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Original Research Article

Assessment of stereoacuity (3D vision) using TNO random dot stereo acuity chart in medical undergraduate students: A cross-sectional study

Amari V Hun[1]*, Shivani B Jariwala[1]

[1]*Dept. of Ophthalmology, Government Medical College, Surat, Gujarat, India*

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ABSTRACT

Background: The study aimed to estimate the level of stereoacuity in medical undergraduate students, factors associated with reduced stereoacuity, and time taken to interpret plates.

Materials and Methods: Cross-sectional study was done at the Medical College of South Gujarat from April 2021 to June 2022, enrolling 400 consenting students. Detailed ocular history was taken; best corrected visual acuity was assessed for distance and near after cycloplegic refraction for cases with subnormal visual acuity and power of glasses documented. Level of Stereopsis was assessed using TNO random dot stereoacuity chart and time taken to read plates 1 and 5 was recorded. Data were entered and appropriate statistical tests were applied.

Results: Out of 400 students, 64.25% had a refractive error. Simple myopia was most prevalent refractive error (43.25%), followed by compound myopic astigmatism (19.5%). Seven students had anisometropic amblyopia and two had strabismic amblyopia. 19.75% cases had subnormal stereopsis. Among them, 10.25% cases had simple myopia, 7.25% had high compound myopic astigmatism, 1.75% had anisometropic amblyopia and 0.5% cases had strabismic amblyopia. Average time taken by emmetrope to read plate 1 and plate 5 was 13.93 ± 14.03 and 19.03 ± 20.66 respectively and for cases with refractive errors, time taken was 17.59 ± 13.95 and 27.83 ± 20.77 respectively. This was statistically significant ($P < 0.05$).

Conclusions: Most of the students had good stereoacuity as they were already wearing refractive correction. Commonest cause of subnormal stereopsis ware simple myopia, compound myopic astigmatism and amblyopia. Time taken to read the plates is more for refractive error as compared to emmetropes.

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1. Introduction

Stereopsis is important in many areas of life, such as motor skills, employment and education prospects.[1,2] Medical profession, which is a visually demanding occupation, requires fine judgments of distance and depth. The current guidelines of medical undergraduate admission require general medical fitness certificate. However, it doesn't include screening for detailed visual assessments like colour vision, stereo acuity, etc. Uncorrected refractive errors are associated with decreased vision-related quality of life (QOL) and increasing difficulty in performing vision-related tasks.[3] Reduced stereoacuity can affect performance of various tasks especially related to fine skills.[4] The visual screening will help to identify the medical undergraduate students with subnormal vision, subnormal stereoacuity, factors associated with it and advise possible remedial measures timely.

* *Corresponding author*.
E-mail address: dramarihun10@gmail.com (A. V. Hun).

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2. Materials and Methods

A cross-sectional study was conducted in medical undergraduate students at Medical College of South Gujarat from April 2021 to June 2022, after obtaining approval from the Institutional Ethics Committee. Total 400 (251 males and 149 females) consenting students were screened. Students with an ocular organic morbidity like Corneal opacity, traumatic or developmental cataract, retinal pathologies were excluded. Students' characteristics such as age and gender were noted. History regarding diminution of vision for distance and near, headache, eye ache, blurring of vision, diplopia and past history like glass wear, contact lens wear and ocular trauma was also noted. Then the students were evaluated for visual acuity assessment. Distant vision for all students was recorded using Snellen's illuminated chart at a distance of 6 meters and near vision with Roman's chart at 40 cm. Cycloplegic refraction was done for cases with subnormal visual acuity. Topical cyclopentolate (1%) eye drops were used to dilate pupils.

Refractive correction and best corrected visual acuity were documented. Myopia was graded into: low myopia (≥−0.5 to <-3 D), moderate myopia (≥ −3 D to ≤ −6 D), and high myopia (>6 D). Hyperopia was graded as: low hyperopia (≥+0.5 D to ≤+2 D), moderate hyperopia (≥+2.25 D to ≤+5 D), and high hyperopia (>+5 D). Astigmatism was classified as low <1 D and high ≥1 D cylinder. Anisometropia was documented when difference of power was >2.00 D between two eyes.[5,6]

The assessment of stereoacuity level was done using random dot stereoacuity chart (TNO chart) in well illuminated room at distance of 40 cm viewed through red and green glasses. TNO (The Netherlands Organisation) chart consists of seven plates: Three gross stereo (plate 1 -3), one suppression (plate 4) and three graded (plates 5-8) containing segmented circles with disparities ranging from 480 to 15 seconds (arc sec). The level of stereopsis was categorized as: Normal stereoacuity (< 120 sec arc), Equivocal stereoacuity (120–240 sec arc), Abnormal stereoacuity (>240 sec arc).[3] Before executing this study, we did pilot test on few Ophthalmology resident doctors whereby some students commented that they had difficulty in identifying plate1 as compared to other plates in gross stereopsis and took too long to identify. This gave initial false interpretation as lack of gross stereopsis. Literature search on time required to read the plate mentioned "Ample of time should be given to the candidate", however there was no information about average time that should be provided. Hence, we decided to note time required to read plate 1 and plate 5, so that the average time required to respond, can be evaluated from the study.

