The Basis of Corneal Biomechanics in Overnight Orthokeratology

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IRB approved research study at Salus University

Purpose

This pilot study's primary aim is to investigate the relationship between corneal biomechanics and the effect on vision shaping treatment (VST). These factors include corneal hysteresis, corneal resistance factor, and pachymetry. These values will be compared to the corneal surface's dioptric change, the effect on refractive error, and visual acuity improvement after one night of orthokeratology wear.

Methods

This research study took place at The Eye Institute (TEI) at Salus University. Dr. Feng recruited 12 subjects through email. Informed consent was obtained before data collection.

Inclusion Criteria: 2nd - 4th-year students optometry students, 19 to 39 years old with a moderate amount of myopia, spherical Rx in the least myopic meridian at least -1.00 to -5.00D) and astigmatism (0 to 1.50D) at any axis, must be knowledgeable in the insertion and removal of orthokeratology contact lenses

Exclusion Criteria: 1st-year optometry, all hyperopia, astigmatism >1.50D, known history of corneal degenerations, dystrophies, dysgenesis, ectasia, previous corneal surgeries, presbyopia, and pregnant females

Data Collected: corneal hysteresis (CH) and corneal resistance factor (CRF) using Ocular Response Analyzer (ORA), unaided Snellen visual acuity, topography, and pachymetry using Pentacam, and cycloplegic refractive error using the autorefractor. Data was collected at two appointments, at baseline, and at the one-day follow-up

Euclid generously provided lenses that were empirically designed using topographic maps and refraction we sent. Lenses were dispensed to the subject without an appointment, no fluorescein pattern, and vision assessment before wear

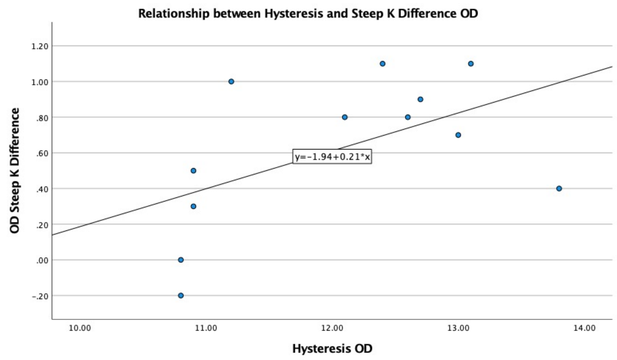
Subject's Schedule: subject decides to participate → subject makes an appointment for baseline measures → subject will get a call when CLs are ready to be picked up at TEI → follow-up appointment made within five weeks of baseline, ensuring PIs are present at clinic and when patients can guarantee at least eight hours of nighttime wear the night before the visit → subject to remove lenses upon awakening → subjects to present for follow up appointment within three hours of awakening → follow up examination → subject participation is completed

Conclusion

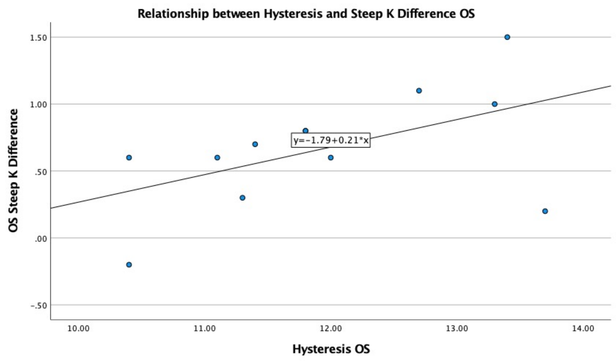
This study recognized the influence corneal biomechanics had on overnight orthokeratology; however, results were not statistically significant, and there was a limited sample size. Future extensive studies are needed to explore this hypothesis. Studying the rate of regression of corneal treatment concerning corneal hysteresis could also yield beneficial data.

References

1. González-Méijome, J. M., Villa-Collar, C., Queirós, A., Jorge, J., & Parafita, M. A. (2008). *Pilot Study on the Influence of Corneal Biomechanical Properties Over the Short Term in Response to Corneal Refractive Therapy for Myopia. Cornea, 27(4), 421–426.*



GRAPH 1: Relationship between Hysteresis and Steep K difference OD



GRAPH 2: Relationship between Hysteresis and Steep K difference OS

Correlations

		CRFOD	HysteresisOD	ODacuitydiff	ODflatdiff	ODsteepdiff
CRFOD	Pearson Correlation	1	.875**	-.180	.110	.595*
	Sig. (2-tailed)		<.001	.575	.734	.041
	N	12	12	12	12	12
HysteresisOD	Pearson Correlation	.875**	1	-.191	.074	.532
	Sig. (2-tailed)	<.001		.552	.819	.075
	N	12	12	12	12	12
ODacuitydiff	Pearson Correlation	-.180	-.191	1	.365	-.209
	Sig. (2-tailed)	.575	.552		.243	.514
	N	12	12	12	12	12
ODflatdiff	Pearson Correlation	.110	.074	.365	1	.474
	Sig. (2-tailed)	.734	.819	.243		.120
	N	12	12	12	12	12
ODsteepdiff	Pearson Correlation	.595*	.532	-.209	.474	1
	Sig. (2-tailed)	.041	.075	.514	.120	
	N	12	12	12	12	12

