ORIGINAL ARTICLE

Efficacy and Safety of Corneal Collagen Cross-linking in Keratoconus; A One Year Follow-up

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ABSTRACT

Objective: To evaluate the efficacy and safety of collagen cross linking in stabilizing the visual acuity and keratometric readings one year after the procedure.

Study Design: A Case Series.

Place and Duration of Study: All the procedures were performed at Amanat Eye Hospital Rawalpindi from January to June 2011.

Materials and Methods: Sixteen cases suffering from progressive keratoconus which underwent collagen cross-linking were analyzed retrospectively. After epitheliectomy and instillation of topical Riboflavin, UV light exposure was given for 30 min. A bandage contact lens was applied postoperatively for 5 days. The patients were followed up after 5 days, one month, 3 months, 6 months and then one year. During all the postoperative visits, visual acuity, slit lamp examination and keratometry were performed.

Results: Sixteen cases completed one year's follow-up. Un-corrected visual acuity improved in 12 out of 16 eyes, remained stable in 4 out of 16 and deteriorated in none. Best-corrected visual acuity improved in 9 out of 16 eyes, remained stable in 6 out of 16 and deteriorated in one out of 16.

Mean pre-operative Keratometry was 50.23 D which reduced to 49.77 D after one year. Progression of original disease (increase in K-value by > 0.50 D) was seen in only 2/16 eyes after one year of follow-up. Keratometric improvement (decrease in K-value by > 0.50 D) was seen in 6/16 eyes while 8/16 eyes (50%) showed keratometric stability (i.e. K-value within 0.50 D of the preoperative value).

Conclusion: Collagen cross-linking is effective and safe in providing visual and keratometric stability for keratoconus.

Key Words: *Collagen Cross linking, Keratoconus, Efficacy.*

Introduction

Progressive myopia with astigmatism and frequent changes in glasses during the teen years is the hallmark of keratoconus. It is caused by thinning and ectasia of corneal stroma. Its association with other genetic conditions like Marfan's and Down's syndrome and family history suggest genetic factors in its etiology.[1]

The treatment of keratoconus includes refraction and prescription of glasses, rigid gas-permeable hard contact lenses, intacs (to correct the ectasia and irregular astigmatism) and penetrating keratoplasty in cases of corneal opacification. None of these procedures corrects the underlying problem. Collagen cross-linking (CXL) emerged as a promising procedure. It is indicated in cases having clear cornea but evidence of progression. CXL is the only procedure which addresses the underlying pathophysiology of keratoconus i.e. corneal collagen structural weakness.[2]

It was introduced by Wollensak et al[3] with the idea of providing mechanical and biochemical stability to the corneal collagen structure."Dresden Protocol" was established, which provided the safety measures for the procedure.[4]According to this protocol, after epitheliectomy, the residual thickness must be at least 400 µm. This would protect the underlying endothelium, lens and retina from the harmful effects of UVA radiation. Isoosmolar 0.1% riboflavin in 20% dextran solution is used for 30 min and exposed to UVA radiation of 370 nm at 3 mW/cm2for 30 min.CXL utilizes riboflavin eye drops (as photosensitizer) and ultraviolet radiation to strengthen the corneal collagen structure.[5] Riboflavin also acts as a shield to protect the

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underlying structures from the harmful effects of UV radiation. CXL can be performed both with epithelium on and epithelium off. However, the epithelium-on technique results in some reduction of UV penetration into the corneal stroma. Epithelium-on CXL can be utilized in cases with thin cornea (<400µm), where epitheliectomy would result in further thinning and more penetration of UV light. Other methods of CXL in thin corneas can be pachymetry-guided epithelial debridement before cross-linking, parameters modification (conc. of riboflavin, intensity/wavelength of UV radiation and exposure time) and utilization of hypo-osmolar riboflavin for CXL.[2]

Studies have shown stabilization in un-corrected visual acuity (UCVA), improvement in best-corrected visual acuity (BCVA) and reduction in keratometry after CXL. All these factors suggest stabilization of keratoconus. Safety of the procedure is suggested by stable corneal thickness, endothelial cell density and foveal thickness.[6] Haze and increased density of anterior stroma have been cited as the only direct complications of the procedure.[7]

There is scarcity of literature about CXL results in keratoconus in our population. The present study was conducted to evaluate the efficacy and safety of CXL in achieving visual and keratometric stability, one year after the procedure.

