INFERIOR LIMBAL ANGLE ESTIMATION

A statistical analysis comparing student estimated anterior chamber angles using the Inferior Limbal and the van Herick Techniques

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ABSTRACT

Background: This study was intended to further investigate an alternative approach to anterior chamber angle grading in order to prevent primary angle closure glaucoma (PACG). This grading technique was compared and contrasted with the traditional Van Herick method with the purpose of determining which estimation is most accurate. This new technique, which will be referred to as the Inferior Limbal method, was taught to second and third year optometry students who were in the process of learning angle estimation methods. *Methods:* Thirty-four optometry students were asked to accurately grade photographs of thirty-two anterior chamber angles. Sixteen of these photographs were of the classic Van Herick method and the other sixteen were of the Inferior Limbal method. During the survey students were given the rubric for grading both Van Herick and Inferior Limbal angles. The results of this survey were compiled and then a statistical analysis was conducted in order to determine which method was more accurate during student estimations. *Results and Conclusions:* There was no statistical difference in accuracy between Inferior Limbal and Van Herick angle estimation methods. Future studies concentrating on better photographic quality should be considered as this was the major limitation.

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Introduction

Primary angle closure glaucoma results from the occlusion of the traditional aqueous drainage pathways within the anterior chamber. This occlusion leads to elevated eye pressure which exerts stress on retinal ganglion cells. Angle closure can occur through acute episodes secondary to pupil dilation or can be chronic due to anatomical variations.[1] Primary angle closure glaucoma is responsible for roughly 15% of irreversible blindness worldwide.[1] Many anatomical conditions are likely to increase the prevalence of PACG. Shallow anterior chamber depth, lens thickening, anterior lens position, hyperopia, and small corneal diameter often increase the chance of a closed angle event.[2] Pharmalogical pupil dilation also increases the chances of closing an angle especially when anatomical anomalies exist. Anterior chamber angle screenings are the best way to avoid an anatomical or pharmacologic angle closure. Several screening methods exist which help clinicians estimate the likelihood of angle closure. These methods help determine if extra precaution needs to be taken prior to dilation or if laser treatment is indicated (this research is dedicated to angle estimation methods and treatment of PACG will not be discussed). Standard angle estimation methods include the Van Herick method (Table 1) and the Oblique Shadow test. These methods are simple screenings and are usually conducted prior to dilation during routine eye exams. If screening methods indicate a narrow angle Gonioscopy, Optical Coherence Tomography (OCT), or Ultrasound Biomicroscopy (UBM) will be used in diagnosis.[1]

Table 1. Van Herick Method of Angle Grading[3]

Angle Grade	4	3	2	1
Cornea to Angle Ratio	Anterior Chamber Depth (space between corneal endothelium and iris) is Equal to or Greater Than Corneal Thickness	Anterior Chamber Depth is Between ¼ and ½ the Corneal Thickness	Anterior Chamber Depth is Equal to ¼ the Corneal Thickness	Anterior Chamber Depth is Equal to Less Than ¼ the Corneal Thickness

Gonioscopy is indicated first when a suspect angle presents to the examiner. While some subjectivity exists, using a gonio lens in most cases allows the examiner to determine the patency of the anterior chamber angle. Gonioscopy can also be used to view the angle in cases of pigmentary glaucoma, psuedoexofoliative glaucoma, and angle recession, in addition to other pathologies that may compromise ocular drainage flow .[4] In reference to angle depth, several gonioscopy protocols exist and are identified in the following tables:

Table 2. Shaffer System of Gonioscopic Evaluation[5]

Grade	Clinical Interpretation	Shaffer Angle in Degrees
4	Closure impossible	45-35
3	Closure impossible	35-20
2	Closure possible	10-20
1	Closure likely with dilation	1-10
0	Closed	0

Table 3. Scheie System of Gonioscopic Evaluation[5]

Grade	Clinical Interpretation	Scheie Classification
0	Closure impossible	All structures visible
1	Closure impossible	Iris root visible
2	Closure possible	Ciliary Body obscured
3	Closure likely with dilation	Posterior Trab. Obscured
4	Closed	Only Schwalbe's line visible

Table 4. Spaeth System of Gonioscopic Evaluation[5]

