Original Article

Pentacam topographic changes after collagen cross-linking in patients with keratoconus

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Abstract

Background: Corneal cross-linking (CXL) with riboflavin and ultra-violet A is less invasive in comparison with other procedures such as penetrating keratoplasty. Hence, we planned this study to evaluate the efficacy of CXL in disease progression and to compare keratoconus indices before and 1 year after cross-linking by Pentacam.

Materials and Methods: In this prospective clinical trial, we enrolled 37 eyes of 37 patients suffering from keratoconus who were candidates for CXL. All eyes were examined before and one 1 year after surgery with a slit lamp and Pentacam for corneal topography. To compare the mean of each Pentacam parameter and index before and 1 year after the surgery, we used paired *t*-test.

Results: There were 23 males and 14 females. The mean age was 21.5 years 18-30 years). At the 12th month examination, the corneal thickness had decreased ($P = 0.0068$) and the Index of Height Decentration (IHD) had increased ($P = 0.016$). There were no statistically significant differences in other indices and parameters 1 year after CXL.

Conclusion: Most of the parameters and indices had not changed during 1 year after CXL. The procedure seems to be effective in stopping the disease progression at least for 12 months after surgery.

Key Words: Collagen cross-linking, keratoconus, Pentacam, riboflavin

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INTRODUCTION

Keratoconus is a bilateral non-inflammatory disease. One of its characteristics is reduction of biomechanical strength of cornea and stromal thinning, which gradually decreases corneal thickness and induces irregular astigmatism, myopia, corneal scaring, and reduction of visual acuity.[1,2]

For early stages of keratoconus, one would use spectacles and contact lenses though the progression of the disease can lead to irregular astigmatism or corneal scaring, leaving no other option but corneal transplantation in about 20% of patients.[3] Corneal transplantation is an expensive procedure with many complications such as high astigmatism and graft rejection; hence, seeking for a way to halt this progressive disease seems to be of crucial importance.[4]

For more than a decade, corneal cross-linking (CXL) with riboflavin (vitamin B2) and ultraviolet A (UV-A)

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has been considered as the only method for improving corneal biomechanical power.[5] UV-A and riboflavin increase the connections of collagen fibers in cornea which would stabilize the corneal biomechanical indices.[6,7]

In this study, we sought to assess the efficacy of riboflavin UV-A light–induced cross-linking in stopping the progression of keratoconus and to compare keratoconus indices before and after cross-linking by Pentacam criteria. We also aimed to evaluate whether this procedure can reduce the need for corneal transplantation.

MATERIALS AND METHODS

In this prospective clinical trial, we enrolled 37 eyes of 37 patients suffering from keratoconus who were candidates for CXL and were eligible for this surgery. Patients with mild to moderate keratoconus – maximum K reading less than 58 D, minimal corneal thickness more than 400 μm – and of age between 18 and 30 years were included. Exclusion criteria were corneal opacity, any previous surgery on eyes, previous ophthalmic herpes infection, past history of uveitis, diabetes mellitus, or collagen vascular diseases, and pregnancy.

This study was approved by the ethics committee of Isfahan University of Medical Sciences and signed informed consent was obtained from the participants prior to the study. We also described the necessity of this surgery and efficacy of CXL in halting the disease progression to the participants.

Pentacam system has several keratoconus indices that can show the severity of keratoconus and evaluate the progression or regression rates by measuring these indices before and after surgery.[8,9]

Other parameters for evaluation of progression were: (i) corneal thickness at the thinnest point, (ii) minimal curvature radius (R_{min}), and (iii) height of the maximum anterior and posterior elevation map with best-fit sphere reference.

Surgical technique was as follows. After local anesthesia was administered with tetracaine solution 1% (Sina Darou, Tehran, Iran) under sterile condition, the corneal epithelium was removed mechanically. Then, cornea was impregnated with standard isotonic riboflavin solution 0.1% (LightMed Collagex; Australia) every 5 min for 30 min and then was followed by UV-A irradiation at 5 cm for 30 min. After 1 h of surgery, ciprofloxacin 0.3% eye drops (Sina Darou, Tehran, Iran) was used and bandage lens was placed on the cornea. Then, betamethasone 0.1% (Sina Darou, Tehran, Iran) and ciprofloxacin 0.3% (Sina Darou, Tehran, Iran) were applied four times a day for a week. After this, the contact lens was removed and fluorometholone 0.1% eye drops (Sina Darou, Tehran, Iran) was applied three times a day for 3 weeks. All surgeries were performed by a single surgeon.

