A Comparison Study of 3 Auto-refractors and How they Correlated To the Standard Subjective Refraction for Accuracy, Validity and Efficiency of Use

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Abstract

The purpose of this study was to determine the accuracy, validity, and efficiency of three auto-refractors. The accuracy will be determined by comparing the auto-refraction results to the proven gold standard of a subjective refraction. The efficiency of the auto-refraction units will be determined by the time needed to complete the auto-refraction. The three types of auto-refractor units include two handheld models, the Nikon Retinomax and the portable Welch Allyn SureSight, and a standard non-mobile (table-top) Topcon unit. Refractive data was collected for 63 subjects so that conclusions on the accuracy, validity, and efficiency the three auto-refractors can be made.

Introduction

Refractive disorders of the visual system account for most cases of functional vision loss in persons younger than 45 years of age (1). While in most situations refractive error is easily correctible with ophthalmic lenses incorporated into spectacles. Determining the exact prescription (the refraction) can be somewhat time consuming and variable. This variability is often dependent upon the age, gender, physical abilities and communication skills of the specific patient.

Vision screenings have been developed to obtain superficial information on the status of one's visual system in a timely manner. The Orinda study has proven screenings to be the best method of referral of patients requiring treatment (2). Four tests, including visual acuity, cover test, retinoscopy, and ophthalmoscopy, provide sufficient knowledge on which to base the necessity of referral. While this works relatively well on school-aged children, more in-depth screenings, such as those done on mission trips (3), require a more definitive assessment of refractive error in as little time as possible.

A subjective refraction has been deemed the "gold standard" from which to base the most accurate spectacle prescription due to its repeatability or reliability (4). However, subjective refractions require a considerable amount of time and patient cooperation. A technique that requires less time to determine the spectacle prescription is more desirable in a screening setting. Such a technique would be an objective form of refraction determination for which the standard is Retinoscopy (5). Over the last twenty years, however, auto-refractors have emerged and challenged retinoscopy as the new standard for objective refractions. Although auto-refractors are relatively expensive devices they may provide accurate, valid, and efficient measures from which to help prescribe spectacles in both primary office settings and in third-world countries. This paper will compare the accuracy, validity and ease of use of 2 portable (hand-held) auto-refractors and one tabletop unit to the subjective refraction.

Methods

Data was compiled from sixty-three subjects providing data of 126 (n = 126) refractive errors due to the use of monocular prescriptions. The subjects were college students at Ferris State University. The majority were optometry students and all ranged in age from 18 to 33 years of age. The average age was 23 years. Subjects were all free of ocular pathologies and none were amblyopic. Therefore the subjects all had a best-corrected visual acuity of 20/20, which was tested using a Snellen visual acuity chart.

The examiners for this study were two third year Michigan College of Optometry student interns. Four refractive procedures were performed in a moderately lighted room, with the order of these four procedures being random (random number generator) for each subject. One student performed monocular subjective refractions using a Snellen visual acuity chart. The starting point for the refractions was the current spectacle prescription that was determined by lensometry. The monocular subjective refraction was performed instead of a binocular balanced refraction so that the comparison to the auto-refractors monocular readings would be more relevant.

The other student performed auto-refractometry using the following three instruments: Topcon table top auto-refractor (KR 8000), Nikon Retinomax, and Welch Allyn SureSight (see appendix 1, 2 & 3). The Topcon tabletop auto-refractor used the average of three readings as its endpoint. The Nikon Retinomax averaged eight refractive error readings. The Welch Allyn SureSight measured and then averaged five to eight readings. The SureSight measured subjects in the adult mode. The Topcon tabletop measured the refractive components using 0.12 D steps while the Retinomax and SureSight used 0.25 D steps.

Each of the methods of refraction was timed using identical digital timers (fig 1). Timing began at the start of instructions to the patient and ended after a prescription was found. The time was recorded to the nearest second.

Results

The determination of accuracy of the auto-refractor units was based on measurements within +/- 0.50 D of the subjective refraction. Data was analyzed by spherical component, cylindrical component and cylindrical axis. Efficiency of the four refractive procedures was determined by the average time to complete the procedure.

