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Prevalence of Keratoconus and The Role of Advanced Optical Techniques for Correcting Vision

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الملخص: هدفت دراسة مقطعية، شملت مرضى مستشفى بنغازي التعليمي لطب العيون ومركز دلتا للبصريات، إلى تقييم مدى انتشار القرنية المخروطية (KC) ودراسة توزيع وفعالية التقنيات البصرية المتقدمة المستخدمة في علاجها. أُجري استبيان شمل 500 مشارك، واستُخدم برنامج SPSS لتحليل 413 استجابة صالحة. أظهرت النتائج أن القرنية المخروطية منتشرة بشكل كبير (59.6%)، وخاصة بين الفئات العمرية الأصغر. في حين لم تكن هناك علاقة ارتباطية ذات دلالة إحصائية بين القرنية المخروطية والعمر أو الجنس أو سُمك القرنية، فقد وُجدت علاقة ارتباطية إحصائية ذات دلالة إحصائية بين القرنية المخروطية والاستجماتيزم غير المنتظم ونوع العلاج. على الرغم من أن مرضى القرنية المخروطية كانوا أكثر عرضة للخضوع لإجراءات أكثر تعقيدًا مثل تثبيت القرنية، وزرع حلقات داخل القرنية، وزراعة القرنية، إلا أن النظارات ظلت الوسيلة التصحيحية الأكثر شيوعًا. تُبرز هذه النتائج أهمية الكشف المبكر، وتثقيف المرضى، وتطبيق أحدث أساليب التشخيص والعلاج في رعاية العيون.

الكلمات المفتاحية: القرنية المخروطية؛ الانتشار؛ الربط المتقاطع للقرنية؛ الاستجماتيزم؛ المتقدم.

Abstract: A cross-sectional study, patients at the Benghazi Teaching Hospital for Ophthalmology and Delta Optics Center, aimed to assess the prevalence of keratoconus (KC) and investigate the distribution and efficacy of advanced optical techniques used to treat it. A survey with 500 participants was conducted, and SPSS was used to analyze 413 valid responses. The findings showed that keratoconus was quite prevalent (59.6%), specifically among younger age groups. While there was no significant correlation between KC and age, gender, or corneal thickness, there was a significant statistical correlation between KC and irregular astigmatism and the type of treatment. Although keratoconus patients were more likely to undergo more complex procedures like corneal cross- linking, intracorneal ring implantation, and transplantation, glasses remained the most common corrective measure. These findings highlight the importance of early screening, patient education, and the application of state-of-the-art diagnostic and therapeutic approaches in ophthalmic care.

Keywords-; Keratoconus; prevalence; corneal crosslinking; astigmatism; advanced.

I. INTRODUCTION

1.1 Definition:

Keratoconus is a progressive, non-inflammatory eye disorder characterized by thinning and cone-like protrusion of the cornea, leading to irregular astigmatism and visual impairment. The condition typically begins in adolescence or early adulthood and can progress for 10 to 20 years before stabilizing. Fig (1). Its etiology is multifactorial, involving genetic, biochemical, and environmental factors, including chronic eye rubbing and atopy (Gomes *et al.*, 2015). Recent advancements in diagnostic technologies, such as corneal topography and tomography, have significantly improved early detection and classification of keratoconus. Furthermore, treatments like corneal collagen cross-linking (CXL) have proven effective in halting disease progression, reducing the need for corneal transplantation (Wollensak *et al.*, 2003; Hersh *et al.*, 2011).

Fig (1): Keratoconus of the Eye.

1.1 History Keratoconus:

Keratoconus was first reported by Benedict Duddell in 1736. (Wyman,1992); Following its first description,

various terminologies such as 2 relapses cornea, cornea conica, sugar- loaf cornea, and procidentia cornea .(Grzybowski, 2013) Around a century later, John Nottingham furnished the primary designated description of the disorder in his landmark book in 1854 (Grzybowski, 2013; Gokul, 2016) Pickford defined the conical cornea as a sickness that is "intractable in nature and deadly to vision" and One in which" the pathology and remedy are so little understood. Around a hundred and seventy years later, keratoconus stays an enigmatic disease. Over the beyond few decades, speedy development in diagnosing and coping with keratoconus has been observed. Originally described as a tremendous illness with the resource of the use of the National Institute of Health with an incidence of plenty much less than 1 consistent with 2,000 People (Ferrari, 2020), it's far now acknowledged that keratoconus is a great deal greater not unusual place than firstly thought. The pronounced occurrence is pretty variable from 0.2 consistent with 100,000 in Russia (Gorshkova, 1998) to 33 consistent with 1,000 in Iran (Hashemi, 2013). A meta-analysis from 15countries reported a global prevalence of 1.4 per 1,000 (Hashemi, 2020). A better incidence is cited in Asian and Middle Eastern populations. Pediatric populations have a better occurrence fee, with a suggested occurrence fee starting from 5.2 consistent with 1,000 people In New Zealand to 47. nine consistent with 1,000 human beings in Saudi Arabia (Torres, 2018; Papali, 2019). In addition, it is one of the most now no longer unusual place signs for keratoplasty in plenty of countries. (Ting, 2012; Park, 2015) Nonetheless, a few nations have suggested a lowering fashion withinside the wide variety of keratoplasty for Keratoconus in view of the implementation of corneal cross- linking (Sandvik, 2015, Godefrooij, 2016).

1.2 Aim of This Study:

This study aimed to investigate the prevalence of keratoconus and assess the effectiveness and distribution of advanced optical techniques used in its treatment among patients attending the Benghazi Teaching Hospital for Ophthalmology and Delta Optics Center. Also, determine associations between keratoconus prevalence and demographic, anatomical, and treatment variables.

II. KERATOCONUS OVERVIEW AND LITERATURE REVIEWS

2.1. Genetics Causes:

Keratoconus has long been considered to have a genetic component, given its association with other genetic syndromes (such as Down's syndrome (Mathan, 2020) Leber's congenital amaurosis (Elder, 1994; Damji, 2001), Ehlers-Danlos syndrome (Robertson, 1975) and Noonan syndrome (Lee, 2014), its prevalence in first- degree relatives (Rabinowitz, 2021; Shaag A, 2013, Almusawi LA, 2021, Lapeyre G, 2020) and occurrence in monozygotic twins,(Edwards, 2001; Tuft SJ, 2012). It has been anticipated that a relative of an individual with keratoconus has a 15 to 67 times greater risk of developing keratoconus than an individual with no family history of keratoconus (Wang, 2000). Keratoconus follows an apparently autosomal dominant/recessive mode of inheritance in some families (Bisceglia, 2009; Gonzalez, 1996).