Iris Insertion	Angular Approach	Peripheral Iris	Pigment of T.M.
A. Anterior to Schwalbe's Line	0-50	R=regular F=flat	0=No pigment
B. Between S. Line and Scleral Spur	"	S=steep B=bowed P=plateau iris	1+ =Minimal
C. Scleral Spur Visible	"	"	2+ =Mild
D. Deep with C. Body Visible	"	Q=queer C=Concave	3+ =Moderate
E. Extremely deep with >1mm C. body visible	"	"	4+ =Intense

UBM and OCT can be used to analyze the angle depth in cases where gonioscopy cannot provide a definitive diagnosis. These methods eliminate nearly all subjectivity which may prevent proper angle analysis. UBM, a contact method, allows for high resolution imaging of the major landmarks within the anterior chamber angle. This technique is fairly time intensive and often requires increased patient cooperation. Therefore, it is reserved as a last resort method. Like UBM, another objective viewing method is OCT. It has made giant strides in recent years with the advent of its anterior segment imaging. OCT is a non-contact method of imaging anterior chamber angles in suspect patients.[1] It is likely that OCT technology will become the go to method of objective angle imaging.

This study is intended to challenge the traditional angle screening method—Van Herick's. Van Herick's estimation of anterior chamber angle grading is the accepted norm in optometric practice and education today. Frequent use of this method is practiced because it is easily administered, efficient, and a fairly reliable predictor of

anterior chamber angle depth before dilation. An alternative method of anterior chamber angle grading is offered through this study. The alternative method, called the Inferior Limbal technique, has often been used by clinicians but little data exists which supports or denies its accuracy compared to the traditional Van Herick technique.

The Inferior Limbal technique of angle grading is administered in the slit lamp by focusing an optic section on the middle portion of the inferior cornea. The angular value of space between the anterior focused light beam and defocused posterior light beam should be assessed. This angular value corresponds to a scale—based on the Shaffer System of gonioscopy— and indicates the relative depth of the inferior anterior chamber angle. The hypothesis of this study is that anterior chamber angles are more accurately estimated by students when using the Inferior Limbal technique compared to the Van Herick. To test our hypothesis, thirty-four second and third year optometry students were exposed to an assortment of photographs that displayed angle-grades using the Van Herick and Inferior Limbal techniques. Using a criterion sheet as their guide, the students graded thirty-two total anterior chamber angles using both methods. At the completion of the survey, a statistical analysis was performed to determine if the Inferior Limbal technique was a better predictor of anterior chamber angle depth.

During slit lamp training, optometry students have been taught several angle estimation methods but instruction is most often based around the Van Herick method. The Van Herick method has several inherent flaws that often confound angle estimation by students and practicing clinicians alike. Utilizing Van Herick's method of anterior chamber angle grading, the angle depth is assessed based on parallelepiped width relative to the potential space between the parallelepiped and the posterior iris slit beam.[6] To the

novice clinician, this potential space can be difficult to grade because the light beam must be focused directly on the limbus to make an accurate prediction. Subtle eye movements coupled with the clinician's inability to maintain a focused and steady light beam may lead to an inaccurate prediction of angle depth. Another disadvantage of the Van Herick technique regards the specific angles it was meant to grade—temporal and nasal. Anatomically speaking, the inferior chamber angle is the most open and least likely to close.[7] Suspiciously narrow angles temporally and nasally can mislead the clinician and gonioscopy will likely be performed unnecessarily. Since the clinician wants to make sure that at least one angle will not close during dilation it seems prudent that the clinician view the most open angle.

The Inferior Limbal estimation seeks to correct the inherent disadvantages of the Van Herick technique. With this method, the corneal light beam assesses the widest anterior chamber angle and also helps reduce clinician error secondary to slit lamp defocus. Since the slit lamp beam is focused vertically on the inferior angle slight misgivings in focus or movement are much more tolerable. Also, by assessing the most anatomically open angle clinicians will likely reduce the number of times they are misled by suspect narrow angles. This will decrease the number of times gonioscopy is performed and increase clinical efficiency.

Materials and Methods

Anterior chamber angles were screened and graded utilizing the Van Herick and Inferior Limbal methods at the Michigan College of Optometry in Big Rapids, MI and Anderson Eye Center in Saginaw, MI. The Van Herick method of angle grading was conducted using an eight millimeter vertical slit tapered down to one millimeter in width

using a Haag-Streit slit lamp. The slit beam was flared out to a 45-degree angle using only the temporal angle on each eye screened. Verification of each Van Herick angle grade was confirmed using a Goldmann 4-mirror gonioscopy lens. The Goldmann four-mirror lens was positioned to grade the corresponding angle of each eye.

