



Verification of the reliability of anterior segment OCT in measuring limbus-insertion distance in horizontal recti muscles

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Abstract: Background: Measuring limbus-insertion distance of horizontal recti muscles can have many benefits in observing muscle changes postoperatively and in finding correlation between the degree and type of ocular misalignment and limbus-insertion distance, many modalities were introduced to image extraocular muscles (1)(2) but anterior segment OCT remains the most recent modality introduced for such purpose. **Patients and Methods:** Prospective observational case series study was carried out in 40 eyes in 20 patients with manifest strabismus who were planned for surgical correction, all patients were subjected to complete ophthalmological examination and to preoperative and intraoperative measurement of limbus-insertion distance by anterior segment OCT and surgical caliper respectively. **Results:** When comparing the measurements via the two methods a statistically significant correlation was evident with tendency of anterior segment OCT to overestimate the limbus-insertion distance. **Conclusion:** Anterior segment OCT is a reliable method in determining limbus-insertion distance in eyes undergoing primary squint surgery. **Aim of the work:** Assessing the reliability of Anterior Segment OCT in measuring limbus-insertion distance of horizontal recti muscles.

[Ali Hammouda Ghoraba, Heba Mohamed Shafik, El Sayed Samir Arafa, Ahmed Lotfi Ali. **Verification of the reliability of anterior segment OCT in measuring limbus-insertion distance in horizontal recti muscles.** *Biomedicine and Nursing* 2020;6(4): 16-22]. ISSN 2379-8211 (print); ISSN 2379-8203 (online). <http://www.nbmedicine.org>. 3. doi: [10.7537/marsbnj060420.03](https://doi.org/10.7537/marsbnj060420.03).

Keywords: Limbus-insertion distance, Anterior segment OCT, strabismus.

1. Introduction

Strabismus is a condition in which the eyes are misaligned. While one eye is directed at an object, the other eye may turn in (esotropia), out (exotropia), up (hypertropia), or down (hypotropia). This misalignment may be persistent or intermittent.

Anterior segment OCT is a new modality which was first introduced in 1994(3) and was available commercially in 2001(4). New studies were made for making the best use of this highly advanced technology in the field of strabismus by trying to identify muscle changes postoperatively and limbus-insertion distance before and after the operation(5)(6)(7)(8). Such trials were made by other modalities like CT and MRI but met many technical difficulties(1)(9)(2). By administration of such device for locating muscle insertion without the need for surgical exploration, a better understanding of the causes of recurrence after surgery can be achieved, and new correlations can be made between degree of deviation and limbus-insertion distance.

Not only can these correlations help us find certain surgical formulas that would decrease the variability in response to squint surgeries but also give

better understanding of the nature of the disease and its prognosis.

Assessing the reliability of Anterior Segment OCT in measuring limbus-insertion distance is vital for such technique to insure its authenticity.

2. Patients and methods

This prospective observational case series study was carried out in 40 eyes in 20 patients attending ophthalmology outpatient clinic in Department of Ophthalmology Tanta university hospitals from April 2019 to October 2019. All patients received complete explanation of the nature and purpose of the study, an informed written consent was obtained from all participants in the research before inclusion, all the names of the participants were hidden and replaced by a code number to maintain their privacy and confidentiality of the data.

Patients:

Inclusion criteria

Patients with manifest squint who are planned for surgical correction.

Exclusion criteria

Age less than 5 years.

Methods

All patients were subjected to:

- 1- Complete ophthalmological examination.
- 2-Imaging method

Anterior segment OCT was done for all patients in a private center.

Imaging obtained by single ophthalmologist using the same device: Topcon 3D OCT-2000™ (Topcon medical systems inc).

Measurements were taken in sitting position and the head in primary position, an axial cross-section was taken (16 mm) while patients had to look to the opposite side of the same muscle in order for the muscle insertion to be displayed (about 15° temporal gaze for the medial rectus and 30° nasal gaze for the lateral rectus) taken into consideration that a small degree of eye rotation will not put the site of insertion into view while the extreme gaze will make the limbus disappear from image.

In the cross-section image, the insertion site was defined as the end of the cleft between the extraocular muscle and the sclera, while the corneoscleral limbus was indirectly determined by locating the iris root which lies approximately 1.0 mm posterior to the limbus and as a result adding 1.0 mm to the measurement obtained (Figure 1).