2.2. Cellular Biochemistry:

To date, 117 proteins and protein commands have been implicated withinside the pathophysiology of keratoconus. Differential expression of numerous corneal proteins effects in modifications withinside the structural integrity and morphology of the keratoconus cornea, through altering its collagen content and keratocyte apoptosis and necrosis in the (Yam, 2019; Srivastava, 2016). Oxidative stress markers and antioxidants are dysregulated in keratoconus, associated with an imbalance of redox homeostasis in tears, cornea, aqueous humour and blood (Navel, 2020). Keratoconus is related to a typical boom in oxidative strain markers, mainly in reactive oxygen and nitrogen species and malondialdehyde.

2.3. Biomechanical factors:

The degeneration of the proteoglycans across the stromal collagen fibrils in keratoconus corneas results in breakage of, and degeneration of the microfibrils within, collagen fibrils (Alkanaan, 2019). Erato-conic corneas have decreased levels of aldehyde dehydrogenase Class 3 (Gondhowiardjo, 1993) and superoxide dismutase enzymes (Behndig, 1998), Both enzymes play vital roles withinside the reactive oxygen techniques of various species. The reactive oxygen accumulation causes cytotoxic deposition of malondialdehyde and peroxynitrites, which could potentially damage corneal

tissue (Navel, 2020, G¨oncü, 2015; Kiliç 2016; Shetty, 2017).

2.4. Hormones:

Vision changes with keratoconus often occur during a change in hormone levels, 2 such as:

- Puberty.
- Pregnancy.

2.5. Risk factors:

Several environmental and familial factors are associated with an increased risk of developing keratoconus, table (1). Allergy and atopy have long been associated with keratoconus, with the majority of studies showing a positive association and the reported prevalence being 11 to 30% (Ahuja, 2020). Another strongly associated risk factor in the pathogenesis of keratoconus is eye rubbing (Hashemi, 2020), figure (1). A common mediator to these major risk factors is Immunoglobulin E, which has been identified as elevated, even in some patients with keratoconus without inflammatory symptoms and signs (Ahuja, 2020). In keratoconus patients, the incidence of elevated levels of total serum Immunoglobulin E was between 52% and 59% for raised serum specific Immunoglobulin E levels (Kemp, 1982).

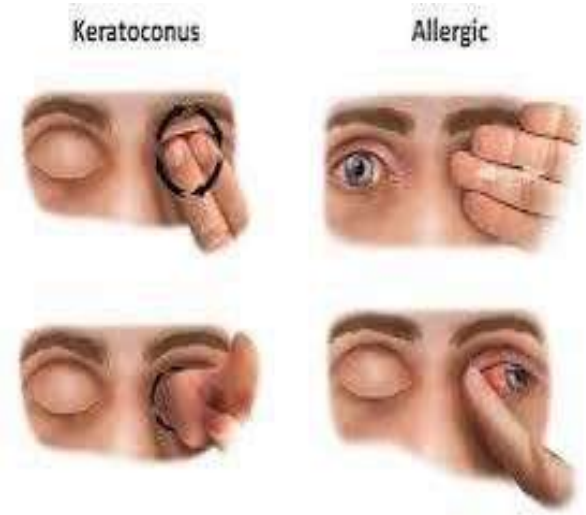

Fig (1): Allergic reaction led to keratoconus.

Table (1): Environmental and familial risk factors for Keratoconus:

No.	Factors	Relative Risk
1	Family history of keratoconus	6.3
2	Eye rubbing	3.1
3	Eczema	3.0
4	Ashma	1.9
5	Allergy	1.4

Fig (2): Irregularities of corneal surface.

2.6. Signs and Symptoms of Keratoconus:

1. **Progressive Vision Deterioration of The Eye:**
One of the maximums now not uncommon location early symptoms. Patients experience a gradual decline in vision, usually due to increasing irregularities on the corneal surface. (Rabinowitz, 1998; Kanski, 2015) These changes lead to irregular, astigmatism and myopia (nearsightedness). Figure (2).

2. **Blurred or Distorted Vision:**
Due to the irregular refraction of light caused by the altered shape of the cornea, patients often suffer from persistent visual blurriness, even when wearing glasses.

3. **Halos and Glare Around Lights:**
This is a characteristic sign, especially at night or in dim lighting. Patient may notice halos or glare surrounding light sources, caused by the uneven corneal surface. (Davidson, 2014).

4. **Frequent Changes in Glasses or Contact Lens Prescriptions:**
Because the corneal shape continues to change, patients often need frequent updates to their optical prescriptions, and, traditional corrective lenses may become ineffective over time. (McMonnies, 2015). Figure (3).

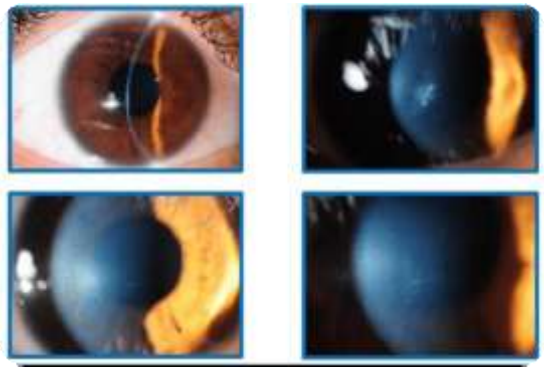

Fig (3): Corneal halos and glare.

5. Photophobia:

A common symptom due to increased light scattering caused by the abnormal curvature of the cornea.

6. Poor Night Vision:

Many patients report difficulty seeing in the dark or in low-light environments, which is linked to higher-order optical aberrations.

7. Eye Irritation or Itching:

Patients may feel persistent irritation or itching, often associated with chronic eye rubbing — a major contributing factor Withinside the improvement of the condition.

