CORNEAL SAGITTAL DEPTH WHEN FITTING SCLERAL CONTACT LENSES: MEDMONT E300 CORNEAL TOPOGRAPHER VS. VISANTE OPTICAL COHERENCE TOMOGRAPHY

by

Patrick Michael Meade & Donald William Rademacher

This paper is submitted in partial fulfillment of the

requirements for the degree of

Doctor of Optometry

Ferris State University

Michigan College of Optometry

May, 2012

CORNEAL SAGITTAL DEPTH WHEN FITTING SCLERAL CONTACT LENSES: MEDMONT E300 CORNEAL TOPOGRAPHER VS. VISANTE OPTICAL COHERENCE TOMOGRAPHY

by

Patrick Michael Meade & Donald William Rademacher

Has been approved

May, 2012

Ferris State University
Doctor of Optometry Senior Paper
Library Approval and Release

CORNEAL SAGITTAL DEPTH WHEN FITTING SCLERAL CONTACT LENSES: MEDMONT E300 CORNEAL TOPOGRAPHER VS. VISANTE OPTICAL COHERENCE TOMOGRAPHY

I, Patrick Michael Meade & Donald William Rademacher, hereby release this Paper as described above to Ferris State University with the understanding that it will be accessible to the general public. This release is required under the provisions of the Federal Privacy Act.

Doctoral Candida

4/30/12
Date

ABSTRACT

Background: Scleral contact lenses offer practitioners another option when fitting complicated contact lens patients. Vaulting the entire cornea, scleral contact lenses provide a new option for fitting patients with corneal dystrophies, ectasias and patients who have difficulty with traditional gas permeable lenses. Sagittal depth measurements are used in selecting an initial trial lens. Determining a more accurate sagittal depth will allow practitioners more accurate initial trial lens selection. *Methods:* Thirty patients, sixty eyes, were imaged using both the Medmont E300 corneal topographer, and the Visante OCT. Utilizing the analysis tool of the Medmont E300 and the built-in caliper tool of the Visante OCT, the sagittal depth at a 10.00 mm chord was measured for all participants. The results from the 10.00 mm chord were analyzed to determine if there was a clinically significant correlation between the two instruments. Additionally, a 15.80 mm chord was drawn and the sagittal depth measured from the 10.00 mm chord to the 15.80 mm with the Visante OCT. *Results:* Statistical analysis showed no statistical significance when measuring the sagittal depth at a 10.00 mm chord with either the Medmont E300, or the Visante OCT. Analysis of the sagittal depth collected at the 15.80 mm chord showed a mean sagittal depth of 2391.83 ± 193.92 microns. A linear regression was used to determine the equation Visante OCT 15.80 mm chord = -258.192 + 1.482(1259.756 + .297(Medmont E300 10.00 mm chord)). *Conclusion:* A more accurate sagittal depth will allow practitioners better starting information when

determining an initial scleral trial lens. This allows a better initial fit and fewer follow up appointments for the patient. The determined equation allows practitioners who do not have a Visante OCT to accurately determine the sagittal depth at 15.80 mm after obtaining the corneal height at a 10.00 mm chord with the Medmont E300 topographer.

TABLE OF CONTENTS

LIST OF FIGURES

INTRODUCTION:

The advent of scleral lenses has allowed practitioners another option when fitting challenging and complex contact lens patients. Scleral lenses are indicated for patients with keratoconus, pellucid marginal degeneration, dry eye, irregular corneas, and previously failed RGP (rigid gas permeable) lens fits[1-3]. Using the principle of vaulting the corneal surface and limbal bearing, the demand for anterior segment imaging has become apparent[4].

Optical Coherence Tomography (OCT) has been used widely utilized for infrared imaging of the retina and posterior segment ocular structure. The Visante Anterior Segment OCT utilizes an intense light source, 1310 nm, to image the anterior segment structures. Light is emitted in two paths from the OCT, a reference path and a sample path into the tissue. The returning light from the sample path is combined with the reference path to create real-time imaging. The intense light provides penetration of the corneal structures with limited penetration to the retina[4-5].

