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Original Article

Ophthalmology Section

Predictive Value of Brückner Test in Detecting Refractive Errors among Children

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ABSTRACT

Introduction: Uncorrected refractive errors form a major ocular morbidity in children. They often go unnoticed and affect child development. The prevalence of refractive error in Indian children is 10.8%. They are known to affect the overall development of children. However, if the error is high it could lead to amblyopia or strabismus. Snellen's visual acuity along with cycloplegic refraction is an accepted method to detect refractive errors, but in children, it needs special skill, patience and understanding. The Brückner test is useful for early detection of refractive errors especially in children.

Aim: To re-evaluate the results of Brückner test in the form of sensitivity, specificity and provide data about a simpler, easy, ergonomic technique for mass screening of refractive errors.

Materials and Methods: This cross-sectional study was conducted at Bharati Hospital (tertiary care hospital), Pune, Maharashtra, India, among 532 children (1064 eyes) in the age group of 2-15 years visiting the Ophthalmology Outpatient Department from October 2018 to September 2020. Position and size of pupillary crescent was recorded among children with direct ophthalmoscope. Children were classified according to errors of refraction as Emmetropia (no crescent), Myopia {inferior crescent (mild (<1/3), moderate (1/3-2/3), high (>2/3)}, Hypermetropia {superior crescent (mild (<1/3), moderate (1/3-2/3), high (>2/3)}. Subsequently, cycloplegic refraction was performed using auto-refractometer. Sensitivity, specificity, positive predictive value and negative predictive value of the test for emmetropia, myopia and hypermetropia were calculated. Subjective refraction was prescribed to children diagnosed with refractive errors during the course of this study.

Results: Total 275 females and 257 males (mean age 8.3 years) were included in this study, out of which, the study found 354 Emmetropic eyes, 326 Myopic eyes and 384 Hypermetropic eyes. Sensitivity of Brückner for emmetropia was 86.4%, specificity was 95.2%. Whereas for myopia, sensitivity was 95.1% and specificity was 94.6%. Also for hyperopia sensitivity was 95.3% and specificity was 98.8%. The crescent size was found to be significant (p-value<0.001) in diagnosing grades of myopia and hypermetropia as divided.

Conclusion: The Brückner test has good sensitivity, specificity, positive and negative predictive value. It is a useful, accurate, and simple screening test.

Keywords: Hypermetropia, Myopia, Screening, Sensitivity, Specificity

INTRODUCTION

Refractive errors are a major cause of preventable blindness in young school-going children. Uncorrected refractive errors form a major cause of ocular morbidity in young children. They are also known to affect the overall development of children inclusive of their social, scholastic and psychological well-being. However, these can often go unnoticed and if the error is high it can lead to amblyopia or strabismus [1]. The prevalence of refractive error in India among children, for myopia, hypermetropia and astigmatism is 10.8% [2].

As part of the Indian National Program for Control of Blindness, school vision screening is widely practised at present in the country. The criteria usually used are the visual acuity by Snellen's chart [3]. Children with learning difficulties are also often brought to paediatrician or ophthalmologist for evaluation of an ocular disorder that could be responsible for the disability. Snellen's visual acuity along with cycloplegic refraction is a widely accepted way to detect refractive errors, but in children, it needs special skill, patience and understanding.

The Brückner test is useful for early detection of refractive errors especially in children. It is an objective test and therefore it can be utilised for testing preverbal and uncooperative children [4,5]. The American Academy of Paediatrics currently recommends red reflex assessment as a component of the eye evaluation in the neonatal period and during all subsequent routine health supervision visits [6].

The screening tests of refraction used in children to identify significant refractive error include cycloplegic auto-refraction which needs automated refractor. It is not usually available at all basic healthcare levels. Other methods of screening include the use of High end photo-screeners which are not in widespread use due to high cost. There are studies which prove that Brückner test is a cost-effective, easy to learn, ergonomic, quick and reliable for screening of refractive errors [4,5]. Kothari MT has reported the Brückner test has sensitivity of 91%, and specificity of 72.8% [5]. As there are few studies with variability of data in literature, the present study was conducted to evaluate the sensitivity and specificity of this test.

