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Case Report

In Vivo Early Visual Outcomes and Corneal Biomechanical Properties after Combined Transepithelial Phototherapeutic Keratectomy (t-PTK), with Topography Guided Photorefractive Keratectomy (t-PRK) and Accelerated Corneal Crosslinking (ACXL) for Keratoconus: A Case Report

Vaishal P Kenia[1], Raj V Kenia[2], Onkar H Pirdankar[3]

[1]Medical Director, Kenia Eye Hospital, Mumbai, India
[2]Research Assistant, Kenia Foundation, Mumbai, India.
[3]Clinical Researcher and Faculty, Kenia Medical and Research Foundation, Mumbai, India.

Corresponding Author: Onkar H Pirdankar

ABSTRACT

Purpose is to report a case of in vivo early visual outcomes and corneal biomechanical properties after combined transepithelial phototherapeutic keratectomy (t-PTK), topography guided photorefractive keratectomy (t-PRK) and accelerated corneal crosslinking (ACXL) for keratoconus.
Case Details and results: A 23 year old male with unilateral keratoconus underwent combined topography guided photorefractive keratectomy (t-PRK) using the CATz module of Nidek EC 5000 CX III excimer laser (NIDEK Co Ltd, Gamagori, Japan) and accelerated corneal crosslinking (ACXL) using CCL 365 vario (MLase AG, Germany). Post surgery, we noted reduction in manifest refraction astigmatism, spherical equivalent, steep keratometry, Kmax. Improvement in corneal stiffness was noted. There was reduction in deformation amplitude, highest concavity peak, highest concavity radius, DA ratio suggesting improved biomechanics.
Conclusion: Combined t-PRK+ t-PTK+ CXL in keratoconus not only improve the visual outcomes but also stabilize the cone biomechanics as shown by the increase in the corneal stiffness parameter and regularize the corneal shape.

Key words: transepithelial phototherapeutic keratectomy (t-PTK), topography guided photorefractive keratectomy (t-PRK), accelerated corneal crosslinking (ACXL), visual outcomes, corneal biomechanical properties, keratoconus.

INTRODUCTION

Keratoconus treatment is aimed at halting the progression of keratoconus and improving visual functions. Treatment with spectacle and contact lens do not halt the progression of keratoconus and in advance cases, patient eventually has to undergo corneal transplantation to restore his vision. Corneal cross-linking (CXL) is common procedure used worldwide to halt the progression of keratoconus by increasing corneal biomechanical strength. [1] CXL alone causes less flattening effect in cases with peripheral cones as compared to central cones. [2] Procedures like t-PRK helps in regularization of cornea by corneal topo-guided laser. However this laser ablation of tissue could weaken the cornea or increase the risk of ectasia. When these procedures (T-PTK, t-PRK) simultaneously combined with a strengthening procedure like CXL, has a beneficial effect of both regularization and strengthening of the cornea. Efficacy of CXL in combination with t-PRK and/or T-PTK have been found to be effective in halting the keratoectasia progression and reducing spherocylindrical refraction, keratometry and corneal higher order aberration (CHOA). [3-6] Nevertheless to best of our knowledge, none of the reports have described corneal biomechanics after combined T-PTK+t-PRK+ACXL in vivo. Here we describe a case of early in vivo visual outcomes and corneal topographical and biomechanical changes in keratoconus patients post combined T-PTK+t-PRK+ACXL that is at 3 and 6 months post operatively.

