

# **Intraoperative Corneal Thickness During Corneal Cross Linking in Keratoconus**

Thesis submitted in partial fulfillment for M.Sc degree in  
Ophthalmology

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## Abstract

**OBJECTIVE:** To monitor the changes in corneal thickness during accelerated pulsed corneal collagen cross-linking procedure by using dextran free riboflavin solution with HPMC in keratoconus patients.

**MATERIALS AND METHODS:**

The central corneal thickness measurements were obtained by pachymetry before epithelial removal, after epithelial removal, following the instillation of dextran free riboflavin solution with HPMC for 10 min, and after 8 min of pulsed ultraviolet A irradiation ( $30 \text{ mW/cm}^2$  surface irradiance for total treatment of  $7.2 \text{ J/cm}^2$ ).

**RESULTS:**

Twenty eyes of eleven patients with progressive keratoconus ( $n = 20$ ) were included in this study. The mean central pachymetric measurements were  $506.8 \pm 35 \mu\text{m}$  before epithelial removal, declined to a mean of  $474.9 \pm 40 \mu\text{m}$  after de-epithelialization of the cornea, declined further to a mean of  $445.7 \pm 31 \mu\text{m}$  following 10 min instillation of dextran free riboflavin solution with HPMC and  $444.65 \pm 35 \mu\text{m}$  following 8 min of pulsed ultraviolet A irradiation to the cornea.

**CONCLUSION:**

Performing accelerated pulsed corneal cross-linking procedure with dextran free riboflavin solution with HPMC induce corneal thinning of 12.3% which is less than cornea thinning induce by riboflavin with dextran and conventional CCXL .

**Keyword:** HPMC-CACXL-pl-ACXL-MMP

## List of Abbreviations

|                |                                                                        |
|----------------|------------------------------------------------------------------------|
| <b>A-CXL</b>   | <b>Accelerated corneal crosslinking</b>                                |
| <b>BFS</b>     | <b>Best fit sphere</b>                                                 |
| <b>CACXL</b>   | <b>Contact Lens-Assisted Collagen Cross-Linking</b>                    |
| <b>CCT</b>     | <b>Central corneal thickness</b>                                       |
| <b>CCXL</b>    | <b>Corneal cross linking</b>                                           |
| <b>DLK</b>     | <b>Diffuse lamellar keratitis</b>                                      |
| <b>FTIR</b>    | <b>The potential of Fourier Transform Infrared (FTIR) spectroscopy</b> |
| <b>HPMC</b>    | <b>Hydroxypropyl Methycellulose</b>                                    |
| <b>IVCM</b>    | <b>In vivo confocal microscopy</b>                                     |
| <b>KC</b>      | <b>Keratoconus</b>                                                     |
| <b>kDa</b>     | <b>Kilo Dalton</b>                                                     |
| <b>KISA%</b>   | <b>Keratometry, I-S, Skew percentage, Astigmatism</b>                  |
| <b>LASIK</b>   | <b>Laser assisted in situ keratomileusis</b>                           |
| <b>MMP</b>     | <b>Matrix metalloprotenase</b>                                         |
| <b>OCT</b>     | <b>The spectral-domain optical coherence tomography</b>                |
| <b>PK</b>      | <b>Penetrating keratoplasty</b>                                        |
| <b>pl-ACXL</b> | <b>Pulsed accelerated cross linking</b>                                |
| <b>PMD</b>     | <b>Pellucid marginal corneal degeneration</b>                          |
| <b>PRK</b>     | <b>Photorefractive keratectomy</b>                                     |
| <b>ROS</b>     | <b>Reactive oxygen species</b>                                         |
| <b>TCT</b>     | <b>Thinnest corneal thickness</b>                                      |
| <b>UVA</b>     | <b>Ultraviolet A</b>                                                   |

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# **Introduction and Aim of Work**

## Introduction

Keratoconus is a progressive, noninflammatory dystrophy of the cornea of unknown pathogenesis,<sup>(1)</sup> characterized by a number of histopathologic abnormalities, which lead to a progressive mechanical strength reduction of the cornea over time.<sup>(2-4)</sup>

Corneal collagen cross-linking (CCXL) is a low-invasive treatment aimed to improve biomechanical stability in eyes with keratectasia <sup>(5-7)</sup> A photodynamic reaction induced by photosensitizing riboflavin and ultraviolet A (UVA) light causes an increase of the number of intra- and interfibrillar covalent bonds and the corneal collagen resistance against enzymatic degradation <sup>(8-10)</sup> Increased stromal biomechanical strength and lamellar compaction lead to stabilized corneal shape and better corneal symmetry, potentially causing an improvement in visual function <sup>(11-13)</sup>

In CXL, riboflavin has a dual function acting both as a photosensitizer inducing the physical collagen cross-linking and as an absorber of the UVA irradiation, preventing damage to deeper ocular structures <sup>(14-15)</sup>

Wollensak proposed a corneal preoperative thickness of 400 micron as a minimum safety limit to avoid endothelium, lens, and retinal damage. He also reported corneal keratocytes apoptosis after CXL of up to 300 micron depth in rabbit corneas <sup>(14)</sup>. This cell apoptosis follows the Lambert–Beer law, according to which smaller irradiances can lead to shallower cell death.<sup>(14)</sup>

Many studies suggested that corneal thickness decreases during the procedure of corneal cross linking, it has been reported by some studies that it reached 300 microns or less, <sup>(319, 328-330, 335-339)</sup> which compromises the corneal endothelium and may lead to endothelial de compensation <sup>(294, 298)</sup>.

## **Aim of Work**

The aim of work is to study the effect of Accelerated Pulsed Corneal Cross Linking using dextran free Riboflavin with HPMC on the intraoperative corneal thickness.

# Review of Literature

# Corneal Ectasias

## 1- Keratoconus

Keratoconus is a bilateral, noninflammatory corneal ectasia with an incidence of approximately one per 2,000 in the general population, although less obvious cases such as early forme fruste presentations are thought to be much more common. Keratoconus is characterized by a progressive increase in corneal curvature, with apical thinning and irregular corneal astigmatism. Eventually, an obvious cone-shaped protrusion of the corneal surface may develop.

Keratoconus often becomes apparent during the teenage years and classically progresses until the third and fourth decades of life, when many affected individuals experience an arrest of disease progression or at least a reduction in the rate of progression<sup>(16)</sup>



**Fig. 1: keratoconus**<sup>(17)</sup>

## **2-Pellucid marginal corneal degeneration**

**(PMD)** is less common than keratoconus. It usually affects the inferior peripheral, rather than paracentral, cornea in about 85% of cases and the superior peripheral cornea in 15%. It occurs in a crescentic fashion typically between the 5 and 7 o'clock positions<sup>(18,19)</sup> It is more common in males, with a male to female ratio of approximately 3:1.<sup>(19)</sup> Its age of onset is usually later than keratoconus, presenting between the 2nd and 5th decades. It is typically bilateral and affects all ethnicities.<sup>(18,19)</sup> The incidence and aetiology of PMD remain unknown. It often presents with progressive with severe against the rule astigmatism typically with good spectacle corrected acuity until the advanced stages of the disease. Hydrops and even spontaneous perforation can occur.<sup>(18,19)</sup> Topography typically shows a “lobster-claw pattern” but this is not pathognomonic and may also occur in keratoconus and there is overlap between the two conditions, as well as with keratoglobus.<sup>(19,20)</sup>