The Visante OCT provides anterior segment imaging of the cornea, limbus, iris, ciliary body and anterior crystalline lens. Corneal pachmetry, angle structures, iris insertion, corneal-scleral junction and corneal sagittal depth can be determined from these images. The visualization of the anterior cornea to the corneal-scleral junction allows the corneal sagittal depth to be determined at various corneal chord lengths. The Visante OCT captures a 16.00 mm wide image in the anterior segment mode with transverse accuracy of 0.217 mm and an axial accuracy of 0.034 mm[4-5].

Computerized video-keratoscopes provide corneal topography maps of the central and peripheral cornea. These maps provide essential information for fitting contact lenses in patients with both normal and irregular corneal structures. The Medmont E300 corneal topographer utilizes Placido rings to provide a continuously updated topographic map of the cornea when an improved image is captured. These topographic maps provide corneal elevation maps along with visualization of the corneal-limbus junction. The Medmont E300 has a high level of accuracy and precision when compared to similar corneal topographers[6].

The purpose of this experiment is to determine if there is a correlation between the corneal sagittal depth at a 10.00 millimeter (mm) chord obtained with the Medmont E300 topographer and the Visante OCT. Using the Visante OCT, the sagittal depth from a 10.00 mm chord to a 15.80 mm chord can be determined. This information can be combined with the corneal sagittal depth obtained from the Medmont E300. The corneal sagittal depth is essential when practitioners fit scleral contact lenses. The more accurate determination of the corneal sagittal depth allows the appropriate initial trial scleral lens selection based on measurements with either the Visante OCT or Medmont E300. This would subsequently lead to increased initial fit success and minimize patient follow up visits.

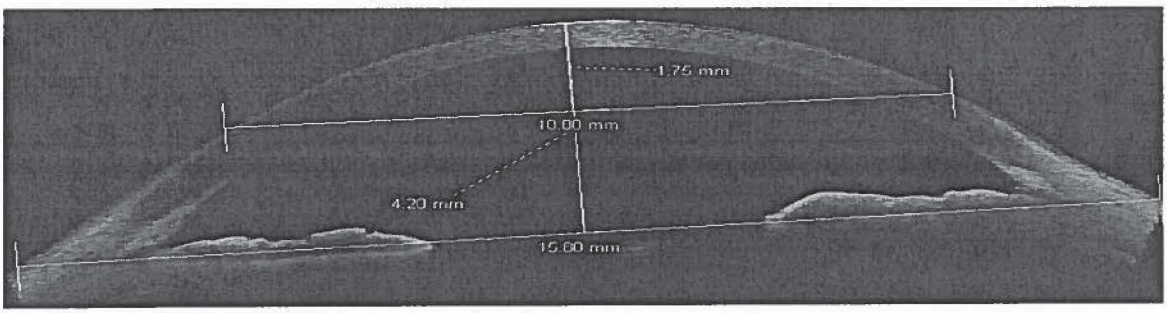

Figure 1: Visante OCT 16.00 mm anterior segment image. Sagittal depth at 10.00 mm and 15.80 mm chord.

METHODS:

This study was completed on a single day at the Michigan College of Optometry in Big Rapids, MI. Subjects were selected on a volunteer basis. The majority of patients were second and third year optometry students ranging from 22-28 years old. Subjects signed a written consent form outlining the purpose of this study, and also explained the non-contact and non-invasive techniques which the Medmont E300 topographer and the Visante Anterior Segment OCT would be used to collect required data.

Thirty patients, sixty eyes, were imaged using both the Medmont E300 corneal topographer, and the Visante OCT. The topographical map provided by the Medmont E300 topographer depicts the anterior corneal topography. Utilizing the analysis tool on the Medmont E300 topographer, a measurement of the corneal height or sagittal depth was determined at a 10.00 mm chord. The Medmont E300 provides limited reliability when determining the sagittal height in the region of the peripheral cornea such as the bearing zone of a scleral lens[6].