8. Monocular Diplopia or Multiple Images from One Eye:

This is a complex visual symptom where patients see double or multiple images from a single eye due to

abnormal corneal refraction, usually in superior levels of the disease sensation of Pressure or Mild Eye Discomfort. (Sykakis, 2015). In some cases, patients may feel a mild pressure or discomfort in the eye, particularly as the disease progresses Sudden and Severe Vision Loss (in Case of Descemet's Membrane rupture).

2.7. Classification system of keratoconus:

Different class structures presently to be had for assessing keratoconus severity primarily based totally on:

• Corneal morphology and disorder evolution.
• Optical and visible function.
• Descriptors of corneal shape (i.e, index-primarily based totally systems).

2.7.1. Corneal morphology and disease evolution:

The maximum generally used type structures primarily based totally on morphological adjustments and ailment evolution are:

• Morphological (Buxton) classification– This device classifies the illness based completely on the shape and function of the cone into oval, nipple and globe keratoconus (Perry HD, 1980):

(1) In oval keratoconus the cone impacts one or corneal quadrants.
(2) Keratometric classification (Vega Estrada, 2017) – This system categorizes keratoconus into four grades based on the magnitude of the cornea's central corneal power: (a) Mild; (b) Moderate; (c) Advanced.
(3) Hom's classification (Rabinowitz, 1980) – This system classifies keratoconus into four grades based on clinical signs:
(a) Preclinical suggests that no keratoconus symptoms and symptoms are detected.
(b) Mild cases display mild corneal thinning and scissors reflex.
(c) Moderate suggests terrible visible great and corneal thinning without corneal scarring. Table (2).

Table (2): Amsler-Krumeich classification:

No.	Amsler – Krumeich	Alio – Shabayek
1	**Grade I** Corneal steepening Refraction > 5 D Mean number one K readings < 48 D	No scar Coma-like RMS 1.50 to 2.50 µm Mean number one K readings < 48 D
2	**Grade II** No scars Corneal thickness > four hundred µm Refraction > eight D Mean valuable K readings < fifty-three D	No scars Corneal thickness > four hundred µm Mean valuable K readings < fifty-three D Coma-like RMS > 2.50 to ≤ 3.50 µm
3	**Grade III** No scars Corneal thickness > 300 µm Refraction > 10 D Mean central K readings < fifty-five D	No scars Corneal thickness > 300 µm Coma-like RMS > 3.50 to ≤ 4.50 µm Mean central K readings < fifty-five D
4	**Grade IV** Central scarring Corneal thickness > 200 µm Not reliable refraction Mean central K readings > fifty-five D	Central scarring Corneal thickness > 200 µm Coma-like RMS > 4.50 µm Mean central K readings > fifty-five D

2.7.2. Optical and visual function:

This classification associated with a significant decrease in optical quality resulting from increases in ocular aberrations and a loss of corneal transparency in some cases which can affect quality of life (Kandel, 2020).

a) Lio-Shabayek (2006) - This system, which is based on the Amsler–Krumeich classification.

b) Keratoconus Severity Score (KSS) (McMahon, 2006) - This system grades the severity of keratoconus from 0 (suspect) to 5 (severe) primarily based totally on corneal topographic indices (i.e., anterior corneal better order aberration RMS blunders and suggest relevant keratometry).

c) RETICS classification (Ali´o, 2011) – In addition to clinical signs and optical and visual function variables, this category device additionally takes into attention corneal biomechanical parameters (i.e., hysteresis and resistance factor).
Belin ABCD grading system (Belin, 2016) – Keratoconus severity is graded primarily based totally on 4 variables:

- Anterior and posterior corneal radius.
- Curvature of the 3.0 mm central zone of the thinnest corneal location.
- Thinnest pachymetry.
- Distance best corrected visual acuity.

2.7.3. Index-based systems:

These structures might also additionally consist of one or extra variables for keratoconus detection and commonly use cut-off values to permit differentiation among regular corneas, keratoconus suspects, and clinical keratoconus four hundred μm.

2.8. Stages of Keratoconus:

Keratoconus progresses through a series of clinical stages, each characterized by increasing corneal deformation and visual impairment. The classification into stages helps guide treatment and monitor disease progression. The most widely accepted staging system is based on corneal curvature, pachymetry (thickness), visual acuity, and topographic findings.

Stage 1 –Early stage:

- Slight corneal thinning, mostly inferiorly.
- Irregular astigmatism begins to appear.
- Best-corrected visual acuity (BCVA).
- Still good with glasses.
- Topography shows mild asymmetry or inferior steepening.

Stage 2 – The Moderate Stage:

- The corneal protrusion and thinning increased.
- Visual acuity worsens; glasses are no longer sufficient, and rigid gas permeable lenses may be required.
- Keratometric readings (K-values) between 45–52 diopters.
- Topographic signs include a pronounced cone shape and possible scissoring reflex on retinoscopy.

Stage 3 – The Advanced Stage:

- Corneal thinning and ectasia have been noted.
- Vision is significantly reduced; contact lenses may no longer provide stable correction.
- K-readings typically between 52–62 diopters.
- Corneal haze may begin to appear.

Stage 4 – The End-stage:

- Thinning and scarring of the cornea noted to be aggressive.
- Vision is severely affected and often uncorrectable with lenses.
- K-readings exceed 62 diopters.
- Corneal transplantation as the surgical treatment may use at this stage.

2.9. Diagnosis:

2.9.1. Examination:

Scissoring of the red reflex on retinoscopy is a dependable and touchy technique for detecting early-degree KC. External signs consist of the Munson sign (V-formed deformation of the decrease eyelid because of the cone whilst the affected person appears down; And Rizzuti sign (conical illumination at the nasal sclera whilst light is directed at the cornea from the temporal side..(However, these external signs are typically not observed in mild KC (Hashemi H, 2020).

2.9.2. Topography and tomography:

2.9.2.1. Corneal Topography:

Topography permits noninvasive qualitative and quantitative characterization of corneal morphology.

Topographic maps will display abnormal astigmatism with steepening. The following maps are analyzed: anterior, sagittal, and tangential curvature maps; anterior and posterior elevation maps; and the thickness map (Martinez-Abad, 2017).

- **Pentacam Topography:**

Is a diagnostic imaging technique used in ophthalmology to analyze the cornea and anterior segment of the eye. It utilizes a Scheimpflug camera to create detailed maps of the cornea's surface, including its curvature, elevation, and thickness. Figure (4).