The spherical powers determined compared to all three auto-refractors are found on Graph I. The Topcon tabletop unit was found to be most accurate with it being within 0.50 D of the subjective refraction spherical component 84.92 % of the time. The Retinomax had a spherical accuracy rate of 65.08% while the SureSight had a similar accuracy rate of 64.96%

The cylindrical powers determined by subjective refraction compared to the auto-refractors are found on Graph II. The Topcon tabletop unit was again most accurate with a 93.65% rate of being within 0.50 D of the subjective refraction. The SureSight had a cylindrical accuracy rate of 84.96 % while the Retinomax had an accuracy rate of 84.13%.

The cylinder axis of the auto-refractor results was also compared to the subjective refraction. The axis accuracy rates were based on auto-refractor results within either +/- 10-degrees or +/- 20-degrees and are shown in Graph III. These accuracy rates for both the +/- 10 and +/- 20-degree ranges were highest for the Topcon KR 8000 unit at 62.75% and 90.20% respectively. Then followed by the SureSight at 54.90% & 84.31% and lastly with the Retinomax at 54.17% & 77.08%. Also shown in the graph is the significant increase in the accuracy for the +/- 20-degree criteria versus the +/- 10-degree for all three auto-refractors.

Graph IV shows the average of time to complete the individual refractive measures. The longest procedure of course was the subjective refraction, which took an average of 114.41 seconds to complete. The three auto-refractors all proved to be more efficient than the subjective, with average times being under 40 seconds. Of the three auto-refractors, the SureSight proved to be the quickest with an average time of 17.86 seconds. Next was the Retinomax with an average time of 29.19 seconds for a reading, followed by the Topcon at an average of 37.86 seconds

Discussion

The three goals of this study were to show the accuracy, validity, and efficiency of three auto-refractors compared to the "gold standard" of subjective refraction.

The accuracy of the auto-refractors was determined by standard of being within +/- 0.50 D of the subjective refraction endpoint. Analyzing the data shows that the proven Topcon tabletop auto-refractor was the most accurate of the three types of auto-refractors in both spherical and cylindrical components. With 84.92% and 93.65% accuracy rates the Topcon tabletop compares very favorably to the "gold standard" of the subjective refraction. The two hand held auto-refractors, the Retinomax and SureSight, were comparable to each other with having similar accuracy rates in both spherical and cylindrical components. The cylindrical accuracy rates, at 84.13% and 84.96% respectively, were comparable to the subjective refraction results. The spherical component accuracy rate of the hand held auto-refractors, however, only have accuracy rates slightly above 60% leaving room for improvement.

The efficiency of auto-refractometry was proven in this study by comparing the average time for each individual refractive method or procedure to the subjective. As expected the subjective refraction took the longest amount of time to complete, with an average time of 114.41 seconds. The three auto-refractors all had average times that were at least twice as fast a the subjective, with the quickest being the SureSight at 17.86 seconds, then the Retinomax at 29.19 seconds and finally the Topcon at 37.86 seconds.

Combining the efficiency and the accuracy results could show the validity of the auto-refractors as a tool or instrument for use in the estimation of refractive corrections. The results of the spherical power, cylinder power, cylinder axis and the percentage of time below the average time taken for the subjective were combined to create an index of validity. The four parts were weighed equally with the highest rating for each sub-section being 0.25. Therefore the results are measured against the "perfect" validity factor of 1.0. The Topcon auto-refractor was proven to be the most valid overall with the rating of 0.77. This was followed closely by the SureSight with a 0.72 and then by the Retinomax at 0.69.

Conclusions

This study showed the efficiency of the auto-refractor compared to the "gold standard" of subjective refraction. The average times of the auto-refractors demonstrate the time saving ability of auto-refractors, which is especially useful in vision screenings, VOSH mission settings, or with large numbers of participants. The timesavings could be a much as 84% faster using the portable auto-refractor (SureSight)

The accuracy of the Topcon tabletop unit was also proven in this study with high accuracy rates in both spherical and cylindrical components. The handheld auto-refractors were shown to be more accurate in the cylindrical component but were shown to have a spherical accuracy rate of just over 60%.