The anterior segment image created by the Visante OCT shows a complete anterior segment image of the cornea beyond the corneal-scleral junction. Utilizing the built-in caliber tool on the Visante OCT, a 10.00 mm chord was added across the anterior cornea. The sagittal depth was then determined from another vertical chord from the anterior epithelium to the 10.00 mm chord. An additional chord was drawn at a 15.80 mm

diameter beyond the corneal-scleral junction near the landing zone of a scleral lens. The sagittal depth was then determined from the 10.00 mm chord to the 15.80 mm chord with the built-in caliber tool (Figure 1).

The corneal sagittal depth measurements obtained from the two different instruments were then statistically analyzed to determine if there was a clinically significant correlation between the two measurements at the 10.00 mm chord. The sagittal depth at the 10.00 mm chord is easily obtained by either instrument when imaging the cornea for contact lens fitting. The Visante OCT was then used to determine the sagittal depth from a 10.00 mm chord to a 15.80 mm chord. Since the Medmont E300 provides limited accuracy at a 15.80 mm chord, the region beyond the corneal-scleral junction, the measurements were only obtained from the Visante OCT[6]. This value was then statistically analyzed to determine its clinical significance when fitting scleral lenses.

RESULTS:

The study concluded with data collected from 30 participants, 16 male and 14 female. The sagittal depth at the 10.00 mm chord was collected from both eyes of the participants from the Medmont E300 and Visante OCT. The mean value sagittal depth at the 10.00 mm chord measured from the Visante OCT for the right eye was 1797.33 ± 66.54 microns and 1779.00 ± 68.35 microns for the left eye. The Medmont E300 measured the sagittal depth at the 10.00 mm chord at 1779.24 ± 72.19 microns for the right eye and 1781.42 for the left eye. An independent T-test revealed there is no statistical difference between the Visante OCT ($p=0.701$ and $t=1.053$) and Medmont E300 ($p=0.572$ and $t=$

-0.112) for each eye respectively. The values from both eyes were then utilized to compare the significance of the measurements obtained from the Visante OCT and the Medmont E300.

The mean sagittal depth at a 10.00 mm chord for the 60 eyes was 1788.17 ± 67.51 microns measured by the Visante OCT. Measurements obtained from the Medmont E300 revealed a sagittal depth at a 10.00 mm chord for the 60 eyes of 1780.33 ± 74.67 microns. The distribution of the data points can be seen in Figure 2. The paired samples correlations value, 0.328, showed there is a statistically significant low correlation between the Visante OCT and Medmont E300 (p=0.010). An independent T-test revealed there is not a statistically significant difference between the Visante OCT and