- **Autorefractometer:**

Refractometry or optometry is topographic assessing refractive error with a refractometer or optometer instrument. Automated refractors or autorefractors are instruments designed Figure (5), to assess the refractive error and can vary based on the underlying principle (Xiong S, 2017).

2.9.2.2. Corneal Tomography:

Tomography provides additional parameters for evaluating the anterior and posterior corneal surfaces. Early posterior corneal structural changes, including stromal thinning and elevation changes, are observed prior to anterior surface changes in kc.4 this allows for reliable detection of early-stage kc even before a patient becomes symptomatic.

Fig (4): Pentacam Devices.

Fig (5): Autorefractometer Devices.

2.9.3. Other Techniques:

2.9.3.1. Ocular Response Analyzer (Reichert):

Evaluates corneal biomechanics by measuring corneal hysteresis, the difference in applanation pressure when the cornea bends inward in response to a jet of air and when it returns to its normal state (Martinez-Abad, 2017).

2.9.3.2. I Trace aberrometer:

I TRACE is a ray tracing aberrometer which combines both the wavefront aberrometer as well as Placido based corneal topography (Sinha A, 2019). Figure (6)

Fig (6): I Trace aberrometer.

2.10. Management and Treatment:

2.10.1. Mild keratoconus:

Spectacles can only be used in mild cases of keratoconus, and often result in poor visual acuity (Rabinowitz YS, 1998). Figure (7).

2.10.2. Moderate keratoconus:

Currently, it is estimated that 90% of patients affected by corneal irregularity utilize contact lenses (Zadnik K, 1998).

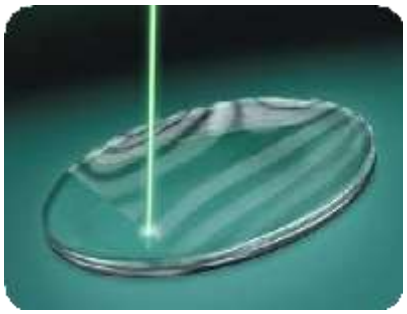

Fig (7): Eye Glasses Keratoconus.

2.10.2.1. Rigid Corneal Contact Lenses:

Rigid corneal touch lenses and piggyback systems. Three techniques had been historically used for becoming inflexible corneal touch lenses in keratoconus which includes apical clearance, apical touch, and three-point touch (Romero-Jim´enez, 2013; Romero-Jim´enez M, 2015).

2.10.2.2. Corneoscleral and Scleral Lenses:

Corneoscleral lenses are described as any inflexible touch lens with shared bearing among the peripheral cornea and conjunctiva overlying the sclera, irrespective of the overall lens diameter (De Luis, 2018). The principal benefits of this lens designs in comparison with inflexible corneal lenses are stepped forward consolation because of the decreased lens edge-eyelid interaction and enhanced stability and centration with larger optical zones for more consistent vision across a range of pupil diameters (Downie, 2015). Figure (8).

2.10.2.3. Soft Contact Lenses:

Soft lenses are to be had in excessive round and toric powers for the correction of myopia and astigmatism in early keratoconus, decentered cones, and for patients with rigid lens intolerance (Yilmaz, 2016; Sultan, 2016).

2.10.2.4. A Hybrid Contact Lens:

A hybrid contact lens consists of a rigid corneal lens and a peripheral soft skirt to combine the optical benefits of corneal rigid lenses and the comfort provided by soft contact lenses. Early generation hybrid lenses were often associated with decreased comfort, complications due to the use of low oxygen permeability materials, and reduced durability of the GP/soft material interface (Rubinstein MP, 1991; Leal F,2007; Pilskalns 2012).

Fig (8): Scleral contact lenses.

2.10.3. Severe keratoconus:

Severe instances of keratoconus can be controlled with scleral lenses, mainly while different lens modalities normally fail to achieve a physiologically acceptable fit (Ling JJ, 2021; Koppen C, 2018; Segal O, 2003; Rosenthal P, 2005).

2.10.3.1. Surgical Procedures:

2.10.3.1.1. Cross-linking Corneal (CXL):

Cross-linking increases the (Santodomingo-Rubido *et al.*, 2017), biomechanical stability and rigidity of the cornea in an attempt to prevent keratoconus progression. The method includes the elimination of imperative 6–7 mm of corneal epithelium accompanied via way of means of the following software of 0.1% riboflavin solution and corneal radiation of ultraviolet-A mild at 370 nm (Sorkin, 2014; O'Brart, 2017; Beckman, 2019). Figure (9).

Fig (9): Corneal Cross Linking.

2.10.3.1.2 Refractive Surgery:

Various refractive surgical operation interventions had been used for keratoconus management, with phakic lens implantation and photorefractive keratectomy (PRK), being the two most widely studied (Kim KH, 2020; Fern´andez-Vega-Cueto L, 2017)

1. Photorefractive keratectomy of the Corneal (PRK):

It makes use of an excimer laser to completely regulate the form of the anterior vital cornea via way of means of getting rid of a small segment of stromal tissue via way of means of vaporization. outcomes in keratoconic eyes were fairly successful, with a few research staring at a vast discount in cone evolution in incipient cases (Kasparova, 2002).

2. Toric intraocular lens implantation (IOL):

Phakic and pseudophakic intraocular lens implantation for the remedy of keratoconus is typically executed together with different corneal refractive surgical treatment methods, such as corneal rings or keratoplasty (Pe˜na-García, 2015).

2.10.3.1.3. Corneal Transplantation and Implantation:

Corneal transplantation is the conventional remedy for superior keratoconus has been suggested to be the cause for 18% of penetrating keratoplasty procedures, and 40% of deep anterior lamellar keratoplasty interventions (Gadhvi , 2019; Arnalich-Montiel, 2016). Figure (10).

Fig (10): Corneal Transplantation.

1. Keratoplasty:

Penetrating keratoplasty (PK), which includes the elimination of the whole thickness of the cornea and alternative with donor tissue (Brierly SC, 2000). Deep anterior lamellar keratoplasty (DALK) is every other surgical method used to update diseased recipient stroma with donor corneal stroma, whilst the recipient corneal endothelium and posterior restricting lamina are retained.

