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ORIGINAL RESEARCH ARTICLE

THE EFFECTS OF SOFT CONTACT LENS WEAR ON CORNEAL THICKNESS, CURVATURE AND SURFACE REGULARITY

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ABSTRACT

Contact lenses have various cosmetic and optical advantages over spectacles. However, long term lens use might affect the normal corneal anatomy and physiology in a variety of ways. The aim of this study was to determine the effect of soft contact lens wear on corneal thickness, curvature, and surface regularity.A total of 138 eyes of 69 subjects wearing contact lenses for more than 1 year were evaluated. One eye of each case was randomly selected for the analysis. Nidek Magellan Mapper corneal topography system was used to evaluate the anterior corneal topography. Central corneal thickness (CCT) was measured using Quantel Medical Axis II PR.Corneal topography and CCT measurements on 138 eyes of 69 subjects were performed. The mean age of the cases and controls was 24.76 ± 5.52 25.13±5.49 years respectively. The mean duration of contact lens wear was 4.83±4.19 years. The mean CCT in case and control group was 527.56±37.40 microns and 544.60±26.10 microns respectively. The mean central corneal thickness in the cases was significantly less by about 16.31 µm in comparison to controls (P <0.05, 95% CI of the difference: 9 µm - 24µm). The SRI and SAI indices were significantly greater in contact lens wearers than in the control group (P = 0.00 for both SRI and SAI).Regular corneal pachymetry and topography assessments are mandatory in soft contact lens users as long term lens wear appears to reduce the central corneal thickness and increase the corneal surface irregularity.

Key Words: *Central Corneal Thickness, Potential Visual Acuity, Soft Contact Lens, Surface Asymmetry Index, Surface Regularity Index.*

INTRODUCTION

Contact lenses are one of the commonest modes of refractive error correction. They are much better than spectacles in various optical aspects. The quality of vision is always protected in different fields of gaze and oblique astigmatism, and various prismatic effects in anisometropic eyes can be avoided, where the spectacles prove to be unsuccessful.[1] Furthermore, the use of contact lenses increases visual acuity to an optimal level, removing the burden of wearing spectacles and securing cosmetic appearance. Although contact lenses have the advantages of providing a larger field of vision and keeping retinal image sizes close to normal, they also have some disadvantages. Contact lens wear has been reported to interfere with normal corneal physiology in a number of ways. It can lead changes to corneal curvature and refractive status of the eye for several days even after discontinuation of contact lenses; [2] moreover, it also leads to changes in corneal surface regularity and alteration in corneal thickness. [3,4,5] However, great individual variations have been noted in these effects; some patients showing chronic corneal thickening while others showing thinning after 18 months of wearing the lenses. [6] Rigid contact lens wear, and to a lesser degree soft contact lens wear, have been observed to cause significant shifts in refraction for weeks after cessation of wear, making spectacle vision correction, or refractive surgery targeting, difficult.[7]

The shape of the anterior cornea may be affected by changes in the normal metabolism (e.g., induced swelling) caused by induced hypoxia or by mechanical forces induced by chronic microtrauma caused during lens wear. Anterior corneal topography changes have been noted with many types of contact lenses including poly(methyl methacrylate), [8] rigid gas permeable [9,10] and soft contact lenses (hydrogels [11,12] and silicone hydrogels [13]). They are associated with central corneal steepening or flattening, [2] changes in regular or irregular astigmatism and loss of radial symmetry. [14] It is interesting to see previous reports which show increase in corneal thickness in subjects who have worn contact lenses for a period of 3 hours to 3 months. [16,17,18] In contrast, a decrease in corneal thickness is reported to occur in individuals who had worn contact lenses for at least several months to years. [2,6,19] It has been reported that Soft and PMMA lenses both induce corneal swelling evaluated after 3 hours of contact lens wear. Both lens types produced greater central vs. peripheral corneal swelling. However, the soft lens induced significantly greater overall swelling than that of PMMA. [20] The frequent-replacement contact lenses, however, cause a small amount of corneal edema, higher in the periphery than in the center. Central corneal swelling disappeared after 6 weeks of wearing. [21] Previous reports have found mild reduction (8–11 m) in average central corneal pachymetry in long-term wearers (3–5 years) of both rigid and soft lenses; [22,23] although a recent report showed a decrease in corneal thickness with long-term contact lens wear that was greater with rigid contact lenses than with soft contact lenses. [2,5]

Corneal thickness is a critical variable when considering any refractive eye surgeries and the risk of iatrogenic keratectasia is a concern when assessing any candidate for keratorefractive surgery. [24-26] Hence, evaluation of corneal thickness is mandatory for those patients who have been using contact lenses for several years and are destined for laser surgery.

