Original Research Article

Comparative Study Between Modified Thorington Test and Von Graefe Phorometry on Near Lateral Phoria Assessment among Emmetropes

*Atuanya, G.N., Uchendu, V.C., Musa, M.J. and Akpalaba, R.U.E

Department of Optometry, Faculty of Life Sciences, University of Benin, PMB 1154, Benin City, Nigeria.
*george.atuanya@uniben.edu

ARTICLE INFORMATION

ABSTRACT

The aim of this study was to compare the modified Thorington test and Von Graefe Phorometry in the assessment of near lateral phoria among emmetropes. A total of one hundred subjects (N=100), consisting of 56 males and 44 females, with a mean age of 22.57±3.26 years participated in the study. The modified Thorington and Von Graefe techniques were performed at near (40 cm) using the Bernell muscle imbalance measure card commonly known as Thorington card and the Phoropter respectively under standard testing procedures. Results showed that the near phoria measurements with the Von Graefe technique ranged from 6Δ esophoria to 12Δ exophoria with a mean of 4.90±3.84Δ exophoria, while that with modified Thorington technique ranged from orthophoria to 12Δ exophoria with a mean of 4.67±2.91Δ exophoria. Although the Von Graefe phorometry showed a broader range of exophoria as compared with the modified Thorington, it was not statistically significant (p<0.05). In conclusion, the Von Graefe technique cannot be replaced by the modified Thorington technique in the measurement of near phoria.

1. INTRODUCTION

The error of alignment that takes place when fusion is suspended is called heterophoria or phoria. A phoria may be viewed as a measure of the error between the desired alignment of the eyes and the position produced by the actions of tonic, accommodative and proximal convergence. Most binocular anomalies result in the misalignment of the visual axes. The fusion reflex maintains correct alignment of the two eyes. If this fusion reflex is suspended, the eyes will adopt a fusion-free position and a measurable amount of deviation of the visual axes will occur (Grosvenor, 2007).

Over the years, several clinical and experimental methods have been proposed to assess heterophoria. The most commonly used tests to measure heterophoria are the cover test (CT), the Von Graefe method (VG),

and the Maddox rod test (MR). However, the modified Thorington test (MT) has been shown to yield more repeatable results than the VG and MR (Asonye and Ogugua, 2010). The modified Thorington procedure is quick and simple to perform and is also easy for subjects to understand. Nevertheless, despite its increasing popularity for measuring near heterophoria, its repeatability has not been well established for distance heterophoria measures (Andrew et al., 2014). The measurement of any physiological variable is subject to error and to biological variability. Heterophoria is a clear example of this; however, errors may arise owing to different factors such as the test card used, luminance level, accommodation control and convergence. Other possible sources of error include the quantification method (estimate, prisms, or graded scales), the patient's state, objectivity, and examiner skill among many others (Goss et al., 2010; Andrew et al., 2014). Dissociated phoria testing is an important part of the clinical evaluation of binocular vision. Probably, the most commonly used subjective dissociated phoria test is the Von Graefe test (Grosvenor, 2007).

Repeatability is the extent to which the measurements of a test remain consistent over repeated test of the same subject under identical conditions. Studies have consistently found the modified Thorington test to be more repeatable than the Von Graefe test (Hyun-Jin et al., 2012; Andrew et al., 2014). To be of most value to the practitioner, clinical tests should be both reliable (repeatable) and valid. A good binocular vision assessment is very crucial in elucidating problems associated with binocular vision. Hence, this study was aimed at comparing the modified Thorington test and Von Graefe phorometry in the assessment of near lateral phoria among emmetropes.

2. MATERIALS AND METHODS

2.1. Survey Methods and Subject Selection

This was an observational cross-sectional study carried out at the Optometry clinic, University of Benin, Edo State, Nigeria. The study spanned for a period of six (6) months. Prior to the study, informed consent was sought from the subjects after explaining the procedures clearly to them. Ethical approval for the study was given by the Department of Optometry, University of Benin ethical committee. A total of a hundred (100) subjects (males and females) aged 17years to 32years (22.57±3.26) were recruited for study, having fulfilled the inclusion criteria of being emmetropes (i.e., refractive power ≤ +0.50D to -0.50D in both eyes and astigmatism ≤ 0.75D). However, subjects with ocular pathology and ammetropes were excluded from the study. The materials used included Phoropter, Bernell Muscle Imbalance Measure Cards – Thorington Card, Red Maddox rod, Penlight and Measuring rule.

