AXIAL LENGTH CHANGES ASSOCIATED WITH ORTHOKERATOLOGY TREATMENT PROCEDURES

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ABSTRACT

This investigation was one component of the multifaceted FSU College of Optometry Orthokeratology Study. Specifically, this investigation was designed to assess the changes that occur in axial length as a result of orthokeratology contact lens fitting procedures. Ultrasound A-scan biometry for axial length was performed pre-treatment and at approximately two months into treatment on ten randomly selected orthokeratology patients. Results showed an unpredicted slight mean increase in axial length of 0.174 ± 0.108 mm. This finding suggests that the myopia reduction associated with orthokeratology procedures results to a greater extent from the increase in the radius of curvature and sphericalization of the cornea than from any changes in the eye's overall axial length.

INTRODUCTION

The eye's refractive status is a result of five interrelated optical variables. Namely, the power of the cornea, the power of the crystalline lens, the depth of the anterior chamber, the index of refraction of the media, and the axial length of the eye combine to create the refractive state. Of these physical variables, the cornea is most accessible and the easiest to manipulate.

Orthokeratology procedures are based on the manipulation of corneal curvature through the use of specifically designed rigid gas permeable lenses of moderate to high Dk. The goal of the procedures is to safely and effectively reach an emmetropic refractive state which can be maintained through the minimal use of retainer lenses. The best candidates for emmetropization have been found to be myopes of less than 6.00 diopters with less than 3.00 diopters of astigmatism. In addition, corneas with keratometry readings from 40.00 through 46.00 diopters which are steeper in the center and flatter in the periphery are most likely to give the best response.[1]

Reaching a state of emmetropia usually involves three to five sets of progressively flatter lenses. Eventually, a plateau will occur where the patient achieves maximum unaided visual acuity. It is at this stage that a retainer lens is designed for minimal wear to maintain the plateau of maximum unaided visual acuity. The time it takes to reach the plateau stage varies from patient to patient (and from study to study), but recent studies have reported a time frame of one to six months with most changes accomplished in three months.[2]

Many of the early controlled orthokeratology studies

expressed a concern that although orthokeratology is a safe procedure, the responses are variable, unpredictable, and uncontrollable.[3-5] Additionally, many of these extensive studies were unable to agree upon the exact mechanism by which orthokeratology occurs, i.e., which specific structures change as a result of orthokeratology.

Present day thinking, although varied, most often assumes that the refractive changes that occur are a result of reduced central corneal curvature and sphericalization of the cornea.[2,6] This investigation was designed to contribute to the rather limited body of knowledge relating to the ocular structural changes associated with orthokeratology.

METHODS

Ten patients were randomly selected from the list of twenty patients who were initially recruited to participate in the FSU College of Optometry Orthokeratology Study. As an initial assessment to determine if the patient met the selection criteria, patients were required to have had a complete optometric primary care examination within the year. To qualify for the study, patients needed to have between one and four diopters of myopia with less than one diopter of astigmatism, each eye correctable to 20/20, and to be free of systemic and ocular disease.

Once the ten study patients were established, an axial length measurement was performed on each eye of each patient. This measurement was performed by a single experimenter and before any orthokeratology procedures were begun with the patient.

The instrument used to measure axial length was an OPHTHASONIC A-Scan/B-Scan III Ultrasound Imaging System (TEKNAR, Inc.). In the utilized Auto Biometric A-Scan mode, the system stored and averaged ten measurements per eye. Additionally, the instrument only recorded data when a valid measurement was detected. For the measurement of axial length (distance from the front surface of the cornea to the front surface of the retina), this valid measurement occurred only when the ultrasound transmission was echoed along the patient's visual axis. The biometer owner's guide claims an instrument accuracy of ± 0.01 mm.[7] Various studies have investigated the patient measurement accuracy, reproducibility, and intersession variability of ultrasound biometry. Measurements are reported to be accurate to better than ± 0.1 mm, and most findings indicate that there are no significant experimenter or interaction effects.[8-9] Clinically reliable and reproducible results can be obtained provided an average of at least three measurements is used.[10]

Following pre-treatment measurements, each of the patients was started on an individualized orthokeratology program utilizing lenses supplied by Contex, Inc. Most patients were initially fit with the Ortho-K3 RGP lens design which has an overall diameter of 9.5 mm, an optic zone diameter of 6.0 mm, an intermediate zone of 3.00 diopters steeper than the base curve, and a flat aspheric peripheral curve. The base curve for the initial Ortho-K3 lens was chosen to be 1.00 to 1.50 diopters flatter than the patient's central keratometry measurements. Due to rapid improvements in the patients' unaided visual acuities, most patients were wearing the second treatment lens (usually 0.50 to 1.00 diopter flatter than the previous lens) in the first two to three weeks. At two months into the study, most patients were wearing the second or third treatment lens.

