DISCUSSION

Keratoconus is a non-inflammatory disorder characterized by progressive corneal thinning, steepening and anterior protrusion of the cornea. These corneal changes result in irregular astigmatism and corneal scarring, both of which reduce the best-corrected visual acuity (BCVA) of the patient.[1,2,161] In early stages of the disease, spectacles may improve vision to an acceptable level. As the disease progresses, myopia and irregular astigmatism are significant and vision corrected with spectacles or soft contact lenses is no longer acceptable to the patient. Rigid gas permeable (RGP) contact lenses are the optimal treatment for keratoconus as they provide good vision by providing a new, regular optical surface.[1,161-163]

Nowadays, most studies in the literature are focused on the surgical management of keratoconus, e.g., intracorneal ring segments, lamellar and penetrating keratoplasty and even topography-guided photorefractive keratectomy. The visual results of these surgical procedures (quantitative and qualitative) are not always satisfactory to the patient and the doctor. Rigid gas permeable contact lenses still have a prominent role in providing the keratoconus patient with better vision (quantitative and qualitative) compared to all current surgical procedures.

The main aim of this study was to try to find a correlation between the topographic features of mild and moderate cases of keratoconus and the parameters of the rigid gas permeable contact lenses that gave them best-corrected visual acuity. This correlation – if found – would be used to guide the contact lens fitter finding the best lens for his/her keratoconus patient.

Topographically, the patients in our study were found to have two types of cones: nipple type and oval type.

Our results are divided into two categories: the clinical data, the topographic data and the correlation between the contact lens parameters and topographic parameters in both groups.

i. The clinical data:

1. Keratometry , topographic cylinder and subjective refraction astigmatism:

In our study there was no statistically significant difference between the nipple and oval cones regarding keratometry, topographic cylinder and subjective refraction astigmatism.

Nejabat M et al [164] in a study included 134 keratoconus patients (156 eyes, 76 eyes (48.6%) had nipple cone and 80 eyes (51.4%) had oval cone), found a statistically significant differences between the nipple cone and oval cone groups in values of keratometry, corneal cylinder and subjective refraction astigmatism. These findings were explained on the basis of the influence of the cone position on the visual axis. Nipple cone impinges upon and covers the visual axis and therefore results in higher values of astigmatism, flat meridian (Sim K1), steep meridian (Sim K2), and corneal cylinder compared with patients with oval cone. In patients with oval cone, the cone location is relatively outside the visual axis and has less effect on spherical and astigmatism refraction and also on K readings.

We think the difference in the results may be attributed to the large number of eyes and the more advanced cases that were included in Nejabat et al study (5% were mild, 61% were moderate and 53% were severe).

2. Visual acuity:

In our study, there was no statistically significant difference between the nipple cone group and oval cone group regarding the RGP corrected visual acuities. This was similar to the results of Nejabat M et al study (164). The finding that RGP corrected visual acuity is independent of the location of cone can be explained by the fact that regardless of the corneal topography, RGP contact lenses form a new, regular optical surface over the surface of the cornea and virtually neutralize the regular and irregular corneal astigmatism.

Our results showed that RGP lenses in comparison to spectacles, improved visual acuity in both oval and nipple cone groups (90% in the oval group and 85% in the nipple group). The number of eyes with 0.5 or better corrected vision was better in the oval group than in the nipple group with RGP lenses. These results are similar to the results of a study performed by Lin et al (165) on 25 patients (48 eyes) with keratoconus. In Lin et al study, the number of eyes with 20/40 or better corrected vision increased from 70.83% with spectacles to 97.92% with RGP fitting. In another study of Zadnik et al (166) on 1579 keratoconus cases, the number of eyes with 20/40 or better corrected vision increased from 58% with spectacles to 88% with RGP fitting [22]

ii. The topographic data:

Computer-assisted videokeratoscopes, which generate color-coded maps and topographical indices, are currently the most used devices for confirming the diagnosis of keratoconus.(2) Due to the irregular shape of the cornea, fitting the keratoconic patient with RGP lenses can be very difficult and time consuming. (120, 121, 167) The use of video-keratography for diagnosis of keratoconus is quite common but, its use in actually determining the contact lens parameters such as the BOZD and LD and how they relate to the shape and size of the cone has been under-utilized. (168)

The correlation between the contact lens parameters and the topographic data:

1. Base curve:

In our study 57.5 % of eyes were fitted steeper than the flat K obtained by placido-based topography, 27.5 % fitted flatter and 15 % fitted on K.