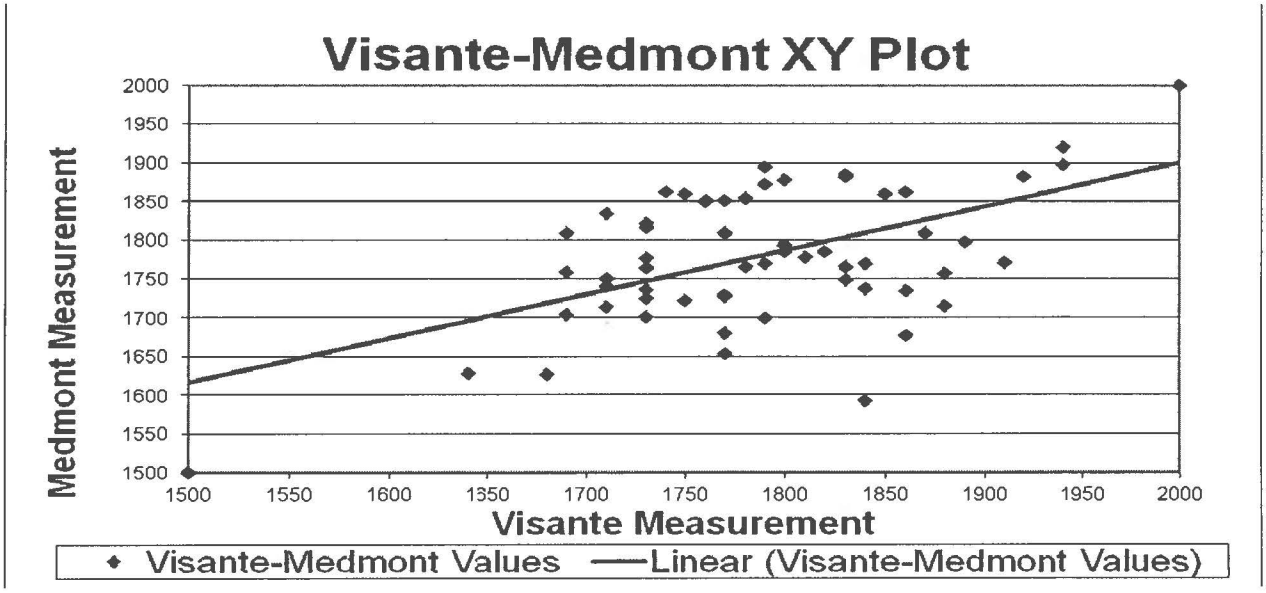

Figure 2: Sagittal depth measurements at a 10.00 mm corneal chord, measured from the Medmont E300 and Visante OCT.

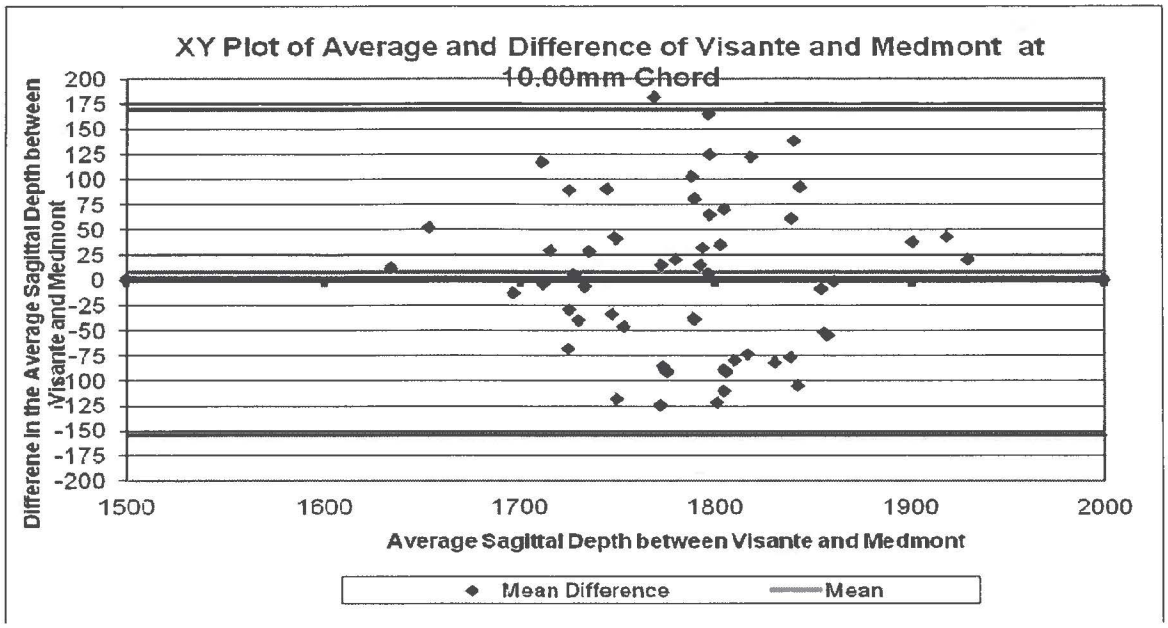

Figure 3: Difference in the average sagittal depth at a 10.00 mm chord between the Visante OCT and Medmont E300

Medmont E300 for the sagittal depth at a 10.00 mm chord (p=0.465 and t=-0.735). Overall, the mean difference between the Visante OCT and Medmont E300 was 7.8 microns (Figure 3).

The data obtained from the 10.00 mm chord to the 15.80 mm chord (Figure 1) was only obtainable from the Visante OCT. The Medmont E300 provides limited information regarding corneal sagittal depth beyond the corneal-scleral junction at a 15.80 mm chord length thus providing unreliable data[6]. Using the Visante OCT, the mean reading for the left eye was 2407.67 ± 203.77 microns and 2376.00 ± 185.65 microns for the right eye. An independent T-test revealed there is no statistical difference between the right and left eye at the 15.80 mm chord obtained from the Visante OCT (p=0.532). The mean value

of the sagittal depth from a 10.00 mm chord to a 15.80 mm chord for all 60 eyes was 2391.83 ± 193.92 microns.

