



## Comparison of the EyeQue Personal Vision Tracker with the Topcon KR-800 Autorefractor

Summary of white paper, October 7, 2016

### Synopsis

The following has been extracted from a broader study conducted by EyeQue™ over a three-month period. This study aims to compare the EyeQue Personal Vision Tracker™ (PVT) against an industry standard autorefractor. In measuring spherical equivalent, astigmatism, and resultant visual acuity, the EyeQue PVT produces comparable results within 0.77 diopters of the autorefractor. Of the sample tested, 69% of eyes using EyeQue PVT results had visual acuities that were equal to or better than those using the autorefractor. To discuss the details of the full study, contact EyeQue at [info@eyeque.com](mailto:info@eyeque.com).

### Introduction

The EyeQue Personal Vision Tracker (PVT) is a self-administered, monocular refraction system using an optical miniscope (EQ100) and a smart phone (figure 1). In conjunction with the miniscope, the myEyeQue mobile application guides the user through interactive measurements that estimates the user's refractive error. The results are uploaded to a secure cloud environment called EyeQue Cloud™ where they are stored and processed.

The EQ100 miniscope is portable, does not require electric charge, and can be manufactured at a much lower cost than industry-standard autorefractors and phoropters found in doctors' offices. Currently, the miniscope and myEyeQue mobile application are compatible with the devices listed in Table 1, however EyeQue is continuously expanding compatibility to more mobile systems.

**Table 1.** Compatible devices and operating systems.

Smartphones	Software
Galaxy S5	Android 4.X
Galaxy S6	Android 5.X
Galaxy S6 Edge	Android 6.X
Galaxy S7	
Galaxy S7 Edge	
Huawei Nexus 6Pv	
LG G5	
iPhone 6 / 6 Plus	iOS 9.3 and above
iPhone 6s / 6s Plus	
iPhone 7 / 7 Plus	



**Figure 1:** The EyeQue Personal Vision Tracker: Optical miniscope (EQ100) with smartphone and myEyeQue mobile application.

Together, the device and mobile display operate on the Inverse Shack-Hartmann principle described by patent US 2013/0027668 A1, "Near Eye Tool for Refraction Assessment"<sup>1</sup>. The user views the mobile screen through the attached miniscope and is tasked with aligning a series of parallel lines. The adjustment needed for each measurement directly corresponds to a dioptric refractive error. Results obtained through these exercises are processed through EyeQue's proprietary algorithm which generates a refractive error for sphere and cylinder in 0.25D increments, and axis in one degree increments. The EyeQue PVT can measure refractive error with a range from -12.00 diopters to +8.00 diopters for spherical power, and up to 5.00 diopters of cylinder power.

## Methods

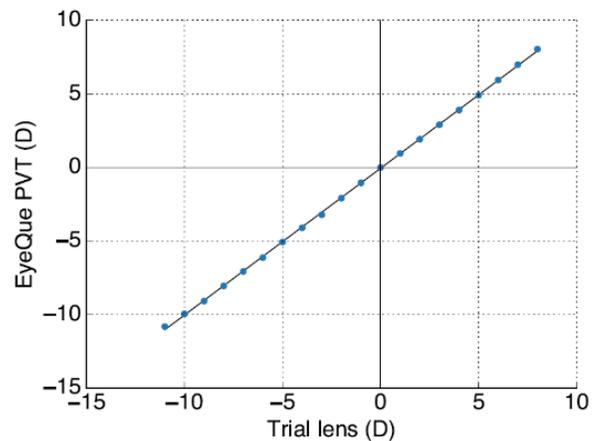
In order to evaluate the EyeQue PVT's objective ability to accurately measure refractive error, known trial lenses substituting as the human eye were first tested in a laboratory controlled trial. Test subjects who met inclusion criteria were then tested for refractive error using an industry-standard autorefractor (Topcon KR-800) and the EyeQue PVT. The refractive error results from the EyeQue PVT were compared to the autorefractor results. Finally, to test whether subjects can achieve good vision using the results from the EyeQue PVT and/or the autorefractor, the results from both methods were built into trial lenses and visual acuities were measured for each eye. A full description of methods can be found in the complete EyeQue white paper.