Materials and Methods

This is a case series of sixteen cases of progressive keratoconus which underwent collagen cross-linking with UVA light and riboflavin. All the cases completed one year's follow-up. The procedure was performed at Amanat Eye Hospital, Rawalpindi by a single surgeon from January to June 2011.

The keratoconus was diagnosed by history, refraction, slit-lamp examination, keratometry and orbscan II. Those with evidence of progression of keratoconus and clear cornea underwent CXL. All the cases with stable keratoconus or corneal scarring were excluded from the procedure.

The procedure was performed with standard epitheliectomy. This was followed by instillation of 0.1% riboflavin eye drops in 20% dextran solution for 30 min. UVA radiation exposure (370 nm at 3 mW/cm2) was given for 30 min. A bandage contact lens was placed for 5 days. Postoperative treatment consisted of antibiotic/steroid combination alongwith lubricant, given for two weeks.

Follow-up visits were conducted after 5 days, one month, 3 months, 6 months and one year. On follow-up visits, UCVA, BCVA, slit-lamp examination, refraction and keratometry were performed. In the final visit, alongwith the above, orbscan II was also performed. Efficacy was determined with respect to UCVA, BCVA, average and steepest meridian keratometry. Safety was determined by complications recorded.

Results

A total of 16 cases of CXL which had completed one year of follow-up were included in the study. 8 were male and 8 female eyes. The age range was 14 to 32 years. UCVA improved in 12 out of 16 eyes, remained stable in 4 out of 16 and deteriorated in none (Fig 1). There was improvement in BCVA in 9/16 eyes. BCVA remained stable in 6/16 and deteriorated in only 1/16 eyes (Fig 2). 5/16 eyes showed improvement in visual acuity by 2 or more lines.

Preoperative mean K-reading was 50.23D which reduced to 49.77D one year after the procedure. Progression of original disease was defined as increase in K-reading by >0.50 D and stability as keratometric reading within 0.50 D of original K-reading. According to that criteria, only 2/16 eyes showed progression. Stability of original disease was seen in 8/16 and improvement in 6/16 eyes, one year post-operatively (Table I). K-value in steepest meridian remained stable in 9/16 eyes, improved in 5/16 eyes and deteriorated in 2/16 eyes (Table II).Mean steepest meridian K-reading reduced from 52.38 D (SD 5.27) to 52.09 D (SD 5.08)and flattest meridian K-reading decreased from 48.06 D (SD 4.56) to 47.80 D (SD 3.44)during the same time period (Table IV). None of the eyes developed corneal haze or infection postoperatively.

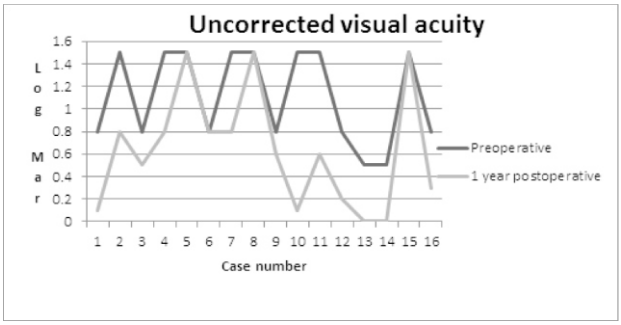

Fig 1: Comparison of pre-operative vs post-operative UCVA

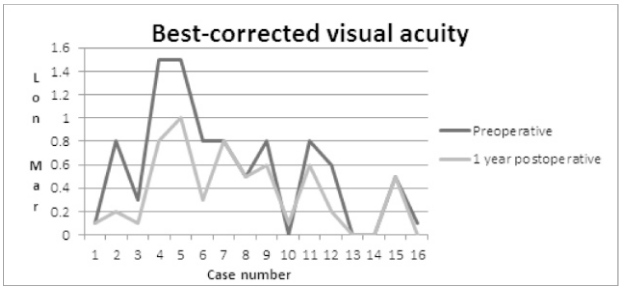

Fig 2: Comparison of pre-operative vs post-operative BCVA

Table I: Comparison of pre-operative vs one year post -operative mean keratometry