The data were entered in Microsoft Excel Windows 10 and analysed using SPSS version 26 and appropriate statistical tests (chi square test, Fischer's exact test and unpaired t test) were applied for finding an association between refractive error and stereopsis. P<0.05 was considered as significant.

3. Results

A total of 400 students were included in the study. 257 (64.25%) had refractive error**.** Out of them, 2.5% students were diagnosed to have refractive error during our screening test and were completely unaware about their subnormal vision. Myopia was the most prevalent refractive error 67.31%, followed by compound myopic astigmatism 30.35% (Table 1).

In the present study, it was observed that out of 67.31% simple myopes, 38.52% and 12.06% students having low and moderate simple myopia respectively; had normal stereopsis and 12.06% of all simple myopia cases had abnormal stereopsis. Out of 257 students, four (1.55%) students were having simple hypermetropia and all of them had anisometropic amblyopia resulting in subnormal stereopsis. 30.35% compound myopic astigmatism were evaluated, out of which 10.89% cases of subnormal stereopsis had high compound myopic astigmatism, whereas three had anisometropic amblyopia (Table 1).

On comparison, level of stereopsis in candidates with and without refractive errors, majority of emmetropes had normal stereopsis whereas 14.75% cases of refractive error had abnormal stereopsis. One candidate could not read even gross stereopsis plate 1 and was suffering from anisometropic amblyopia (Table 2).

It was observed that out of 400 students, 19.75% students had stereopsis less than expected normal range. Among them, 51.89% cases had simple myopia, followed by 36.70% students who had high compound myopic astigmatism, and 11.38% cases had amblyopia causing subnormal stereopsis (Table 3).

In this study we also noted the time taken to interpret the plate 1 (i.e., gross stereopsis) and plate 5 (i.e., fine stereopsis). The average time taken by emmetrope to read plate 1 and plate 5 was 13.93 ± 14.03 and 19.03 ± 20.66 respectively. The time taken by cases with refractive errors was 17.59 ± 13.95 and 27.83 ± 20.77 respectively. This was statistically significant (P <0.05). Though we didn't record time taken to read plate 2, but many students gave feedback that reading plate 2 was easier than plate 1 of gross stereopsis. (Table 4)

4. Discussion

Medical profession is a skill-based profession and stereoacuity is important for skill acquisition; especially the fine motor tasks. There are evidences of not only reduced but total absence of stereoacuity on TNO testing when performed in practicing surgeons.[7] So, stereoacuity assessment, as done in this study, on medical undergraduates, is necessary to know the level of stereopsis

Table 1: Level of stereopsis as per refractive errors

Types of refractive error	Amount of refractive Error	Stereopsis Normal	Equivocal	Abnormal	Total
Simple myopia	Low	99(38.52%)	5(1.94%)	21(8.17%)	125(48.63%)
	Moderate	31(12.06%)	4(1.55%)	9(3.50%)	44(17.12%)
	High	2(0.77%)	1(0.38%)	1(0.38%)	4(1.55%)
Subtotal		**132 (51.36%)**	**10(3.89%)**	**31(12.06%)**	**173(67.31%)**
Simple hypermetropia	Low	0	0	0	0
	Moderate	0	0	4(1.55%)	4(1.55%)
	High	0	0	0	0
Subtotal		**0**	**0**	**4(1.55%)**	**4(1.55%)**
Compound myopic astigmatism	Low	2(0.77%)	1(0.38%)	3(1.16%)	6(2.33%)
	High	44(17.12%)	6(2.33%)	22(8.56%)	72(28.01%)
Subtotal		**46(17.89%)**	**7(2.72%)**	**25(9.72%)**	**78(30.35%)**
Compound hypermetropic astigmatism	Low	1(0.38%)	0	0	1(0.38%)
	High	1(0.38%)	0	0	1(0.38%)
Subtotal		**2(0.77%)**	**0**	**0**	**2(0.77%)**
Total		180	17	60	257

Table 2: Distribution of students on basis of level of stereopsis

Level of stereopsis	Emmetropia	Refractive error	No of participants
Normal	141(35.25%)	180(45.00%)	321(80.25%)
Equivocal	0	17(4.25%)	17(4.25%)
Abnormal	2(0.5%)	59(14.75%)	61(15.25%)
No stereopsis	0	1(0.25%)	1(0.25%)
Total	143(35.75%)	257(64.25%)	400(100%)

