Ophthalmic Perspective

Current review and a simplified "five-point management algorithm" for keratoconus

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Keratoconus is a slowly progressive, noninflammatory ectatic corneal disease characterized by changes in corneal collagen structure and organization. Though the etiology remains unknown, novel techniques are continuously emerging for the diagnosis and management of the disease. Demographical parameters are known to affect the rate of progression of the disease. Common methods of vision correction for keratoconus range from spectacles and rigid gas-permeable contact lenses to other specialized lenses such as piggyback, Rose-K or Boston scleral lenses. Corneal collagen cross-linking is effective in stabilizing the progression of the disease. Intra-corneal ring segments can improve vision by flattening the cornea in patients with mild to moderate keratoconus. Topography-guided custom ablation treatment betters the quality of vision by correcting the refractive error and improving the contact lens fit. In advanced keratoconus with corneal scarring, lamellar or full thickness penetrating keratoplasty will be the treatment of choice. With such a wide spectrum of alternatives available, it is necessary to choose the best possible treatment option for each patient. Based on a brief review of the literature and our own studies we have designed a five-point management algorithm for the treatment of keratoconus.

Key words: Algorithm, cross-linking, Intacs, keratoconus, normogram

Keratoconus is a noninflammatory disease characterized by thinning of the corneal stroma that may or may not lead to irregular astigmatism with an associated decrease in visual acuity.[1,2] Ever since its first description by the German oculist Burchard Mauchart in 1748, this degenerative disorder has seen advancements in both diagnostic and treatment modalities.[3] Cone location and magnitude index are a relatively new parameter for diagnosing the disease.[4,5] Based on current literature and the array of treatment modalities available, we designed a simplified "five-point management algorithm" for the management of keratoconus.

Step I: Demography

The prevalence of keratoconus ranges from 0.3/100,000 in Russia to 2300/100,000 in Central India (0.0003–2.3%).[6,7] In our tertiary care center, we have recorded a prevalence of 5200/100,000 (5.2%). Such a wide range is seen due to variable diagnostic criteria and heterogeneous populations studied.[6,7] Two survey reports from the United Kingdom indicate a 4.4–7.5 times greater prevalence in Asians (Indian, Pakistani and Bangladeshi) compared with Caucasians, suggesting a significant role of ethnicity.[8,9]

Keratoconus affects both genders, but it is unclear whether any significant difference exists between males and females.[6,8,9] Of the total 5200 cases seen by us over 7 years (unpublished data, January 2007 to January 2014), 2440 were males (46%) and 2760 females (53%) with 5044 (97%) cases showing bilateral involvement. Even those patients who had unilateral involvement on clinical examination had bilateral early keratoconus or forme-fruste on topographical analysis. Family history of keratoconus has been found to be variable, ranging from 6% to 21.74%.[10,11] There was a positive family history in 94 patients in our cohort (6.8%).

The disease typically has its onset at puberty and is progressive until the third or fourth decade of life, by when it usually arrests.[10] In India, it presents at a younger age and progresses more rapidly.[12] The average age of presentation in our study group was 21.5 years with 1970 patients (37.9%) having an onset of disease before 20 years of age, 2130 (41.0%) in the third decade and in the remaining 1100 (21.1%) after that. Late onset was seen predominantly in females (89.9%) associated with a present (21.7%) or previous history of pregnancy (43.6%). Ocular rubbing secondary to atopy, ocular allergies, Down's syndrome and tapetoretinal degeneration are known to be associated with a higher incidence of keratoconus.[8,9] A total of 910 (17.5%) patients had a history of eye-rubbing, 440 (8.46%) had allergic eye disease and 147 (2.82%) had other associated ocular pathologies such as retinitis pigmentosa, Leber's congenital amaurosis and congenital cataract. Eleven patients (0.21%) had a history of diabetes mellitus, which is associated with a lower incidence of keratoconus.[13]

Pentacam (Oculus, Wetzlar, Germany) has good repeatability of its parameters when compared to other Scheimpflug imaging devices.[14] We have defined progression in our earlier studies as an increase of 0.5 diopter (D) or more in two or more keratometric values in the steep meridian between two sagittal curve maps or a decrease in corneal thickness of 10%

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or more at the thinnest point between two pachymetry maps on Pentacam in the preceding 6 months.[15] Certain diseases and conditions (eye-rubbing, vernal keratoconjunctivitis, atopic eye disease, pregnancy, frequent change of glasses) are associated with a more rapid progression of keratoconus.[1,10] We have compiled important high-risk factors that can predict the progression of keratoconus [Table 1]. These characteristics help us to "triage" patients into the appropriate treatment plan. However, the final decision on the best treatment plan will be based on clinical evaluation only.

