between in-person and remote evaluations varied among readers from 63% to 69% (kappa values = 0.19-0.35), with one reader showing 65% intra-observer agreement with their own in-person assessments (kappa = 0.18).

The main goal of the present study is to describe the diagnostic concordance between the initial diagnosis issued by the teleophthalmology service and the definitive diagnosis provided by the high-specialty departments to which patients are referred.

Methods

An observational research study carried out on patients from the Mexican Institute of Ophthalmology (IMO) from January 1, 2021, to December 31, 2021. This study was conducted in accordance with current legislation regarding the protection of personal information, and with IRB approval (CI/IMO – 001/2022 & CEI/IMO – 003/2022).

IMO has 4 vision centers (peripheral outpatient clinics run by an optometrist) where teleophthalmology is practiced. The present study was held at the San Juan del Río (SJR) vision center and it followed the IMO methodology developed for teleophthalmology consultation.

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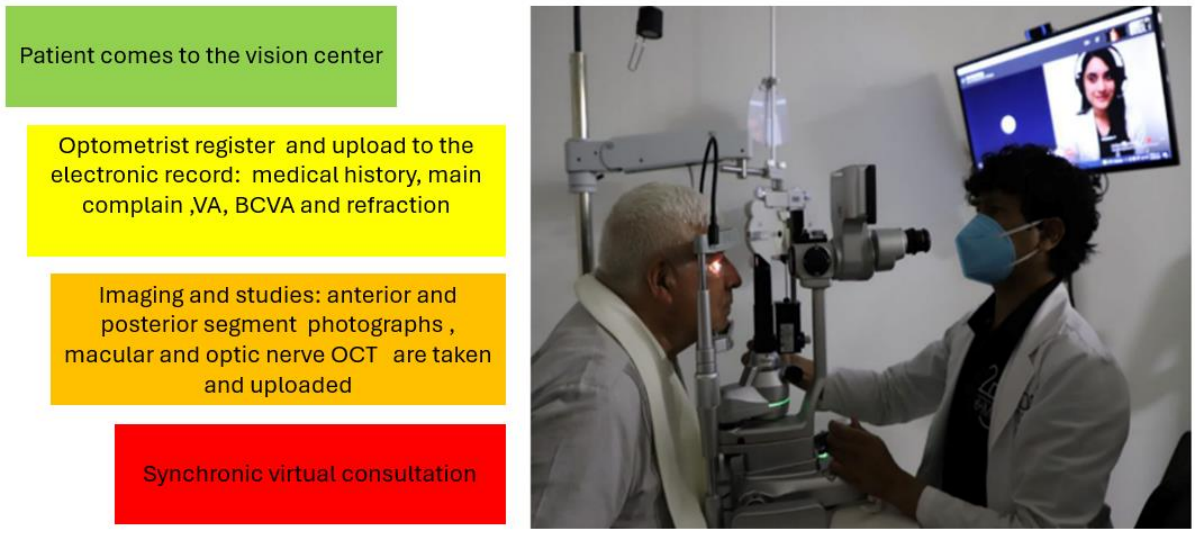

Figure 1. IMO methodology for teleophthalmology

The teleophthalmology consultation at IMO is at follows: patient is attended by an optometrist, who conducts a comprehensive evaluation that includes:

- Measurement of visual acuity using the VA-1 LCD optotype screen
- Evaluation of intraocular pressure with the iCare TA01i tonometer
- Determination of refraction using the NIDEK ARK-1 autorefractometer (and retinoscopy if needed)
- Conducting a detailed inquiry on the reason for the consultation and medical history
- Obtaining images using the Optical Coherence Tomograph (OCT) NIDEK RS-330 Retina Scan Duo, which captures:
- Macula OCT
- Optic nerve OCT
- Clinical photograph of the anterior segment
- Photograph of the posterior pole

All the collected information is integrated into the electronic medical record, which is accessed by an ophthalmologist from the Mexican Institute of Ophthalmology (IMO) in Querétaro. After analyzing the studies and medical history, a synchronous virtual consultation is conducted via the Skype platform. During the virtual consultation, the ophthalmologist and the patient interact in real time. At the end of the consultation, the patient is provided with complete information about their pathology, the clinical approach to be followed, and all their questions are answered. After the consultation some of the patients are referred to central IMO for surgical procedures, special studies or for being evaluated by a sub specialist.

We compared the concordance between the initial diagnosis provided by the teleophthalmology service and the final diagnosis issued by the subspecialty departments to which the patients were referred. A statistical analysis was conducted using central tendency measures and Cohen's Kappa test for concordance. Sensitivity and specificity were analyzed using contingency tables. The obtained data were analyzed using the SPSS program.

