# Correlation between Near Point of Convergence and Stereoacuity

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**Abstract:-**

➢ *Aim:*

To determine the correlation between stereo acuity NPC and among the students of Vittala International Institute of Ophthalmology (VIIO).

➢ *Methodology ;*

Out of 47 subjects, 35 students with average age of 21.5 ± 2.44 years were selected according to inclusion and exclusion criteria for this study. NPC and NPA were measured with push up method, after that NFV and PFV were measured with the help of prism bar, followed by assessment of stereo acuity with the help of TNO. Then, forced vergence test was measured by the help of 4 prism diopter where first divergence was induced by the help of base-in prism and NPC with the help of push up method, then stereo acuity was examined. After that, convergence was induced with the help of base-out prism and NPC and stereo acuity was measured.

➢ *Results:*

The correlation between the parameters Normal NPC& Normal Stereo acuity shows a Poor positive correlation, which is not statistically significant(p=0.94).The correlation between BI NPC & BI Stereo acuity shows a Poor positive correlation, which is not statistically significant(p=0.302). The correlation between the parameters BO NPC & BO Stereo acuity shows a Moderate positive correlation, and is not statistically significant (p= 0.216).

➢ *Conclusion;*

Since there was a moderate positive correlation between induced convergence and stereo acuity and poor correlation between normal, induced divergence and stereo acuity, there are chances to expect changes in stereo acuity clinically in convergence related anomalies more compared to divergence related anomalies.

## I. INTRODUCTION

### A. Convergence :

Convergence is a conjugate movement in which both eyes rotate inward so that the lines of sight intersect in front of the eyes. Allows bifoveal single vision to be maintained at any fixation distance. Convergence is a very complex process. Convergence is of two types. Namel ; Reflex and voluntary convergence. Reflex convergence is defined as the convergence of visual axis which is not under complete voluntary control. Reflex convergence has four components;

a) Tonic convergence

b) Fusional convergence

c) Accommodative convergence

d) Proximal convergence

Tonic vergence innervation converges the eyes from their divergent anatomical position of rest approximately17 prism diopter horizontally in those with normal vision to the tonic vergence resting state, which is approximately 3 to5 Pd convergent from straight ahead in those with normal vision. Fusional convergence is produce to ensure those similar retinal images are projected on to corresponding retinal areas.

Accommodative convergence is the convergence that occurs when the eyes accommodate. Stimulus for the accommodative convergence is blurred retinal images rather than the retinal disparity that stimulates fusional convergence. Convergence accommodation helps to clear the fixation target as disparity vergence aligns the eyes to that target. Convergence accommodation serves as a proportional bias for reflex accommodation, which means that, as the accommodation and convergence demands increase, so does the assistance to reflex accommodation from disparity vergence .This action helps to minimize blur at all distances so that reflex accommodation can perform efficiently. Proximal convergence is induced by proximity of object of regard or the awareness of the proximity of a near object. Proximal vergence and proximal accommodation are triggered by any clue that elicts its depth and distance perception. In other words, the stimulus to proximal innervation is perceived nearness. The proximal mechanism serves as a source of proportional bias innervation for both reflex accommodation and disparity vergence, helping to minimize blur and fixation disparity as targets move closer.

*B. Stereopsis:*

Stereopsis is the highest degree of binocular vision. It is the ability of brain to neurologically integrate and fuse two horizontally disparate retinal images, producing a sensation of depth.[1,2] It is well established that horizontal disparities between the images presented to the two eyes induce a compelling sensation of depth. The lateral separation of the two frontally located eyes allows slightly disparate views of an object and provides the geometrical basis for the phenomenon of stereoscopic depth perception. Generally it is not well developed in young infants before 3 months and is believed to be developed by 6 months of life.[3]

*C. Stereoacuity:*

Stereo acuity is basically based on the retinal disparity (two line of sight does not intersect at point of fixation) created in the eye. It is the smallest binocular disparity that can be readily detected, i.e. it is the minimum disparity beyond which no stereoscopic effect is produced. Generally a threshold of 15-30 arc can be regarded as excellent stereoscopic acuity.