The effects of long term contact lenses wear on corneal topography and thickness have been reported with wide range of findings from different countries. This study was an approach to establish those changes among individuals of Nepal and compare our results with other similar studies across different geographical regions because the wearing modality and type of lenses used vary considerably among different countries. Thus, we conducted a case-control study among the contact lens users in Nepal to confirm the association of long-term soft contact lens wear with corneal curvature, corneal surface regularity and central corneal thickness.

MATERIALS AND METHODS

This study was a hospital-based, case-control study. The place of study was BP Koirala Lions Center for Ophthalmic Studies (BPKLCOS); a tertiary eye care center of Nepal. The patients attending contact lens clinic of BPKLCOS wearing soft contact lenses for more than 1 year were included in the study. The study period was of one year (November 2010 to October 2011). All of our study participants were myopic and using soft contact lenses for more than 1 year. Hyperopic contact lens users were not enrolled as we encountered only very few of them during our study period. Patients with known history of ocular pathology, corneal disease or previous ocular surgery, RGP contact lenses users and those not willing to participate were excluded from the study.

Informed verbal consent of every patient was obtained. The tenets of the declaration of Helsinki were followed for examination of all human subjects. The study was approved by Institutional review board of Institute of Medicine, Tribhuvan University, Kathmandu, Nepal. All the relevant patient particulars were noted on the proforma specially designed for the study which included: age and sex, type of contact lens used, contact lens material, contact lens power, refractive error, duration of lens wear and contact lens wearing time (hours /day).

The Nidek Magellan Mapper corneal topography system was used to evaluate the anterior corneal topography. Patient was advised to place their chin on chinrest, forehead on headrest and fixating on the target, the recordings were considered valid when all the axes (x, y, and z) coordinate values turned green. Manufacturer's recommendations were followed for all recordings. The topographical indices included were: Simulated Keratometry (Sim K1 and Sim K2), Minimum Keratometry (Min K),Surface Regularity Index (SRI),Surface Asymmetry Index (SAI) ,and Potential Visual Acuity (PVA).

Quantel medical Axis II PR was used for measuring central corneal thickness. The ocular surface was first anesthetized with 4% xylocaine. With subjects in sitting position and fixating a target located about 6 meters away, the probe was gently placed perpendicularly to the central (3mm) corneal plane to record the measurements. The mean of 5 consecutive readings with standard deviation no more than 5 microns was recorded as mean CCT.

Control Group was defined as: age, sex and refractive error matched normal subjects having; no complaints of ocular irritation, no history of contact lens use, no corneal fluorescein staining, no anterior segment abnormality on biomicroscopic examination.

Our study comprised only users who wore spherical soft contact lenses. Though we had few patients (2) using soft toric contact lenses, they were excluded from the study in order to avoid biases. All of them wore frequent replacement lenses on a daily wear basis. The material of contact lens used by all users was PHEMA (poly hydroxyl ethyl methacrylate) having water content of 45%. To avoid short term effects of contact lens on corneal physiology, all the examinations were performed after contact lenses had been removed for at least 1 week. Data was analyzed with a computer software program SPSS version 17.0 and Microsoft Excel version 2010.

RESULTS

Total of 138 eyes of 69 subjects wearing soft contact lenses for more than one year were evaluated for corneal topography and central corneal thickness. Each of the cases was compared with age, sex and refractive error matched controls. One eye of each case was randomly selected and was compared with the randomly selected eye of the control. There was a female predominance (85.5%) in our contact lens user group. The mean age of the cases and controls was 24.76±5.52 and 25.13±5.49 years (age range 18 - 47 years) respectively.