## Results and Conclusions

For more effective statistical analysis, sphere, cylinder, and axis measurements were converted into vector notation described by Thibos et al<sup>2</sup>.  $M$  refers to mean spherical equivalence,  $J0$  to the astigmatism along the 0(180) degree meridian, and  $J45$  to the astigmatism along the 90 degree meridian. All vectors are noted in diopters and  $J$  values account for astigmatic magnitude and axis.

### Trial lens testing without human subjects

Testing using known trial lenses showed that the EyeQue PVT is highly accurately calibrated to measure refractive error in the absence of human error. A linear regression plot was used to demonstrate the accuracy of EyeQue PVT's ability to measure spherical error. An ideal correlation coefficient ( $r$ ) of 1.00 represents complete accuracy. As seen in figure 2, the EyeQue PVT results have a nearly perfect correlation ( $r^2 = 0.999$ ) with spherical trial lenses. Measuring astigmatism also showed high accuracy: the mean difference between EyeQue results and the actual refractive error for  $M$  was  $0.01D \pm 0.08$ , for  $J0$ ,  $0.00D \pm 0.06$ , and for  $J45$ ,  $0.00D \pm 0.04$ .



**Figure 2:** Linear regression plot for trial lens testing using EyeQue PVT. Equation of the line is  $y=0.997x-0.06$ ,  $r^2= 0.999$ .

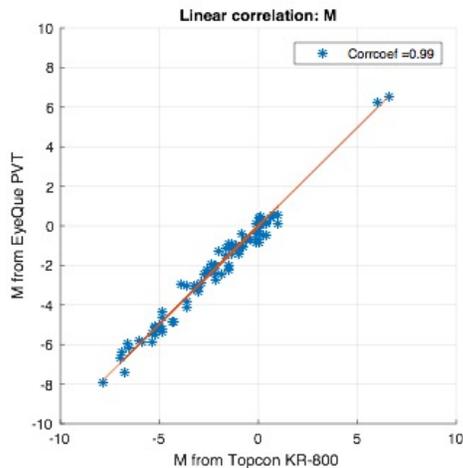
## User testing

Eighty-eight total eyes from 49 subjects were included in analysis, with subject ages ranging from 16 to 74 years old. Their average refractive errors converted into vector format as measured by the Topcon KR-800 and the EyeQue PVT are listed in table 2.

**Table 2.**  
Mean values of  $M$ ,  $J_0$  and  $J_{45}$  in diopters measured in 88 eyes.

	$M$	$J_0$	$J_{45}$
<b>Topcon-KR800</b>	-2.111 ±2.62	-0.018±0.45	+0.014±0.22
<b>EyeQue</b>	-2.176±2.57	+0.017±0.41	+0.013±0.20

Linear regression was used to compare the vectors  $M$ ,  $J_0$ , and  $J_{45}$  calculated from results found using the EyeQue PVT and Topcon KR-800 autorefractor. The correlation between the two methods in measuring spherical equivalent was highest,  $r^2 = 0.99$ , followed astigmatic magnitude  $J_0$  with  $r^2 = 0.85$ . Linear regression for  $J_{45}$  was lower ( $r^2 = 0.72$ ), however this may be because most subjects had with-the-rule astigmatic axes centered in the plot around 0. The linear regression curve for spherical equivalence is shown in figure 3.

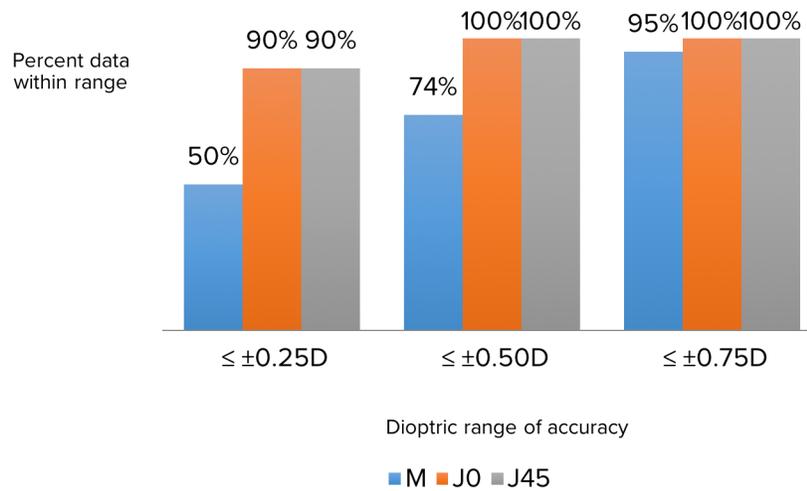


**Figure 3.**  
Linear regression analysis of spherical equivalence between Topcon KR-800 and EyeQue PVT with respective correlation coefficients.