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

TABLE 1: Correlations table OD

Correlations

		CRFOS	HysteresisOS	OSacuitydiff	OSflatdiff	OSsteepdiff
CRFOS	Pearson Correlation	1	.955**	.165	.337	.569
	Sig. (2-tailed)		<.001	.609	.284	.054
	N	12	12	12	12	12
HysteresisOS	Pearson Correlation	.955**	1	.054	.187	.522
	Sig. (2-tailed)	<.001		.867	.560	.082
	N	12	12	12	12	12
OSacuitydiff	Pearson Correlation	.165	.054	1	.283	.124
	Sig. (2-tailed)	.609	.867		.373	.701
	N	12	12	12	12	12
OSflatdiff	Pearson Correlation	.337	.187	.283	1	.850**
	Sig. (2-tailed)	.284	.560	.373		<.001
	N	12	12	12	12	12
OSsteepdiff	Pearson Correlation	.569	.522	.124	.850**	1
	Sig. (2-tailed)	.054	.082	.701	<.001	
	N	12	12	12	12	12

**. Correlation is significant at the 0.01 level (2-tailed).

TABLE 2: Correlations table OS

Results

Tables 1 and 2 presents the correlation data for the right and left eyes, respectively, for CH, CRF, acuity improvement, flat keratometric (Kf) change, and steep keratometric (Ks) change. Correlations with simulated keratometry value and hysteresis were explored in detail because it mainly pertains to our initial hypothesis that corneas with lower hysteresis value would show greater keratometric change. All values display a positive correlation; however, the Ks showed a higher Pearson Correlation score (0.532 OD and 0.522 OS) than Kf. This means a more significant effect is observed when CH is increased, displayed in Graph 1 for OD and Graph 2 for OS. However, both were statistically insignificant. Hysteresis, in correlation with visual improvement, had variable results. The right eye displayed a negative correlation with a Pearson coefficient of -0.191. The left eye showed a positive correlation with a Pearson coefficient of 0.054. Both were statistically insignificant. Lastly, we analyzed if the dioptric change in simulated K values correlates precisely with the change in the spherical component of the refraction. There appears to be no one-to-one correlation in our study.

Discussion

This study revealed several findings which may be impactful to the practice of orthokeratology. Corneal hysteresis is an inherent biomechanic property of the cornea and can be measured using the ORA. It is used to differentiate the biomechanical behavior or ectasia and post-refractive corneas against the normal corneas in clinical practice. Our research study analyzed corneal hysteresis impact on vision shaping therapy. Jose Gonzales-Meijome et al. concluded a fast response to orthokeratology treatment with a lower CH and CRF. Their most clinically significant value was CH on Ks. They concluded this to be the case because the steep meridian has the largest difference in relation to an orthokeratology lens's base curve, which would justify the most significant change and relation with corneal biomechanics[1]. However, our results contradict their conclusion based on the data we gathered. We found a greater change in the steep keratometry when corneal hysteresis increased. The higher resistance cornea here showed a faster response. Another conclusion we drew was that wet autorefraction showed no correlation to corneal dioptric change. This is a commonly described metric in monitoring orthokeratology patients; the data supports looking at these findings independently.

One potential limitation of this study is ordering our lenses empirically and not ensuring a good fit ("bulls-eye pattern") before dispensing the lens. A poorly fitting lens can lead to poor outcomes, subsequently skewing the data set. Another limiting factor is our sample size of 12 subjects. Future studies involving a larger cohort of subjects may be beneficial in establishing better conclusions about biomechanics. Another limiting factor is measuring post-orthokeratology refraction using the autorefractor instead of performing subjective refraction. Some subjects had a worse cylindrical refraction post lens wear than before wearing. There could be a poor equivalence between the autorefractor and subjective refraction due to an increase in higher-order aberrations post-treatment. Another major concern with our study is the variability of refractive error of our study's cohort. Subjects with more mild myopia will have more minor refraction changes than patients with more moderate/high myopia, even if they have the same hysteresis. Future studies should consider consistent variables (refractive error, corneal curvature) so corneal hysteresis impact on overnight orthokeratology can be more thoroughly examined.