Inferior Limbal angles were observed by making a vertical eight millimeter slit which was tapered down to one millimeter in width. This slit was positioned over the center of the inferior cornea. About seven millimeters of the vertical slit was focused on the corneal surface, with the remaining millimeter overlapping onto the inferior limbus. The anterior chamber angle grade was determined by estimating the angular separation between the defocused anterior iris light beam and the focused posterior corneal light beam. The criterion for grading Inferior Limbal angles is listed in Table 5.

Table 5. Inferior Limbal Technique

Angle Grade	4	3	2	1
Angular Separation between Cornea and Iris	35-45°	20-35°	10-20°	<10°

Over 50 angles were screened and photographed. Photography was done using an Olympus Stylus 10x digital camera positioned at the eyepiece of the slit lamp. Sixteen Van Herick and sixteen Inferior Limbal photographs were chosen because of their clarity and resolution. Out of the sixteen angles chosen and retained for viewing, five were grade 4, seven were grade 3, three were grade 2, and one was grade 1 as indicated by gonioscopy. These photographs were printed and assembled into photo-albums. Two albums were made of each angle grading method. To demonstrate the Inferior Limbal method of angle grading, two inferior limbal angles displaying a >40 degree angular

separation were enlarged and placed on a separate sheet of computer paper. These enlarged photographs were to serve as an example to second and third year optometry students who had not been exposed to the inferior limbal method of anterior chamber angle grading.

Thirty-four 2nd and 3rd year optometry students were given an answer sheet and given unlimited time to make the 32 angle estimations. Students were instructed to observe the photo-albums and place a number 1-4 next to the answer blank corresponding with each picture. To aid them in the angle grading process, a criterion sheet for both Van Herick and Inferior Limbal angles was provided. This criterion sheet was the same sheet used by the researchers when preparing the photographs. The students were encouraged to make their best guess even in cases which seemed ambiguous and were able to ask questions of the examiners throughout the survey.

Results and Implications

After completing all student surveys a statistical analysis was conducted for the purpose of supporting our hypothesis that Inferior Limbal angles allow for more accurate angle estimation. To support this hypothesis several propositions must be answered from the data gathered. First, is there a statistical difference between student estimated Van Herick angles and the correct Van Herick angles? Second, is there a statistical difference between student estimated Inferior Limbal angle and the correct Inferior Limbal angle? Finally, is there a statistical difference between the student estimated Van Herick angles and the student estimated Inferior limbal angles as compared to the correct values of each?

Descriptive data was evaluated in order to look at standards such as count, mean, standard deviation, minimum and maximum (Table 6). This method of data analysis was not helpful in supporting or denying the hypothesis that Inferior Limbal angles are more accurate than Van Herick angles. Descriptive data does not allow for statistical significance and usually requires another numerical analysis. The Wilcoxon signed-rank test (calculated with Microsoft SPSS) was used in order to determine statistical significance in this case. Significance is indicated by the P-value where values greater than .005 are not significant and those less than or equal to .005 are significant.

Table 6. Descriptive Statistics

	Correct VH	Correct IL	Student Est.VH	Student Est.IL
N	544	544	544	544
Mean	3.00	2.75	2.69	2.60
Std. Deviation	.867	1.032	1.112	1.074
Minimum	1	1	1	1
Maximum	4	4	4	4

The Wilcoxon signed-rank test was selected based on several assumptions. First, it is based on ordinal statistics—meaning there is a rank order to the data gathered. Second, it can be used as an alternative to the Student t-test when normal distribution of data cannot be confirmed. Third, it involves comparisons and differences between the measurements gathered in testing.[8]

In reference to the first proposition—is there statistical significance between the student estimated Van Herick angles and the correct Van Herick angles—it was important that the data indicated a significance between the two. This would signify that

the students were not accurate in their ability to grade angles using the Van Herick method and therefore support the hypothesis. The Wilcoxon analysis determined that there was a statistical difference between the student estimated Van Herick angle gradings and the correct Van Herick angle gradings as indicated in Table 7. This finding was supportive to our hypothesis and indicated that the students surveyed had trouble appropriately identifying the correct angles using the Van Herick method.