Since the data reliability beyond the corneal-scleral junction is limited for the Medmont E300, the data was statistically analyzed to determine a predictive value for the 10.00 mm to 15.80 mm chord obtained from the Visante OCT. Using a linear regression, a value was predicted based on the Visante OCT sagittal depth data from the 10.00 mm to a 15.80 mm based on Medmont E300 10.00 mm chord. This yields the predictive equation of Visante OCT 15.80 mm chord = -258.192 + 1.482(1259.756 + .297(Medmont E300 10.00 mm chord)). The mean value of the sagittal depth from a 10.00 mm chord to a 15.80 mm chord for all 60 eyes was 2391.83 ± 32.84 microns (p=0.004). The distribution of the predicted versus actual values is seen in Figure 4 and difference between the predicted and actual value is seen in Figure 5.

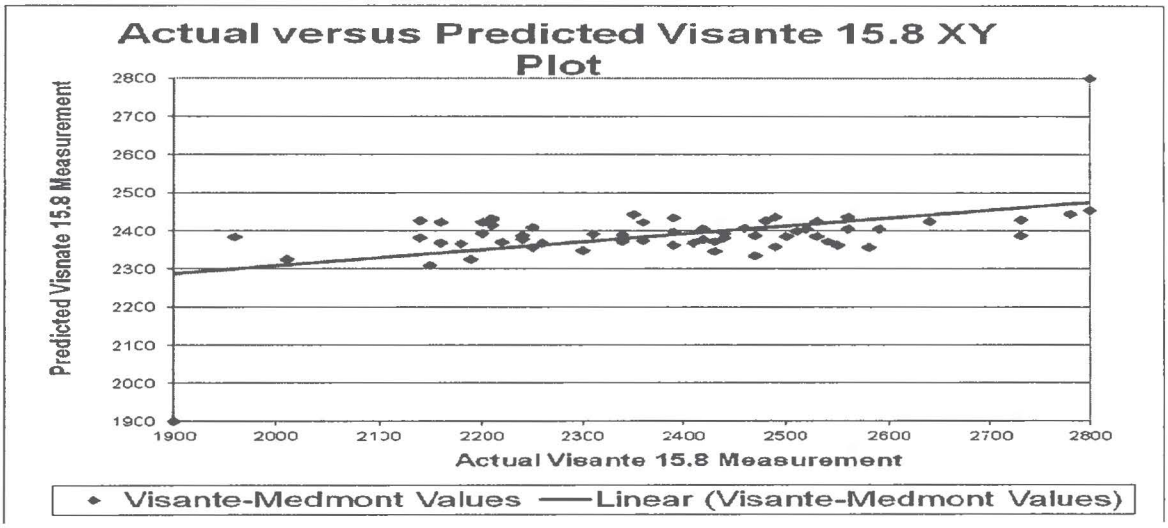

Figure 4: Actual and predicted sagittal depth values at a 10.00 mm to 15.80 mm based on Visante OCT measurements.