Woodward (169) found the initial base curve (BC) to be close to the flatter meridian in mild forms, but commented that keratometry becomes increasingly meaningless with more advanced keratoconus. Zadnik and Barr (170) suggested the initial BC should split the flat and steep readings, or should be slightly flatter than the average corneal curvature, but the final optimum BC must be determined by qualitative observation of the fluorescein appearance, and may need to be flatter or steeper. Edrington et al. (99) described a fitting protocol for the collaborative longitudinal evaluation of keratoconus (CLEK) study, in which the initial BC matched the steeper keratometry reading, and adjusted flatter or steeper until the desired appearance was reached.

We think that the variability in the relationship between the BC and keratometry is attributed to the geometry of the lenses used and the cornea-to-lens fitting relationship desired.

The lens geometry determines the starting point to a large degree: the CLEK study used a standardized lens design with a relatively small overall diameter and BC, 8.60 and 6.50 mm, respectively. In our study we used a trial lens set with variable back optic zone diameter (BOZD) and lens diameter, where steeper lenses have smaller BOZD and smaller lens diameter.

The fitting relationship also determines the final base curve. In our study we aimed for three point touch, but that was not possible in all cases. Three point touch is only possible when the topography within the area covered by the lens is virtually symmetrical around the cone axis. A marked difference in the clearance along the vertical meridian may be seen in other examples, with minimal clearance superiorly but excessive inferiorly. The difference in the clearance along the vertical meridian may be very pronounced due to the steeper corneal slope in the inferior sector compared to the superior. Three point touch may be reduced to two point touch along the vertical meridian and one point touch along the horizontal meridian. In these cases, flattening the BC or increasing the axial edge lift further increases the inferior clearance. Flattening the BC also causes more compressive apical contact and may make the lens more mobile, and increases the risk of apical erosions. Use of larger diameter lens may impinge more on the superior cornea; a smaller diameter is often selected but may increase the mobility or may cause the lens to lock in place at the cone apex. [171]

Keratometry gives an indication of the corneal irregularity, but apart from early low grade cases, its relationship with the base curve of the fitted lens is loosely correlated at best, and there are no clear guidelines or consensus for the interpretation of the readings.

2. Cone diameter , BOZD and lens diameter:

In our study we obtained two measurements from the tangential map, the cone peak diameter and the overall cone diameter.

There was negative correlation between the cone peak diameter and:

- K2 (in mm)
- Base curve
- BOZD and LD

These correlations were statistically significant only in the nipple cone group. That means with increasing steepness of the nipple cone the cone peak diameter increases as it becomes more conical in shape. In order to fit this cone, we need small BOZD and small LD.

Regarding the overall cone diameter, it was positively correlated with:

- K2(in mm)

- Base curve
- BOZD and LD

These correlations were statistically significant only in the oval cone group. That means the overall cone diameter is larger in flat cones and with increasing steepness of the cone, the overall cone diameter decreases.

Papers describing the use of small or large diameter lenses with either nipple or oval cones have been few. Lembach described the use of small 8.5–9.0 mm lenses for nipple cones and 9.2–9.7 mm for oval cones [(133)]. Edrington et al. [(172)] and Sorbara et al [(173)] mentioned that nipple cones will do better with small diameter lenses. Only Leung [(121)] and Ozkurt et al [(174)] discussed the BOZD of the lenses and their effect on the lens fit, pointing out that steep lenses have smaller BOZD which reduce the central sagittal depth of the lens and that too large BOZD may cause bubbles around the cone and sealing of the periphery of the lens to the cornea due to the increase in the sagittal depth of the lens.

Sorbara et al [(168)] in a cross-sectional observational study looked at the records of 100 keratoconic patients randomly chosen. The parameters of their most current lenses that they were successfully wearing on a full time basis were collected. The diameter of the nipple and oval cones were measured and related to the steepest K readings. To measure the size of the cone, a 1-mm grid was placed over the topographic map and the horizontal diameter of the cone was measured to one tenth of a millimeter. They studied the correlation between the cone diameter and BOZD. There was a significant correlation between the cone diameter and the BOZD only for the oval cones ($R= 0.54$, $p<0.05$, Tukey post hoc test).

From our results we can assume that in the nipple cones, the cone peak diameter is the determining factor for the cornea-lens fitting relationship; while in the oval cone the overall cone diameter is more important.

In our study we attempted to show that when the final BOZD and LD were correlated to the size of the cone, this may result in an adequate fitting relationship. Smaller diameter lenses with back optic zone diameters that get progressively smaller will center better as cones progress, and will minimize bubbles around the cone by minimizing the gap above and below the cone where pooling of tears would occur. This will result in better lens centration and alignment with the cone. On the other hand, larger diameter lenses with back optic zone diameters that get progressively larger will fit better for early cases.

One can see that utilizing the corneal topographical maps to identity cone types and cone size can direct CL fitting in determining the best lens fit. We can assume that in the cases where we cannot achieve adequate centration, we can modify the BOZD and LD to match the size of the corneal peak diameter in nipple cone and the overall cone diameter in the oval cone but this needs further studies with larger sample size to evaluate if this will increase the success of the fitting.