Unlike the first proposition, a desirable result for the second—is there statistical significance between the student estimated Inferior Limbal angles and correct Inferior Limbal angles—would be to find that there was no significance between the two. This would ultimately mean that students are accurate when it comes to grading angles using the Inferior Limbal method. In this case, Wilcoxon analysis again indicated that there was a statistical difference between the student estimated Inferior Limbal angle gradings and the correct Inferior Limbal angle grading (Table 7). This was an unfavorable finding and like the Van Herick grading system this study indicated that the Inferior Limbal grading system is inaccurate.

Finally, in the third proposition—is there a statistical significance between the student estimated Van Herick angles and student estimated Inferior Limbal angles—the survey needed to indicate that a statistical significance existed between the two. It is important to note that this was a comparison of accuracy between the Van Herick and Inferior Limbal student estimates. In this case, the Wilcoxon test indicated that there is not a statistically significant difference between Van Herick and Inferior Limbal student estimates. This means that, statistically speaking, neither method is more likely to yield the correct angle grade when compared to its counterpart.

The Wilcoxon Signed Rank test also determined a Z value in each case. The Z value indicates how far a set of data deviates from the mean. A negative value suggests that this set of data is consistently lower than the mean and a positive value indicates above the mean. In the first two cases, data revealed a negative Z score indicating students consistently estimated angles as smaller than the correct value. The Z value in case three was negative as well—although not as great of a value. Here students estimated Van Herick angles as smaller on average as compared to Inferior Limbal. As compared to the P value, the Z value score is inconsequential in regards to the study hypothesis. However it is interesting to note that students consistently estimate angles as more narrow than the correct value. From a safety standpoint this would be advantageous—as compared to the alternative.

Table 7. Wilcoxon Signed Ranks Test Results

	Student Est. VH vs. Correct VH	Student Est. IL vs. Correct IL	Student Est. VH vs Student Est. IL
Z	-8.476[a]	-3.385[a]	-1.229[a]
P value(Asym. Sig.)	.000	.001	.219

[a] based on positive ranks

Future Studies

There are several possible confounding factors that could have played a role in the results of this study. The major factor was defiantly picture quality. Pictures were taken with a handheld Olympus Stylus 10x digital camera through the oculars of the slit lamp. This provided for adequate image quality but in most pictures there was at least a mild

blur or glare element. Also, these images obviously did not allow for three dimensional viewing which is a key component in correctly estimating anterior chamber angles. Another confounding factor was that both second and third year student at Michigan College of Optometry were used in this survey. Second year students have been estimating angles for several months in laboratory and third year students have had over a year of experience estimating angles in lab and clinic. Surveying second year students who have just recently learned to grade angles could have led to much of the inaccuracy. Also, the gonioscopic analysis conducted by the examiners could result in mild inaccuracy as well. Gonioscopy is hampered by some subjectivity and UBM or OCT would provide for definite diagnosis of angle patency.

If this study was conducted again there should be several improvements. As mentioned above something needs to be done about the image quality issues. A slit lamp mounted digital camera would probably eliminate some of the blurriness and glare which was experienced secondary to slight hand movements of the examiner. That being said, it does not eliminate the problem of two dimensional viewing. In an ideal setting, students would directly view Van Herick and Inferior Limbal angles through the slit lamp. A study like this would be very time intensive and require many "participant" angles as well as student volunteers. The examiners would also need to eliminate some of the experience factor by sticking to 3rd year students only. These students would have enough experience to make solid estimations of both Van Herick and Inferior Limbal angles. Lastly, UBM or OCT should be used to provide a definitive diagnosis of angle depth. This would remove inherent subjectivity which may influence the results of this survey.

Conclusion

Optometric clinicians will always be searching for ways to increase the efficiency and accuracy of their eye exams. While it is a small segment of optometrist's protocol, anterior chamber angle grading is extremely important. Avoiding angle closure will eliminate the chance for secondary vision loss and also decrease the chances of a legal action against the clinician. While this study did not indicate that Inferior Limbal angle grading is more accurate than the traditional Van Herick technique the investigators feel it is still worth exploring. Taking into account the suggested future modifications will likely aide in supporting the hypothesis of this study.

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