An axial length measurement was then performed on each eye of each patient this time at approximately two months into the orthokeratology treatment. After removal of the treatment lens, ultrasound A-scan biometry for axial length was performed exactly as it had been performed pre-treatment by the same experimenter with the same instrument. Once again, the Auto Biometric A-Scan mode was used so that only valid measurements were recorded and the average of ten measurements per eye was produced.

RESULTS

Table 1 summarizes the pre-treatment and during treatment findings associated with the ten study patients. Seven females and three males in the age range of twenty to thirty years of age constituted the group. All were free of systemic and ocular disease at both the pre-treatment and during treatment stages. Acceptable orthokeratology lens wear and study compliance was demonstrated by each patient.

A statistical comparison of the pre-treatment axial lengths to the during treatment axial lengths for the finite population produced a slight mean increase in axial length of 0.174 mm over the approximate two month period. Due to the relatively small sample size (n = 20 eyes) and a standard deviation of 0.226 mm, the 95 percent confidence interval extends from 0.0660 mm to 0.282 mm as an increase in axial length (0.174 ± 0.108 mm). These values are ultimately limited by the reported optimum patient measurement accuracy of "better than ± 0.1 mm" for ultrasound A-scan biometry.[8-9]

TABLE 1

Pat.	Eye	AXIAL LENGTH AVERAGE (mm) Pre (date)	During (date)	CHANGE (mm)	UNAIDED VA Pre	During
EA	R	25.57 (3/23)	25.47 (5/07)	-0.10	20/200	20/50
	L	25.54 (3/23)	25.55 (5/07)	+0.01	20/200	20/60
AB	R	24.84 (2/19)	24.90 (5/07)	+0.06	20/200	20/80
	L	24.88 (2/19)	25.05 (5/07)	+0.17	20/250	20/80
CB	R	24.34 (3/19)	24.28 (5/12)	-0.06	20/200-	20/30-
	L	24.16 (3/19)	24.27 (5/12)	+0.11	20/200	20/30
AC	R	23.76 (2/19)	23.82 (4/13)	+0.06	20/70	20/20
	L	24.12 (2/19)	24.37 (4/13)	+0.25	20/200	20/25-
BC	R	22.68 (3/09)	22.78 (4/15)	+0.10	20/200	20/60
	L	22.63 (3/09)	22.76 (4/15)	+0.13	20/200	20/60
CD	R	23.93 (3/24)	24.42 (5/05)	+0.49	20/50	20/30
	L	24.00 (3/24)	24.25 (5/05)	+0.25	20/50	20/30
JD	R	24.09 (2/19)	24.47 (5/07)	+0.38	20/60	20/20-
	L	23.76 (2/19)	24.39 (5/07)	+0.63	20/50	20/25
AH	R	23.18 (3/23)	23.26 (5/07)	+0.08	20/400	20/100
	L	23.00 (3/23)	23.20 (5/07)	+0.20	20/400	20/200
KH	R	23.28 (3/15)	23.22 (5/12)	-0.06	20/400	20/100
	L	22.46 (3/15)	23.22 (5/12)	+0.76	20/300	20/80+
RR	R	24.55 (3/17)	24.53 (5/07)	-0.02	20/400	20/80
	L	24.51 (3/17)	24.55 (5/07)	+0.04	20/400	20/80

DISCUSSION

Finding a slight mean increase in axial length associated with improved unaided visual acuity and a decrease in myopia suggests that orthokeratology procedures have their greatest effect through corneal curvature and power reduction rather than through any significant axial length reduction. This absence of a marked axial length reduction is apparent even though the measurements of the small axial length changes are limited by the patient measurement accuracy of the ultrasound A-scan biometer.

The slight increase in axial length may be related to the reported epithelial edema that is sometimes present during the early adaptation period associated with a new lens.[11] This edema, however, is usually transient especially with the use of the newer moderate to high Dk rigid gas permeable orthokeratology lens designs.

With axial length reduction ruled out as a major contributor to the decrease in myopia, investigative emphasis needs to focus upon the specific changes that occur in corneal structure during orthokeratology procedures. It has been reported that the actual dioptric corneal curvature decrease is often less than the associated decrease in myopia.[12] This discrepancy has been attributed with some uncertainty to an unstable corneal curvature prone to fluctuations.[13] Pinpointing the exact mechanism and accompanying ocular structural changes will ultimately make orthokeratology more predictable and controllable. This, in turn, will allow more eye care practitioners and their patients to take advantage of the many benefits that orthokeratology has to offer.

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