*D. TNO :*

It is graded to provide retinal disparities ranging from 15 to 480 sec of arc. It is tested at a distance of 40 cm. It consists of a booklet containing seven plates. Each test plate consists of a stereogram in which various shapes have been created by random dots in complementary color. The plates contain two types of figures, the one which can be perceived when viewed binocularly with red green spectacles by normal subject having stereopsis. The second set of figures can be seen with and without spectacles even in the absence of stereopsis.

First 3 plates are demo plates just to see whether a person has stereopsis or not, which have stereoscopic targets like Butterfly, plus sign, circle ,diamond , square, triangle.

Fourth plate is for checking suppression and remaining three plates (5-7) gives quantitative measurement of stereopsis from 480-15 arc sec. A person has to identify a circle with a cut edge and tell which side the circle is open or cut.[2]

*E. Forced vergence (By using prism):*

Prism power is presented in fixed amounts, alternating between base-in (to force divergence) and base out (to force convergence).

ARC is commonly associated only with strabismus. However, recently it has been shown that changes in retinal correspondence may occur in normal who are subjected to binocular stress. Binocular stress can be produced by forced convergence, which is the introduction of a change in the convergence stimulus without a coordinated change in the accommodative stimulus. In previous study it has been reported that individuals subjected to forced convergence exhibited statistically significant shifts in retinal correspondence of up to about 1degree. The presence of these vergence induced shifts in retinal correspondence were disclosed by examination of the small differences between the convergence of the eyes measured objectively using binocular search coils and subjectively using nonious lines.

The spatial characteristic of lateral shifts in retinal correspondence induced by forced convergence is largely unknown. There are two distinct possibilities. A uniform shift of the cortical correspondence maps may occur in which the cortical projections from the two eyes are displaced laterally relative to the normal locations. Such uniform lateral shifts in correspondence would have little effect on the shape of the line horopter. [2, 4]

## II. AIM AND OBJECTIVE

❖ *Aim:*

To determine the correlation between stereo acuity and NPC among the students of Vittala International Institute of Ophthalmology (VIIO).

❖ *Objective:*

To find out the comparison and correlation between stereo acuity and NPC in normal, Base in and Base out conditions (Forced vergence)

## III. METHODOLOGY

A total of 35 students of Vittala International Institute of Ophthalmology, Bangalore were taken as subjects. The age ranged between 18 to 25 years. It was a prospective correlational study.

➢ *Study design:* Prospective and Pearson's correlational study
➢ *Study place:* Vittala International Institute of Ophthalmology, Bangalore
➢ *Data collection technique:* Based on inclusion and exclusion criteria subjects were enrolled in this study.

● *Inclusion criteria:*
✓ Normal subjects with no significant ocular pathologies and abnormalities.
✓ Stereo acuity $\geq$ 100 arc seconds as measured through the TNO stereo acuity.

● *Exclusion criteria:*
✓ Subjects with significant ocular pathologies, or limitation of extra ocular motility.
✓ Subjects with refractive error more than 3D and astigmatism $\pm$0.75D
✓ Subjects with manifest strabismus (Tropias).
✓ Subjects with latent strabismus more than 7 prism diopter.

➢ *Materials :*
● Distance and Near log MAR visual acuity charts
● Trial set
● Retinoscope (Heine Beta 200 STREAK RET.2.5V)
● Prism Bar
● Loose prisms
● Slit lamp
● Direct ophthalmoscope

- RAF ruler
- TNO stereopsis book

> *Study Parameter:*

The study was conducted in the premises of Vittala International Institute Of Ophthalmology, Bangalore in subjects of classes from BSC first year to Intern students. After explaining about the procedure clearly consent was taken from the subjects. After which demographic data was collected. Subjects were assessed for any pathology using slit lamp as well as fundus was also examined through Direct Ophthalmoscope. After fundus examination certain gap was given for patient of minimum 2 hour .Then Cover test was done to check whether there was phoria or not. Both the distance and near visual acuity was performed using Log MAR visual acuity chart. Objective as well as subjective retinoscopy was performed. Those who came under the inclusion criteria were taken for the study.