Results

The Vision Center of SJR, provided 2,580 consultations to 2363 patients from January 1st to December 31, 2021. 230 (9.7%) patients did not have a complete medical record and were excluded from the study. Of the 2133 patients with complete medical records, 46.5% (993) were referred to high specialty services, 70% (696) of the referrals attended an in- person consultation at the IMO. From the referrals attending IMO 64 patients (9.1%) did not have a conclusive initial diagnosis and were excluded, resulting in a sample of n= 632 patients.

The average age of the patients who attended the consultation was 56.66 years, with a range between 1 and 95 years; 55.3% of the patients who attended face-to-face consultations were 60 years or older. 55.4% of the patients seen were women (386).

REFERRED PATIENTS

From the 993 referred patients, the 5 most frequently referred were cataracts with 236 patients (23.5%), glaucoma/suspected glaucoma with 122 patients (12.4%), ametropia with 112 patients (11.2%), proliferative diabetic retinopathy with 79 patients (7.5%) and keratoconus/suspected keratoconus with 39 patients (3.9%)

It is important to mention that the group named "other pathologies" encompasses multiple diseases that individually have a low proportion of patients, so they were grouped into one category, 176 patients (17.7%).

As mentioned, to obtain the proportion of patients with concordance between the teleophthalmology diagnosis and the in-person consultation diagnosis, 64 patients (9.1%) without a conclusive initial diagnosis were excluded, resulting in a sample of 632 patients.

Table 5 illustrates, the total number of referred patients (993) grouped by diagnosis, percentage of attendance and percentage of conclusive diagnosis which was established in 90.8% of the patients (632). Illustrating the distribution of diagnoses in percentage is the fourth column.

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Table 5: Total referred patients according to diagnosis, percentage of attendance and percentage of conclusive diagnosis

Initial Diagnosis	Referred patients, N (%)	Attendnace N (%)	Conclusive Diagnosis N (%)	Distribution of Conclusive Diagnoses %
Cataract	234 (23.6%)	187 (26.86%)	178 (25.57%)	28.2%
Others	174 (17.5%)	116 (16.67%)	97 (13.93%)	15.4%
Glaucoma	124 (12.5%)	79 (11.35%)	79 (11.35%)	12.5%
Ametropía	112 (11.3%)	71 (10.20%)	53 (7.61%)	8.4%
PDR	76 (7.65%)	59 (8.47%)	55 (7.90%)	8.7%
Queratoconus	39 (3.9%)	27 (3.87%)	27 (3.87%)	4.3%
Pterigion	38 (3.8%)	20 (2.87%)	20 (2.87%)	3.2%
ERM	22 (2.2%)	12 (1.72%)	10 (1.43%)	1.6%
NPDR	19 (1.9%)	12 (1.72%)	11 (1.58%)	1.7%
Strabismus	35 (3.5%)	26 (3.73%)	26 (3.73%)	4.11%
Lid pathology	26 (2.6%)	17 (1.44%)	15 (2.15%)	2.37%
LMDR	26 (26.2%)	20 (2.87%)	18 (2.58%)	2.9%
DME	24 (2.4%)	17 (1.44%)	15 (2.15%)	2.4%
Foreign body	16 (16.1%)	11 (1.58%)	11 (1.58%)	1.74%
RD	14 (14.1%)	11 (1.58%)	7 (1.00%)	1.11%
ARMD	14 (14.1%)	11 (1.58%)	10 (1.43%)	1.58%
Total	993 (100.0%)	696 (70.1%)	632 (90.8%)	100%

PDR = proliferative diabetic retinopathy; ERM = epiretinal membrane; NPDR = non proliferative diabectic retinopath,; LMDR = laser modified diabteic retinopathy; DME = diabetic macular edema ; RD = retinal detachment ; ARMD = age related macular degeneration

A concordance study was conducted using cross-tabulations and a simple linear regression analysis between the initial and final diagnoses, reporting a concordance of 89.9%, with a correlation coefficient of 88% and a p-value of 0.000003, which is considered statistically significant.

Sensitivity and specificity, as well as positive and negative predictive values for each diagnosis, were obtained through contingency tables as illustrated in Table 8.

Table 8: Sensitivity, Specificity, Positive predictive value and Negative Predictive Value of each diagnose

Pathology	Sensitivity (%)	Specificity (%)	PPV (%)	NPV(%)
Cataract	97.13	98.03	94.94	98.9
Glaucoma	87.8	98.72	91.13	98.2
PDR	91.22	99.5	94.55	99.13
Ametropía	80.33	99.3	92.5	97.93
Queratoconus	91.66	99.17	81.5	99.66
NPDR	81.82	99.68	81.81	99.68
LMDR	100	99.51	83.33	100
Pterigion	100	100	100	100
ERM	100	100	100	100
DME	92.3	99.51	80	99.83
Strabismus	91.67	99.34	84.61	99.67
RD	77.78	100	100	99.68
ARMD	72.72	99.68	80	99.51
Eyelid pathology	81.25	99.67	86.66	99.51
Foreign body	100	100	100	100

Discussion

As previously mentioned, teleophthalmology is a tool with great potential, considering that it provides care in vulnerable areas with difficult access to health services, allowing the early detection of vision-compromising diseases, timely referral of ophthalmological emergencies, and the remote management of non-serious pathologies, ensuring periodic follow-up in remote areas, avoiding migration or justifying their transfer.