The validity of the auto-refractors was rated out of a scale of 0.0 to 1.0, with the Topcon KR 8000 proving to have the highest rating (0.77), while the Retinomax had the lowest (0.70). This rating implies that the Retinomax results would not be valid more than 30% of the time it was used.

The results of the paper showed that the Topcon tabletop unit rated the best choice overall when considering the aspects of accuracy, validity and efficiency. Even though it was not the fastest auto-refractor used, it could still shorten the "refraction time" by 66% and with fairly high accuracy measures.

The portability of the hand-held auto-refractors are highly desirable and the accuracy rates show that it is a good screening tool, but higher spherical accuracy rates are desirable to produce less false negatives at screenings. Also higher spherical accuracy rates are needed before these auto-refractors can be used to prescribe spectacle prescriptions.

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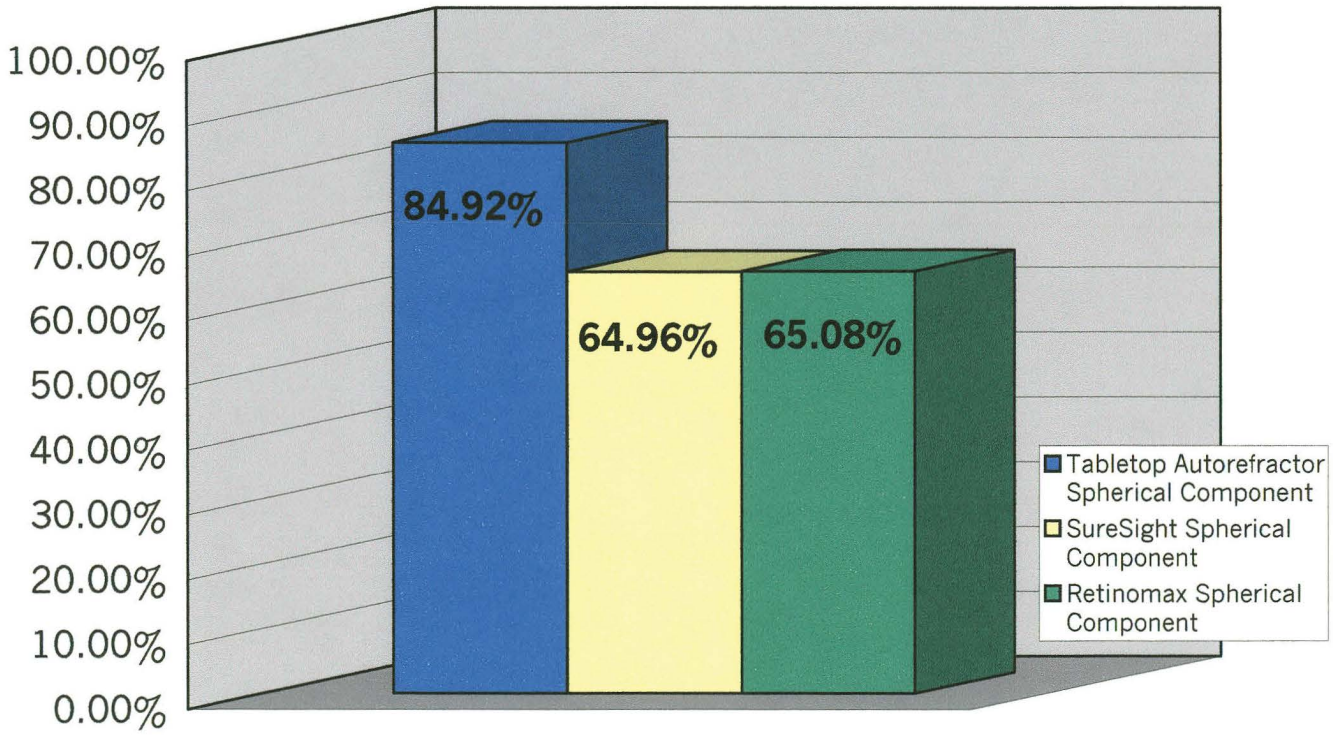
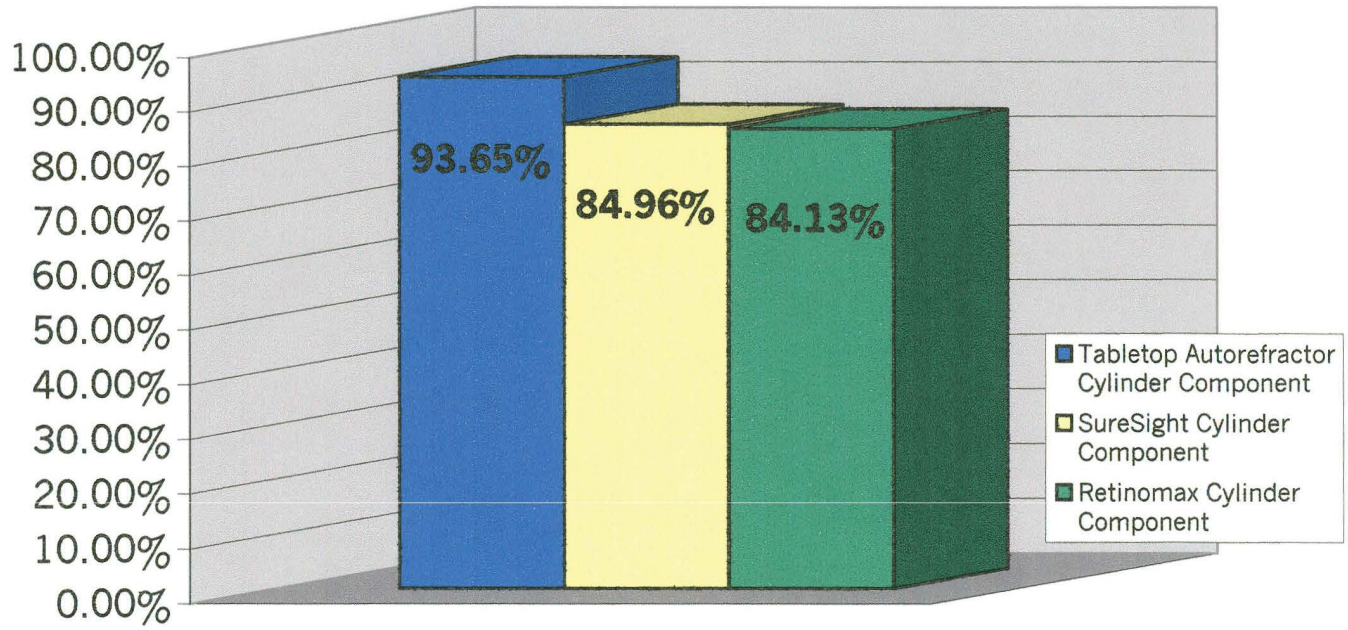
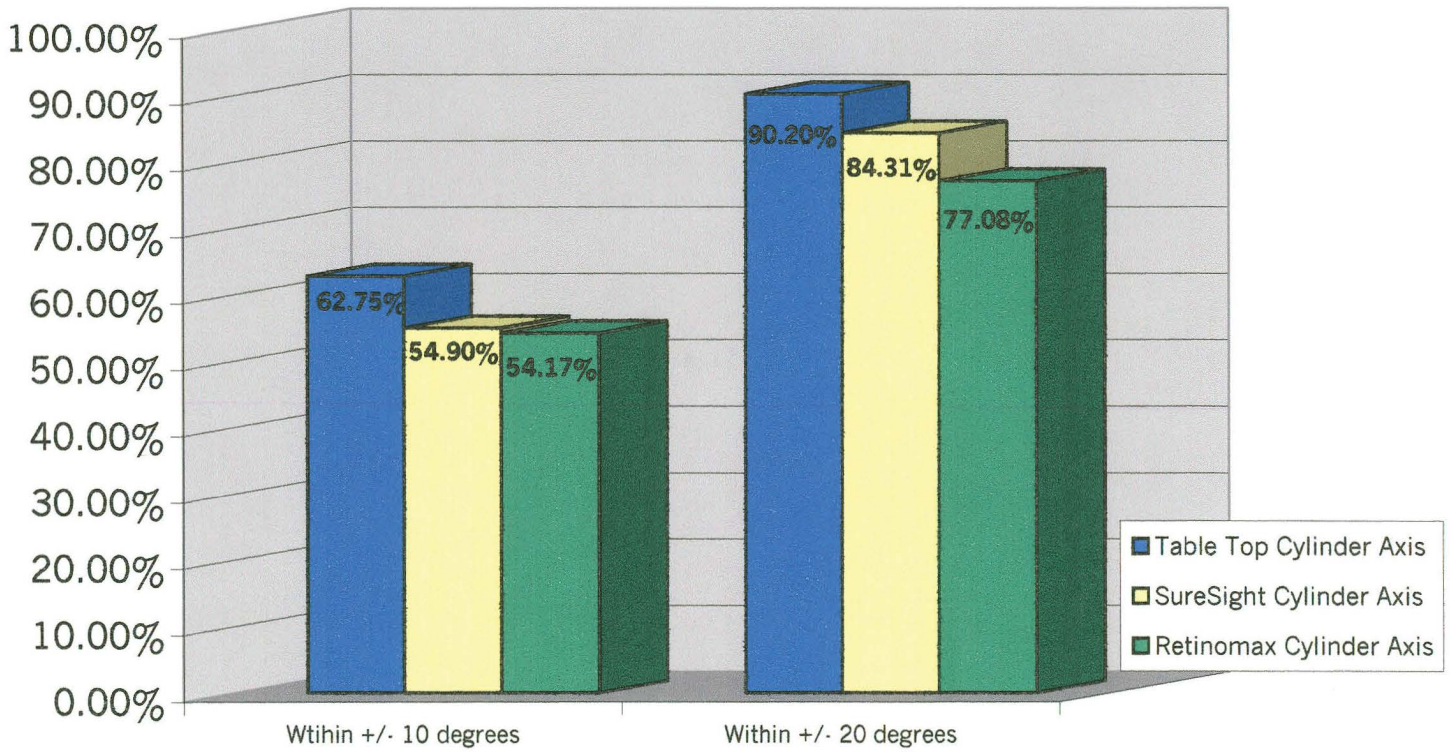
Percentage of the Autorefractors' Spherical Component within +/- 0.50 D of the Subjective Refraction