The difference between EyeQue PVT and Topcon KR-800 measured results was also analyzed. A perfect match between the two methods would show an average difference of zero diopters in each vector

component and standard deviations of zero. This would mean every measurement taken by the EyeQue PVT and the Topcon KR-800 was exactly the same. However, this is unlikely considering that even the repeatability of doctors performing subjective refraction shows a degree of variability<sup>3-4</sup>. Bland-Altman statistical analysis of this data can be found in the full white paper<sup>5</sup>.

The average difference for *M* was -0.07 D, *J0* was 0D, and *J45* was 0D. Clinically important differences in measuring spherical equivalence is shown in figure 4. 73.86% of spherical equivalent results measured by the EyeQue PVT falls within 0.50 diopters of the Topcon KR-800. 95.45% falls within 0.75 diopters. In measuring *J0*, 97.73% of results from the EyeQue PVT fell within 0.50 diopters of the Topcon KR-800, and 85.23% within 0.25D. For *J45*, 100% of EyeQue PVT results fell within 0.50D, and 89.77% within 0.25D of the Topcon KR-800.

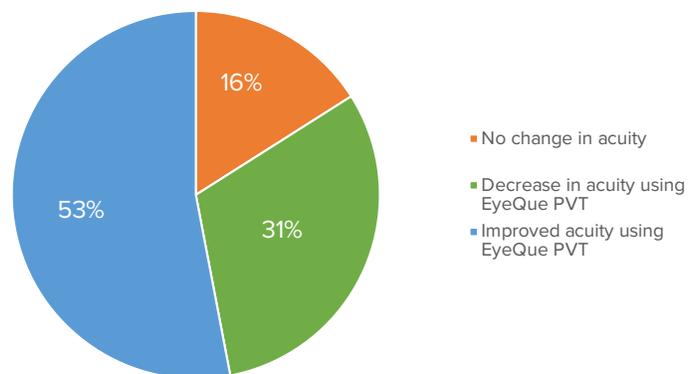


**Figure 4.** Accuracy of EyeQue PVT compared with Topcon KR-800.

## Visual acuity

To further validate the EyeQue PVT results compared to the Topcon KR-800, visual acuity was tested using both sets of results. All eyes included in the study were required to have at least 20/20 vision using either the EyeQue PVT or Topcon KR-800 results.

Visual acuities were logged as the gain or loss of letters read using the EyeQue PVT results compared to the Topcon KR-800 (figure 5). Of the visual acuities that changed, 53% of eyes showed an improvement using the EyeQue PVT results. The average difference in all visual acuities using the



**Figure 5.** Visual Acuity Change

EyeQue results was a gain of 0.45 letters read. This shows that tested vision using the EyeQue PVT results has no statistical or clinical difference to vision tested using the autorefractor results.

## Conclusion

In conclusion, the EyeQue PVT is precisely calibrated to detect refractive error and when used correctly, achieves comparable accuracy to an industry standard autorefractor. Although using the EyeQue PVT to personally measure and track refractive error has the benefits of detecting change between regular eye exams, it does not replace a comprehensive eye exam that evaluates ocular health or binocularity. It is an accessible and accurate tool that can empower the public to be more aware of vision changes. Given its equivalent accuracy, the EyeQue PVT is a low cost refraction method that performs as well as autorefractors that sell at two orders of magnitude in cost.

## References

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## About EyeQue

EyeQue™ is on a global mission to elevate eye care. The Company is dedicated to inspiring people to learn about and care for their eyes by putting affordable, accurate vision tests directly into their hands. The EyeQue optical miniscope and myEyeQue™ mobile application create an intelligent vision solution for anyone to use anywhere, at any time – convenient, low-cost, and fun. Results are instantly processed and stored in the cloud, creating a vision record history that can be shared with doctors and used immediately to order corrective eye wear. Founded by serial entrepreneurs, Tibor Laczay and John Serri, the Company innovates from its Silicon Valley headquarters.

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