Evaluation of Simultaneous Topography-guided PRK and Corneal Collagen Cross-linking for Treatment of Early Keratoconus

Thesis
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By
Mohamed Mostafa Mohamed Ammar
M.B., B.Ch., M.Sc.
Faculty of Medicine, Cairo University

Under Supervision of

Prof .Dr. Yehia Mahmoud Salah Eldin
Professor of Ophthalmology
Faculty of Medicine, Cairo University

Prof .Dr. Sherif Ali Gamal Eldin
Professor of Ophthalmology
Faculty of Medicine, Cairo University

Dr. Ahmed Mohamed Sherif
Lecturer of Ophthalmology
Faculty of Medicine, Cairo University

Faculty of Medicine
Cairo University
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ABSTRACT

Keratoconus is a bilateral, non-symmetric, non-inflammatory progressive corneal degeneration that frequently manifests in post-pubescent young adults. The progression of the disorder can be impeded by riboflavin-ultraviolet A (UVA) corneal collagen cross-linking (CXL). The irregular astigmatism in keratoconus can be confronted with the use of customized laser ablations that restore the refractive properties of the anterior corneal surface. Topography-guided custom ablation and CXL combines the benefits of both treatments with the potential for creating a safe and stable optical improvement of the irregular ectatic cornea.

Patients and methods: In this study, 20 eyes of 14 early keratoconus patients underwent simultaneous topography-guided PRK and corneal collagen cross-linking. UCVA, BCVA, refraction, corneal topography and pachymetry were measured preoperatively and postoperative follow up visits.

Results: Improvement in UCVA at 1st month postoperative compared to preoperatively. Also Improvement in BCVA at 6th month postoperative. Reduction in cylindrical error at 1st month postoperative compared to preoperatively. Reduction in K Max and K Min readings at 3rd month postoperative.

Conclusion: The simultaneous topography guided PRK and CXL is a safe and effective technique in treating early stages of keratoconus.

Key Words:

Keratoconus, Cornea, CXL, Topography-Guided, Pachymetry.

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ABBREVIATIONS

AB	Asymmetric Bowtie
A-CXL	Accelerated Cross-Linking
BCVA	Best corrected visual acuity
CCT	Central corneal thickness
CH	Corneal hysteresis
CLSM	Confocal laser-scanning microscopy
Cm	Centimeter
CXL	Collagen Cross-Linking
D	Diopter
DCI	Dynamic Corneal Imaging
DLK	Deep Lamellar Keratoplasty
d.RCT	Dynamic Rasterstereographic Corneal Topography
E	Elastic modulus
EDTA	Ethylenediamine tetra-acetic acid
ETS	Eye Tracking System
FAD	Flavin adenine dinucleotide
FFKC	Forme Fruste Keratoconus
FMN	Flavin mononucleotide
g	Gram
Hz	Hertz
IOL	Intraocular lens
IOP	Intraocular pressure
IS	Inferior Steep
J	Joule
K	Keratometric
KC	Keratoconus
Km	Mean keratometric reading
K Max	Maximum Keratometric reading

K Min	Minimum Keratometric reading
LASIK	Laser Assisted In situ Keratomeleusis
LED	Light emitting diode
LogMAR	Logarithm of the Minimum Angle of Resolution
Min	Minute
Ml	Milliliter
Mm	Millimeter
µm	Micrometer
mmHg	Millimeter mercury
mol	Mole
mW	Mill Watt
nm	Nanometer
OCT	Optical Coherence Tomography
OPD	Optical path difference
ORA	Ocular Response Analyzer
PKP	Penetrating keratoplasty
PMD	Pellucid Marginal Degeneration
PRK	Photorefractive keratectomy
PTK	Phototherapeutic keratectomy
Q- value	Asphericity
SB	Symmetric bowtie
SD	Stardard deviation
SRAX	Steepest Radial Axis Index
SPSS	Statistical Package for Social Sciences
SS	Superior Steep
TEC	Torsion Error Correction
TCT	Thinnest corneal thickness
UCVA	Uncorrected visual acuity
UVA	Ultraviolet A
v	Poisson’s ratio

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INTRODUCTION

Keratoconus is a bilateral, non-symmetric, non-inflammatory progressive corneal degeneration that frequently manifests in post-pubescent young adults as progressive steepening attributed to biomechanical stromal collagen weakening ***(Kanellopoulos, 2009).***

The increased number among eyes undergoing screening for laser refractive surgery suggests the prevalence may be higher than previously thought ***(Kanellopoulos et al., 2006*** and ***Ertan and Colin, 2007)***. Current surgical/nonsurgical interventions such as spectacles, contact lenses, intracorneal ring segment implantation, penetrating keratoplasty, and deep lamellar keratoplasty; although popular, have limitations ***(Kanellopoulos, 2009)***.

It has been shown that the progression of the disorder can be impeded by riboflavin-ultraviolet A (UVA) corneal collagen cross-linking (CXL) ***(Wollensak et al., 2003)***. The application of CXL is capable of stabilizing the cornea in keratoconus and in postoperative refractive ectasia for up to 5 years after the procedure ***(Raiskup-Wolf et al., 2008)***.

The irregular astigmatism in keratoconus can be confronted with the use of customized laser ablations that restore the refractive properties of the anterior corneal surface. The application of customized topography-guided surface ablation has been reported in patients with stable or subclinical keratoconus with promising visual outcomes ***(Cennamo et al., 2008*** and ***Alpins and Stamatelatos, 2007).***

The disadvantage of ablative procedures is that tissue removal might lead to further destabilization of corneal biomechanics and progression of the ectatic disorder. Until recently, the combination of CXL with laser ablation has been reported only as a two-step procedure of CXL with consequent photorefractive keratectomy (PRK) ***(Kanellopoulos and Binder, 2007)***.