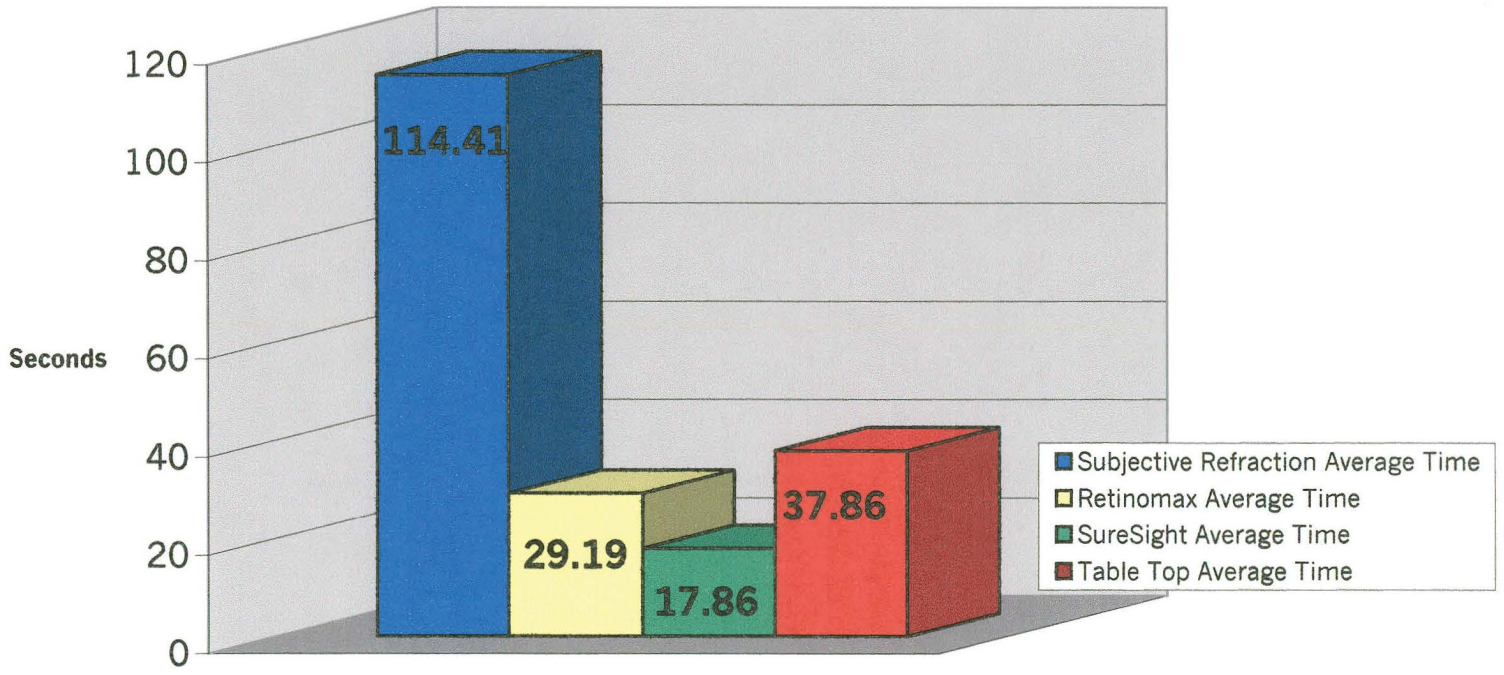
Percentage of the Autorefractors' Cylinder Component Within +/- 0.50 D of the Subjective Refraction



