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Color Light Emitting Diode Reflection Topography- Clinical Applications

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Abstract

Purpose: Report pre and post arcuate keratotomy (AK) values, guided by laser emitting diode (LED) topography, for residual astigmatism in pseudophakia, laser *in situ* keratomileusis(LASIK), and ingrowth patients.

Setting: Private clinical practice in Barcelona, Spain.

Methods: Prospective, interventional study using LED topography anterior keratometric map for post-surgical AK. Pre and post-operative variables included uncorrected visual acuity (UCVA), best corrected visual acuity (BCVA), subjective sphere, astigmatism, and axis, LED and Orscan topography cylinder, SimK, and axis (steep). Data reported as mean and standard deviation, student t- test to assess statistical significance, Pearson correlation, and linear regression analysis were calculated. Bonferroni adjustment for p values.

Results: AK performed on pseudophakic (45 eyes), LASIK (10 eyes), and ingrowth patients (5 eyes). Pre and post AK mean astigmatism results, respectively, for pseudophakia were: subjective: 0.82 ± 0.4/0.2 ± 0.3D; p<0.001, LED 1.1 ± 0.5/0.8 ± 0.4D; p<0.0001, Orbscan 1.2 ± 0.7/0.7 ± 0.6D, LASIK: subjective: 0.75 ± 0.2/0.2 ± 0.3D; p<0.001, LED 0.8 ± 0.4D/0.61 ± 0.4D; p<0.05, Orbscan 0.78 ± 0.45/0.49 ± 0.2D; p>0.05, and ingrowth subjective: 1.2 ± 0.2/0.6 ± 0.4D; p>0.05, LED 2.1 ± 0.6/2.1 ± 0.4D; p<0.01, Orbscan 1.9 ± 0.9/1.1 ± 0.4D; p>0.05. Pseudophakia LED *vs.* Orbscan astigmatism R^2=0.60, p<0.0001 and SimK values R^2=0.90, p<0.0001. Correlation between topographers for LASIK was R^2=0.60, p<0.0001 for SimK and R^2=0.86, p<0.0001 for axis values, while for ingrowth values were R^2=0.87, p>0.01 for SimK and R^2=0.85, p>0.01 for axis values. Subjective *vs.* topography axis correlation for LASIK was R^2=0.83, p>0.05 for Orbscan and R^2=0.81, p>0.05, for LED. For ingrowth, values were R^2=0.81, p>0.01 for Orbscan and R^2=0.91, p>0.05 for LED.

Conclusion: LED topography guided AK significantly improved UCVA in pseudophakic, LASIK, and ingrowth residual astigmatism. Strong correlation for astigmatism and SimK values between LED and Orbscan values in pseudophakic eyes.

Keywords: Astigmatism; Ingrowth; Keratotomy; LASIK; Pseudophakia; Topography

Introduction

Recent articles have shown that new color light emitting diode (LED) reflection topographers offer a true elevation based topography analysis, are very precise in measuring corneal astigmatism, particular large values, and have improved axis and keratometry repeatability [1-5]. LED topography not only has the potential for toric intraocular lens calculation (IOL), but has been also tested for cylinder assessment in pseudophakia, keratoconus and corneal scars [1,3,5-7]. Its clinical applications could also include other cases involving astigmatism correction, like post-surgical residual astigmatism.

Arcuate keratotomy (AK) safely and effectively reduces astigmatism and improves visual acuity in post cataract or LASIK cases with residual astigmatism [8-11]. Ferreira et al. reported that astigmatism value was better assessed with LED topography in pseudophakic eyes [4].

We report results after LED topography guided paired AK for treating post phacoemulsification and monofocal IOL or multifocal IOL (MF-IOL) implantation, laser in situ keratomileusis (LASIK), or stable epithelial ingrowth residual astigmatism and comparing values with Orbscan topography.