CASE DETAILS

A 23 years old male visited with complain of decrease in vision in OS since few months. There was no history of systemic illness, ocular surgery, and allergy. On examination, his aided visual acuity was 6/6, N6 in OD and 6/9, N6 in OS. The refraction was -3.00/-0.50*10 and -1.75/-4.50*120 in OD and OS respectively. Intraocular pressure using Goldmann applanation tonometer was 14 and 12 mm of Hg in OD and OS respectively. Slit examination revealed normal anterior and posterior segment in OD whereas in OS Fleischer rings were noted. Patient was further advised with corneal topography and biomechanics assessment which revealed the keratoconus (AmslerKrumeich grade 1) in OS. Table 1 describes the corneal refractive and topographic parameters in both eyes. Patient was advised combined trans-epithelial photo therapeutic keratectomy (T-PTK), topography guided PRK (t-PRK) with accelerated CXL (ACXL). Patient underwent T-PTK with 50 µm ablation, (t-PRK) with optical zone (5.00 mm) and transition zone (7.00 mm) using the CATz module of Nidek EC 5000 CX III excimer laser (NIDEK Co Ltd, Gamagori, Japan) and immediate ACXL (30 minutes soaking time, isotonic 0.1% riboflavin with HPMC, 9 mW/cm^2 for 10 minutes) using CCL 365 vario (MLase AG, Germany).

Table 1: Corneal refractive and topographic parameters in both eyes.

Topography Variable	OD	OS
Front K1 (Diopters)	42.2	40.1
Front K2 (Diopters)	43.0	45.2
Front Astigmatism (Diopters)	0.8	5.1
Front Axis (Steep)	106.8	36.1
Kmax (Diopters)	43.3	48.7
Back K1 (Diopters)	-5.9	-5.1
Back K2 (Diopters)	-6.2	-6.3
Back Astigmatism (Diopters)	0.4	1.2
Back Axis (Steep)	114.3	37.6
Pachycenter (µm)	565	561
Pachy Apex (µm)	565	555
Pachy Thin location (µm)	555	516
Belin-Ambrósio enhanced ectasia display Parameters		
Deviation of front elevation difference map (Df)	0.36	6.02
Deviation of back elevation difference map (Db)	0.36	4.64
Deviation of average pachymetric progression (Dp)	1.15	8.05
Deviation of minimum thickness (Dt)	-0.47	0.67
Deviation of ART max (Da)	1.32	3.18
Total Deviation (D)	1.60	7.93

Patient was examined at Post CXL 1 week, 3 months and 6 months follow up. Refraction was performed at 3 months where reduction in astigmatism was noted (Table 2). Best corrected visual acuity (BCVA) was 6/6, N6 and was stable. IOP was within normal limit in OS for all the follow ups. Post-surgery topography revealed decreased in corneal steepening in central 3mm zone and Kmax at 1 week, 3 months (Table 2) and these changes were stable suggesting stable keratoconus. Pachymetry revealed decreased in corneal thickness at 1 week which was recovered by 3 months and was stable at 6 months follow up. Corneal higher order aberrations (HOA) were measured by OPD scan III (NIDEK, Japan) for 6mm pupil at 3 and 6 months. We noted the reduction in corneal higher order aberration post operatively. Table 2 describes the refractive error changes, topography. Biomechanical parameters were assessed using Corvis ST-pentacam system

(Oculus Technology; Wetzlar, Germany) and are discussed in details elsewhere. [7] Increase in the stiffness parameter and decrease in deformation amplitude was noted at 3 months post-surgery suggestive of better corneal biomechanics. Also applanation length 1 and 2 was reduced. Similar observations were noted at 6 months follow up. Table 2 describes the CHOA, and biomechanical parameters in OS.

Table 2: Visual outcomes, corneal topographical parameters, corneal higher order aberrations and corneal biomechanical changes pre and post combined T-PRK+ t-PTK+ ACXL in OS.