The average duration of contact lens wear was 4.83±4.19 years (range 1-22 years). The mean contact lens wearing time was 10.27±1.91 hours per day and, 6 days per week. The mean refractive error in cases and the control group was -4.40±2.56 D (range -0.75to -14.00 D) and -4.15±2.09D (range -1.00to-13.00 D) respectively. The mean contact lens power was -3.97±2.20D. (range: -0.75to -13.00 D).

Mean Topographic and Pachymetry Indices

The Mean of Simulated Keratometry (Sim K1) & (Sim K2) and Minimum Keratometry (Min K) were found slightly flatter in eyes of contact lenses users however the difference with control group was both statistically and clinically non-significant. Compared to normal eyes, the eyes wearing contact lenses had significantly greater SRI and SAI values. No significant difference was observed in the PVA index between the two groups. The mean central corneal thickness was reduced in contact lens users in comparison to normal controls and the difference was statistically significant (p=<0.05). The mean central corneal thickness was 17.04±5.50µm (9 to 24 µm) thinner in subjects wearing contact lenses than in normal eyes. The mean of topographic and pachymetry values are shown in Table 1.

Table 1: Topographic and pachymetric data between cases and controls

Corneal Parameters	Type of patient		P Value
	Case	Control	
SimK1(D)	44.03±1.84	44.33±1.45	0.294
SimK2(D)	44.73±1.92	44.80±1.46	0.816
MinK (D)	43.80±1.80	42.86±7.59	0.316
SRI	0.35±0.23	0.18±0.18	< 0.05
SAI	0.37±0.08	0.26±0.12	< 0.05
PVA	1.31±0.17	1.34±0.22	0.315
CCT(µm)	527.56±37.40	544.60±26.10	< 0.05

No statistically significant correlation was found between central corneal thickness and duration of contact lens wear(r=0.001 and P = 0.994) Although, a weak positive correlation was found between SRI and duration of contact lens wear, it was not statistically significant(r=0.155, P=0.205)(figure1)

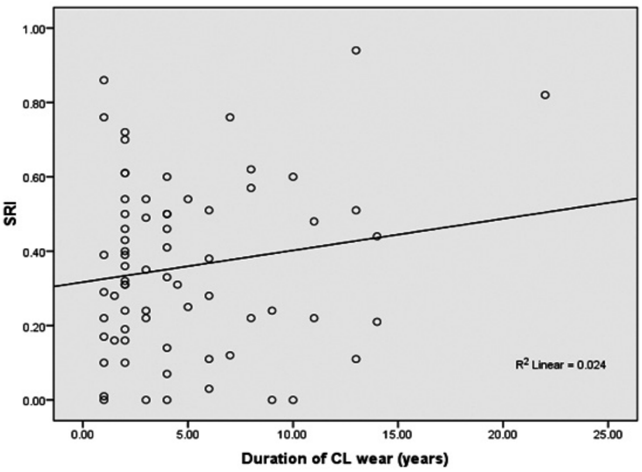

Fig 1: Correlation between duration of contact lens wear and SRI.

A weak positive correlation between SAI and duration of contact lens wear was observed although it was also statistically not significant (r= 0.142, P=0.245).

Although a strong negative correlation was found between central corneal thickness and contact lens wearing time it was statistically not significant (r= -0.87, p=0.479). There was no correlation between SRI and contact lens wearing time No correlation was found between SAI and contact lens wearing time.

No statistically significant correlation was observed between central corneal thickness and degree of myopia (D) in subjects wearing contact lenses (r=-0.075, P =0.382). To confirm this observation, the correlation between corneal thickness and degree of myopia was also evaluated in the control group of 138 eyes of 69 normal myopic subjects with no history of contact lens wear using the same instrument. The mean diopters of myopia in these subjects was-4.21± 2.01 D (range: -1.00– -10.25 D) and their mean central corneal thickness was 544.03±25.55 µm (range: 480-616 µm). No correlation was noted between central corneal thickness and degree of myopia in this group (r=-0.079 P =0.356) as well. (Figure 2).