Once demographic and high-risk characteristics are

recorded in a case of keratoconus, the management can be accordingly be either conservative or surgical, with the ultimate aim of seeing an improvement in the patient's quality of life [Table 1]. Those with a high-risk for progression may be considered for cross-linking without having to wait for documented progression [Fig. 1].

Step II: Contact Lenses/Spectacles

Keratoconus patients often complain of progressive visual blurring and distortion secondary to myopia and high astigmatism.[1,10] In the initial stages, spectacle correction is adequate in patients who can achieve 20/40 or better vision,[2] but without correct the associated irregular astigmatism. In these patients, contact lenses may provide better visual rehabilitation.[2] The type of contact lenses prescribed depends on the stage of keratoconus.[19] Soft lenses, soft toric or custom soft toric contact lenses may be adequate early in the disease to correct both the myopia and regular astigmatism. As the disease progresses, rigid gas-permeable (RGP) lenses or various specialized lenses, such as Super Cone, Rose K, hybrid lenses, piggyback or scleral lenses may be required.[2]

In our cohort, 1200 patients had been using contact lenses; 752 (62.67%) were males and 448 (37.33%) females. Of these, 708 (59%) had been prescribed RGP lenses because of a high refractive error associated with astigmatism and the remaining (492, 41%) were being treated with soft, soft toric or custom soft toric lenses. Though patients using soft lenses were comfortable, 318 of patients (45%) using RGP lenses had some discomfort (frequent changing of lenses or cleaning solutions to alleviate eye discomfort, pain, dryness, stinging, itching or tearing). In advanced cases, it was difficult to obtain an "optimal" fit due to significant corneal irregularities.[20] Newer available contact lenses were used in such patients with variable success. Scleral lenses were prescribed in 99 (14%) patients and Rose K in 198 (28%) with
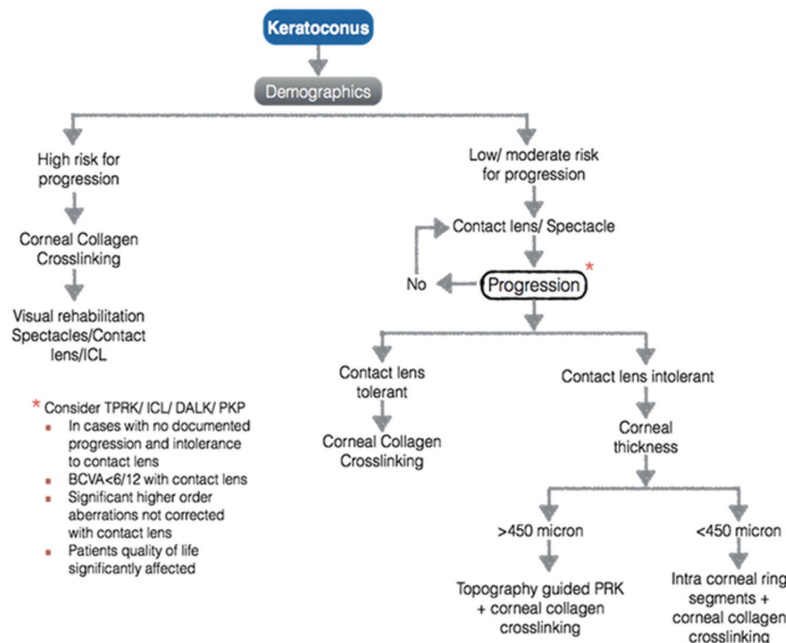
Table 1: HRC for progression of keratoconus

Characteristics	Division	Score
Age (in years)[10,11]	<20	2
	20-30	1
	>30	0
Eye rubbing[8,10,11]	Active	2
	Past history	1
	Absent	0
Atopic eye disease[1,8,10]	Active	2
	Past history	1
	Absent	0
Frequent change of glasses[16]	Present	2
	Absent	0
Others	Pregnancy[17]	2
	Downs syndrome[1,8,18]	2
	Connective tissue disorders[1,8]	1
	Retinitis pigmentosa[1,8]	1
	Lebers congenital amaurosis[1,8]	1

*Scoring for HRC. >8: High risk of progression, 6-8: Moderate risk of progression, <6: Low risk of progression. HRC: High-risk characteristics