2.2. Description of Procedure

Both the modified Thorington test and the Von Graefe test were performed at near working distance (40cm). The modified Thorington test was performed prior to the Von Graefe test. This is because the Von Graefe test causes dissociation of the eyes and might result in a different phoria result being obtained in subsequent testing (Carlson et al., 1998; Grosvenor, 2007).

2.2.1. Modified Thorington test procedure

The modified Thorington card contains vertical and horizontal graded scales with an orifice at the centre where light was directed towards the subject's face. The modified Thorington test was used to measure the amount of heterophoria at near (40 cm). The technique is a modification of the Thorington method, which uses a vertical prism to produce dissociation (Goss et al., 2010). The room light was dimmed and the horizontal axis of the red Maddox rod was placed before the subject's right eye (RE). The subject was instructed to look toward the light at the centre of the card and indicate whether the red vertical line is on the light spot (orthophoria) or to the right (esophoria) or left (exophoria) of the light spot. A situation where the

patient reported that the vertical line was on the light spot, orthophoria is indicated. When the line was to the left of the spotlight (crossed image), the subject had an exophoria. If the line was to the right of the spotlight (uncrossed image), the subject had an esophoria. The size of the deviation was determined by asking the subject which number on the horizontal series of letter on the Thorington card the line passed through, and the number read off the scale corresponded to the amount of prism power in diopters of horizontal heterophoria. The direction and amount of phoria so obtained was recorded (Grosvenor 2007).

2.2.2. Von Graefe test procedure

A Von Graefe near phoria assessment was performed by asking the subject to fixate through the phoropter, with a near phoria target presented at 40 cm. The subject was asked to appreciate the target before 12 prisms base- in were introduced into the right eye dial and six prisms base down into the left eye dial. The subject was asked to confirm seeing two sets of the near target, one slightly above and laterally displaced with respect to the other. The horizontal prism was then gradually reduced in unitary steps until the subject reported a vertical alignment of the two sets of targets. If the subjects reported alignment with prism dial in base-in direction, the subjects is said to be exophoric up to the indicated amount of prisms left and *vice versa.* If the subject however reported alignment with the prism dial at zero, the subject was termed to be orthophoric (Grosvenor 2007).

2.3. Data Analysis

Data was presented in tables and graphs and statistical analysis done using the SPSS version 22.0. Subsequently, the validity of the result was analyzed using analysis of variance (ANOVA), while the limit of agreement between the Von Graefe and Modified Thorington tests was done using the Blant-Altman test statistics (Yu and Ha, 2015).

3. RESULTS AND DISCUSSION

A total of 100 subjects participated in the study with a mean age of 22.57 ± 3.26 years. They consisted of 56 males and 44 females with a mean age of 23.52 ± 3.31 years and 21.36 ± 2.80 years respectively. Table 1. shows the descriptive statistics of the near lateral phoria measurements. Negative values represent esophoria while positive values represent exophoria.

Table 1: The mean near phoria findings in Von Graefe and modified Thorington

	Age (years)	Lateral phoria (D) @ 40cm with Von Graefe (VG)	Lateral phoria (D) @ 40cm with modified Thorington	Difference in degree of phoria (D) between VG and Thorington
Sample size	100	100	100	100
Mean	22.57	$4.90 \pm 3.84\Delta$	$4.67 \pm 2.91\Delta$	0.23
Std. Error of Mean	0.33	0.38	0.29	0.26
Median	23.00	5.00	5.00	0.00
Std. Deviation	3.26	3.84	2.91	0.93
Minimum	17	-6	0	-7.00
Maximum	33	12	12	7.00

The mean phoria at near for the Von Graefe technique was found to be $4.90 \pm 3.84\Delta$ exophoria, while that of the modified Thorington was $4.67 \pm 2.91\Delta$ esophoria. Also, as observed in this study, the difference or mean difference ($0.23 \pm 0.93\Delta$) between both techniques was not statistically significant (P = 0.379) at 95% confidence level. Similarly, Andrew *et al.* (2014) and Hyun-Jin *et al.* (2012) asserted that the difference in phoria was not significant although phoria measurement using phoropter correction yielded a greater coefficient of variation. Conversely, Maples *et al* (2009) reported that the near phorias were significantly

different between the two methods at <.001. Again, these variations among authors may be due to bias in the sample as well as those introduced by the examiner and the instrument.