Topography-guided custom ablation and CXL combines the benefits of both treatments with the potential for creating a safe and stable optical improvement of the irregular ectatic cornea in a less invasive fashion than the currently available treatment options ***(Stojanovic et al., 2010)***.

AIM OF THE WORK

To evaluate topography-guided PRK accompanied with corneal collagen cross-linking in the same setting for treatment of early keratoconus.

- Major objectives of the study

- To evaluate the technique as a method to improve vision in this group of patients.

- To evaluate the effect of this treatment modality on the progression of keratoconus.

Keratoconus

Introduction:

Keratoconus (KC), which was first described in detail in 1854, derives from the Greek words Kerato (cornea) and Konos (cone). Keratoconus is the most common primary ectasia in the cornea. It is a bilateral and asymmetric corneal degeneration characterized by localized corneal thinning which leads to protrusion of the thinned cornea ***(Zadnik et al., 1996).***

Corneal protrusion causes high myopia and irregular astigmatism, affecting visual quality. It usually becomes apparent during the second decade of the life, normally during puberty, although the disease has also been found to develop earlier and latter in life, and it typically progresses until the fourth decade of life, when it usually stabilizes. In a study by ***Chopra and Jain, (2005),*** has determined that 50% of non-affected eyes of subjects with unilateral keratoconus will develop the disease in 16 years.

Epidemiology:

The incidence and prevalence in the general population has been estimated to be about 5.4 per 10,000 ***(Rabinowitz et al., 2004)***. Differences on the rates reported are attributed to different definitions and diagnostic criteria employed between studies. However, it would not be surprising to expect an increase in the incidence and prevalence rates of this disease over the next few years with the current wide spread use of corneal topography leading to improved diagnosis. Keratoconus affects both genders, although it is unclear whether significant differences between males and females exist. Some studies have not found differences in the prevalence between

genders ***(Rabinowitz et al., 2004)***; others have found a greater prevalence in females ***(Owens and Gamble, 2003)***; while other investigators have found a greater prevalence in males ***(Pearson et al., 2000)***.

Keratoconus is also known to affect all ethnicities; in a study undertaken in the United Kingdom, the incidence found was 7.5 times higher in Asians compared to Caucasians. It was hypothesized to be attributed to consanguineous relations, especially first-cousin marriages, which commonly take place in the Asian population of the area assessed ***(Georgiou et al., 2004)***.

Clinical features:

The ocular symptoms and signs of keratoconus vary depending on disease severity. At incipient stages, also referred to as subclinical or frustre forms, keratoconus does not normally produce any symptoms and thus can go unnoticed by the patient and practitioner unless specific tests like corneal topography are undertaken for diagnosis ***(Arntz et al., 2003)***.

Disease progression is manifested by a significant loss of visual acuity which cannot be compensated for with spectacles. Therefore, eye care practitioners should be suspicious about the presence of keratoconus when a visual acuity of 6/6 or better is difficult to achieve with increasing against-the-rule astigmatism. Near visual acuity is generally found to be better than expected from the refraction, distance visual acuity and age of the patient. The appearance of “scissor” shadows while performing retinoscopy suggests the development of irregular astigmatism. Keratometry readings are commonly within the normal range, but may appear irregular. Corneal thinning, where the thinnest part of the cornea is

normally located outside the visual axis, is also a common sign preceding ectasia (***Rabinowitz, 1998)***.

In moderate and advance cases of keratoconus, a hemosiderin arc or circle line, commonly known as Fleischer's ring, is frequently seen around the cone base .This line has been suggested to be an accumulation of iron deposits from the tear film onto the cornea as a result of severe corneal curvature changes induced by the disease and/or due to modification of the normal epithelial slide process ***(Barraquer-Somers et al., 1983)***.

Another characteristic sign is the presence of Vogt's striae , which are fine vertical lines produced by compression of Descemet's membrane, which tend to disappear when physical pressure is exerted on the cornea digitally or by gas permeable contact lens wear ***(Davis et al., 1993)*** **(Figure 1)**.

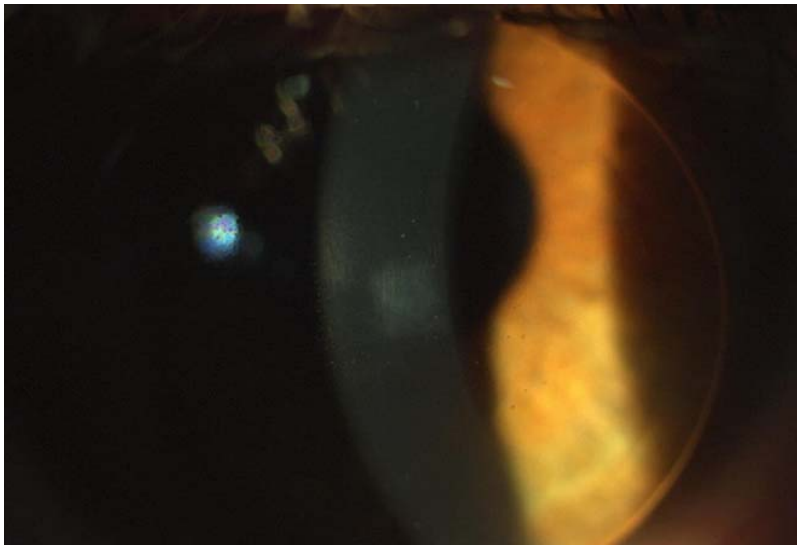

Fig. 1: Vogt's Striae sign. Vertical lines in Descemet's membrane are noted **(Romero-Jimeneza et al., 2010).**