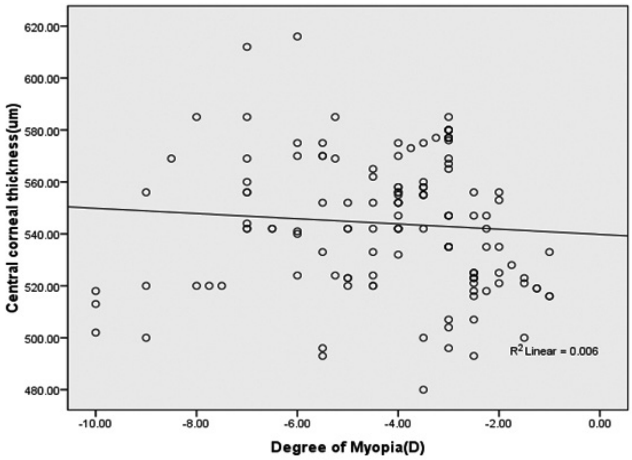

Fig 2: Correlation between degree of myopia and central corneal thickness.

No significant difference between normal eyes and eyes wearing contact lenses was noted in the color patterns of the anterior corneal surface elevation maps and curvature maps as measured by the Magellan Mapper Corneal topography System

DISCUSSION

Our results show that females were predominant in our contact lens user population. The reason for this might be, females being cosmetically more aware in their appearance than males. All of the study participants were using daily wear frequent replacement lenses. Two participants who we encountered during the initial phase of our study using monthly disposable lenses were later excluded due to their inadequate number and to avoid heterogeneity in the sample. Most of our study participants were using frequent replacement lenses which might suggest inadequate availability of other lens types in Nepal or one of the cost effective methods for using contact lenses in a developing country as these lenses are considerably cheaper than other lenses.

Although there are various advantages of contact lens wear, there are a range of anatomical and physiological effects in the cornea that a contact lens wear might induce. Contact lens on human cornea acts as a barrier to normal physiological process which affects the regular metabolic activities. Contact lens wear may cause corneal curvature alterations. These changes occur as a result of corneal hypoxia and mechanical effects on the cornea and are accepted normal in some definite limits. Nutrition of the cornea depends on glucose diffusing from the aqueous humor and oxygen diffusing through the tear film. In addition, the peripheral cornea is supplied with oxygen from the limbal circulation. Contact lens wear reduces the oxygen supply and changes the corneal physiology by mechanical effects. Glycogen that is stored in the cornea can be metabolized in an aerobic or anaerobic atmosphere when the tissue needs additional energy in emergency situations, such as hypoxia and trauma.[2] Hypoxia, which can be caused by contact lens wear, increases anaerobic metabolism and decreases aerobic metabolism. Anaerobic metabolism provides less energy than aerobic metabolism, so glycogen storages in the epithelium are reduced. As a result, this causes corneal edema because of lens-induced hypoxia and mechanical effects resulting in corneal curvature alterations. Liu and Pflugfelder[5] investigated the effects of rigid gas permeable and soft contact lenses on corneal curvature and corneal thickness in 64 eyes of 34 patients who wore contact lenses for 5 to 35 years. They found a significant increase in minimum K and maximum K values. Sanati and Temel did not observe any significant corneal curvature changes with soft contact lens wear, but noted a significant flattening in the steep meridian. Montenegro et al. also reported that rigid gas-permeable contact lenses induced corneal curvature more often than did soft contact lenses.

Some studies have reported an increase in corneal curvature, whereas others have noted either decreased or no change. [2] In our subjects, Sim K values being 44.03±1.84 and 44.73±1.92 in cases and 44.33±1.45 and 44.80±1.46 in controls; mild decreased corneal curvature was observed but it was not significant both statistically and clinically.

The surface regularity index (SRI) and surface asymmetry index (SAI), indices evaluate corneal surface regularity. The SRI is determined from a summation of local fluctuations in power along 256 equally spaced hemi meridians on the 10 central mires. The SAI is a centrally weighted summation of the differences in corneal power between corresponding points 180° apart on 128 equally spaced meridians that cross the four central photo-keratoscope mires. Both of these indices will increase with increasing irregular corneal astigmatism. Miller estimated that regular or irregular astigmatism is induced in 70% of contact lens wearers.Indeed; both SRI and SAI were increased in the contact lens wearers in this study compared to the non-contact lens wearing controls. Possible causes for this observation include hypoxia, chronic microtrauma and surface molding induced by contact lenses. Corneal surface irregularity has been reported to resolve after discontinuing contact lenses; however, irregularity was still present in our subjects who had discontinued contact lens wear for at least a week prior to the examination.

