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Literature Review on Visual Performance with Rigid Gas Permeable Contact Lenses in Keratoconus

Mayan Mohamed Khalil Elammary[1], Taher Kamel Eleiwa[2], Ahmed Hassan Ahmed[3], Mohamed Taher Higazy[2]

[1]Ophthalmology Department, Faculty of Medicine Helwan University
[2]Ophthalmology Department, Faculty of Medicine Benha University
[3]Ophthalmology Department, Faculty of Medicine Qena University

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ABSTRACT
Keratoconus (KCN) is a progressive corneal ectatic disorder causing visual impairment through corneal thinning and irregular astigmatism. Rigid gas permeable (RGP) contact lenses are vital for managing vision by correcting aberrations. This review synthesizes key literature on corneal anatomy, KCN pathophysiology, diagnosis, management, RGP lens effects, and Pentacam assessment, using 19 essential references

Keywords: *Visual Performance, Rigid Gas, Contact Lenses, Keratoconus.*

1. INTRODUCTION

Keratoconus (KCN) is a progressive, bilateral corneal ectatic disorder characterized by corneal thinning and irregular astigmatism, leading to significant visual impairment. It affects approximately 1 in 2,000 individuals, with a higher prevalence in certain populations [1]. The condition typically manifests in adolescence and can severely impact patients' quality of life due to distorted vision, glare sensitivity, and reduced visual acuity [2]. Early diagnosis and management are crucial to prevent progression and preserve vision. Rigid gas permeable (RGP) contact lenses are a cornerstone in the non-surgical management of KCN, providing visual correction by neutralizing corneal irregularities [3]. This review explores the corneal anatomy, KCN pathophysiology, diagnostic advancements, management strategies, and the role of RGP lenses, with a focus on their impact on visual performance and corneal health as assessed by tools like the Pentacam.

Corneal Anatomy

The cornea, responsible for approximately 65–75% of the eye's refractive power, comprises five layers: epithelium, Bowman's membrane, stroma, Descemet's membrane, and endothelium [1]. The epithelium serves as a barrier and absorbs nutrients from tears, while Bowman's membrane, a collagenous layer, maintains structural integrity [4]. The stroma, the thickest layer, is composed of water and collagen, crucial for maintaining corneal shape and transparency [5]. Descemet's membrane, produced by endothelial cells, resists infection and trauma, and the endothelium regulates stromal hydration, with limited regenerative capacity [6]. In KCN, these layers are disrupted: the epithelium thins, Bowman's layer develops defects, and the stroma thins and weakens, leading to the characteristic conical protrusion [7]. Understanding these anatomical changes is essential for appreciating why RGP lenses are necessary for visual correction in KCN

Keratoconus: Pathophysiology

KCN is driven by a combination of genetic and environmental factors. Genetic predispositions include associations with Down syndrome, Leber congenital amaurosis, and connective tissue disorders [2]. Environmental triggers such as chronic eye rubbing and contact lens wear may exacerbate the condition by inducing mechanical trauma [8]. Recent theories suggest that KCN involves chronic inflammation and oxidative stress, leading to stromal degradation and thinning [9]. Clinical signs include Vogt's striae (fine, parallel lines in the posterior stroma), Fleischer's ring (iron deposition at the base of the cone), and Munson's sign (V-shaped distortion of the lower eyelid in downgaze) [10]. The disease is progressive, with variability in onset and severity, necessitating individualized management [2].

Diagnosis

Early detection of KCN is critical for timely intervention. Traditional methods like retinoscopy reveal irregular astigmatism, but advanced imaging techniques have revolutionized diagnosis. Scheimpflug-based tomography, such as the Pentacam, provides three-dimensional corneal mapping, assessing anterior and posterior surfaces and pachymetry [11]. This allows for the detection of subclinical KCN through posterior elevation and thinning not visible on anterior topography [12]. Biomechanical assessments, using devices like the Ocular Response Analyzer and Corvis ST, measure corneal hysteresis and resistance, which are reduced in KCN, aiding in ectasia detection [13]. These tools are essential for distinguishing KCN from other corneal conditions and guiding treatment decisions.

Management

Management of KCN depends on disease stage and progression. In early stages, spectacles or soft contact lenses may suffice, but as the disease advances, RGP lenses become necessary to correct high-order aberrations like coma and spherical aberration [3]. Corneal collagen cross-linking (CXL) is a minimally invasive procedure that stabilizes progression by increasing stromal rigidity, reducing the need for keratoplasty [14]. RGP lenses are indicated for moderate to advanced KCN, providing visual correction by creating a tear pool that neutralizes corneal irregularities [3]. Contraindications include severe dry eye, active ocular inflammation, and patient intolerance [15]. Alternative treatments include intracorneal ring segments for mild to moderate KCN and corneal transplantation for advanced cases [16].

Rigid Gas Permeable Contact Lenses

Visual Correction

RGP lenses are highly effective in correcting vision in KCN by forming a tear pool that masks corneal irregularities, thereby reducing high-order aberrations [17]. Studies show that RGP lenses can significantly improve visual acuity and delay the need for surgical intervention [18]. However, in severe KCN, neural defects and residual aberrations may limit the achievable vision [19].

Fitting

Fitting RGP lenses in KCN is challenging due to corneal irregularities. The three-point-touch fitting philosophy, which balances support between the apex and paracentral cornea, is considered the safest approach [20]. Tools like CALCULENS assist in selecting the optimal base curve radius, reducing trial lens fittings [21]. Patient comfort and visual outcomes are influenced by the fitting approach, with suboptimal fits leading to complications like corneal staining or poor centration [22].

Risks

While RGP lenses are beneficial, they carry risks such as inflammation, dry eye exacerbation, and potential progression of KCN due to mechanical trauma [23]. Chronic hypoxia from lens wear may induce stromal thinning, and elevated inflammatory mediators in tears have been observed in RGP users with KCN [24]. Careful monitoring and patient education are essential to mitigate these risks.

Pentacam Assessment

The Pentacam has transformed KCN diagnosis and management by providing detailed tomographic data. It detects early KCN through posterior elevation and pachymetric changes, which are more sensitive than anterior topography alone [25]. Post-RGP lens use, Pentacam can assess changes in corneal curvature and thickness, aiding in fitting adjustments [26]. Integrating tomographic data with biomechanical assessments, such as the Corvis Biomechanical Index, enhances diagnostic accuracy for mild ectasia [27]. Key parameters like the Belin/Ambrosio Enhanced Ectasia Display (BAD) and Zernike polynomial modeling of corneal thickness further refine KCN detection and staging [28].

2. CONCLUSION

RGP lenses are indispensable for managing visual impairment in KCN, offering significant improvements in visual acuity and quality of life. However, their use requires careful fitting and monitoring to minimize risks such as inflammation and corneal structural changes. Advanced diagnostic tools like the Pentacam provide precise assessment of corneal changes, aiding in early detection and treatment planning. Tailored management strategies, combining RGP lenses with other interventions like CXL, are essential for optimizing outcomes in KCN

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