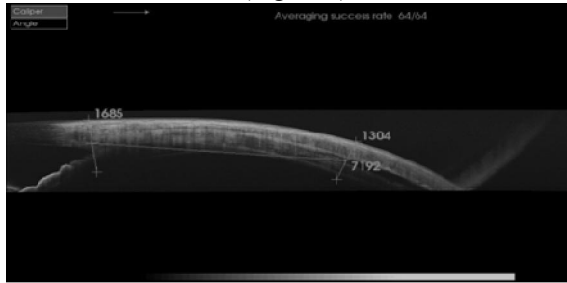


Figure (1): Measure is taken from the cleft between muscle and sclera to the iris root

Three consecutive readings were taken, and the mean and SD were calculated.

3-Intraoperative measuring of the limbus-insertion distance of the horizontal recti by a surgical caliper was carried out by two squint surgeons who were masked to the Anterior segment OCT readings, while fulfilling the following criteria:

- Measuring from the posterior limbus.
- Measuring from the posterior edge of the insertion.
- Measuring before muscle disinsertion.

Statistical Analysis

The data obtained from the surgical caliper and AS-OCT was entered into an Excel spreadsheet.

In this study, the analysis was calculated by SPSS version 25 (SPSS Inc., Chicago, IL). Furthermore, the qualitative parameters were described by number of frequency and percentage while the quantitative variables were described by mean, standard deviation and range.

In addition, the comparison of two dependent quantitative variables was calculated by (**T paired test**) while the comparison of two independent quantitative variables was calculated by (**T test**).

Comparison between two qualitative variables was done by (**Chi square test**). The correlation was done by (**Pearson test**).

3. Results

The study included a total of 40 eyes for 20 patients who underwent preoperative measurement of limbus-insertion distance by anterior segment OCT then intraoperative measurement by surgical caliper.

Demographic data of included patients

Our study included 12 males and 8 females with their age ranging from (5 -60) years, with 7 patients presenting with esotropia preoperatively while 13 patients presenting with exotropia (Table 1).

Table 1: Demographic data.

Sex	Male (N=12)	Female (N=8)
Type of deviation		
Esotropia (N=7)	2 (16%)	5 (62.5%)
Exotropia (N=13)	10 (84%)	3 (37.5%)
Age (according to years)		
5-20	4 (33%)	5 (62%)
21-40	6 (50%)	2 (25%)
41-60	2 (17%)	1 (13%)

Overall, strong correlation was evident between two different techniques of measurement with statistical significance as guided by low P-value (<0.001) (Table 2).

Table 2: overall comparison between the two different measuring techniques showing statistically significant correlation between OCT and surgical caliper.

	Range			Mean	±	SD	Differences		Paired Test	
	Min	Max	Mean	Mean	SD	Mean	SD	t	P-value	
Intraoperative	4	-	7.5	5.950	±	0.956	-0.612	0.903	-4.290	<0.001*
OCT	5	-	8.1	6.563	±	0.799				

It can be noted that Anterior segment OCT tends to overestimate limbus-insertion distance by about 1 mm when compared to surgical caliper intraoperative measurements (Figure 2).

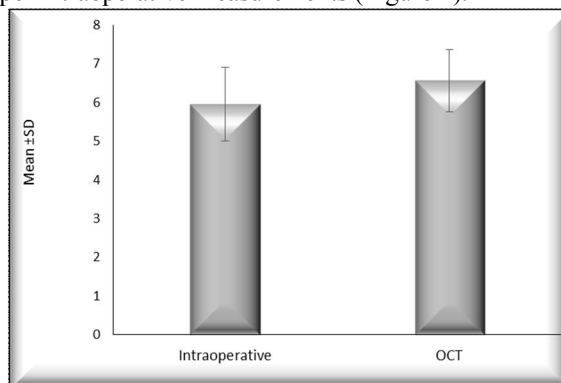


Figure 2: values are higher in OCT group

The degree of difference between the two measurements shows promising similarities with 70% of cases showing similar or less than 1 mm difference and only 30% of cases having more than 1 mm difference (Table 3).

Table 3: show comparative differences between the two methods.