2. Anterior proscribing lamina transplantation:

Anterior limiting lamina transplantation is a novel technique that may stabilize progressive ectatic corneal changes in eyes with advanced keratoconus, which are too steep or too thin for CXL or ICRS (Brierly SC, 2002).

3. Implantation of stem cells (Intrastromal):

There is Two methods of intrastromal implantation, first implanting of stem cells with a biodegradable scaffold; second of stem cells with a non- biodegradable scaffold; and intrastromal implantation of stem cells with a decellularized corneal stromal scaffold (Arnalich- Montiel, 2016; Ali´o, 2020).

- **Ring Segments (Intracorneal):**

Intracorneal ring segments (ICRS) are small PMMA (polymethyl methacrylate) devices, which might be implanted into the cornea aiming to alter its geometry and enhance its refractive homes and patient's visible acuity. Colin delivered using ICRS implantation for the control of keratoconus in 2000 (Colin J,2000). Nevertheless, Reynolds become the primary to implant a 360° intracorneal ring for the control of myopia in 1978 (Burris,1998). Figure (11).

Fig (11): Intracorneal Ring.

2.11. Literature Reviews:

In Kenya a prospective, a cross-sectional study Aly Rashid Z, H *et al* about the Prevalence and demographic profile of keratoconus among high school students in Kenya, from 25th October 2021 to the 26th August 2022 through Using a stratified cluster random sampling

method. As students diagnosed with visual acuity measurement, auto-refraction, retinoscopy and corneal topography. (Rashid *et al*., 2021). Their result shows 57.3% where female, also had disease prevalence of KC and KCS to be 1.7% and 3.8% respectively, also with no significant relationship between prevalence of keratoconus and (gender and age) (Aly Rashid *et al.*, 2025).

In study by Kenyan authors Aly Rashid and colleagues were used an online questionnaire distributed among ophthalmic clinical officers and optometrists, from 13th September to 28th October 2021, used retinoscopes, slit lamps, corneal topographer as diagnosed methods in their study, as majority of respondents 90.2% in their study treated with spectacles in mild cases, 29% n moderate cases and only 1.9% in severe cases and 26.1% of patients with keratoconus referred for CXL (Aly Rashid *et al*., 2023).

A cross-sectional Sweden study by Binder J.T, Vibeke Z.H aimed to assess prevalence and incidence of keratoconus from 1st January, 2010, to 31st December, 2020, the prevalence of keratoconus in their study was 169.5 per 100,000, however 75% of them were male. Also, the prevalence was highest in the age group 21 to 30 years, 348.4 per 100,000 (Binder, 2023). However, a Danish study by Bak-Nielsen *et al*, had prevalence of keratoconus was estimated to be 3.6 per 100,000 annually. Additionally, most of keratoconus Patients were male (Bak- Nielsen *et al*., 2025).

III. METHODOLOGY

3.1. Study Design and Population:

- Its cross-sectional descriptive study was conducted aimed to explore the prevalence of keratoconus and assess the effectiveness and distribution of advanced optical techniques used in its treatment among patients attending the Benghazi Teaching Hospital for Ophthalmology and Delta Optics Center, from 1st of May to 26th of June.
- A total of (500) patients enrolled in this study from both genders; the process of patient's selection was randomly according to their presence at hospital or center. A structured questionnaire was administered to (500) individuals, out of which (413) valid responses were obtained and included in the final analysis and seven patients were excluded.

3.2. Data Collection Tool:

The process of data collection was through questionnaire self- made based on previous studies. The questionnaire collected: Demographic information (age and gender), clinical characteristics (corneal thickness, type of astigmatism), and details about keratoconus diagnoses through clinical examination or pentacam and methods of treatment used (eyeglasses, contact lenses, cross-linking, corneal transplant, or ring implantation).

3.3. Data Analysis:

Data analysis was performed by using the Statistical Package for the Social Sciences (SPSS). Descriptive data described as Frequencies and percentages. The Pearson Chi-square test was used to determine the relationships between the prevalence of keratoconus and other variables in the study. A significance level of 0.05 was used for all statistical tests.

3.4. Ethical Approval:

The study was approved from Medical Technology college - Optometry &Vision Science department, all the research procedures were carried out for patients after consent with ethical guidelines. Also was permitted form Benghazi Teaching Hospital for Ophthalmology, and Delta Optics Center.

IV. RESULTS

4.1. Descriptive Results:

In an attempt to reinforce what was discussed in the theoretical aspect of this project, a questionnaire was prepared and distributed to 500 people in both Benghazi Teaching Hospital for Ophthalmology, and Delta Optics Center.

413 questionnaires were received, all of which were valid. This data was analyzed using the statistical analysis program SPSS and a chi-square test was conducted to try to describe the relationships between the different variables.

Table (3), and Figure (11): Illustrates the respondents' distribution according to the keratoconus prevalence. It reveals that there were 246 prevalent patients, or 59.6% of the total, and 167 non-prevalent patients, or 40.4%.

Table (3): The distribution of respondent's base on the prevalence of KC:

Keratoconus	umber of respondents	%
Prevalent	246	59.6
Non- prevalent	167	40.4
Total	413	100

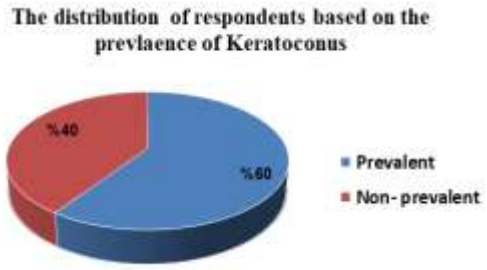

Fig (11): The distribution of respondents based on the prevalence of KC.

Table (4), and Figure (12): Shows the distribution of respondents based on the Gender. It shows that the number of Male patients had greater Keratoconus prevalence 232 (56.2%) than female 181(43.8%).

Table (4): The distribution of respondent's base on the Gender:

Gender	Number of respondents	%
Male	232	56.2
Female	181	43.8
Total	413	100

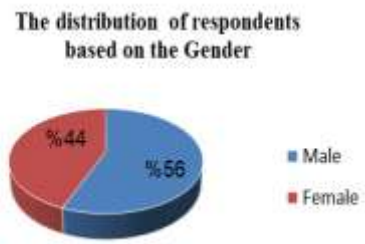

Fig (12): The distribution of respondents based on the Gender.