Sr.no	Preoperative	1 year postoperative	Change in keratometry
1	43.62	43.75	Stable
2	52.5	53.62	Deteriorated
3	53.75	53.62	Stable
4	52.12	51	Improved
5	60	58.12	Improved
6	45.12	45.62	Stable
7	55.37	54.25	Improved
8	50.37	49.62	Improved
9	47.62	50.62	Deteriorated
10	46.12	45.75	Stable
11	56	53.43	Improved
12	50.37	46.25	Improved
13	46.37	46.5	Stable
14	46.75	46.75	Stable
15	53.25	53.12	Stable
16	44.37	44.25	Stable

Table II: Comparison of pre-operative vs one year post-operative steepest meridian keratometry

Sr.no	Preoperative	1 year postoperative	Change in keratometry
1	45	45	Stable
2	57	56.75	Stable
3	56	55.5	Stable
4	54.5	52.75	Improved
5	60	63	Deteriorated
6	46	46.50	Stable
7	57.5	56.25	Improved
8	53	52.25	Improved
9	49	52.25	Deteriorated
10	48.25	47.75	Stable
11	60.75	56.75	Improved
12	52.25	50.75	Improved
13	47.75	47.75	Stable
14	49.25	49.25	Stable
15	56.5	56	Stable
16	45.25	45	Stable

Table III: Comparison of pre-operative vs one year post-operative flattest meridian keratometry

Sr. no.	Pre-operative	One year postoperative	Change in keratometry
1	42.25	42.5	Stable
2	48	50.5	Deteriorated
3	51.5	51.75	Stable
4	49.75	49.25	Stable
5	60	53.12	Improved
6	44.25	44.75	Stable
7	53.25	52.25	Improved
8	47.25	47	Stable
9	46.25	49	Deteriorated
10	44	43.75	Stable
11	51.25	50	Improved
12	48.5	47.75	Improved
13	45	45.25	Stable
14	44.25	44.25	Stable
15	50	50.25	Stable
16	43.5	43.5	Stable

Table no. IV: Mean reduction in keratometric readings and p value

Parameter	Pre-Operative Mean ±SD	Post Operative Mean ±SD	Paired T test, P value (α = 0.05, 95% CI)
Flat Keratometric value (K_1) (D)	48.06 ±4.56	47.80 ±3.44	p=0.625
Steep keratometric value (K_2)(D)	52.38 ±5.27	52.09 ±5.08	p=0.516
Average Keratometry ($K_{avg.}$)(D)	50.23±4.76	49.77 ±4.31	p=0.258

Discussion

In our study, the male and female ratio was 50:50. Both UCVA and BCVA showed improvement in

majority of cases. Un-corrected visual acuity improved in 12 out of 16 eyes, remained stable in 4 out of 16 and deteriorated in none. Best-corrected visual acuity improved in 9 out of 16 eyes, remained stable in 6 out of 16 and deteriorated in one out of 16 eyes.The pre-operative mean cylinder was -3.97±2.29 D which improved to -3.60±2.40 D, one year postoperatively. Majority of the cases showed keratometric stability. Mean pre-operative Keratometry was 50.23 D which reduced to 49.77 D after one year. Progression of original disease (increase in K-value by > 0.50 D) was seen in only 2/16 eyes after one year of follow-up.Keratometric improvement (decrease in K-value by > 0.50 D) was seen in 6/16 eyes while 8/16 eyes (50%) showed keratometric stability (i.e. K-value within 0.50 D of the preoperative value). Safety of the procedure was established by lack of corneal haze and infection in any of the cases.