Materials and Methods

We designed a prospective, longitudinal study involving patients with postoperative residual astigmatism, phacoemulsification with monofocal or MF-IOL implantation, post LASIK, or treated epithelial ingrowth who underwent treatment with AK. The study adhered to the tenets of the Declaration of Helsinki and all patients read and signed an informed consent form. Orbscan and LED reflection topography (Cassini, i-Optics, The Hague, The Netherlands), was performed by one technician (SB) before and one month post AK. With the patient in a sitting upright position, horizontal axis was marked with the Robomarker® (Surgilūm,Wilmington, N.C., USA). Eye was fixed using a FINE-THORTON 13Ø fixation ring (CARL TEUFEL, Liptingen, Germany), and one surgeon (JRST) performed paired AK with a disposable slit angled 3.2 ophthalmic knife (MANI, Park Utsunomiya, Tochigi, Japan) on the steepest angles, using LED reflection topography axial map. Treatment with topical 3 mg/ml tobramycin and

1 mg/ml dexamethasone (Alcon Cusí S.A, Novartis, Barcelona, Spain) bid during 5 days was installed.

For each patient group (pseudophakia, LASIK, ingrowth), pre and post AK data included uncorrected VA (UCVA), best corrected VA (BCVA), subjective sphere, subjective astigmatism, Orbs can and LED topographic astigmatism, SimK, and axis (steep meridian). Data was recorded on a spreadsheet (Microsoft Office Excel 97-2013) and reported as mean and standard deviation. Student t-test to assess statistical significance (paired), Pearson correlation, and linear regression analysis were calculated for pre and post AK data. Statistical significance was set at $p \leq 0.05$ with Bonferroni adjustment to correct for type II errors. Bonferroni adjustment for multiple pair comparisons error was calculated at ά=0.03 for statistical significance in pseudophakic group, ά=0.005 for LASIK group, and ά=0.01 for ingrowth group.

Results

Table 1 summarizes patient´s characteristics for each study group. Figure 1 shows mean pre and post AK visual results for each group. Pre and post BCVA results for each group were: pseudophakia (0.92 ± 0.1/0.94 ± 0.2, p>0.03), LASIK (1.0 ± 0.1; 1.0 ± 0.1, p>0.005), ingrowth (0.96 ± 0.9; 0.96 ± 0.90, p>0.01). Figure 2 compares mean pre AK subjective astigmatism and cylinder results for all groups. Figure 3 shows pre and post AK results for pseudophakic patients. Figure 4 compares pre and post astigmatism results for LASIK eyes. Figures 5 and 6 compare mean SimK and axis values, respectively, for all groups. Pre and post mean AK astigmatism values for ingrowth eyes, respectively, were: subjective 1.2 ± 0.2; 0.6 ± 0.4D (p>0.05), Orbscan 1.9 ± 9; 1.1 ± 0.4D (p>0.05), LED 1.4 ± 1.0;1.0 ± 0.1D (p ≤ 0.01).

Post-operative Orbscan and LED topography SimK values, respectively, were: Pseudophakia: 43.1 ± 2.3D; 44.1 ± 1.5D, LASIK: 39.0 ± 2.9D; 41.4 ± 4.0D, Ingrowth: 40.4 ± 1.8D; 39.2 ± 0.9D. We recorded a p>0.05 for pre and post AK SimK comparisons, for all groups.

In the pseudophakic group, mean pre AK subjective axis (87 ± 54º) compared to topography values, LED (93 ± 49º; R^2=0.3) and Orbscan (100 ± 50º; R^2=0.2).

Mean post AK axis values for Orbscan was 75.3 ± 49.8º (p ≤ 0.05) and 75.1 ± 38° for LED topography. Pre and post results were p<0.03 for Orbscan axis and p>0.03 for LED axis.