Table (5), and Figure (13): It is evident that the age group of [15–24] had the largest percentage of respondents (44.6%), followed by [25–34] (21.8%), [45–54] (18.2%), and [35–44] (15.5%) respectively.

Table (5): The distribution of respondents based on the Age Interval:

Age interval	Number of respondents	%
15-24	184	44.6
25-34	90	21.8
35-44	64	15.5
45-54	75	18.2
Total	413	100

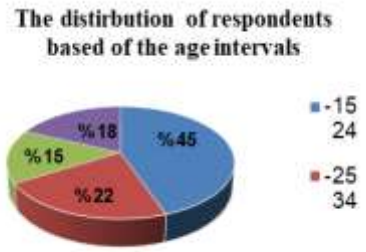

Fig (13): The distribution of respondents based of the age intervals.

Table (6), and Figure (14): Display the respondents' distribution by corneal thickness, with the largest percentage of respondents (71.9%) falling into the "More than 500" category and the lowest number (28.1%) falling into the "Less than 500" category.

Table (6): The distribution of respondents based on the Corneal Thickness:

Corneal Thickness	Number of respondents	%
More than 500	297	71.9
Less than 500	116	28.1
Total	413	100

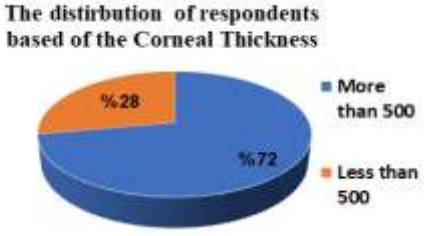

Fig (14): The distribution of respondents based on the Corneal Thickness.

Table (7), and Figure (15): It clear that, the percentage of 59.1% falls in category of irregular Astigmatism, while the percentage of 40.9% falls in category of regular Astigmatism.

Table (7): The distribution of respondents based on the Astigmatism:

Astigmatism	Number of respondents	%
Regular	169	40.9
Irregular	244	59.1
Total	413	100

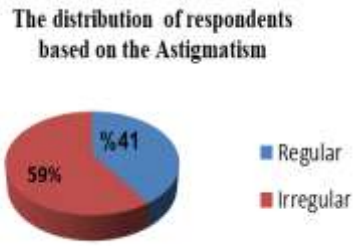

Fig (15): The distribution of respondents based on the Astigmatism.

Table (8), and Figure (16): Demonstrating the respondents' distribution by treatment, it is evident that the eyeglasses category accounted for 43.8% of the total, followed by the corneal cross-linking category with 21.8%, contact lenses with 16.5%, intra-corneal ring implantation with 9.2%, and corneal transplantation with 8.7%.

Table (8): The distribution of respondents based on the Treatment.

Treatment	Respondents	%
Eyeglasses	181	43.8
Contact Lenses	68	16.5
Corneal Cross Linking	90	21.8
Corneal Transplantation	36	8.7
ICR Implantation	38	9.2
Total	413	100

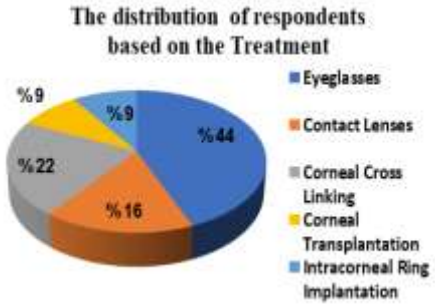

Fig (16): The distribution bas respondents based on the Treatment.

Table (9), and Figure (17): Represent the distribution of the respondents based on the prevalence of Keratoconus and their gender, it seems that, the number of Male prevalence is 131, and the number of Female prevalence is 115.

Table (9): The distribution of respondents based on the prevalence of Keratoconus and their gender:

Keratoconus	Gender		Total
	Male	Female	
Prevalence	131	115	246
Non-prevalence	101	66	167
Total	232	181	413

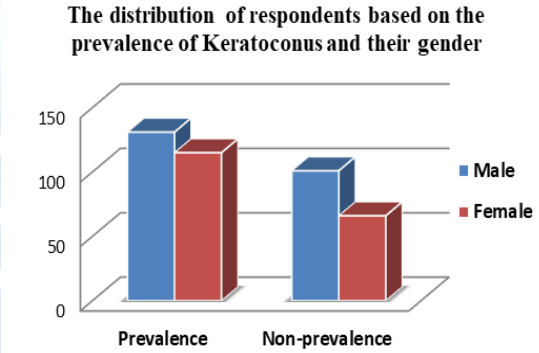

Fig (11): the distribution of respondents based on the prevalence of Keratoconus and their gender.

4.2. Statistical Result:

Table (10): It seems that; at (α=0.05) there is no statistically significant differences between the gender of the respondent and the prevalence of Keratoconus, whereas (Chi-square = 2.110), and P-value (0.146) > 0.05.

Table (10): Chi-square test Gender and prevalence of KC:

	Value	d.f.	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.110	1	0.146

Table (11), and Figure (18): Show that the number of Prevalence respondents of age interval [15-24] was 110, then 49 for age interval [25-34], followed by 42 for age interval [35-44], and lastly 45 for age interval [45-54]. While the number of non-prevalence keratoconus respondents of age interval [15-24] was 74, followed 41 for age interval [25-34], then 22 for age interval [35-44], and lastly 30 for age interval [45-54].

Table (11): The distribution of respondents based on the prevalence of KC, and their age interval:

Keratoconus	Age Interval				Total
	15-24	25-34	35-44	45-54	
Prevalence	110	49	42	45	246
Non-Prevalence	74	41	22	30	167
Total	184	90	64	75	413

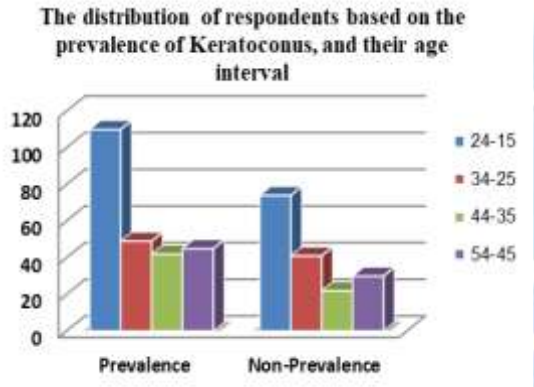

Fig (18): The distribution of respondents based on the prevalence of Keratoconus, and their age interval.