The present study chose a direct ophthalmoscope due to the ease of access. Apart from ophthalmologists, physicians and paediatricians also have access to pocket ophthalmoscopes hence; this can easily be used for screening children without the need for extra equipments. The test can be performed by a non ophthalmologist with equal ease and accuracy as documented by Jain P et al., and Rajalakshmi AR and Rajeshwari M [7,8]. The aim of this study was to re-evaluate the sensitivity, specificity of Brückner test and whether it can be used as an effective screening test for refractive errors.

MATERIALS AND METHODS

This cross-sectional study was conducted at Bharati Hospital (tertiary care hospital), Pune, Maharashtra, India, among 532 children (1064 eyes) in the age group of 2-15 years visiting the Ophthalmology Outpatient Department from October 2018 to September 2020. The Institutional Ethical Committee approval according to the tenets of Declaration of Helsinki was obtained.

Inclusion and Exclusion criteria: All children aged between 2-15 years, whose parents or guardians gave consent for the testing were included in the study. Children with ocular media opacities, history of ocular surgeries, and nystagmus were excluded from the study.

After obtaining a written informed consent from the guardian, a demographic datasheet was filled by the examiner. A thorough anterior segment examination with torch light and slit lamp was done for all the children.

Brückner Test

A semi-darkened room was used for examination. After positioning the patient on examination chair, with gaze fixed on a distant object, both eyes were illuminated with a direct ophthalmoscope (Heine Beta 200 Optotechnik, Germany) simultaneously from a distance of around 1 meter. In order to keep the child's attention enticed, a bright toy was placed on the Snellen's drum. The reflex was observed in the pupillary area. The presence/absence of pupillary crescent, its location in the pupillary area and the size was noted [5].

Based on the reflex observed, the eyes were classified as Emmetropic, Myopic or Hypermetropic as described in the [Table/Fig-1]. After observing the size of pupillary crescent, the refractive errors were classified as per [Table/Fig-1] [5].

Position of crescent	Size of crescent	Interpretation
No crescent	-	Emmetropia
Inferior	<1/3	Myopia (<-2.00 D)
Inferior	1/3-2/3	Myopia (≥-2.00 D TO -4.00 D)
Inferior	>2/3	Myopia (>-4.00 D)
Superior	<1/3	Hypermetropia (<+2.00 D)
Superior	1/3-2/3	Hypermetropia (>OR=2.00 D TO 4.00 D)
Superior	>2/3	Hypermetropia (>4.00 D)

[Table/Fig-1]: Interpretation of the Brückner Test as per crescent size [5].

The Brückner test was followed by cycloplegic refraction for all children. Cycloplegia was achieved by instilling cyclopentolate 1% eyedrops (Cyclogyl, INTAS Pharma). Two drops of cyclopentolate 1% were administered at 5 min intervals in each eye [9]. Refraction was done after 45 minutes by TOPCON KR800, Japan auto-refractometer and wet retinoscopy. The readings of auto-refractometer/retinoscopy were recorded and converted into spherical equivalents. All the readings were recorded in a pre-determined format and the results were compared with that of Brückner test performed earlier. Subjective refraction was carried out later.

STATISTICAL ANALYSIS

The results of this study were coded and entered in MS Excel sheet and the analysis was done by Statistical Package for the Social Sciences (SPSS) software (version 20.0).

Following formulae were used for the calculations [Table/Fig-2]:

1) Sensitivity: Probability that a test result will be positive when the disease is present (true positive rate) i.e., a/(a+b)
2) Specificity: Probability that a test result will be negative when the disease is not present (true negative rate) i.e., d/(c+d)
3) Positive predictive value: Probability that the disease is present when the test is positive i.e., a/(a+c)
4) Negative predictive value: Probability that the disease is not present when the test is negative i.e., d/(b+d). Where 'a' is true positives, 'b' is false negatives, 'c' is false positive and 'd' is true negative.

The gold standard was cycloplegic-refraction.

Brückner test	Cycloplegic refraction positive	Cycloplegic refraction negative	Total
Positive	a	c	a+c
Negative	b	d	b+d
Total	a+b	c+d	a+b+c+d

[Table/Fig-2]: A 2x2 table for sensitivity, specificity, positive predictive value and negative predictive value calculation.

The relative height of crescent observed was documented in each eye and its association with the degree of refractive error was studied using Chi-square's test, the significance was calculated with 95% confidence level and p-value <0.05 was considered as significant.

RESULTS

A total of 532 children (1064 eyes) in the age group of 2-15 years with an average age of 8.3 years, were screened using the Brückner test. It consisted of 257 males and 275 female children.