Figure 1: Management protocol based on the risk of progression

improvement in visual acuity (two lines on Snellen's acuity chart) and refraction. The mean uncorrected distance visual acuity (UCDVA) (logMAR) in patients using different contact lenses group was 0.90 ± 0.43 (soft contact lens), 1.10 ± 0.40 (RGP lens), 1.17 ± 0.37 (Rose K lens) and 1.24 ± 0.32 (scleral lens). The mean best spectacle corrected visual acuity was 0.24 ± 0.12, 0.47 ± 0.27, 0.51 ± 0.25 and 0.55 ± 0.19 respectively. There was a statistically significant improvement in best corrected visual acuity in all the groups ($P < 0.05$). The mean corrected distance visual acuity (CDVA) improved to 0.07 ± 0.11, 0.04 ± 0.09, 0.12 ± 0.08 and 0.10 ± 0.11 respectively. However, 20% of patients who were intolerant to contact lenses reverted to spectacle use. A comparative topographical analysis was done for all patients using contact lenses every 6 months[15] and progression was noted in 624 (52%) patients. Since 412 (66%) of them were comfortable with contact lenses, they required only corneal collagen cross-linking (CXL) to stabilize the disease.

In patients who were intolerant to contact lens use (212, 44%), ablative procedures were used. Those over 21 years and having the thinnest pachymetry >450 microns underwent topography guided refractive correction combined with corneal CXL. Patients with contact lens intolerance but no documented progression of the disease were rehabilitated with topography guided-photorefractive keratectomy (T-PRK),

implantable collamer lenses (ICL), deep anterior lamellar keratoplasty (DALK) or penetrating keratoplasty (PKP) depending on the corneal thickness, scarring and keratometric indices.

Step III: Corneal Collagen Cross-linking

In patients with progressive keratoconus with a clear central cornea and thinnest corneal thickness >400 microns, CXL can reduce the risk of progression. Hypoosmolar CXL is an alternative option for patients with thinner corneas.[21] Several long-term follow-up studies on CXL have reported some improvement in the visual acuity as well as in topographic parameters.[22,23] Table 2 lists the various protocols used for performing corneal CXL and the different formulations available commercially are listed in Table 3. In a 2 years study, we reviewed 342 eyes of 217 patients who underwent conventional CXL. The UCDVA showed a mean improvement of 1.03 lines in 178 eyes (52%), no change in 132 eyes (38%) and a mean loss of 0.68 lines in 32 eyes (9%). There was an improvement in the best CDVA in 143 eyes (42%) by a mean of 0.77 lines while the remaining (58%) maintained their CDVA. There was no loss of CDVA in any of the patients. The mean keratometric values showed a mean reduction of 2.23D at the end of 2 years.

Table 2: Different protocols of cross-linking used

Epithelium	Riboflavin concentration	Riboflavin impregnation	UV-A fluence (365 nm) (mW/cm²)	Irradiation time	Total energy (J/cm²)
Off	0.1% with 20% dextran (conventional)	Every 2 min for 30 min, then every 5 min during fluence	3	30 min	5.4
Off	0.1% with 20% dextran (ACXL)	Every 2 min for 20 min	30	3 min	5.4
Off	0.1% with 20% dextran (ACXL)	Every 2 min for 20 min, then every 2 min during fluence	18	5 min	5.4
Off	0.1% with 20% dextran (ACXL)	Every 2 min for 20 min, then once after 5 min	9	10 min	5.4
On	0.25% with HPMC, sodium chloride, EDTA, benzalkonium chloride (TECXL)	Every 2 min for 30 min	45	2 min, 40 s	7.2
Off	0.5% with 0.9% sodium chloride (hypoosmolar-for corneal thickness <400 μm)	Every 3 min for 30 min, then every 20 s for 5 min (or)	3	30 min	5.4
		1 drop every 5 s till corneal thickness reaches at least 400 μm (Peschke)	18	5 min	5.4

*ACXL: Accelerated cross-linking, TECXL: Transepithelial cross-linking, HPMC: Hydroxypropyl methycellulose, EDTA: Ethylenediaminetetraacetic acid, UV-A: Ultraviolet-A

Table 3: Commercially available riboflavin

VibeX™	Avedro	100 mL solution contains-riboflavin 0.1 g, dextran 500, disodium hydrogen phosphate, sodium phosphate monobasic dihydrate, sodium chloride, water for injectable solution
VibeX Rapid™	Avedro	100 mL solution contains-riboflavin 0.1 g, HPMC, disodium hydrogen phosphate, sodium phosphate monobasic dehydrate, sodium chloride, water for injectable solution
MedioCROSS® M	Avedro	>0.1% riboflavin, HPMC 1.1%
Medicross TE	Peschke Meditrade GmbH	0.25% riboflavin with benzalkonium chloride, sodium chloride and no dextran
ParaCel™ riboflavin	Avedro	0.25% riboflavin, HPMC, benzalkonium chloride, EDTA
RICROLIN®	Sooft Italia SPA	Riboflavin 0.1% in 20% dextran Vectorization factors: Trometamol, sodium edetate
RICROLIN® TE	Sooft Italia SPA	Riboflavin 0.1%, destrane T500 15%, edetate sodium, tromethamine, bihydrate sodium phosphate monobasic, bihydrate sodium phosphate bibasic