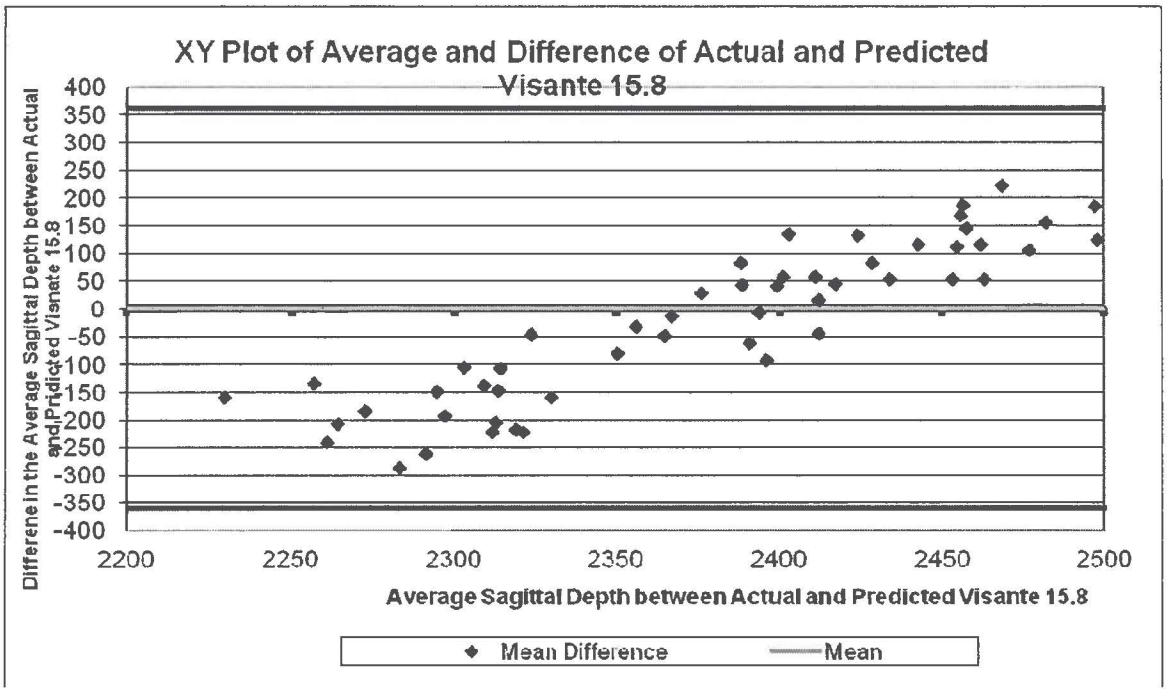

Figure 5: Difference of the sagittal depth between the actual and predicted value at a 10.00 mm to a 15.80 mm chord based on Visante OCT measurements.

DISCUSSION:

The initial fitting success of scleral lenses depends on numerous factors including sagittal depth of the anterior segment, corneal curvature and shape change at the corneal-scleral junction[4]. Large diameter scleral lenses peripheral curves have bearing on the region beyond the corneal-scleral junction, thus information regarding the parameters beyond this region become evident. Measurements obtained from corneal topographers provide minimal information of the corneal profile beyond the corneal-scleral junction. The introduction of anterior segment OCT has provided practitioners with valuable characterization of the cornea and region beyond the corneal-scleral junction. Although

studies have been completed comparing the corneal topography and Visante OCT imaging to predict successful initial soft contact lens fitting, limited studies have been conducted regarding large diameter rigid gas permeable or scleral lenses[4&7-9].

The methods of fitting scleral lenses include the use of trial lens sets to empirically fit the cornea, corneal topography and anterior segment imaging. Initial lens selection is dependent on the radius of curvature of scleral lens determined from the sagittal depth. Previously, initial scleral lens fits have averaged less than two attempts when utilizing the radius of curvature to select an initial lens based on the eccentricity value obtained from the Medmont E300 and the sagittal depth from the Visante OCT[9]. Our goal is to utilize the average or predicted sagittal depth from the 10.00 mm to 15.80 mm chord combined with the 10.00 mm chord and eccentricity value obtained from the Medmont E300 to determine initial lens selection.

Since the reliability of the Medmont E300 is limited beyond the corneal-scleral junction where scleral lenses have bearing, the chord lengths were separated in this study to determine the total sagittal depth at a 15.80 mm chord. The initial measurements of the Medmont E300 and Visante OCT at a 10.00 mm chord length displayed no statistical difference between the measurements with a mean difference of 7.8 microns. Essentially, the value obtained from either the Medmont E300 or Visante OCT yield the same value when determining the sagittal depth at a 10.00 mm chord. The low difference between these two chord lengths would not significantly influence the initial selection of a scleral lens.

Previous studies report a minimum of a 100 micron fluid reservoir or clearance between the scleral lens and cornea required for successful fitting in normal eyes. However, the central corneal has vast variability when fitting irregular corneas with successful fittings ranging from 30-650 micron clearance values[10-12]. The larger the difference between the Visante OCT and Medmont E300 sagittal depth values would lead to an increase or decrease in the clearance between the cornea. As this value would increases/decreases greater than 25-50 microns, variability would be found among the initial lens fitting. Although the sample population is small in this study, knowledge of the difference between the sagittal depths values (7.8 microns) obtained from separate imaging techniques ensures proper initial lens success.