The range of myopia in the present study was -0.50 to -10.00 D. The highest noted myopia in the study was -10.00 D. Most children (53.9%) belonged to low myopia group as per cycloplegic refraction (n=326). The range of hypermetropia was +0.50 D to +7.75 D highest noted hypermetropia was +7.75 D. Most children (51.56%) were found to be in the low hypermetropia group (n=384).

The comprehensive results of Brückner test and refraction under cycloplegia were compared [Table/Fig-3].

Brückner	Cycloplegic auto-refraction			Total
	Emmetropia	Hypermetropia	Myopia	
Emmetropia	306	18	16	340
Hypermetropia	8	366	0	374
Myopia	40	0	310	350
Total	354	384	326	1064

[Table/Fig-3]: Comparison between Brückner and cycloplegic refraction results (n=1064).
Chi-square p-value: <0.0001; p-value <0.05 considered significant

According to Brückner test, out of the total emmetropia eyes, 350 eyes (32.8%) had myopia and 374 eyes (35.2%) had hypermetropia. As per cycloplegic refraction, 326 (30.63%) eyes were myopic and 384 eyes (36.1%) were found to be hypermetropic. The results documented by Brückner test were found to be comparable with that of cycloplegic refraction (p-value <0.001). Brückner test has good sensitivity (95.2%) and specificity (86.44%) for diagnosis of emmetropia. The positive predictive value was found to be 93.37% and negative predictive value is 90% for emmetropia. Sensitivity for hypermetropia diagnosis is 95.3% and specificity is 98.8%. Sensitivity for myopia is found to be 95.1% and specificity is 94.6%. Brückner test has a sensitivity of 86.4% for diagnosing emmetropia and a specificity of 95.2%. A significant association was noted between the size of crescent and the degree of hypermetropia (p-value <0.001) [Table/Fig-4]. A significant association was noted between the size of crescent and the degree of myopia (p-value <0.001) [Table/Fig-5].

Crescent size	<1/3	1/3-2/3	>2/3	Total	p-value
Emmetropia	8	0	0	8	<0.001
< +2.00 D	174	23	1	198	
+2.00 - +4.00 D	3	87	92	182	
>+4.00 D	0	0	4	4	
Total	185	110	97	392	

[Table/Fig-4]: Association of crescent size and degree of hypermetropia (n=374). p-value <0.05 was considered as significant (Chi-square test)

Crescent size	<1/3	1/3-2/3	>2/3	Total	p-value
Emmetropia	38	0	0	38	<0.001
<-2.00 D	159	17	0	176	
-2.00 - -4.00 D	8	51	87	146	
>-4.00 D	0	0	4	4	
Total	205	68	91	364	

[Table/Fig-5]: Association of crescent size and degree of myopia (n=350). p-value <0.05 was considered as significant (Chi-square test)

DISCUSSION

The Brückner test was first described in 1962 in a German paper as a "transillumination test" that could detect small degree of ocular deviations and amblyopia [10]. In 1994, Photographic Brückner test was used for screening preverbal and preschool children to facilitate early diagnosis of correctable amblyogenic factors [11]. Kothari MT then described the use of this test as a rapid screening modality for refractive errors in Indian children in 2007 [5].

The physics behind this however has not been completely deciphered. As described by Borish the explanation of the location of pupillary crescent can be given by a comparison with photoretinoscopy where light source is below the aperture of the camera like direct ophthalmoscope [12]. If the eye is myopic, only the rays from the bottom of the pupil enter the aperture of the ophthalmoscope and it is illuminated on the same side as that of the light source i.e. inferior part. When the eye is hyperopic, only the rays in top half illuminate the upper part in pupillary area.

The present study was conducted to evaluate the Brückner test as a screening method for refractive error. The chosen age of children included in the present study ranged from 2 to 15 years which was comparable with Jalis M et al., and Kothari MT (2007) [4,5]. This study included 257 males (48.3%) and 275 females (51.7%). Almost equal distribution of subjects was noted based on the sex of the patient similar to distributions as in other studies [4,5].