Findings revealed some closeness of the values of the modified Thorington as similar to the findings of Maples et al. (2009). They reported that the mean phoria at near with the MT was 2.09Δ exophoria with a range of from 6 esophoria to 12 exophoria and a mode of 2 exophoria (N=18) while the mean phoria at near with the VG was 6.33Δ exophoria with a range of from 10 esophoria to 19 exophoria and a mode of 9 exophoria (N=14).

A strong, positive and statistically significant relationship was observed between the Von Graefe technique and the modified Thorington technique, hence their repeatability (r = 0.763, P = 0.000). This is as shown in Figure 1. This is in agreement to the findings by Maples et al., (2009) who also found a positive relationship between the tests (r = 0.584) at 95% confidence level.
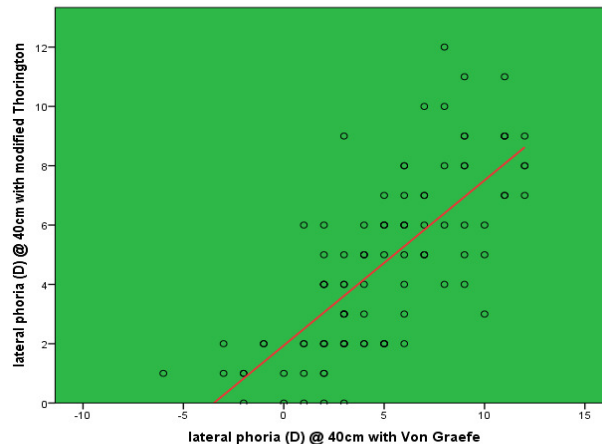

Figure 1: A scatter plot showing the regression line of lateral phoria at 40 cm with MT on lateral phoria at 40 cm with VG

Since the one-sample t-test revealed no significant mean difference (0.23 ± 0.93Δ) in both techniques (P = 0.379) at 95% confidence level, the Bland-Altman's technique (Wong et al., 2002) was employed to further test the agreement between both techniques. The differences in the near phoria between both techniques (VG – MT) were plotted against their averages ((VG + MT)/2). The graph is as shown in Figure 2.

The Bland-Altman's technique was employed to test the agreement between both techniques. The red horizontal line at the middle represents the mean difference (0.23Δ) while the two dark lines above and beneath it represents the upper (5.35Δ exophoria) and lower (4.89Δ esophoria) confidence limits respectively.

This range represents the coefficient of agreement (COA) between the tests. The COA represents the range of differences that could be expected between the two tests 95% of the time. A low COA would thus indicate better agreement. As can be observed from the scatter plot, the COA ranged from 4.89Δ esophoria to 5.35Δ exophoria indicating a high disagreement between both techniques and this difference between them increase with increase in magnitude of the phoria measurements. It therefore implies that the Von Graefe technique cannot be replaced by the modified Thorington since there exist a high disagreement (difference of more than 2Δ) (Maples et al., 2009). Cebrian et al. (2014) also confirmed that measures provided by Von Graefe were generally higher than those from the modified Thorington method. Also, other authors like Carlson et al. (1998), Schroeder et al. (1996), Maples et al. (2009) and Sanker et al. (2012) also opined that the Von Graefe method was found to the most reliable in measurement of phoria yielding more exo-deviation findings than other methods.

From these studies, the variability in the Von Graefe findings have been attributed to differences among prism settings of the Von Graefe technique for phoria measurements (Yu and Ha 2015), inter-examiner difference and test-retest difference (Byeong-Yeon Moon *et al*., 2012), poor correlations between phoria and symptom scores for Von Graefe phorometry unlike the modified Thorington which has better control of accommodation (Goss *et al*., 2010). Also, the influence of proximal vergence (Morgan, 1980) and the influence of free-space (Wong et al., 2002) have also been suggested.
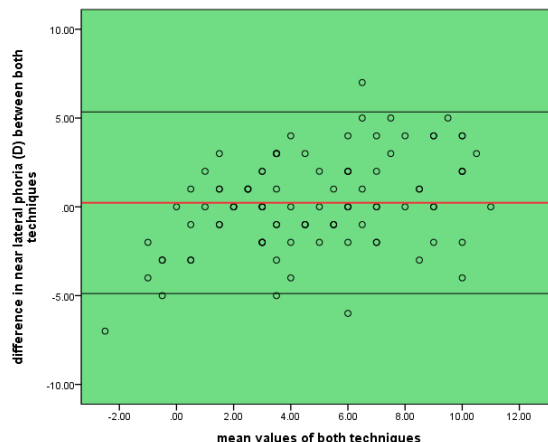