The short comings of our study were: the small number of eyes included in both groups, the narrow range of BOZD and lens diameter, and absence of control group to assess if there is a difference between fitting keratoconus with standardized trial lens set where all the lenses have the same BOZD/LD and trial lens set with variable BOZD/LD.

SUMMARY

Keratoconus is a progressive, bilateral but typically asymmetric, non-inflammatory ectasia of the cornea. The disease is highly variable in its course. Classically, keratoconus has its onset at puberty and is progressive for 10–15 years. This degenerative disorder is characterized by central corneal stromal thinning, apical protrusion, irregular astigmatism, and variable degree of scarring. The thinner apex becomes downwardly displaced giving rise to irregular astigmatism, a hallmark of the disorder, which results in mild to marked impairment in the quality of vision. Most keratoconic patients (74% of eyes) can be managed non-surgically, while the remaining (26%) are managed with keratoplasty.

Fitting of RGP lenses for keratoconus patients can be challenging, involving the trial of many diagnostic contact lenses before a suitable final lens can be prescribed to the patient. The use of corneal topography for diagnosis of keratoconus is quite common but, its use in actually determining the contact lens parameters such as the back optic zone diameter (BOZD) and lens diameter (LD) and how they relate to the shape and size of the cone has been under-utilized.

The purpose of this study was to examine the relationship between cone diameter, steepest K readings derived from corneal topography and the BOZD and LD of the contact lens fitted. The study included 40 eyes suffering from keratoconus. Keratoconus was diagnosed based on clinical findings and topographic findings. Patients who had a history of other ocular co-morbidity, amblyopia, or previous surgery or trauma were excluded.

All patients underwent complete ophthalmologic examination and corneal topography analysis. The tangential radius maps were used to define the exact size and location of the cone. The cones were subdivided into two categories: Nipple cones and oval cones

To measure the size of the cone, a screen caliper was placed over the topographic map and the horizontal diameter of the cone was measured to one tenth of a centimeter. Two measurements were obtained: the cone peak diameter and the overall cone diameter. The parameters of the lenses such as base curve, back optic zone diameter (BOZD) and lens diameter (LD) were recorded. The diameter of nipple and oval cones were measured and related to the steepest K readings and to the lens parameters.

- The mean cone peak diameter in the oval group was 2.89 ± 1.24 cm and in the nipple group was 2.44 ± 0.89 cm & the mean overall cone diameter in the oval group was 8.13 ± 1.21 cm and in the nipple group was 7.75 ± 1.25 cm. There was no statistically significant difference between both groups.
- There was no statistically significant difference between the nipple cone and oval cone groups regarding the BC, BOZD and LD.
- There was negative correlation between K2 and the cone peak diameter and positive correlation between the K2 and over all cone diameters. The only statistically significant correlation was between K2 and the overall cone diameter in the oval cone group.

- There was a negative correlation between the cone peak diameter and the base curve. This correlation was statistically significant only in the nipple cone group. There was a positive correlation between the base curve diameter and the overall cone diameter but it was statistically significant in the oval cone group.

- There was negative correlation between the cone peak diameter and BOZD. This correlation was statistically significant only in the nipple group. There was positive correlation between the overall cone diameter and BOZD but it was statistically significant in the oval group.

- There was negative correlation between the cone peak diameter and lens diameter. This correlation was statistically significant only in the nipple group. There was positive correlation between the overall cone diameter and lens diameter but it was statistically significant in the oval group.

From the results of our study we can conclude that utilizing the corneal topographical maps to identity cone types and cone size can direct CL fitter in determining the best lens fit. Smaller diameter lenses with progressively smaller back optic zone diameters will center better as the cone progress.

CONCLUSIONS

1. The oval and nipple cones are equally common in keratoconus. While the globus cone is uncommon.

2. The relationship between the base curve of the RGP lenses and the keratometry readings is variable. This variability stems from the differences in the methods used to measure the corneal power, differences in lens design and the fluorescein pattern desired.

3. There is no single fluorescein pattern that can be obtained in all cases. If the practitioner could not obtain the fluorescein pattern desired, evaluation of the fit should depend on the lens mobility and comfort with modification of the lens parameters to give the best fit for the patient.

4. Using the topography to detect the type of cone may direct the practitioner to the lens parameters needed.

5. In the nipple cone group, with increasing steepness of the cone the cone peak diameter increases so smaller diameter lenses with smaller back optic zone diameters will fit better in steep cases.

6. In the oval cone group, the overall cone diameter increases with increasing flattening of the cornea so larger diameter lenses with larger back optic zone diameter will fit better in oval flat cones.