Mean pre and post AK axis results for LASIK eyes was subjective 108.5 ± 52°; LED 94 ± 53°; 96 ± 49° (p>0.05), Orbscan 105 ± 46°; 101 ± 35 (p>0.05), while for ingrowth subjective 52 ± 25°, LED, Orbscan 56 ± 26°; 50 ± 22° (p>0.05).

Pre and post mean AK astigmatism values for ingrowth eyes, respectively, were: subjective astigmatism 1.2 ± 0.20; 0.6 ± 0.4D (p>0.05), Orbscan cylinder 1.9 ± 9; 1.1 ± 0.4D (p>0.05), LED cylinder 1.4 ± 1.0; 1.0 ± 0.1D (p ≤ 0.01).

Linear regression analysis between subjective and topography astigmatism (LED and Orbscan, respectively) yielded: Pseudophakia: y=1.204x+0.418; R^2=0.29, y=0.264x+0.472; R^2=0.24, LASIK: y=-0.059x +0.795; R^2=0.01, y=0.136x+0.643; R^2=0.07, Ingrowth: y=0.69x+1.06; R^2=0.09, y=0.01x+1.184; R^2=0.001.

Linear regression for subjective axis and topography values (LED and Orbscan, respectively) were: Pseudophakia: y=0.49x+41.25; R^2=0.013, y=0.39x+45.54; R^2=0.14. Ingrowth: R^2=0.20; R^2=0.10. Figure 7 shows linear regression for subjective astigmatism and topography values in LASIK and ingrowth eyes.

Linear regression analysis for topographic cylinder and SimK values ares depicted on Figure 8 (pseudophakic) and Figure 9 (LASIK and ingrowth eyes).

Pseudophakic	•Results
•Number	•30 patients
•Gender	•18 female; 12 male
•Mean Age	•63 ± 10.9 year
•Total Arcuate Keratotomies (AK)	•45 eyes
•Cases	•Binocular AK-15 cases
	•Monocular AK-15 cases
•Post op time before AK was performed	•377 ± 804 days
	• (Range 15-3285 days)
• Intraocular lens type (IOL)	• Trifocal IOL-32 eyes
	•Segmented IOL-4 eyes
	•Diffractive IOL-2 eyes
	• Monofocal IOL-7 eyes

Table 1: General results.

Discussion

LASIK	Results
•Number	• 10 patients
•Gender	•3 female; 7 male
•Mean Age	•33.6 ± 8.1 years
•Total Arcuate Keratotomies (AK)	•10 eyes
• Cases	•Monocular AK-10 case
•Post op time before AK was performed	•422 ± 249 days
	• (Range 108-650 days)

Table 2: General results.

Reports have concluded that the LED topographer provides highly repeatable corneal power and astigmatism measurements, while values are comparable to other commonly used devices [1-5]. It provides higher keratometry values than Placido and Scheimpflug based devices and axis value agrees well with the latter [4]. Recently, additional clinical applications for the Cassini LED topographer have been reported for keratoconus, corneal scars, toric IOL calculations and in pseudophakia [1,3-7]. For the latter, LED topography seems to be a better technique for astigmatism assessment, compared to Placido or multiple measuring points based topography, and correlates with subjective astigmatism [4].

Epithelial Ingrowth	•Results

•Number	•5 patients
•Gender	•2 female; 3 male
•Mean Age	•40.4 ± 8.0 years
•Total Arcuate Keratotomies (AK)	• 5 eyes
•Post op time before AK was performed	• 304 ± 204 days
	• (Range 120-314 days)

Table 3: General results.

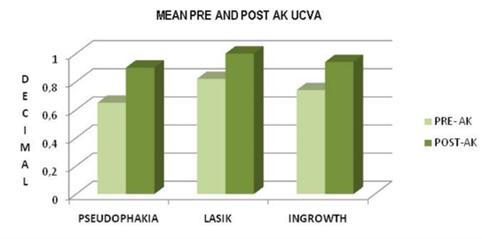

Figure 1: Comparative pre and post AK visual results for all groups. Post AK mean UCVA increased in all groups, significantly for the pseudophakic (p ≤ 0.001) and LASIK (p ≤ 0.03) groups; Ingrowth eyes (p ≥ 0.01).