Visual, topographical and biomechanical parameters in treated (OS) eye	Baseline	Post Op 1 week	Post op 3 months	Post Op 6 months
Refraction	-1.75/-4.50*120	±/-1.00*130	±/-1.00*130	±/-1.00*130
BCVA	6/6-2, N6	6/6, N6	6/6, N6	6/6, N6
bIOP (mmHg)	12.4	15.5	15.4	14.3
PachymetryCenter	561	527	542	555
Pachymetry Apex	555	523	537	549
Pachymetry thinnest location	516	479	492	490
Front K1 (Diopter)	40.1	38.5	38.9	39.3
Front K2 (Diopter)	45.2	42.1	42.7	42.9
Astigmatism (Diopter)	5.1	3.5	3.8	3.6
Axis (Steep) (Degree)	36.1	35.7	40.5	40.0
K max (Diopter)	48.7	48.3	47.9	47.4
Higher order Aberrations (μm)				
Coma	2.264	NA	1.790	1.515
Trefoil	1.642	NA	1.328	1.269
Secondary Astigmatism	0.907	NA	0.373	0.358
Tetrafoil	0.628	NA	0.438	0.180
Spherical Aberration	0.618	NA	0.928	0.832
Biomechanical Properties				
Applanation length 1 (mm)	2.36	2.47	2.02	2.42
Applanation Velocity 1 (m/s)	0.13	0.12	0.12	0.13
Applanation length 2 (mm)	1.95	2.34	1.81	2.01
Applanation Velocity 2 (m/s)	-0.26	-0.26	-0.26	-0.25
Highest Concavity Peak Distance (mm)	5.11	4.86	4.94	4.94
Highest Concavity Radius (mm)	6.79	6.53	6.69	6.02
Deformation Amplitude (mm)	1.08	0.95	0.95	1.00
Inverse Concave Radius (mm^{-1})	0.17	0.18	0.16	0.17
DA Ratio	4.6	4.2	4.3	4.3
Integrated Radius	9.5	9.0	8.8	9.5
ArTh	261.5	190.6	204.6	260.4
SP A1	92.1	101.7	102.4	99.5

DISCUSSION

Understanding of corneal biomechanics assessment has become an essential in diagnosis and treatment of keratoconus. In the journey to assess corneal biomechanics in vivo which is still evolving, various tools like ocular response analyser (ORA), Corvis ST, have been used to understand corneal biomechanical properties. [8,9] Corvis ST analyses a different set of parameter unlike ORA for measuring biomechanical properties. Since the cone was decentered, we performed a combined T-PTK+t-PRK+ACXL to manage keratoconus which promising treatment for keratoconus as compared to alone CXL. A recent study has also reported that combined T-PTK+t-PRK+ACXL is effective in corneal stabilization and vision improvement. [10] Here we highlight the visual, topographical and corneal biomechanical properties pre and post combined T-PTK+ t-PRK+ACXL. Pre surgery best corrected visual acuity of the patient was 6/9 with -4.50D astigmatism and also was complaining of visual blur and wanted to get rid of dependency on spectacle. This was another reason to perform combined surgery. We noted reduction in manifest refraction spherical equivalent, astigmatism steep keratometry and Kmax post operatively. Previous studies have also reported reduction in refractive error and keratometry values in eyes who have undergone t-PRK+CXL. [5,11,12] We noted reduction in CHOA such as coma, trefoil, tetrafoil and secondary astigmatism which is agreement with previous reports of post T-PTK+ACXL. [11] This decrease in CHOA could be attributed to t-PRK which shifts decentered cone more centrally thereby allowing further visual rehabilitation using spectacle, contact lens or posterior phakic lens.

Corneal stiffness parameter has been found to be the most sensitive and specific to describe the corneal stiffness where stiffer corneas have higher stiffness parameter amplitude. Also biomechanically stiffer corneas take longer time to applanate and velocity of applanation is lower suggesting less deformation amplitude. Post-surgery we noted increase in stiffness parameters amplitude. We noted increase in applanation time and velocity with corresponding decrease in the deformation amplitude at 3 and 6 months post-surgery. These parameters are capable of detecting early corneal biomechanical changes post-surgery such as CXL and could be used to assess the efficacy of surgery in terms of corneal biomechanics. [13] We noted strengthening in cornea despite a corneal weakening procedure (PRK) combined with ACXL. This could be explained due to the cross linking efficacy of ACXL procedure. We noted Initial positive trends in corneal biomechanics during short term follow ups which need further exploration with larger sample size and long term, follow up.

In conclusion, combined T-PTK+ t-PRK+ CXL in keratoconus not only improve the visual outcomes but also stabilize the cone biomechanics and regularize the corneal shape.

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