Difference	N	%
Lower by 1 or less	11	27.50
Same	1	2.50
Higher by 1 or less	16	40.00
Higher by more than 1	12	30.00
Total	40	100.00

When measuring the accuracy of Anterior segment OCT according to type of horizontal rectus muscle it's clear that lateral rectus measurements had better accuracy than medial rectus measurements (100% of cases of lateral rectus measurements showed

similar results or less than 1 mm difference comparative to intraoperative measurements, while only about 43% of medial rectus measurements cases showed similar results (Tables 4, 5).

Table 4: comparison between medial and lateral recti measurements.

	Muscle	Muscle						T-Test	
		Medial Rectus			Lateral Rectus			t	P-value
Intraoperative	Range	4	-	6	6	-	7.5	-8.027	<0.001*
	Mean ±SD	5.238	±	0.718	6.737	±	0.402		
OCT	Range	5	-	7.7	5.7	-	8.1	-1.888	0.067
	Mean ±SD	6.343	±	0.895	6.805	±	0.611		
Differences	Mean ±SD	-1.105	±	0.899	-0.068	±	0.524		
Paired Test	P-value	<0.001*			0.576				

Table 5: shows more accurate measurements in lateral rectus measurements.

Difference	Muscle				Chi-Square	
	Medial Rectus		Lateral Rectus		X ²	P-value
	N	%	N	%		
Lower by 1 or less	2	9.52	9	47.37	17.649	0.001*
Same	0	0.00	1	5.26		
Higher by 1 or less	7	33.33	9	47.37		
Higher by more than 1	12	57.14	0	0.00		
Total	21	100.00	19	100.00		

4. Discussion

Measuring limbus-insertion distance has been tried by many devices that are supposed to predict and improve surgical steps and results respectively, many studies were carried for determination of the best methods for each modality to achieve that target(10)(11)(12)(13).

Anterior segment OCT has the benefit of being safe, non contact and advanced technique with which convenience is felt by both the patient and the operator.

While multiple recent studies took interest in evaluating Anterior segment OCT potential for that purpose(5)⁽¹⁴⁾ (14) (15), it can still be considered a novice idea with high expectations yet to be fulfilled.

In our study, we measured limbus-insertion distance in 40 eyes in 20 patients preoperatively using anterior segment OCT and then remeasured intraoperatively using surgical caliper to verify the reliability of the device for such purpose.

It was found in our study that the measurements of limbus-insertion distance in both medial and lateral recti by both anterior segment OCT and surgical caliper had a mean difference of about (-0.6) and standard deviation of (0.9) with a statistically significant p value (less than 0.001), while in case of medial rectus alone it shows a mean difference of (-1.1) with a standard deviation of (0.8), and finally for the lateral rectus the mean is (-0.068) with a standard deviation of (0.5).

Another study by **Liu X et al (2011)**(5) showed a mean difference of (0.3) with a standard deviation of (0.4) in both medial and lateral recti readings, while for the medial rectus only it shows a mean of (0.4) and a standard deviation of (0.4), and for the lateral rectus a mean difference of (0.2) with a standard deviation of (0.3) which even indicates a better reliability of the device than our current study.

Another study by **Cheryl S. Ngo et al (2015)**(15) concluded that the average differences between all measurements by anterior segment OCT and surgical caliper was about (0.4).

In our study, the percentage of results that was exactly the same or within 1 mm difference was 70%.

This is compared to other studies like that done by **Michael J. Venincasa et al (2017)**(16) in which accuracy reached (94%), and also compared to the study made by **Cheryl S. Ngo et al (2015)**(15) where it reached about (90.3%).

Furthermore, in our study, measurements were taken by anterior segment OCT with the patient maintaining certain positions of gaze, about 15° temporal gaze for the medial rectus and 30° nasal gaze for the lateral rectus, which was similar to the study done by **Liu X et al (2011)**(5).

A study by **de-Pablo-Gomez-de-Liano et al (2016)**(17) measured limbus-insertion distance in medial rectus by anterior segment OCT in maximal temporal gaze while in maximum nasal gaze for lateral rectus.

Another study by **Kyung-Ah Park et al (2014)**(14) suggested that accurate measurements in horizontal recti required at least 40° of rotation and found that changes in eye positions didn't significantly affect the insertion distance measured by OCT, however, certain gazes might allow better visualization between the muscle and sclera.

In our study the lateral rectus measurements were more accurate by OCT than the medial rectus measurements, this was also found in two studies, one by **Liu X et al (2011)**(5) and the other by **de-Pablo-Gomez-de-Liano et al (2016)**(17).