Ocular motility test was carried out to determine the normality of extraocular muscles and their impact on eye movement.

A C/A ratio was determined and then the Near point of accommodation was measured by push up method. It is done monocularly as well as binocularly. Here patient was instructed that the image gets blur and we asked patient to inform those blur, and recovery points.

After NPA, Near point of convergence (NPC) was also measured by using push-up method where patient was instructed to inform break point.

Both Negative Fusional Vergence (NFV) and Positive Fusional Vergence (PFV) was measured for distance and near by using prism bar. Base out prism was used for positive fusional vergence (PFV) and Base in prism was used for Negative fusional vergence (NFV). Here we have instructed the patient to look straight on the target, and on increasing the strength of prism first target gets blur then it becomes double and gets recovered. So we asked patient to inform those blur, break and recovery points.

For measurement of stereopsis in order to keep the book parallel to subject's face it was hold by the examiner, and the stereopsis testing was done at the sufficient room illumination. TNO book was kept at 40cm and at first patient was instructed about the chart and subjects were asked to wear red green glasses over their corrections. For general screening test, the first four plates were useful as the disparity is large and provide a qualitative assessment of stereopsis.
Plate 1; two butterflies; one is easily seen, monocularly, the other is only seen in stereopsis.
Plate2; four disc; two are seen without stereopsis. Ask the patient; how many circles? Which is the biggest?
Plate3; four; "HIDDEN" shapes (circle/ square/triangle/ diamond) are arrange around a centrally easily visible cross.
Plate 4; three disc; one seen with right eye, one seen by left and one seen binocularly. Then for the quantitative assessment plate

V, VI &VII was shown and subjects were asked to show the cut end of the circle. They were instructed that they will see a cake of which a piece is cut and they need to show from which portion the piece was cut or is missing. As for each level from 480 to 15 sec of arc, there are two targets and those two targets only were shown at a time by covering the remaining target by a piece of paper. Then the result up to which patient is able to recognize is recorded.

After performing all the above mention procedures, we selected sample size of 35 students, based on our inclusion criteria.

The forced vergence test was measured by the help of 4 prism diopter. First divergence was induced by the help of base-in prism and Near point of convergence was measured by the push up method and then stereo acuity was examined. After that, convergence was induced by the help of base-out prism and Near point of convergence and stereo acuity was measured.

## IV.      RESULTS

**Descriptives:**

Out of 47 subjects, 35 subjects were taken for the study based on inclusion and exclusion criteria. Out of them 35 subjects 20(57.14%) were female and 15(42.85%) were male with average age of 21.5±2.44 (18-25) years.
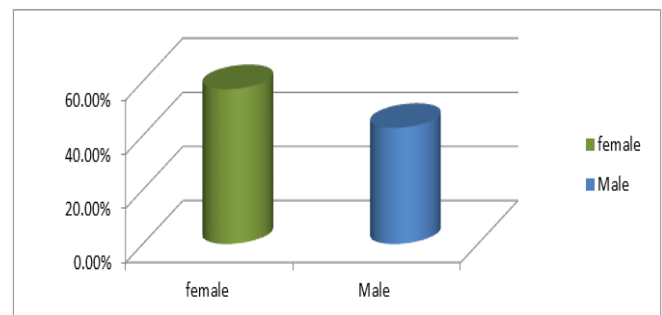