The study concluded with an approximate sagittal depth at a 10.00 mm chord of approximately 1780 microns for normal eyes obtained from the Visante OCT and Medmont E300. This value combined with approximate value of 2400 microns from the Visante OCT at a 10.00 mm to 15.80 mm chord provides the sagittal depth of the cornea at 15.80 mm. The value of 4180 microns provides an empirical value when initial selecting a 15.80 mm scleral lens in normal eyes. This value is dependent only on normal corneas without underlying pathology, refractive or surgical intervention.

The use of formulas derived from the results of this study provides an additional method to determine the sagittal depth at a 15.80 mm chord. The equation of predicting the Visante OCT 15.80 mm chord = -258.192 + 1.482(1259.756 + .297(Medmont E300 10.00 mm chord). Utilizing this equation, the sagittal depth at a 15.80 mm chord is

determined after obtaining the sagittal depth at a 10.00 mm chord. This provides a more individualized approximation of the sagittal depth in a normal eye while considering normal physiological variance among corneas.

CONCLUSIONS:

The more accurate determination of the corneal sagittal depth allows initial trial scleral lens selection based on measurements of the Visante OCT or Medmont E300. With increasing accuracy of sagittal depth values, practitioners would have increased initial fit success and minimize patient follow up visits. This study suggests utilizing the Medmont E300 corneal topographer to determine the sagittal depth at a 10.00 mm chord then utilize an average value from the Visante OCT at a 10.00 mm to 15.80 mm chord to determine sagittal depth. Alternatively, the Medmont E300 can determine sagittal depth based on predictive sagittal depth equations. Further investigation regarding successful scleral lens fits in normal eyes with 15.80 mm diameter lenses based on these two sagittal depth approximations is required.

REFERENCES:

1. Ozkurt Y, Atakan M, Gencaga T, Akkaya S. Contact Lens Visual Rehabilitation in Keratconus and Corneal Keratoplasy. Journal of Ophthalmology 2012; 1-4.

2. Schornack MM, Patel SV. Scleral lenses in the management of keratoconus. Eye and Contact Lens 2010; 36(1): 39-44.

3. Vreugdenhil W, Geerards AJ, Vervaet CJ. A new rigid gas-permeable semi-scleral contact lens for the treatment of corneal surface disorders. Contact Lens and Anterior Eye 1998; 21(3): 85-88.

4. Sorbara L, Maram J, Demond F, Woods C, Simpson T. Metrics of the normal cornea: anterior segment imaging with the Vistane OCT. Clinical Exp Optometry 2010; 93: 150-156.

5. Carl Zeiss Meditec. Vistane Optical Coherence Tomography User Manual. 2006.

6. Tang W, Collins M, Carney L, Davis, B. The Accuracy and Precision Performance of Four Videokeratoscopes in Measuring Test Surfaces. Optometry and Vision Science 2000; 77(9): 483-491.

7. Hall L, Young G, Wolffsohn J, Riley C. The Influence of Corneal Scleral Topography of Soft Contact Lens Fit. Investigative Ophthalmology & Visual Science 2011; 52(1): 6801-6806.

8. Young G, Schnider C, Hunt C, Efron S. Corneal Topography and Soft Contact Lens Fit. Optometry and Vision Science 2010; 87(5): 358-366.

9. Gemoles G. A Novel Method of Fitting Scleral Lenses Using High Resolution Optical Coherence Tomography. Eye & Contact Lens 2008; 34(2): 80-83.

10. DeNaeyer G, Breece R. Fitting Techniques for a Scleral Lens Design. Contact Lens Spectrum. 2009; 1: 34-37.

11. DeNaeyer G. Modern Scleral Contact Lens Fitting. Contact Lens Spectrum. 2010; 6: 20-25.

12. Worp E van der. A Guide to Scleral Lens Fitting. Scleral Lens Education Society; Pacific University. 2010; 1-66.