*HPMC: Hydroxypropyl methycellulose, EDTA: Ethylenediaminetetraacetic acid

Encouraged by the success of conventional cross-linking, other procedures like accelerated CXL (ACXL), hypoosmolar CXL and transepithelial CXL (TECXL) are also being performed.[23-25] A review of patients (unpublished data) who underwent ACXL showed a statistically significant change in mean UCDVA in logMAR (preoperative 0.76±0.26; postoperative 0.61 ± 0.25; *P* < 0.001) and mean CDVA (preoperative 0.24 ± 0.19; postoperative 0.12 ± 0.12; *P* < 0.001) at the end of a 2 years follow-up. There was an improvement in the spherical (preoperative 3.04 ± 3.60 DS; postoperative 2.38 ± 3.37 DS; *P* < 0.001), cylindrical refraction (preoperative 3.63 ± 1.82 DC; postoperative 2.80 ± 1.48 DC, *P* < 0.001) and spherical equivalent (preoperative 4.70 ± 3.86; postoperative 3.75 ± 3.49, *P* < 0.001). The mean preoperative keratometry (K1/K2-48.53 ± 3.57/53.77 ± 4.82) showed a statistically significant (*P* < 0.001) flattening (46.49 ± 4.21/51.70 ± 5.41) at the end of a 2 years follow-up [Table 4 and 5]. The mean endothelial cell count at the end of the study period did not show any significant changes (preoperative 2556 ± 433; postoperative 2433 ± 323; *P* = 0.15). Though TECXL showed stabilization, flattening was limited when compared to conventional CXL (0.35D vs. 2.21D at the end of 2 years). We noticed that in children with VKC, management of allergy with topical steroids prior to ACXL and long-term control with topical cyclosporine would prevent failure of cross-linking.[26] Once a stable cone is maintained for 3 consecutive months following the procedure, the patients can be visually rehabilitated with either contact lenses or spectacles or an ICL. Tables 4 and 5 shows the preoperative and 2 years postoperative results following CXL, ACXL and TECXL.

Step IV: Topography Guided-photorefractive Keratectomy/Intacs

Patients who are intolerant to contact lenses showing progression of the disease will need to be considered for T-PRK with adjunctive CXL rather than CXL alone. CXL will halt the progression but will not address the problem of intolerance

to contact lens. With T-PRK there is regularization of the cornea allowing the patient to have better quality of vision with spectacle correction [Fig. 1]. After the first description by Kanellopoulos, the protocol for T-PRK has undergone many changes, and simultaneous T-PRK with CXL is show to be superior to sequential procedures.[27,28] Patients with early to moderate keratoconus and a preoperative thinnest pachymetry of 450 µm (after epithelial debridement) or a predicted postoperative thinnest pachymetry of at least 400 µm, can be considered for T-PRK, although some investigators have included patients with a minimum pachymetry of 300 µm as well.[27]

The ablative or "Q-based" protocol we use is based on the cone location, the corneal asphericity (Q) value, refractive error correction required and the change it produces. Since it takes four different important parameters into consideration, we believe this to be the most comprehensive protocol. The maximum tangential curvature on corneal topography was used for classifying the cones.[29] The x and y coordinate of the location of the maximum tangential curvature was noted in the tangential curvature map. The distance (L) from the geometric center (x coordinate ¼ 0, y coordinate ¼ 0) of the corneal tangential curvature map was evaluated as the square root of the sum of squares of x and y coordinate. Eyes were subdivided into two groups preoperatively based on L: Group 1 – Cones located within the central 2-mm zone; and Group 2 – Cones located outside the central 2-mm zone. In patients with a central cone, the refractive correction is based on the spherical equivalent and pachymetry. Corneas with a spherical equivalent <6D and with a thinnest pachymetry of >475 µm can undergo partial refractive treatment, but in corneas with a thinnest pachymetry between 450 and 475 µm and a higher spherical equivalent, a refractive procedure in not advised to avoid excessive tissue ablation. If a refractive correction is not being attempted, the Q value alone can be reduced by 20–30% [Fig. 2]. Later, we neutralize the change in defocus to spherical aberration. The refractive error

Table 4: Preoperative parameters in the CXL, ACXL and TECXL groups

Preoperative parameters	Mean±SEM		
	CXL	ACXL	TECXL
CDVA	0.31±0.032	0.24±0.19	0.26±0.2
Manifest cylinder	−4.03±0.43	−3.63±1.82	−3.7±1.6
K1/K2	47.92±0.82/52.89±1.34	48.53±3.57/53.77±4.82	50.8±5.87/54.81±6.8