Fig;1. Male and female percentage

1. *Comparison of Mean and p value of NPC Normal, Base –IN, and Base OUT*

|  | Charts | Mean difference ± SD | P VALUE |
|---|---|---|---|
| Pair 1 | NPC NORMAL<br>NPC BI | -1.06±2.53 | 0.019 |
| Pair 2 | NPC NORMAL<br>NPC BO | -0.09±3.66 | 0.891 |
| Pair 3 | NPC BI<br>NPC BO | -1.14±2.66 | 0.016 |

Table.1;- Mean difference of NPC Normal, base-in and base-out with P value**.**

On comparison of the mean values of normal NPC and BI NPC the mean values of normal NPC was higher with a difference of -1.05714 was statistically significant with a p value of 0.019.

On comparison of the mean values of normal NPC and BO NPC the mean values of was higher with a difference of -0.08571 is statistically not significant with a p value of 0.891.

On comparison of the mean values of NPC BI and NPC BO the mean values of NPC BO was higher with a difference of -1.14286 is statistically significant with a p value of 0.016.
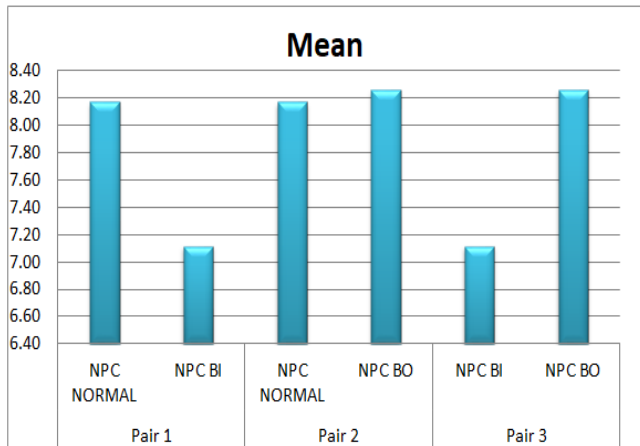


Fig 2:- Bar diagram showing Mean value of NPC for Normal, Base-in and Base-out

2. *Comparison of Mean and p value of stereo acuity with normal, Base in and Base out:*

| | Charts | Mean difference ± SD | P value |
|---|---|---|---|
| Pair 4 | STEREOACUITY NORMAL | | |
| | STEREOACUITY BI | -3.43±19.62 | 0.309 |
| Pair 5 | STEREOACUITY NORMAL | | |
| | STEREOACUITY BO | -7.57±36.1 | 0.223 |
| Pair 6 | STEREOACUITY BI | | |
| | STEREOACUITY BO | -4.14±24.12 | 0.317 |

Table-2: Mean difference of stereo acuity normal, Base in and Base- out with p value

On comparison of the mean values of STEREOACUITY NORMAL and STEREOACUITY BI the mean values of STEREOACUITY BI was higher with a difference of 3.42857 was statistically not significant with a p-value of 0.309.

Whereas on comparison of the mean values of STEREOACUITY NORMAL and STEREOACUITY BO the mean values of STEREOACUITY BO was higher with a difference of 7.57143 was statistically not significant with a p value of 0.223.

As well as on comparison of the mean values of STEREOACUITY BI and STEREOACUITY BO the mean value of STEREOACUITY BO was higher with a difference

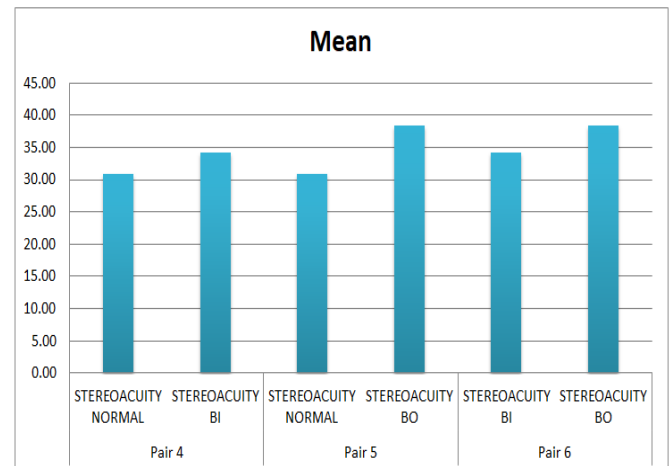of 4.14286 was statistically not significant with a p value of 0.317.