It's to be noted that our study only included eyes undergoing primary squint surgery while in the study made by **de-Pablo-Gomez-de-Liano et al (2016)**(17) accuracy was proved higher in eyes with no history of previous squint surgery than in eyes undergoing reoperation and such differences was attributed to two reasons, first the conjunctival cicatricial and Tenon changes which obscured visualization, second the fact the anterior segment OCT can't detect an area beyond 11 mm from the limbus and even less that amount may be difficult in visualization in uncooperative patients.

In the study done by **Cheryl S. Ngo et al (2015)**(15) it was found that anterior segment OCT could detect muscles as far back as 14 or 15 mm from the limbus for medial, superior and inferior recti and 15-16 mm for the lateral rectus muscle.

Michael J.venincasa et al (2017)(16) found that accuracy of OCT based measurements for eyes undergoing primary operations drop from 83%-94% within 1 mm from intraoperative measured limbus-insertion distance to 53% -60% in reoperations.

A recent study by **J-Y Lee (2017)(8)** for imaging recti muscles postoperatively and found that during the first week postoperatively it was difficult to determine the new insertion site due to tissue swelling, while it could be clearly visualized after 3 months.

Also this study revealed that visualization of postoperative insertion site was difficult after recession surgeries more than 8 mm.

In our study, measurements by anterior segment OCT shown to overestimate the limbus-insertion distance than that done intraoperatively.

Studies by **Liu X et al (2011)(5)** and **Cheryl S.Ngo et al (2015)(15)** showed an overestimation of measurements when done by anterior segment OCT.

On the other hand, the study made by **de-Pablo-Gomez-de-Liano et al (2016)(17)** showed an underestimation of OCT measurements than intraoperative surgical caliper measurements.

Another study from **de-Pablo-Gomez-de-Liano et al (2016)(18)** showed that male measurements by anterior segment OCT were higher than female one.

It has to be emphasized that the method of measuring limbus-insertion distance using anterior segment OCT was not the same in all studies.

In our study and in other studies as made by **Liu X et al (2011)(5)**, **Cheryl S.Ngo et al (2015)(15)** the limbus was determined by locating the iris root or anterior chamber angle then adding 1 mm to the distance between it and the cleft between the sclera and muscle (Figure 3).



Figure 3: using the iris root or anterior chamber angle as an indicator.

Other studies made by **J-Y Lee (2017) (8)**, **Kyung-Ah Park et al (2014)(14)** and **Jung Yeob Han et al (2017)(19)** determined the limbus-insertion distance by measuring the shortest distance between the insertion of the muscle and scleral spur (Figure 4).

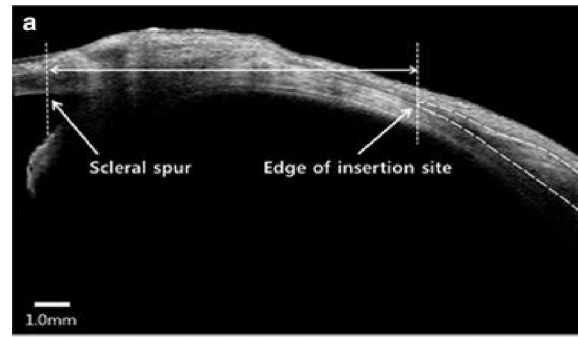


Figure 4: using the scleral spur as an indicator.

A third method by **Michael J.venincasa et al (2017)(16)** used the corneal conjunctival epithelial transition as a landmark of the limbus using greyscale or color modality provided in Anterior segment OCT (Visante; Carl Zeiss Meditec, Dublin, CA) (Figure 5).

In addition to the practical superiority of anterior segment OCT in relation to other modalities being a high resolution non contact method, the accuracy of anterior segment OCT was similar to ultrasound biomicroscopy as a study by **Shuan dai et al (2006) (20)** revealed that 80.5% of measurements done by UBM were within 1 mm difference of that done by surgical caliper intraoperatively.

While a study by **Patrick Watts et al (2002)(11)** indicated an agreement of about 0.71 between the two methods.

A study by **Hayat Ahmad Khan et al (2010) (12)** showed that wide field ultrasound biomicroscopy could image up to 20 mm from the limbus in case of lateral rectus while up to 18 mm in all other three recti, which might be an indication of better visualization of previously operated muscles than anterior segment OCT.