Liu and Pflugfelder[5] had observed an increase in surface regularity index, surface asymmetry index, and indices of TMS-1(Topographic Modeling System), but no difference in the mean corneal astigmatism in 64 eyes of 34 patients who wore contact lenses for 5 to 35 years which was similar to our findings. Numerous studies have shown that contact lenses affect corneal thickness. Corneal thickness was reported to increase in a period of 3 hours to 3 months after contact lens wear. [16,17,18] In contrast, a decrease in corneal thickness was reported to occur in individuals who had worn contact lenses for at least several months to years after several months. [2,6,19] After 18 months of contact lens wear, corneal thinning was seen in some patients while corneal thickening in others. [2]

Because contact lenses induce hypoxia, it causes an increase in anaerobic metabolism, increasing lactate levels and causing stromal swelling. However, a specific reason has not been found for long-term corneal thinning. Some investigators have pointed out that chronic stromal edema and biochemical changes in corneal stromal composition may contribute to corneal thinning. Also, increased tear osmolarity and chronic exposure to a hyperosmotic tear film has been reported to be capable of inducing generalized corneal thinning. Increased keratocyte apoptosis in the anterior corneal stroma has been observed. Interleukin 1 (IL-1) released from traumatized corneal epithelial cells has been implicated as a cause of this keratocytes apoptosis. Preliminary investigations performed by Zuguo Liu and Stephen C. Pflugfelder have found a significant elevated concentration of IL-1a in the tear fluid of contact lens wearers compared to normal controls.[5] Chronic microtrauma and hypoxia induced by contact lenses, especially wear from poorly fitting contact lenses, may contribute to these elevated levels as well.

Liu and Pflugfelder[5] pointed out that the corneal thicknesses of rigid gas-permeable contact lens wearers were less than those of soft contact lens wearers. [7] They also evaluated the corneal thickness, curvature, and surface regularity changes of 64 eyes of 35 patients wearing contact lens (84.3% soft lens wearers and 15.6% rigid gas-permeable lens wearers) over 5 years and compared the measurements with healthy subjects. They pointed out that the corneal thicknesses of contact lens wearers in the central and eight peripheral regions were 30 to 50 μm thinner than the measurements of healthy subjects. They further reported that the central corneas of rigid gas-permeable contact lens wearers were thinner than those of soft contact lens wearers. In our study, we have evaluated a group of contact lens wearers with average contact lens wear experience of 4.83±4.19 years and found that the CCT was thinner by 9 to 24 μm in comparison to age-matched controls. Thus, our data support the need for future prospective studies to evaluate the relative risk of corneal thinning with different contact lens materials. It is necessary and important to measure the corneal thickness in all contact lens wearers who are considering corneal refractive surgery, especially those who have worn contact lenses for many years to see whether the thickness is safe for undergoing corneal surgery or not.

No correlation between the duration of contact lens wear and central corneal thickness was observed in our study unlike the study done by Pflugfelder et al where they found significant negative correlation to the length of time contact lenses were worn. The probable reason for this might be the small range of wearing duration in our study; mean=4.83±4.19 years (range: 1-22 years) whereas the mean duration of contact lens wear in their study was 13.45 ±6.42 years (range: 5–35 years).

Correlation was not found between the duration of contact lens wear with SRI and SAI. Similarly, no correlation was observed between contact lens wearing time and CCT, SRI or SAI. This might be due to variation in duration of CL wear and contact lens wearing time.

We also examined the possibility that corneal thickness is correlated with the degree of myopia. Poor correlation between central corneal thickness and the degree of myopia was found in our study which is consistent with the previously reported studies.

CONCLUSION

Long term soft contact lens wear significantly reduced the central corneal thickness and increased corneal surface asymmetry and surface irregularity as compared to non-contact lens wearers. In this modern era of refractive surgery it would also be imperative to measure the corneal thickness and topography during the preoperative evaluation of patients, especially with longer duration of CLs wear, to determine whether one is suitable of undergoing corneal surgery. It is also important to monitor any physiological and anatomical changes that contact lens wear might have induced to prevent further complications.

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