In the present study, undilated pupillary crescent to perform Brückner test was used. Use of an indirect ophthalmoscope [13] and streak retinoscope [14] was suggested by other studies. A direct ophthalmoscope due to the ease of access was chosen. It did not take longer than 10 seconds per child which was similar to the observation made by Kothari MT [5]. A total of 1064 eyes were examined. Brückner test demonstrated 724 eyes (68%) to have ammetropia and 340 eyes (32%) were diagnosed to be emmetropic. Cycloplegic refraction revealed 710 eyes (66.7%) with ammetropia, which is comparable to the results of the Brückner test. Jalis M et al., in their study documented 83.4% ammetropia [4]. The number of eyes with myopia and hypermetropia was nearly equal in the current study with a marginally higher hypermetropia (36.1% eyes).

After comparing the results of Brückner test with cycloplegic refraction, the test was found to be highly sensitive (95.2%) and specific (86.44%) for detection of refractive error. According Jalis M et al., the test has a sensitivity of 97% and specificity 79% [4]. Kothari MT documented a sensitivity of 91% and 72.8% specificity [5]. The Brückner test was also used to calculate refractive error specific sensitivity and specificity after comparing with results of cycloplegic refraction.

Hypermetropia: Brückner test diagnosed Hypermetropia in 374 eyes, out of which, 366 eyes (97.86%) eyes were true positives as confirmed by refraction under cycloplegia. The total of 8 (0.021%) eyes (n=374) diagnosed falsely by us to have hypermetropia were emmetropic. This error of emmetropic eyes being over-diagnosed as hypermetropic might be accounted to observer errors. A total of 18 (1.69%) hypermetropic eyes (n=1064) were missed by the observer and diagnosed as emmetropic. This can be accounted to the natural ciliary tone and accommodation by the child. Also, these errors ranged from +0.25 to +0.75 DS (spherical equivalent). Thus, the error margin in terms of diopters was found to be in lower grades of hypermetropia.

Out of the 350 Brückner Myopic eyes, 310 (88.57%) eyes were true myopic eyes. The falsely diagnosed 40 (11.4%) eyes (n=350) were found to be emmetropic on cycoplegic refraction. This can be explained by the possibility of lack of fixation on distant target. The role of accommodation in changing the pupillary crescent has been postulated by Kothari MT as well [5]. Thus, it should be considered significant to ensure distance fixation to eliminate the error due to accommodation. The error in myopia diagnosis accounted for 16 (1.5%) eyes only (n=1064). These eyes with myopia were diagnosed as emmetropic on Brückner test. This was again an observer based error in diagnosing and documenting the crescent. However, this accounted for only a small fraction and in lower grades of myopia {-0.25 to -0.75 DS (spherical equivalent)}. There is not enough research documented to analyse the utility of this test in diagnosing individual refractive errors so far.

Authors found that sensitivity for hypermetropia diagnosis is 95.3% and specificity is 98.8%. Also, sensitivity for is myopia is 95.1% and specificity is 94.6%. However, the sensitivity of Brückner test in diagnosing Emmetropia was slightly lower (86.4%) with a specificity of 95.2%. In this study, an endeavour to study the relationship between the size of the pupillary crescent and the degree of refractive error was made. Similar quantification of pupillary crescent was attempted by Jalis M et al., [4]. There was a significant association (p-value <0.01) between the crescent size and the grade of myopia or hypermetropia.

Patients with high myopia and high hypermetropia were found to have a dull glow with a very large crescent. Diagnosis of high ammetropia should not be missed and done carefully. Some conditions which could alter the observations during screening include small pupil size, inability of children to fix appropriately at the target, irregular or obliquely placed crescent in astigmatism. These could have been additional reasons for observer based errors. The Brückner test being quick, non invasive, easy to perform and ergonomic in its nature; can be performed at large for mass screening of children for refractive errors. It is also easy to learn even for non ophthalmologists, hence, it could be a potential rapid screening tool for pediatricians or ophthalmic assistants at health camps as well.

Limitation(s)

Firstly, the study was clinic based and not population based, the possibility of bias in selection should therefore be considered. Secondly, due to the subjective nature of results, there is a possibility of inter and intra-observer variations.

CONCLUSION(S)

The study was conducted to assess Brückner test as a screening modality for refractive errors in children. The results of Brückner test were comparable with that of cycloplegic-refraction. Sensitivity of Brückner test was 95.2% and specificity was 86.44%, positive predictive value of the test was 93.37% and negative predictive value was 90% for emmetropia. The test had good sensitivity and specificity for hypermetropia and myopia. An estimate of degree of refractive error can be made based on the size of the crescent observed. Thus, Brückner test can be used as a screening test for refractive errors in paediatric age group by non ophthalmologists as well.

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