Table 3: Causes of subnormal stereopsis

Causes of subnormal stereopsis	Amount of Refractive Error	No of students	Percentage
Simple myopia (n=41)	Low myopia	26	32.91%
	Medium myopia	13	16.45%
	High myopia	2	2.53%
Compound myopic astigmatism (n=29)	Low myopic astigmatism	2	2.53%
	High myopic astigmatism	27	34.17%
Amblyopia (n=9)	Compound myopic astigmatism with anisometropic amblyopia	3	3.79%
	Simple hypermetropia with anisometropic amblyopia	4	5.06%
	Strabismus amblyopia	2	2.53%
Total		79	100%

Table 4: Time taken to interpret plate 1 and plate 5

Stereopsis plate	Emmetropia(n=143) (mean± SD)	Refractive error(n=257) (mean ± SD)	P value
Plate 1 (sec)	13.93 ± 14.03	17.59 ± 13.95	t=2.5097 p= 0.0125
Plate 5 (sec)	19.03 ± 20.66	27.83 ± 20.77	t=4.0688 p=0.0001

and guide them accordingly. In our study, we found that most of the students were emmetropes. Myopia was the most prevalent refractive error, followed by compound myopic astigmatism and hypermetropia. Similar such observations were found in previous studies conducted in past whereby prevalence of myopia was more as compared to astigmatism and hypermetropia.[8–10]

In this research, majority of students had good stereopsis, which was higher as compared to other studies. The likely reason could be the fact that one third of our participants were emmetropes as compared to other studies, wherein students with refractive errors were enrolled. The factors that cause inappropriate development of stereopsis are many; one notable cause being uncorrected refractive errors.[8,11,12] All types of refractive errors adversely affect stereopsis by inducing visual blur, resulting in decreased binocular function with low sensory fusion.[8,13] In this study, subnormal stereopsis was found more in simple myopia, followed by compound myopic astigmatism and amblyopia. This was in contrast to the previous study[9] found that subnormal stereopsis was present in 29.1% cases of myopia and 34.3% cases of astigmatism. Previous studies reported that cylindrical refractive errors caused poorer stereopsis as compared to spherical errors, as they are expected to have caused more visual blur and difficulty in the fusion of images.[13] Few studies have found stereo acuity of hyperopes to be lesser than that of myopes.[14] However in our study, we had only few hyperopes cases. Researches have also observed that impaired stereoscopic depth perception is the most common deficit associated with amblyopia under ordinary viewing conditions.[15] A previous study, regarding effect of induced anisometropia on surgical task performed by resident doctors in simulated environment, observed that diminution of stereoacuity was proportional to amount of anisometropia induced.[16]

Study done on stereopsis under two-dimensional and three-dimensional viewing conditions, have shown that though stereo absent participants perform significantly worse as compared to stereo normal candidates in free space, however with video assisted system (2D) their performance was equivalent.[17] This suggests that low stereoacuity does not preclude one from skilled task performance especially those done with microscopic aids. However, the knowledge about level of stereoscopic performance will help students to assess his skills during training period and accordingly choose career option.

We noted that more time may be required by cases with refractive errors to interpret the plates. This finding was statistically significant ($P < 0.05$) for both plate 1 and plate 5. This observation will be helpful in performing and interpreting the test because the literature on TNO test does not specify the time to be given to read the plates. So, practically if a candidate is not able to read, it becomes difficult for us to decide when to switch to other plate. Again, this information is especially important while performing test in paediatric age group, as delay in response may falsely be misinterpreted as low stereopsis. We suggest, plate 2 of gross stereopsis should be shown first followed by plate 1 and 3 so that candidates are more confident and also to avoid anxiety in them in case if they take long to read plate 1. There is no study done previously to specify the time taken by cases with refractive error and those with non-refractive error. Time taken to read the plate 1 is on an average half a minute for candidates without refractive errors and slightly more for candidates with refractive errors. So, candidate with delayed response should be motivated to focus for at least a minute, in order to avoid misinterpretation of results.

5. Conclusion

Screening of medical undergraduate students for visual assessment including stereoacuity testing, gives an opportunity to identify candidates with uncorrected refractive error and low stereoacuity. Though most students had good stereoacuity as they were already wearing refractive correction; commonest causes of subnormal stereopsis were simple myopia, compound myopic astigmatism and amblyopia. Such candidates with subnormal stereopsis should be counselled for remedial measures like trial of contact lens in cases with refractive error and evaluated for improvement in stereoscopic performance. Hence, there is a need to incorporate detailed vision assessment including stereoacuity prior to admission in medical field as common vision related problem can be timely identified and remedial correction can be given which improves performance of vision related tasks. Subnormal stereopsis particularly that due to amblyopia, hampers skilled performance, especially when done without microscopic aids. Hence, knowledge of poor stereoscopic performance can help students to further explore skill performance under supervision during training period and decide career options.

6. Source of Funding

None.

7. Conflict of Interest

None.

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Author biography

Amari V Hun, Resident

Shivani B Jariwala, Associate Professor

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