Conclusion

Based on our study:

1) Anterior segment OCT has high accuracy and reliability in imaging limbus-insertion distance and up to 70% of measurements were within 1 mm or less difference from the intraoperative measurements.

2) Anterior segment OCT measurements are most likely to overestimate the actual limbus-insertion distance than underestimate it.

3) Measurements of lateral rectus are less prone to errors than measurements of medial rectus.

4) Adjustment of gaze while obtaining the image by anterior segment OCT is crucial to reveal essential anatomical structures required for measuring limbus-insertion distance.

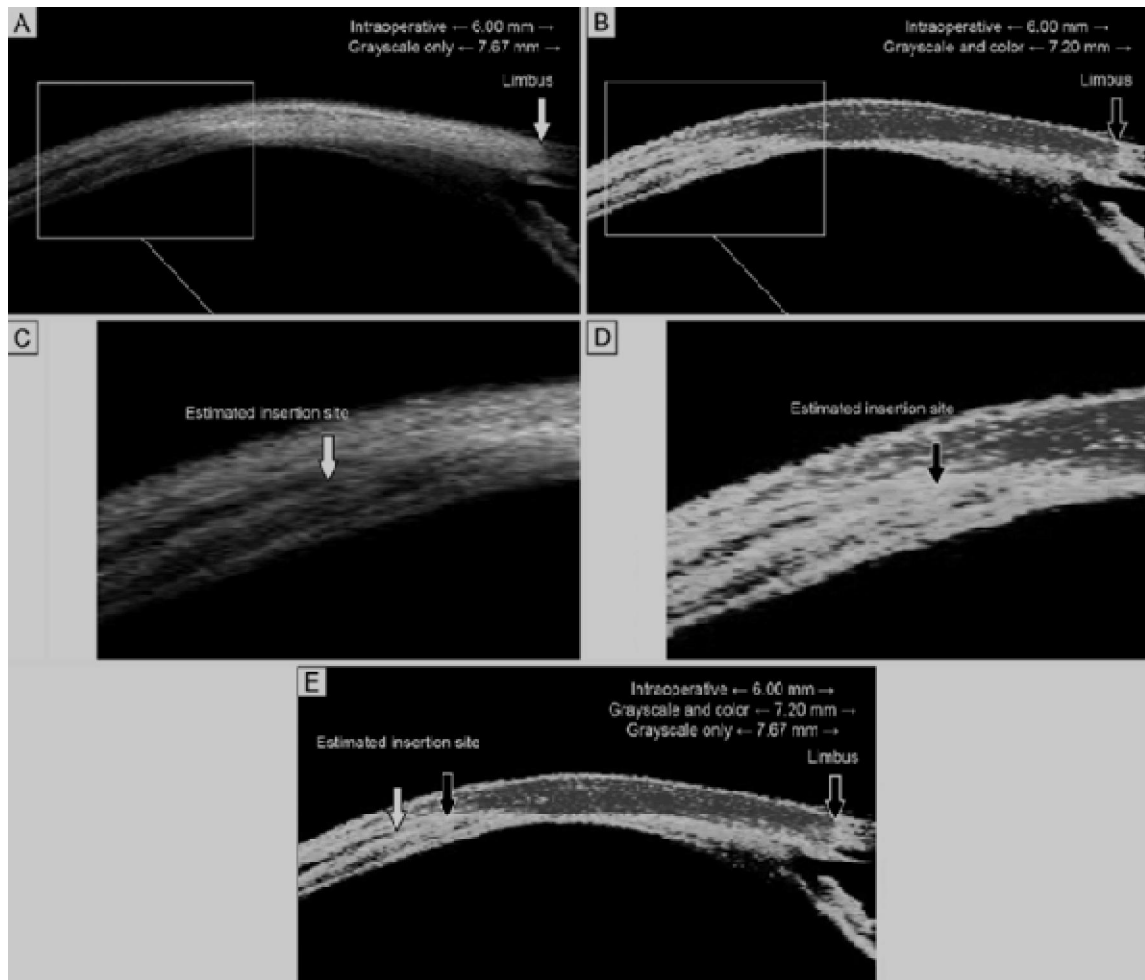


Figure 5: using the corneal conjunctival epithelial transition as a landmark of the limbus

Acknowledgements

This research received no specific grant from any funding agency in the public, commercial, or not for profit sectors.

Conflict of interest

No conflict of interest is declared by the authors with no funding for this project.

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10/7/2020