Razmjoo et al[8] completed topographical corneal changes on 66 patients. Just like our study, their cases also completed one year of follow-up. The age range was 18- 29 years. The mean age was 22.4 ± 5.4 years. The age range resembled our study i.e. 14-32 years since keratoconus starts in teanage and continues till mid thirties. There were 54.55% males and 45.45% females.

Frederiket al[9] conducted the long-term study regarding dampening effect of riboflavin and UV-A on progressive keratoconus by collagen cross-linking. 6 months of follow-up was completed by 241 eyes. In the first year, there was a decrease in steepening by 2.68 D. It further decreased by 2.21 D in the second year and 4.48 D in the third year. There was a significant improvement in BCVA by ≥ I line in 53% among 142 eyes (in first year), 57% of 66 eyes in the year falling and 58% among 33 eyes in the third year. In the first year, BCVA remained stable in 20% of 142 eyes. In second year, 24% of 66 eyes and in third year, 29% of 33 eyes showed stable BCVA. Only two patients experienced continued progression and needed another CXL. The study proved a long-term stabilization and improvement after CXL.

A study of CXL with corneal de-epithelialization was conducted on 14 eyes of 14 patients by GoldichYakov et al.6 As compared to pre-operative BCVA, 24 months postoperative BCVA showed significant improvement (0.21± 0.1 to 0.14±0.1, P=0.002). The steepest meridian K-reading showed a significant decrease i.e. 53.9±5.9 to 51.5±5.4(P=0.001). The mean cylinder also showed significant decrease i.e. 10.2±4.1 to 8.1±3.4(P=0.001). There was no significant alteration in foveal reflex. According to their conclusion, UCVA showed stability, BCVA showed improvement and keratometry depicted reduction after 2 years of CXL. Safety of the procedure was proved by stability in corneal thickness, density of corneal endothelial cells and thickness of fovea.

Deepa Viswanathan and John Males[10] evaluated long-term efficacy of CXL in 51 eyes of 35 patients. The mean follow-up was 14.38±9.36 months. The treated patients were compared with a control group of 25 fellow eyes which were not treated. The treated group showed significant flattening of maximum keratometry by 0.96±2.33 D(p=0.005).The BCVA showed significant improvement i.e. 0.05±0.13 logMAR(p=0.04). The maximum K- reading increased significantly in control group i.e. 0.43±0.85 D (P=0.05) and BCVA decreased by mean 0.05±0.14 (P=0.2). Their study concluded that CXL decreases corneal curvature and improves visual acuity in keratoconus.

In young patients with keratoconus, there are more chances of rapid progression and they are more likely to require penetrating keratoplasty for visual improvement.[11] 18 paedietric patients (25 eyes) were evaluated for efficacy of CXL in progressive keratoconus.[12] The paedietric age was defined as 18 years of age or younger. The mean age of the patients was 14.3±2.4 years and mean follow-up of 20.1±14.25 months. Pre-operative mean K-reading in flattest meridian which was 46.34 D reduced postoperatively after 20 months to 45.67 D(P=0.03). Preoperative mean K-reading in the steepest meridian which was 50.06 D reduced to 49.34 D (P= 0.005). There was a reduction in topometric astigmatism from mean 3.50 D to 3.25 D (P=0.51). Their study concluded that CXL is an effective option for paedietric patients with progressive keratoconus.

A twenty four months follow-up prospective study of CXL cases was performed in 57 eyes of 55 patients.[13] As compared to our study where Orbscan was used, they examined the patients with Pentacam, IOL Master and Ocular Response Analyzer. Our study focused on visual acuity, mean keratometry, steepest

& flattest meridian keratometry. Their study additionally concentrated on thinnest point keratometry. Twenty four months after CXL, there was a significant improvement in BCVA ($p<0.01$), a significant decrease in corneal thinnest point keratometry readings at the corneal apex and corneal volume ($p<0.01$).

The limitations of our study are smaller sample size and shorter duration of follow-up. Future studies with a three to five year follow-up should be conducted to evaluate the long-term effects of CXL.

Conclusion

CXL is effective and safe procedure in providing visual and keratometric stability for keratoconus.

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