For teleophthalmology consultations to be viable, diagnostic accuracy is necessary. Therefore, the macular and optic nerve OCT implemented in the consultation plays a crucial role.

The present study aimed to evaluate the concordance between diagnoses issued by teleophthalmology and in-person consultations. Using the Cohen's Kappa test, a concordance of 0.891 with a p-value < 0.05 was obtained. Out of the 15 diagnoses evaluated in this study, a sensitivity ranging from 72.72% for AMD to 100% for RDML, pterygium, epiretinal membrane, and foreign body diagnoses was found.

The most frequent diagnoses were cataracts (23.5%), followed by glaucoma or suspected glaucoma (12.49%). The third most frequent diagnosis was ametropia, mostly for evaluating refractive surgery.

Regarding specificity, the lowest value was 98.03% for cataracts, while pterygium, epiretinal membrane, retinal detachment, and foreign body had a specificity of 100%. Both the sensitivity and specificities found are higher than those reported in past studies.

A limitation in the research is due to the lack of a sample of patients without ocular pathology, making it impossible to calculate sensitivity and specificity of teleophthalmology across all diagnoses.

In the future, a prospective study with a healthy group could be conducted, considering that they must attend both telemedicine and in-person consultations to perform the analysis.

Another limitation is that only one initial and one final diagnosis per patient were considered, which implies a bias that can be addressed by conducting a more comprehensive study that includes all the diagnoses of a patient.

Of the referred patients, 7.65% did not have a conclusive initial diagnosis, and the majority were sent to the retina service for peripheral evaluation by indirect ophthalmoscopy, which could not be assessed by teleophthalmology. Another frequent situation was patients referred to the mentioned service with a cataract diagnosis, as media opacity did not allow the visualization of the fundus.

With the reported results, it is possible to affirm that teleophthalmology consultations are a viable option for the care of patients in remote areas, being an accessible option, but above all providing an accurate diagnosis, comparable to an in-person evaluation.

Thanks to this IMO teleophthalmology consultation modality, 1140 patients (53.45%) were able to be managed remotely, achieving the objectives and taking advantage of the benefits of a telemedicine service: avoiding unnecessary patient transfer, resulting in economic savings, reduced care times, and relief in the workload.

It is important to emphasize that the model of care of the IMO teleophthalmology at Vision Centers is not the standard of care in every teleophthalmology service, and this can lead to differences in diagnostic accuracy.

The IMO teleophthalmology model evaluated in this study is synchronous and includes macular and optic nerve OCT, unlike other centers where the patient and the doctor do not communicate in real-time.

Reports from other medical specialties demonstrate that direct video consultations produce a high degree of patient satisfaction with similar results and greater cost-effectiveness compared to standard in-person visits. Based on this, a study is proposed to evaluate the satisfaction of patients treated at the IMO Vision Centers, thus finding areas of opportunity to improve the service while investigating the reason for patient non-attendance at in-person consultations, as this protocol reported a 30% non-attendance rate.

Technological advances allow teleophthalmology to be a viable option for providing remote health care and meeting visual health needs. Among the main causes of blindness are diabetic retinopathy, glaucoma, and cataracts; the first two are preventable, and the latter is treatable and reversible.

With teleophthalmology, timely care is provided without the need for transfers, reducing expenses in resources and time. This is particularly significant in developing countries where a high proportion of people live in remote areas. Additionally, it is a cost-effective consultation modality for patients with difficulty traveling, such as the elderly and people with disabilities. Considering the population growth trend, especially within the elderly group, and taking into account the increased incidence of eye diseases within this population group, more health centers offering teleophthalmology consultations should be sought.

Conclusion

The study results revealed five ocular pathologies that provide a detailed description of the visual health problems in our study population. Cataracts 23.5%, glaucoma/suspected glaucoma (12.4%), refractive error (11.2%), proliferative diabetic retinopathy (7.5%), and keratoconus/suspected keratoconus (3.9%). It is important to emphasize that these pathologies are similar to the main causes of blindness and visual impairment worldwide, according to the Global Burden of Disease Study 2019.

The results obtained showed that the diagnoses issued by IMO teleophthalmology service were highly consistent with traditional face to face consultations with a correlation coefficient of 88%.

The relevance of this study increases considering the potential implications in the public health area, by facilitating and creating another option for specialized care, especially in urban or remote areas where the lack of specialized health services and/or transportation difficulties is a persistent reality.[24-27]

The implementation of teleophthalmology will help improve access to ophthalmological care in Mexico and enhance the quality of life. However, it is a priority to develop guidelines and protocols for the implementation of teleophthalmology in clinical practice.

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