SEM: Standard error of mean, CXL: Corneal collagen cross-linking, ACXL: Accelerated corneal collagen cross-linking, TECXL: Transepithelial corneal collagen cross-linking, CDVA: Corrected distance visual acuity

Table 5: Two years postoperative parameters in the CXL, ACXL and TECXL groups; (*P* value comparing preoperative and postoperative *P* values)

Postoperative parameters	Mean±SEM		
	CXL	ACXL	TECXL
CDVA	0.24±0.03 (*P*-0.053)	0.12±0.12 (*P*<0.001)	0.22±0.16 (*P*-0.003)
Manifest cylinder	−4.08±0.40 (*P*-0.13)	−2.38±3.37 (*P*<0.001)	−3.3±1.5 DC (*P*<0.001)
K1/K2	45.83±0.71/51.87±1.00 (*P*-0.23/0.01)	46.49±4.21/51.70±5.41 (*P*<0.001)	50.46±6/54.12±6.87 (*P*<0.001/<0.001)

SEM: Standard error of mean, CXL: Corneal collagen cross-linking, ACXL: Accelerated corneal collagen cross-linking, TECXL: Transepithelial corneal collagen cross-linking, CDVA: Corrected distance visual acuity

used to neutralize is then added to the final refraction to be corrected. This step is important as this compensates for a change in the asphericity and induced refractive change. We attempt to limit the refractive correction to maximum 40 microns.

In a study of 17 keratoconus patients with centered and 12 with decentered cones, we found that the UCDVA and CDVA improved more in the centered (UCVA: $P = 0.01$; CDVA: $P <0.0001$) than in the decentered group (UCVA: $P = 0.03$; CDVA: $P = 0.03$). The sphere, cylinder, spherical equivalent, steep and flat K improved postoperatively more in the centered than in the decentered group ($P < 0.05$). This may be attributed to the inadequacy of the treatment patterns of T-PRK to ablate and the inability of the broad beam CXL to treat decentered cones [Figs. 3-6].[29] Ideally CXL is done immediately after T-PRK in the same sitting,[27] and ACXL is preferred as it causes lesser postoperative haze as compared to the Dresden protocol.

Though T-PRK has been used for refractive correction in patients with forme-fruste keratoconus, in established cases its primary aim is regularization of the corneal surface. Simultaneous cross-linking leads to increase in the

biomechanical strength of the cornea as measured by corneal hysteresis and corneal resistance factor. In a recent study of 27 eyes of 27 patients with progressive keratoconus done with the Institute's Ethics Committee approval, T-PRK with simultaneous cross-linking using the Dresden protocol was performed. It was found that corneal hysteresis decreased temporarily from 8.42 ± 0.37 mmHg at preoperative to 7.73 ± 0.47 mmHg at 1-month postoperative ($P < 0.05$), but increased to 8.87 ± 0.27 mmHg at 12 months ($P < 0.05$). Similarly, the corneal resistance factor decreased temporarily from 8.54 ± 0.33 mmHg at preoperative to 7.65 ± 0.42 mmHg at 1-month postoperative ($P < 0.05$), but increased to 9.1 ± 0.19 mmHg at 12 months ($P < 0.05$). Thus, the biomechanical strength of the cornea decreased in the acute phase after treatment but improved on long-term follow-up.

Intrastromal Corneal Ring Segments

Intrastromal corneal ring segment (ICRS) implantation coupled with CXL is a viable treatment option for patients having moderate to advanced disease with a thickness of > 450 microns in the central 6 mm zone on tomography.[30,31] An ICRS can reduce the corneal steepening and decrease irregular astigmatism, thus potentially improving the visual acuity.[32-34] The rings are implanted in a channel made manually or by using a femtosecond laser under topical anesthesia
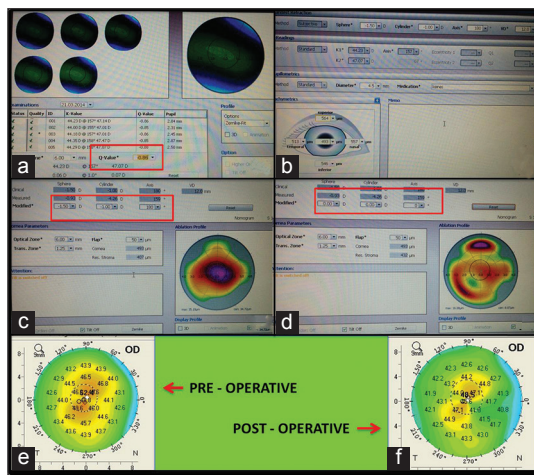