Table (12): It seems that; at (α=0.05) there is no statistically significant differences of the relationship between the age interval of the respondent and the prevalence of Keratoconus, whereas (Chi-square = 1.965), and P-value (0.580) > 0.05.

Table (12): Chi-square test:

	Value	d.f.	Asymp. Sig. (2-sided)
Pearson Chi-Squar	1.965	3	0.580

Table (13): The distribution of the Prevalence of Keratoconus, and the Corneal Thickness:

Corneal Thickness		Keratoconus	Total
> 500		< 500	
170	**Prevalence**	76	246
127	**Non-Prevalence**	40	167
297	**Total**	116	413

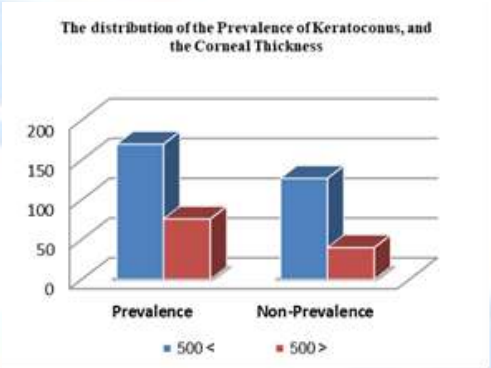

Fig (19): The distribution of the Prevalence of Keratoconus, and the Corneal Thickness.

Table (13), and Figure (19): Display the amount of prevalence of Keratoconus with > 500 Corneal Thickness is 170, and the amount of prevalence of Keratoconus with < 500 Corneal Thickness is 76. However, the number of non- prevalence of Keratoconus with > 500 Corneal Thickness is 127, and the number of non-prevalence of Keratoconus with < 500 Corneal Thickness is 40.

Table (14): It seems that; at (a=0.05) there is no statistically significant differences of the relationship between the Corneal Thickness of the respondent and the prevalence of Keratoconus, whereas (Chi-square = 2.373), and P-value (0.123) > 0.05.

Table (15), and Figure (20): Display the amount of prevalence of Keratoconus and Regular Astigmatism is 10, and the amount of prevalence of Keratoconus and Irregular Astigmatism is 236. However, the number of non-prevalence of Keratoconus regular Astigmatism is 159, and the number of non-prevalence of Keratoconus and Irregular Astigmatism is 8.

Table (14): Chi-square test:

	Value	d.f.	Asymp. Sig.
Pearson Chi-Square	2.373	1	0.123

Table (15): The distribution of the Prevalence of Keratoconus, and the Astigmatism:

Keratoconus	Astigmatism		Total
	Regular	Irregular	
Prevalence	10	236	246
Non-Prevalence	159	8	167
Total	169	244	413

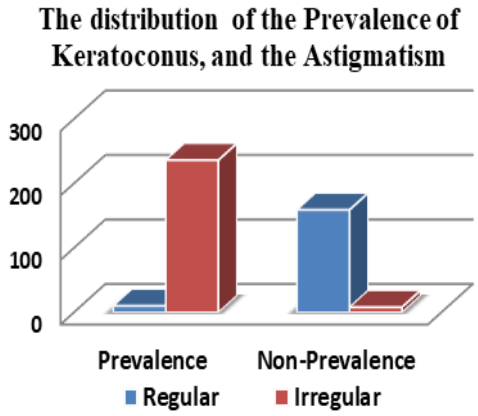

Fig (20): The distribution of the Prevalence of Keratoconus, and the Astigmatism.

Table (16): Chi-square test.

	Value	d.f.	Asymp. Sig. (2-sided)
Pearson Chi-Square	341.811	1	0.000

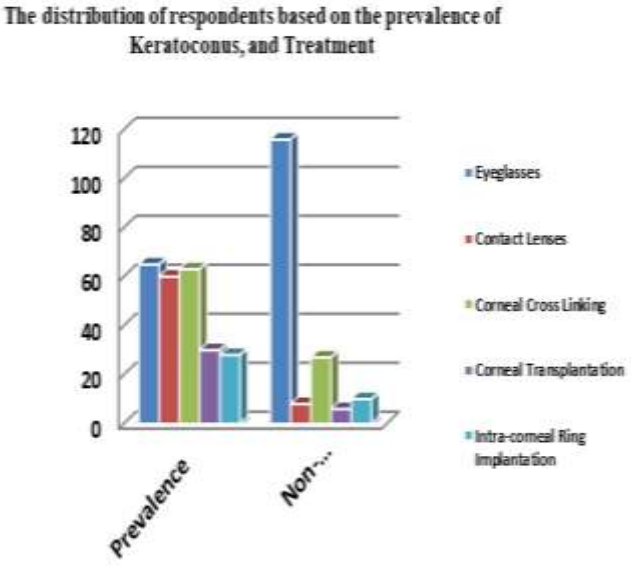

Fig (21): The distribution of respondents based on the prevalence of Keratoconus, and Treatment.

Table (15): It seems that; at (a=0.05) there are statistically significant differences of the relationship between the Astigmatism of the respondent and the prevalence of Keratoconus, whereas (Chi-square = 341.811), and P-value (0.000) < 0.05.

Table (16), and Figure (21): Display the amount of prevalence of keratoconus and eyeglasses treatment, which was 65, followed by the amount of prevalence of keratoconus and contact lenses treatment, which was 60; then the amount of prevalence of keratoconus and corneal cross-linking treatment 63; then the amount of prevalence of keratoconus and corneal transplantation 30; and lastly the amount of prevalence of intra- corneal ring implantation treatment was 28.

According to Table (17), the number of non-prevalence of keratoconus and eyeglasses treatment was 116, followed by the number of non-prevalence of keratoconus and contact lens treatment, which was 8, then the number of non-prevalence of keratoconus and corneal cross-linking treatment was 27; then number of non-prevalence of keratoconus and corneal transplantation was 6; and lastly, the number of non-prevalence of keratoconus and intra-corneal ring implantation treatment was 10.