As expected, for pseudophakic patients undergoing LED topography guided AK for residual astigmatism, we recorded significant decrease in subjective astigmatism and sphere values [8-9]. Mean UCVA also significantly improved for all groups, with this technique, however, unlike reports from Akura et al., BCVA improvement was not significant [9]. Post AK sphere also decreased for all groups, significantly solely for pseudophakic eyes [11]. LED and Orbscan topography cylinder values also significantly decreased, however SimK values decreased non-significantly.

Contrary to Ferreira et al. findings, subjective astigmatism values did not significantly correlate with either Orbscan (y=0.264x+0.472; R^2=0.24) nor LED (y=1.204x+0.418; R^2=0.29) topographers, in pseudophakic patients. However, cylinder values did correlate significantly between both LED and Orbscan topographers (R^2=0.60; p<0.0001).

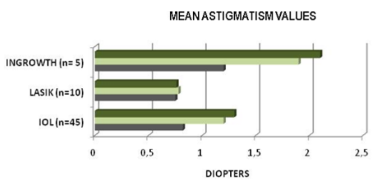

Figure 2: Mean cylinder values for each clinical group, before arcuate keratotomy. LED topography values were higher for pseudophakic and ingrowth patients (p>0.03, for both). Orbscan values were slightly higher than LED for LASIK patients (p>0.05). Ingrowth eyes had the highest astigmatism values.

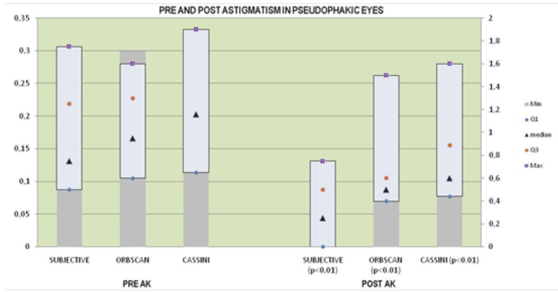

Figure 3: Comparative mean subjective, Orbscan, and LED astigmatism values decreased significantly in pseudophakic eyes after arcuate keratotomy (AK), p ≤ 0.03.

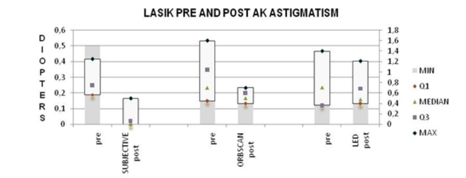

Figure 4: Comparison between pre and post arcuate keratotomy (AK) astigmatism/ topography cylinder in LASIK eyes. All values decreased; subjective (p ≤ 0.01), LED (p=0.53), Orbscan (p=0.07) post keratotomy.

Subjective astigmatism did not correlate with topography values in LASIK (LED p ≥ 0.05; R^2=0.01 and Orbscan p ≥ 0.05; R^2=0.2) nor for ingrowth eyes (LED p ≥ 0.05; R^2=0.09 and Orbscan p ≥ 0.05; R^2=0.01). LED and Orbscan astigmatism values also correlated poorly in LASIK (p>0.05; R^2=0.23) and ingrowth eyes (p>0.05; R^2=0.62).

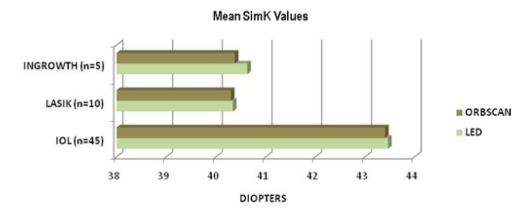

Figure 5: Mean topographic pre AK SimK value for all clinical groups. LED topography values were slightly higher than Orbscan; p>0.05 all groups.