Figure 2: Planning topography guided photorefractive keratectomy. (a) The Q value and scans that are considered for planning treatment. The Q can be changed as per requirement. (b) The pachymetric data is entered. (c) The modified refraction is seen in the red box, one can correct the refractive error as per evaluation or proceed to (d). (d) The modified refraction is set to 0 when no refractive correction is planned (red box). (e) Preoperative topography of the patient. (f) Postoperative topography of the same patient
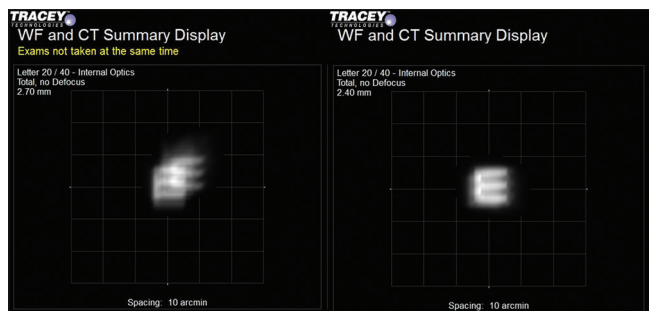

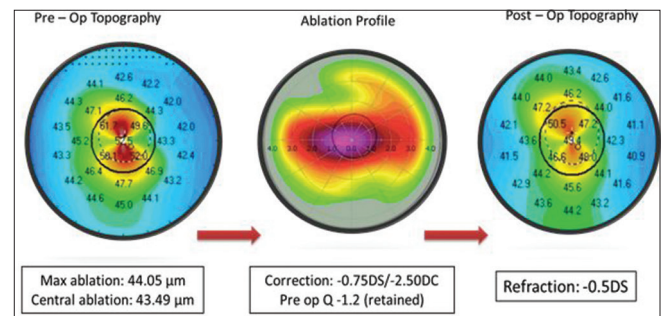**Figure 4:** Simulated Snellens E-chart

Figure 3: Topography guided ablation of the cornea in keratoconus with a central cone (in 3 mm zone). The preoperative topography (left) data is fed to the machine, which generates an ablation profile (middle). After deciding the treatment plan according to keratometry, pachymetry, Q value and spherical equivalent, Ablation is done leading to a more regular postoperative topography pattern
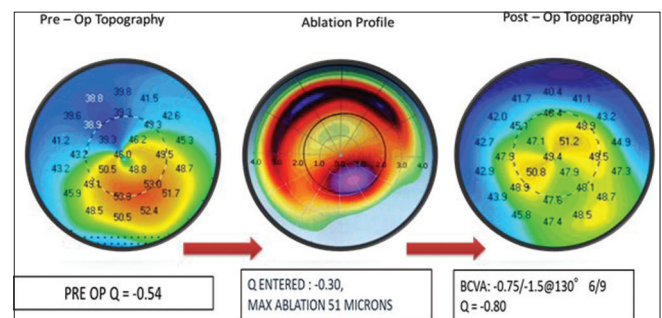

Figure 5: Topography guided ablation of the cornea in keratoconus with a decentered cone (>50% cone outside 3 mm zone). The preoperative topography (left) data is fed to the machine, which generates an ablation profile (middle). After deciding the treatment plan according to keratometry, pachymetry, Q value and spherical equivalent, ablation is done leading to a more regular postoperative topography pattern

with incisions for Intacs placement at the steep axis based on topography.[35] The depth of the channel is 70–75% of the minimum pachymetry in the area of ring implantation.[36,37]

Meticulous planning is a prerequisite while implanting ICRS to achieve optimal results with adequate flattening of the cornea. We have earlier reported a nomogram for Intacs in keratoconus for both centered and decentered cones [Fig. 7].[38] The above procedures when combined with CXL leads to stabilization of the disease [Fig. 8]. Our patients with advanced keratoconus who have undergone ICRS implantation with Intacs have shown an improvement in both spherical and cylindrical refractive error with a reduction in the average keratometry readings. The values have remained stable at 1-year follow-up with improvement in contact lens fit and better visual quality in 60% of patients.[39,40]

Step V: Surgical Management

In patients with advanced keratoconus with stromal scarring in the visual axis, treatment options such as contact lenses, T-PRK or ICRS may fail to improve the CDVA often requiring keratoplasty, either lamellar or full thickness, depending on the extent of the stromal scar.
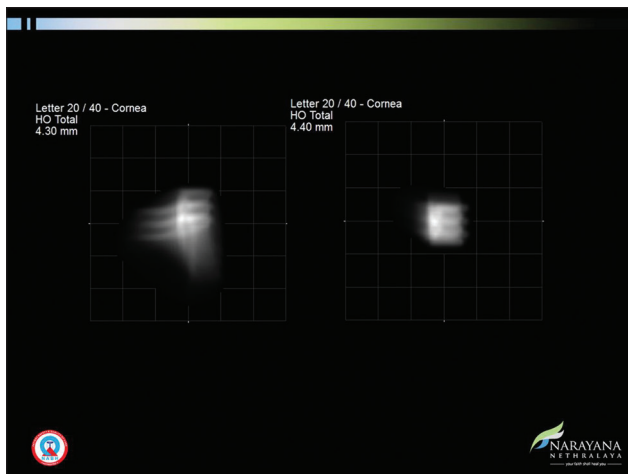

