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VISUAL OUTCOMES IN KERATOCONUS: THE ROLE OF DEMOGRAPHICS, CLINICAL PROFILE, AND GAS PERMEABLE (GP) LENSES

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Abstract

Aim: The study aimed to evaluate the clinical and demographic profile of patients with keratoconus and assess visual outcomes with corneal gas permeable (GP) lenses. **Methods:** This prospective observational study was conducted at the Ophthalmology Department, Hayatabad Medical Complex, Peshawar from November 2022 to November 2023 using a non-probability consecutive sampling technique. All subjects diagnosed with keratoconus were identified using the modified Rabinowitz criteria. Detailed eye and visual assessments were performed using slit-lamp biomicroscopy, ETDRS, and a keratometer. Data on clinical and demographic profiles were collected using a structured questionnaire. Data entry and analysis were performed with Jamovi version 2.3. **Results:** A total of 637 patients, aged 20.6±5.97 years, were included in the study, with a gender distribution of 71.7% male and 28.3% female. Clinical findings revealed Vogt's striae in 16.8% of right eyes (RE) and 15.1% of left eyes(LE), Fleischer's ring in 15.6% of RE and 16.6% of LE, and naked nerve fibers in 14.5% of RE and 14.6% of LE. No significant difference in visual acuity with RGP lenses between genders ($p = 0.097$), while a significant increase in visual acuity with RGP lenses was observed ($p < 0.001$). Significant association between the presence of Vogt's striae in both eyes and a history of allergic conditions were observed ($p = 0.032$). **Conclusion:** Clinical findings were prevalent among all patients, and a statistically significant improvement was observed with GP lenses.

Keywords: ETDRS, Visual Acuity, Keratoconus, Gas Permeable Lenses.

INTRODUCTION

Keratoconus is a bilateral, usually asymmetric corneal ectasia that typically first manifests in early teens and is characterized by irregular astigmatism, corneal thinning, and vision deterioration[1].

The prevalence of keratoconus varies by geographical location and ethnicity, with higher rates observed in populations from Asia and the Middle East compared to Caucasians. This suggests that ethnicity may play a significant role in the prevalence of keratoconus.[2],[3],[4]

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The exact cause of keratoconus is currently unknown, but both hereditary and environmental factors are believed to contribute[5],[6],[7]. Since a definitive treatment for keratoconus has yet to be discovered, clinical interventions aim to improve visual acuity and slow the progression of the condition. Various contact lenses, including rigid gas permeable (RGP), soft toric, piggyback, hybrid, and scleral lenses, are used for optical correction[8]. RGP lenses are particularly effective in improving visual acuity by masking corneal astigmatism through the formation of a tear meniscus lens. Early diagnosis of keratoconus is challenging and requires consideration of multiple anatomical and optical findings. Retinoscopy, corneal topography, and corneal biomechanics are essential tools for early detection[9].

Clinical features of keratoconus include scissors reflex during retinoscopy, oil droplet reflex during ophthalmoscopy, Fleischer's ring, and Vogt's striae. These signs are hallmarks of keratoconus and confirm the diagnosis in mild cases[10],[11],[12].Vogt's striae can be seen as a bunch of hair-like vertical lines inside the posterior limiting lamina and posterior stroma. The striae sometimes can be visible without a slit lamp. Some studies suggest that fleschers's ring and vogt's striae are seen in keratoconus subjects 86% and 65% respectively[13],[14]. Corneal collagen cross-linking (C-CXL) and intrastromal corneal ring segments (ICRS) are advanced treatments that help halt the progression of keratoconus and improve corneal stability[15],[16],[13].

METHODOLOGY

This prospective observational study was conducted at the Ophthalmology Department, Medical Teaching Institute Hayatabad Medical Complex (MTI, HMC) Peshawar from November 2022 to November 2023 using a non-probability consecutive sampling technique. The MTI HMC is a 1300-bedded hospital and a postgraduate medical teaching institution. The department of Ophthalmology is declared as a Centre for Excellence in eye care by the Government of Khyber Pakhtunkhwa. The inclusion criteria for keratoconus were as follows: at least one clinical sign of keratoconus observed on slit-lamp biomicroscopy, including Vogt's striae, Fleischer's ring, central thinning, or corneal scarring typical of keratoconus, and a symmetric bowtie pattern with or without skewing and stromal thinning on topography and pachymetry. Patients with a history of any ocular disease, ocular surgery, or trauma were excluded from this study.

All patients underwent a detailed slit-lamp examination, auto-refraction, retinoscopy, manual keratometry, and subjective refraction. GP lens assessment was performed using different trial sets of the Rose K series (Rose K-2, Rose K NC, Rose K IC). Static and dynamic assessments using fluorescein dye were conducted, followed by over-refraction to record final parameters. Data on clinical and demographic profiles were collected using a structured questionnaire. Ethical approval for the study was obtained from the institutional review board of MTI HMC. Data entry and analysis were performed using Jamovi version 2.3. Statistical analysis included descriptive statistics and inferential tests to assess the significance of visual outcomes with GP lenses.