Table (17): The distribution of respondents based on the prevalence of Keratoconus, and Treatment:

Keratoconus	Treatment					Total
	Eyeglasses	Contact Lenses	Corneal Cross Linking	Corneal Transplantation	Intra-corneal Ring Implantation	
Prevalence	65	60	63	30	28	246
Non-Prevalence	116	8	27	6	10	167
Total	181	68	90	36	38	413

Table (18): It seems that; at (α=0.05) there are statistically significant differences of the relationship between the Treatment of the respondent and the prevalence of Keratoconus, whereas (Chi-square = 80.910), and P-value (0.000) < 0.05.

Table (18): Chi-square test:

	Value	d.f.	Sig. (2- sided)
Pearson Chi-Square	80.910	4	0.000

V. DISSCUSSIONS

"Keratoconus has been found to affect all ethnicities, although the prevalence and incidence are higher among South Asians and Middle Easterners compared with those of European ancestry." (Kanski, 2015). The intent of this study was to investigate the probability of keratoconus among patients attend visit Delta Optics Center and Benghazi Teaching Hospital for Ophthalmology, as well as any potential correlations between the condition and clinical and demographic factors**.**
The result shows that keratoconus affected about 59.6% of patients, indicating a relatively significant disease burden in this area. Despite statistical analysis using the chi-square test showing no significant association between gender and keratoconus prevalence (p = 0.146), males had a slightly higher prevalence of keratoconus (53.3%)

than females. In contrast higher prevalence of KC in this study compared to study reported in kenya, Denmark**.**

Also, a Saudi Arabia study demonstrate that majority of middle east countries had higher prevalence KC (Kennedy, 2000; Assiri, 2005). Opposite to this a study by Aly Rashid *et al*.,2021) Kenyan study where female had higher prevalence of keratoconus over male, while some studies shown no difference between gender (Gomes,2022), in compatible with this study by Aly Rashid Z, H et al. where prevalence of KC was not significantly associated with gender (p = 0.80). (Aly Rashid,2023)**.**

However, estimated prevalence of KC to be 7.9% in Africa a meta-analysis of a finite number of studies by Akowuah (Akowuah *et al.*, 2021), as consider lower when compared to this study.

Also, a lower prevalence of KC ranges from 1.4 to 4.8% In Turkey, India and the Middle East (Salman A,2022; Özalp O,2021; Jonas,2009; Torres Netto,2018)**.** Concerning the age of participants as found, the 15–24 age group had the highest prevalence (44.7%), which is consistent with research demonstrating keratoconus often begins in adolescence or early adulthood. Even if younger people are more impacted, age by itself may not be a predictive element in this group also, relationship between 34 Statistically, age groups and the prevalence of keratoconus were not significant (p = 0.580). This suggests that other variables like heredity, environmental exposures, or eye habits may be more important predicting elements for keratoconus than age alone.

Similarly, a study by Kenyan authors Aly Rashid and colleagues found non-significant association between frequency of keratoconus and age (Aly Rashid *et al*., 2025). By contrast in a cross-sectional study in Sweden, where prevalence was higher in the age group of 21 to 30 years (Binder, 2020), implying that regional

variance may be explained by variations in population characteristics, environmental conditions, and genetic predisposition. Age and gender alone cannot be regarded a deciding factor. The variances seen between several studies draw attention to the impact of genetic and environmental variation between populations.

In this study about 71.9% of the participants had a thickness greater than 500 microns, also, however still the correlation between corneal thickness and keratoconus prevalence found not significant ($p = 0.123$). This might indicate that although corneal thinning is a characteristic of keratoconus, it is not the only factor that determines early diagnosis or detection in this disease.

A statistically significant association was remarkably noted between keratoconus and astigmatism ($p < 0.001$). In 95.9% of patients with keratoconus had irregular astigmatism, which is consistent with the disease's known clinical profile. This result demonstrated how crucial comprehensive screening for astigmatism is in detecting possible cases of keratoconus as discussed before in theoretical part.

Eventually, as marked in the results a significant relationship was found between the type of treatment used and keratoconus prevalence ($p < 0.001$). Contact lenses, corneal cross-linking, and surgical procedures like corneal transplantation and intracorneal ring implantation were more common among keratoconus patients, even though eyeglasses were still the most popular treatment for all groups.

Also, in Sweden Kenyan study had found majority of the respondents prescribed spectacles in mild cases of keratoconus fewer patients where on for contact lenses and CXL and surgery treatment (Aly Rashid ,2025; Aly Rashid, 2023; Binder J.T,2020). Overall, the relatively higher prevalence incident reflects “the prevalence of KC appears 35 to be higher in countries with hot and dry climates compared to cooler climates” (Santodomingo-Rubido, 2022).

This distribution reflects both the severity and progression of the disease in those affected. This finding only represents patients in Benghazi and is not entirely conclusive because it only applies to one hospital and clinic and does not represent the entire Libyan population.

CONCLUSION

Keratoconus is relatively common among patients visiting ophthalmology centers in Benghazi, particularly among young people. While gender, age, and corneal thickness were not significantly associated with the disease, irregular astigmatism had a strong and statistically significant relationship. Furthermore, the treatment options for keratoconus and non-keratoconus patients differed significantly, with the former receiving more advanced interventions.

This result represents the population in Benghazi not the entire country of Libya. Additionally, furthermore studies required in despite sample size, because the majority of participants come from a single hospital and clinic, cause sampling locations are not diverse. As noted, this study emphasizes the need for early screening for astigmatism in young people to help with early diagnosis and treatment. The study also supports the idea that treatment should be different for each patient based on disease degree and condition.

RECOMMENDATIONS

1. Encourage younger adults for early screenings regarding keratoconus specially for patients with irregular astigmatism, for early diagnosis and treatment, and emphasize them for continuous follow-up as irregular astigmatism consider related to keratoconus.
2. Increase population awareness through learning courses and programs regarding keratoconus signs and symptoms, risk factor so as to promote early diagnosis and treatment.
3. Improve the education of the eye care providers through training learning sessions about modern optical techniques and how to keep up with modernity about keratoconus.
4. Emphasize the important of conduct continuous studies related to keratoconus in Libya, address the updated concerning the risk factors, causes of disease.
5. Offer in public health care institutions updated diagnostic instruments and treatment options.

ACKNOWLEDGMENT

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