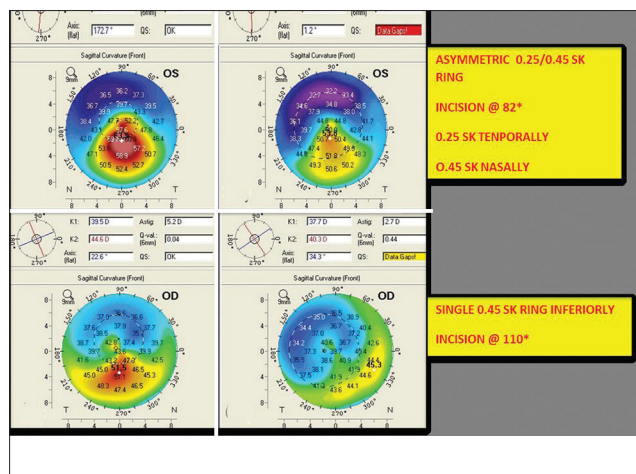**Figure 6:** Simulated Snellen's E-chart

Figure 8: Two patients who have undergone Intacs implantation showing improvement in keratometric values

Deep Anterior Lamellar Keratoplasty/ Femtosecond Enabled Keratoplasty

Deep anterior lamellar keratoplasty is indicated in advanced keratoconus with stromal scars.[41,42] It is cost effective with optical and visual quality comparable to PKP.[43] Our unpublished retrospective data of 46 eyes of 46 patients with a mean age of 23.45 ± 8.7 years revealed an improvement in the mean preoperative UCDVA, CDVA, spherical power, cylindrical power and spherical equivalent [Table 6]. There was no significant decrease in the mean endothelial cell count at the end of 2 years.

Femtosecond enabled the keratoplasty (FEK) is fast emerging as an alternative to manual or automated DALK. It has a higher precision with flexibility of wound construction in both the donor and the host cornea leading to better approximation and earlier wound healing. Our group has published the initial results of FEK with a 10 months follow-up.[44] We also analyzed all patients who have completed 2 years of follow-up with 40 eyes of 34 patients who underwent mushroom pattern FEK showing an improvement in UCDVA, CDVA, refraction and spherical equivalent [Table 7]. Wound edges had a good approximation with scarring by 4 months of follow-up allowing earlier suture removal and faster tapering of topical steroids. There was no evidence of graft rejection or primary graft failure in any of the cases [Fig. 9].

Rehabilitation

Patients who are intolerant to contact lenses and have a stable keratometry can be treated with ICL.[45] It is feasible in patients who have had a stable refraction for 3 consecutive months following procedures such as CXL or Intacs combined with
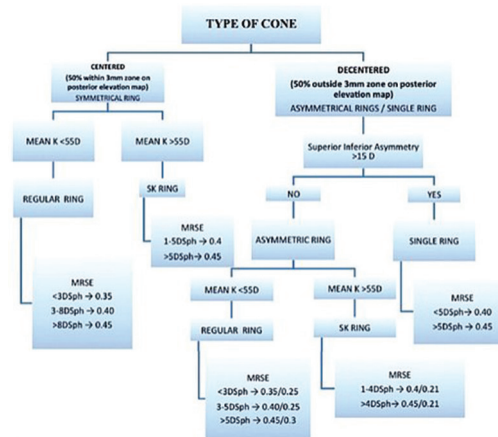

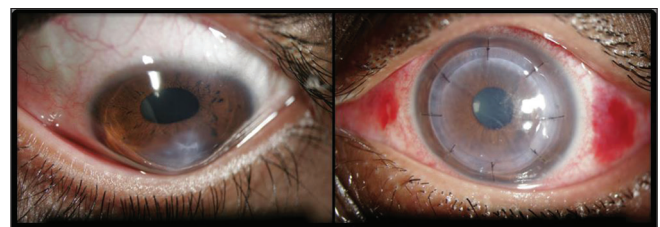**Figure 7:** Intacs nomogram[34] (with permission from IJO)

Figure 9: Pre- and post-operative day 1 images of a patient who has undergone femtosecond enabled keratoplasty

Table 6: Change in vision and refraction over 2 years in patients who underwent DALK