All patients were examined with a slit lamp on the same day, and 1 week and 1 month after surgery. One year after surgery, we examined the eyes with the slit lamp and Pentacam. For comparing the mean of each eye's Pentacam parameters before and 1 year after the surgery, we used paired *t*-test. Data analyses were carried out by IBM SPSS version 18.0 software (SPSS Inc., Chicago, IL, USA) and $P < 0.05$ were considered significant.

RESULTS

In this study, there were 23 male (62.2%) and 14 female (37.8%) participants. The mean age was 21.5 years (range: 18-30 years).

One month after CXL, there was anterior stromal haziness (grade 1 and grade 2) in 25 eyes, but at slit-lamp examination performed 12 months after CXL, all the eyes had been cleared. There were no serious complications such as infection and corneal scar.

After 1 year, the corneal thickness decreased (mean difference = −12 μm, $P = 0.0068$) and the index of height decentration (IHD) increased (mean difference = 0.01, $P = 0.016$) as compared to pre-treatment values.

There was no statistically significant difference in other indices and parameters before and 1 year after CXL [Table 1].

Table 1: Preoperative and postoperative shape factors

	Normal value	Pre-operation (mean±SD)	1 year post-operation (mean±SD)	*P* value
Minimal thickness, μm	>500	478.64±50.98	466.62±55.78	0.006
Anterior float, μm	<12	21.40±13.05	21.56±13.32	0.72
Posterior float, μm	<18	43.13±24.58	44.83±23.14	0.20
Posterior R_{min}, mm	>6.71	4.94±0.77	4.88±0.80	0.08
Anterior K_m, D	<48	46.83±2.87	46.72±3.14	0.43
ISV	<37	68.67±38.66	67.83±39.71	0.61
IVA	<0.28	0.69±0.46	0.67±0.47	0.60
KI	<1.07	1.17±0.14	1.16±0.02	0.44
CKI	<1.03	1.04±0.03	1.03±0.04	0.41
IHA	<19	24.07±15.05	28.05±18.77	0.11
IHD	<0.014	0.06±0.05	0.07±0.06	0.01

CKI: Center keratoconus index, IHA: Index of height asymmetry, IHD: Index of height decentration, ISV: Index of surface variance, IVA: Index of vertical asymmetry, KI: Keratoconus index, K_m: Maximum keratometry, R_{min}: Minimum radius

DISCUSSION

Our findings showed that there were no statistically significant differences between the parameters and indices of keratoconus before and 1 year after treatment, except for minimal thickness and IHD. Based on the fact that the maximal progression of keratoconus occurs during the second and third decades of life,[10] and also based on our participants' age (18-30 years old), our results indicate that over the ensuing 12 months from the procedure, there was no significant progress in keratoconus and the progressive process of this disease had been stopped during 1 year after CXL.

Among the parameters, minimal thickness decreased 1 year after treatment; this could be because of keratocyte apoptosis that could have occurred following UV-A exposure. [11]

Koller *et al*. reported a significant increase in minimum radius (R_{min}) (P = 0.01) 1 year after the procedure, which shows flattening of cornea. Four keratoconus indices, including index of surface variance (ISV), keratoconus index (KI), center keratoconus index (CKI), and IHD, showed significant decrease 1 year after CXL, which indicates reduction of keratoconus severity. Similar to our study, minimal corneal thickness showed significant reduction (P = 0.002) and other parameters and indices had no significant change 1 year after treatment.[8]

In a study by Greenstein *et al*., after 1 year of CXL, significant increase in R_{min} was found, which means flattening of cornea. In this study, ISV, index of vertical asymmetry (IVA), and KI were decreased (P < 0.01), which shows reduction in keratoconus severity, but CKI, index of height asymmetry (IHA), and IHD had no significant difference after 1 year of treatment as compared to pre-treatment status.[9]

Arbelaeza *et al*. reported decrease in anterior maximum keratometry (K_m) with a mean of 1.4 D after 1 year of CXL and decrease in anterior elevation 6 months after CXL (P = 0.15). But after 1 year of surgery, there was no statistically significant difference in anterior elevation. In this study, there was no significant decrease in posterior elevation.[12]

Kanellopoulos and Asimellis reported a statistically significant decrease in Kmax after 12 months of CXL, which shows flattening of cornea; they also reported a statistically significant decrease in ISV and IHD, which indicates reduction in corneal irregularity.[13]

Our results show that most of the parameters and indices have not changed during 1 year after CXL, pointing toward the efficacy of this method in halting the disease progression at least for the first year after surgery, though in other studies, there had been improvement in some parameters and indices and the corneas had become more regular 1 year after CXL. Further research is needed to clarify the effects of this procedure during 2, 5, 10, and more years after surgery.

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