Figure 2: Graph showing the Bland-Altman's plot of both techniques

4. CONCLUSION

The near phoria measurement of Von Graefe and the modified Thorington do not differ statistically although the Von Graefe test gives a broader range and more exophoric measurements than the modified thorington at near (40 cm) on the same subject. This however does not imply that both techniques can be used interchangeably as both can result to different diagnoses.

5. ACKNOWLEDGMENT

The authors are grateful to Dr Isoken of Isoks Eye clinic, Asaba, Nigeria for providing the modifidied Thorington test card used for this study.

6. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

REFERENCES

Asonye, C.C and Ogugua, C.A. (2010). Corneal Contours in the general populations as revealed by the Photokeratoscope. *Journal of Nigerian Optometric Association*, 4(5), pp. 30-40.

Andrew, K.C., Abby, L., Jessie, C and Wong, K. (2014). Comparison of near heterophoria tests under varying conditions on an adult sample. *Ophthalmic and Physiological Optics*, 25(2), pp. 162-167.

Byeong-Yeon, M., Sun-Young, P and Hyun, G.C. (2012). Repeatability and reliability of a new phoria test using flashed and auto-flashed presentation. *Journal of the Optical Society of Korea,* 16(4), pp. 418-424.

Carlson, N., Franklin, D., Harrington, J and Major, R. (1998). A comparison among near phorias measured by cover test, the Von Graefe method and Modified Thorington. In: American Academy of Optometry, October 4-8, Orlando, Florida, USA.

Cebrian, J.L., Antona, B., Barrio, A., Gonzalez, E., Gutierrez, A and Sanchez, I. (2014). Repeatability of the Modified Thorington card used to measure far heterophoria. *Optometry and Vision Science,* 91, pp. 786-792.

Goss, D.A., Moyer, B.J. and Teske M.C. (2010) A comparison of dissociated phoria test findings with Von Graefe phorometry and Modified Thorington testing. *Journal of Behavioural Optometry,* 19(6), pp. 145-149.

Grosvenor, T. (2007). *Anomalies of Refraction*. In: Primary eye care optometry (fifth edition). Butterworth-Heinemann Elsevier, pp. 13-14.

Hyun-Jin, O., Ha-Young, D and Seung-Jin, O. (2012). A study on the measurement and tendency of heterophoria using Von Graefe test and Maddox rod test. *Journal of Digital Convergence,* 10(11), pp. 485-491.

Maples, W.C., Savoy, R.S., Harville, B.J., Golden, L.R. and Hoenes, R. (2009). Comparison of distance and near heterophoria by two clinical methods. *Optometry and Vision Development,* 40(2), pp. 100-106.

Morgan, M.W. (1980). The Maddox classification of vergence eye movements. *Journal of the American Optometric Association,* 61, pp. 98-110.

Sanker, N., Prabhu, A and Ray, A.A. (2012). Comparison of near dissociated heterophoria tests in free space. *Clinical and Experimental Optometry,* 95, pp. 638-642.

Schroeder, T.L., Rainy, B.B., Goss, D.A and Grosvenor, T.P. (1996). Reliability of and comparisons among methods of measuring dissociated phoria. *Optometry Vision Science* 73, pp. 389- 397.

Wong, E.P., Fricke, T.R. and Dinardo, C. (2002). Interexaminer repeatability of a new, modified prentice card compared with established phoria tests. *Optometry and Vision Science,* 79, pp. 370-375.

Yu, D. and Ha, E. (2015). Comparisons of Phoria test among prism settings of Von Graefe technique. *Journal of Korean Ophthalmic Optics Society,* 20, pp. 211-218.