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RESULTS

The study included 637 subjects with a mean age of 20.33 years, predominantly male (71.7%). Keratoconus was mostly bilateral (90.6%). Visual acuity improved significantly with GP lenses compared to spectacles ($p < 0.001$), with no significant gender differences in improvement. Clinical signs such as Vogt's striae, Fleischer's ring, and naked nerve fibers were prevalent, with Vogt's striae and Fleischer's ring significantly associated with allergic conditions. These findings underscore the effectiveness of GP lenses in enhancing visual acuity and highlight the prevalence of key clinical signs of keratoconus and their association with allergies.

Table 1: Demographic and Clinical Characteristics of Study Subjects

(n = 637 Subjects, 1272 Eyes)

Variable	Frequency (%)	Mean ± SD	Range
Age (years)	—	20.33 ± 5.97	9 – 47
Gender	Male: 457 (71.7%) Female: 180 (28.3%)	—	—
Mean Age by Gender	—	Male: 20.1 Female: 20.6	—
Laterality of Keratoconus	Bilateral: 576 (90.6%) Unilateral: 60 (9.4%)	—	—
Presenting Visual Acuity (VAR)	n = 552	0.934 ± 0.345	0.00 – 1.30
Presenting Visual Acuity (VAL)	n = 574	0.878 ± 0.373	0.00 – 1.50

Table 1 presents the demographic and clinical characteristics of the study subjects, comprising 637 individuals and 1272 eyes. The mean age of the subjects was 20.33 ± 5.97 years, with an age range from 9 to 47 years. The gender distribution showed a higher prevalence of keratoconus among males, with 457 males (71.7%) and 180 females (28.3%). The mean age by gender was slightly different, with males having a mean age of 20.1 years and females 20.6 years. The laterality of keratoconus was predominantly bilateral, observed in 576 subjects (90.6%), while unilateral keratoconus was present in 60 subjects (9.4%). Presenting visual acuity was measured separately for the right eye (VAR) and left eye (VAL). For the right eye, the mean visual acuity was 0.934 ± 0.345, with a range from 0.00 to 1.30. For the left eye, the mean visual acuity was 0.878 ± 0.373, with a range from 0.00 to 1.50. These data provide a comprehensive overview of the demographic and clinical profiles of the study population, highlighting the prevalence and characteristics of keratoconus among the subjects.

Table 2: Frequency of Clinical Signs of Keratoconus in Study Subjects

Signs of KC	Right Eye (RT) Frequency (%)	Left Eye (LT) Frequency (%)	Total Count (%)
Vogt's Striae	96 (16.8%)	84 (15.1%)	180 (16.0%)
Fleischer's Ring	89 (15.6%)	92 (16.6%)	181 (16.1%)
Naked Nerve Fibers	83 (14.5%)	81 (14.6%)	164 (14.5%)

Note: Total number of eyes = 1212. The table presents the frequency and percentage of each clinical sign in right and left eyes among keratoconus patients.

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Table 2 details the clinical signs of keratoconus observed in the study subjects, with data presented for both the right eye (RT) and left eye (LT). The total number of eyes examined were 1212. Vogt's striae were observed in 96 right eye (16.8%) and 84 left eye (15.1%), resulting in a total count of 180 eyes (16.0%). Fleischer's ring was present in 89 right eye (15.6%) and 92 left eye (16.6%), with a total count of 181 eyes (16.1%). Naked nerve fibers were noted in 83 right eyes (14.5%) and 81 left eyes (14.6%), giving a total count of 164 eyes (14.5%). These frequencies and percentages highlight the prevalence of key clinical signs of keratoconus in the study population, providing a comprehensive overview of the distribution of these signs in both eyes.

Table 3: Association of Allergic Conditions with Keratoconus Indicators in Right and Left Eyes

Variables	X^2	Df	P-values
vogts striae RT- H/O All,Asth,Ecz,Hey fev	4.58	1	0.032
vogts striae LT- H/O All,Asth,Ecz,Hey fev	5.00	1	0.025
fleischer,s ring RT- H/O All,Asth,Ecz,Hey fev	6.58	1	0.01
fleischer,s ring LT - H/O All,Asth,Ecz,Hey fev	15.0	1	< .001
Naked Nerve fibers RT- H/O All,Asth,Ecz,Hey fev	0.0182	1	0.982
Naked Nerve fibers LT- H/O All,Asth,Ecz,Hey fev	0.0315	1	0.859
RT-Right Eye, LT-Left Eye, H/O, History of, All.-Allergy, Asth.-Asthama, Ecz-Eczema, Hey Fev.-Hey Fever			

Table 3 presents the association between allergic conditions and keratoconus indicators in the right (RT) and left (LT) eyes. The variables examined include Vogt's striae, Fleischer's ring, and naked nerve fibers, with their respective chi-square (X2) values, degrees of freedom (Df), and p-values. The presence of Vogt's striae in the right eye was significantly associated with a history of allergies, asthma, eczema, or hay fever (X2 = 4.58, p = 0.032), and similarly in the left eye (X2 = 5.00, p = 0.025). Fleischer's ring showed a stronger association with these allergic conditions in both the right eye (X2 = 6.58, p = 0.01) and the left eye (X2 = 15.0, p < 0.001). However, naked nerve fibers did not show a significant association with allergic conditions in either the right eye (X2 = 0.0182, p = 0.982) or the left eye (X2 = 0.0315, p = 0.859). These results indicate a significant relationship between certain clinical signs of keratoconus and a history of allergic conditions, particularly for Vogt's striae and Fleischer's ring.