LED SimK values were higher than Orbscan values (p>0.05) in all groups, as already reported for other Placido topographers [3,4]. SimK values significantly correlated between topographers for pseudophakia (R^2=0.90; p<0.0001) and LASIK (R^2=0.90; p<0.0001) eyes. For ingrowth eyes, LED and Orbscan SimK values strongly correlated but results were not significant (R^2=0.87; p ≥ 0.01), probably due to the low sample number.

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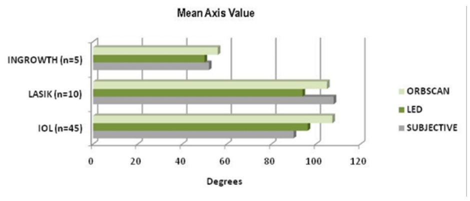

Figure 6: Mean axis values were higher for Orbscan topography (p>0.05).

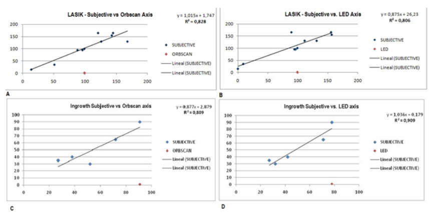

Figure 7: Linear regression analysis. Subjective and topography axis strongly correlated for LASIK (A&B) and ingrowth eyes (C&D); p>0.05 for both groups.

Subjective axis values LASIK (LED p>0.05; R^2=0.81, Orbscan p>0.05; R^2=0.83) and ingrowth (LED p>0.05; R^2=0.91, Orbscan p>0.05; R^2=0.81) significantly correlated with topographers. However, poor subjective axis correlation was recorded for pseudophakic eyes (LED p>0.05; R^2=0.20, Orbscan p>0.05; R^2=0.20). On the other hand, AK was performed as early as 15 days, in MF-IOL patients, while the time range was more homogeneous in LASIK and ingrowth patients, which did show correlation between subjective and topography axis. In addition, residual astigmatism is more relevant in these two groups, contrary to the pseudophakic with IOL, especially MF-IOL, who will poorly tolerate postoperative residual astigmatism. If total cornea astigmatism had been measured, perhaps this correlation would increase.

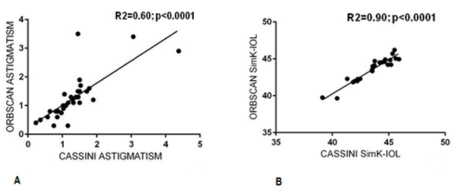

Figure 8: For pseudophakic patients undergoing AK, we found significant correlation for SimK (A) and astigmatism values (B), between LED and Orbscan topographers. Axis values were poorly correlated between topographers; y=0.407x+68.97; R^2=0.14.

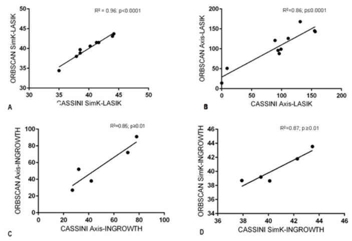

Figure 9: For LASIK eyes, SimK (A) and Axis (B) values strongly correlated between topographers. For ingrowth eyes, correlation was recorded for Axis (C) and SimK (D) between topographers, p>0.05 for both groups.

Our results differ from those reported by Ferreira, regarding poor subjective astigmatism correlation with LED and Orbscan topography values. They recruited patients with at least 3 months after surgery, while our patients had at least 2 weeks and many had postoperative dry eye syndrome that could explain these results. Significant more variability in keratometry and astigmatism measurements have been reported in dry eye syndrome [12,13]. In addition, most patients had multifocal IOL implantation, which usually requires earlier emmetropia for improving visual satisfaction. We also used the earlier software, which required a learning curve for our technician and patients while Ferreira et al. had 2 technicians.

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