	Mean preoperative	Mean postoperative 2 years	P
UCVA	0.06±0.10	0.53±0.14	<0.001
CDVA	0.23±0.07	0.71±0.09	<0.001
Sphere (D)	−8.71±2.54	−2.23±3.86	<0.001
Cylinder (D)	−6.44±4.23	−2.74±2.33	<0.001
Spherical equivalent	−11.36±2.45	−3.91±1.56	<0.001

DALK: Deep anterior lamellar keratoplasty, CDVA: Corrected distance visual acuity, UCVA: Uncorrected visual acuity

Table 7: Changes in vision and refractive parameters in patients with advanced keratoconus who underwent femtosecond enabled keratoplasty at the end of a 2-year follow-up

	Mean preoperative	2 years postoperative (mean)	P
UCVA	0.05 (±0.12)	0.35 (±0.13)	<0.001
CDVA	0.25 (±0.19)	0.63 (±0.25)	<0.001
Sphere (D)	−8.37 (±4.23)	−0.73 (±1.22)	<0.001
Cylinder (D)	−7.56 (±4.77)	−1.74 (±1.35)	<0.001
Spherical equivalent	−12.15 (±3.45)	−1.60 (±1.75)	<0.001

CDVA: Corrected distance visual acuity, UCVA: Uncorrected visual acuity
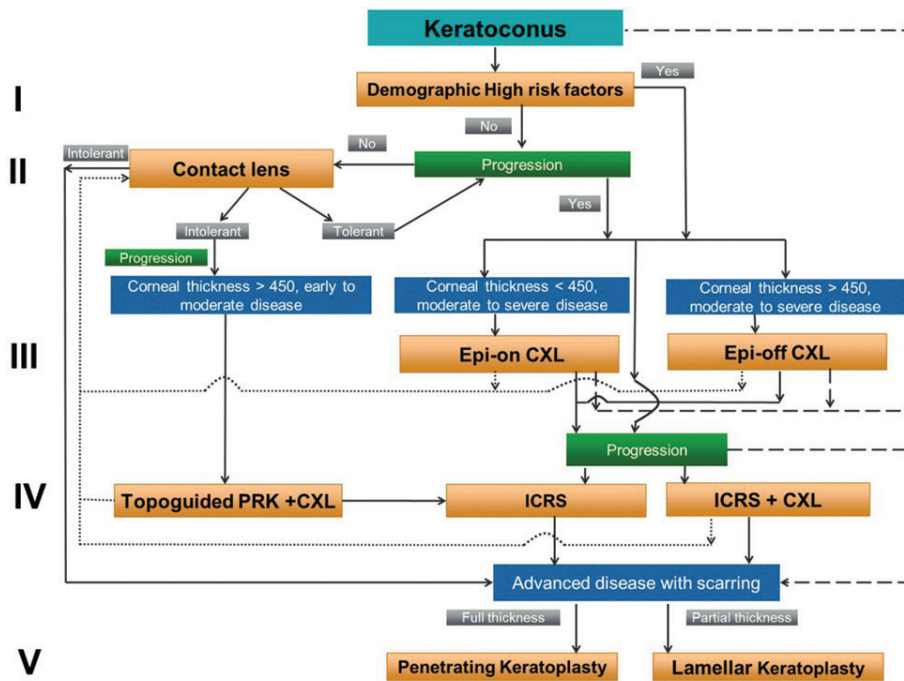
Figure 10: "Five point" management algorithm for keratoconus

CXL or DALK/FEK.[46] These patients should have a clear central cornea, keratometric values ≤52.00D with a central or centralized cone. In our study of ten eyes of seven patients,[47] the preoperative mean refractive spherical equivalent (MRSE) of −7.21 ± 2.25D decreased to −0.55 ± 1.53D at 6 weeks and −0.44 ± 1.21D at 6 months. Nine eyes (90%) had a stable MRSE. Visual quality indices correlated inversely with secondary coma ($P = 0.026$), negative vertical coma ($P = 0.014$), the root mean square of total aberrations ($P = 0.021$), and higher order aberrations ($P = 0.015$). Good refractive correction was achieved with toric ICL in these patients, but the gain in visual quality was limited in eyes that had an associated high corneal total and higher order aberrations.

Conclusion

The various management options available so far for keratoconus have been successful in stabilizing the progression (CXL) of the disease, reducing the refractive error or flattening the cornea (ICRS), reducing the surface irregularity (T-PRK) and in cases of advanced cases helping in visual rehabilitation (DALK/ PKP/FEK). However, there seems to be a lack of published data on selecting the best treatment modality for a particular stage of keratoconus. We therefore designed a simplified flow chart based on our practice patterns and personal observations, which could serve as a possible guideline for other clinicians [Fig. 10].

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