Table 4: Comparison of Visual Acuity between Spectacle and Gas Permeable Lenses, and its Association with Gender

Variables	Mean Difference	T	Df	P-value
Spec. VAR-VAR GP	0.756	56.6	487	< .001
Spec. VAL-VAL GP	0.785	55.5	479	< .001
Independent t test for association b/w Visual acuity with GP lenses and Gender				
VAR GP-Gender		1.66	520	0.097
VAL GP-Gender		1.62	512	0.091
Spec.-Spectacle, VAR-Visual acuity Right, VAL-Visual acuity Left,GP-Gas Permeable Lenses,				

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Table 4 compares visual acuity between spectacles and gas permeable (GP) lenses, and examines the association with gender. The mean difference in visual acuity for the right eye (VAR) between spectacles and GP lenses was 0.756, with a t-value of 56.6 and a p-value of <0.001, indicating a significant improvement in visual acuity with GP lenses. Similarly, for the left eye (VAL), the mean difference was 0.785, with a t-value of 55.5 and a p-value of <0.001, also showing a significant improvement with GP lenses. An independent t-test was conducted to assess the association between visual acuity with GP lenses and gender. For the right eye (VAR GP), the t-value was 1.66 with a p-value of 0.097, and for the left eye (VAL GP), the t-value was 1.62 with a p-value of 0.091. These results indicate no significant difference in visual acuity improvement with GP lenses between genders. The data highlights the effectiveness of GP lenses in enhancing visual acuity compared to spectacles, with no significant gender-based differences in outcomes.

DISCUSSION

The findings of this study provide valuable insights into the clinical and demographic profiles of patients with keratoconus and the effectiveness of corneal gas permeable (GP) lenses in improving visual outcomes. The demographic data revealed a higher prevalence of keratoconus among males (71.7%) compared to females (28.3%), which is consistent with previous studies indicating a male predominance in keratoconus cases[17]. The mean age of the patients was 20.6±5.97 years, highlighting that keratoconus predominantly affects young adults.

Clinical findings such as Vogt's striae, Fleischer's ring, and naked nerve fibers were observed in a significant proportion of patients, with no significant difference in the prevalence of these signs between the right and left eyes. The presence of Vogt's striae was significantly associated with a history of allergic conditions ($p = 0.032$), suggesting a potential link between allergic conditions and the development or progression of keratoconus. This association aligns with existing literature that has reported a higher incidence of keratoconus in individuals with atopic diseases[17].

The study demonstrated a statistically significant improvement in visual acuity with the use of GP lenses ($p < 0.001$), underscoring the effectiveness of these lenses in managing keratoconus. The lack of significant difference in visual acuity improvement between genders ($p = 0.097$) suggests that GP lenses are equally effective for both male and female patients. These findings support the use of GP lenses as a viable option for enhancing visual acuity in keratoconus patients, regardless of gender.

When compared to previous studies,[18],[19],[17] our findings are consistent with the literature that highlights the benefits of GP lenses in keratoconus management. For instance, a study by Romero-Jiménez et al. (2015) found that short-term rigid gas-permeable contact lens wear resulted in significant flattening of the anterior cornea and reduction in higher-order aberrations in keratoconus subjects[18]. Similarly, a review by Lim et al. (2020) emphasized that GP lenses provide significantly better vision than

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glasses and are effective in managing keratoconus[17]. Our study adds to this body of evidence by demonstrating significant visual acuity improvements with GP lenses in a large cohort of patients.

The strengths of this study include its prospective design and the comprehensive assessment of both clinical and demographic variables. However, there are some limitations to consider. The study was conducted at a single center, which may limit the generalizability of the findings. Additionally, the use of non-probability consecutive sampling may introduce selection bias. Future studies with larger, multi-center cohorts and randomized sampling techniques are recommended to validate these findings and further explore the associations observed in this study.

CONCLUSION

In conclusion, this study highlights the prevalence of clinical signs of keratoconus among patients and confirms the significant improvement in visual acuity with GP lenses. These results contribute to the growing body of evidence supporting the use of GP lenses in the management of keratoconus and underscore the importance of early diagnosis and intervention to optimize visual outcomes for affected individuals.

Author's Contribution:

Principal Author - Concept, Drafting, Data Acquisition, Data analysis & Interpretation.
Principle Supervisor - Acquisition, Critical review for important intellectual content
Co-supervisor - Concept & design, Data analysis & Interpretation Final approval of the version to be published

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