Percentage of the Autorefractors' Cylinder Axis Within Given Degrees of Subjective Refraction



Average Times of Refraction



Patient #	Subjective Refraction Spherical Component	Table Top Spherical	Difference TT - SR	+/- 0.50 D	
1	-2.5	-2.87	-0.37	Y	11 N AT 31 PTS
1	-2.75	-3.12	-0.37	Y	* = Refractive Surgery
2*	-0.25	-0.5	-0.25	Y	
2*	plano	-0.37	-0.37	Y	19 N AT 63 PTS
3	-1.75	-2.12	-0.37	Y	107 Y OUT OF 126
3	-2.25	-2.37	-0.12	Y	107/126= 84.92%
4	plano	plano	0	Y	
4	-0.25	-0.25	0	Y	
5	-4	-4.25	-0.25	Y	
5	-4	-3.87	0.12	Y	
6	-4.5	-5	-0.5	Y	
6	-2.5	-2.62	-0.12	Y	
7	-11.25	-11	0.25	Y	
7	-11.25	-12	-0.75	N	
8	-0.5	-1.12	-0.62	N	
8	-0.75	-0.5	0.25	Y	
9	plano	0.12	0.12	Y	
9	plano	0.12	0.12	Y	
10	-0.25	-0.37	-0.12	Y	
10	-0.25	-0.12	0.12	Y	
11	-6.25	-6.87	-0.62	N	
11	-6.5	-6.75	-0.25	Y	
12	plano	-0.37	-0.37	Y	
12	-0.25	-0.75	-0.5	Y	
13	-2.25	-2.75	-0.5	Y	
13	-3.25	-3	0.25	Y	
14	-6	-5.87	0.12	Y	
14	-5	-4.75	0.25	Y	
15	-3	-3.62	-0.62	N	
15	-2.5	-2.37	-0.12	Y	
16	-1.25	-1.62	-0.37	Y	
16	-2.75	-3.12	-0.37	Y	
17	0.75	plano	-0.75	N	
17	0.75	0.5	-0.25	Y	
18	-3	-3.75	-0.75	N	
18	-2.75	-3.62	-0.87	N	
19	-3.5	-4.25	-0.75	N	
19	-3.5	-4	-0.5	Y	
20	-2	-2	0	Y	
20	-2	-2.25	-0.25	Y	
21	plano	0.25	0.25	Y	
21	-0.25	-0.37	-0.12	Y	
22	-4	-4.37	-0.37	Y	
22	-5.75	-5.75	0	Y	
23	-5.5	-6	-0.5	Y	
23	-5.75	-6	0.25	Y	
24	-9.25	-8.87	0.37	Y	
24	-10.25	-9.62	0.87	N	
25	-6.25	-6.12	0.12	Y	