Fig 3:- Bar diagram showing Mean value of stereo acuity normal, Base- in and Base-out

3. *Correlation between NPC and stereo acuity:*

| S NO | PARAMETERS BEING CORRELATED | Correlation(r) | P VALUE |
|---|---|---|---|
| 1 | NPC NORMAL & STEREOACUITY NORMAL | 0.013 | 0.94 |
| 2 | NPC BI & STEREOACUITY BI | 0.18 | 0.302 |
| 3 | NPC BO & STEREOACUITY BO | 0.214 | 0.216 |

Table-3; P value and r value of NPC and stereoacuity.

The correlation between the parameters NORMAL NPC & NORMAL STEREOACUITY shows a Poor POSITIVE correlation, and is NOT SIGNIFICANT with a p value of 0.94.The correlation between the parameters BI NPC &BI STEREOACUITY shows a Poor POSITIVE correlation, and is NOT SIGNIFICANT with a p value of 0.302.The correlation between the parameters BO NPC& BO STEREOACUITY shows a Moderate POSITIVE correlation, and is NOT SIGNIFICANT with a p value of 0.216.
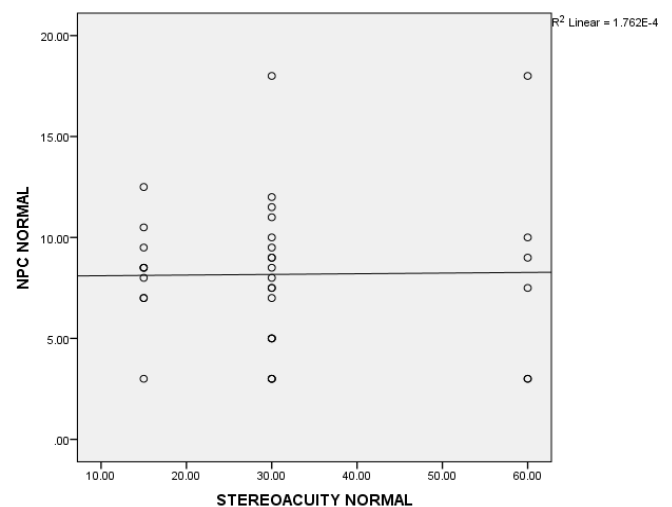


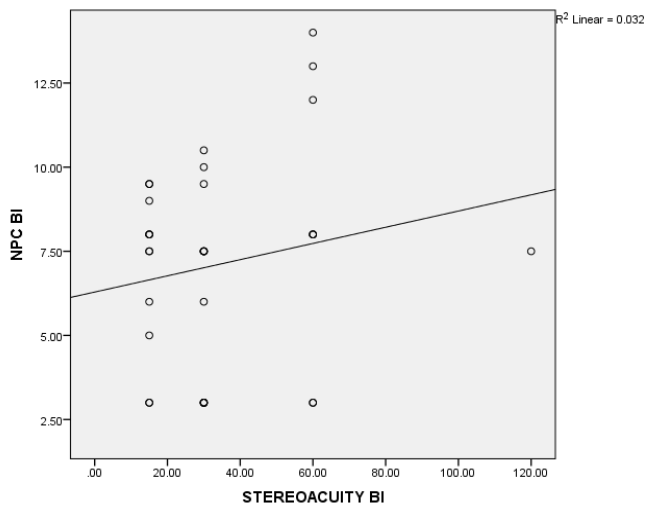Fig 4:- Graphical representation of normal NPC and stereo acuity

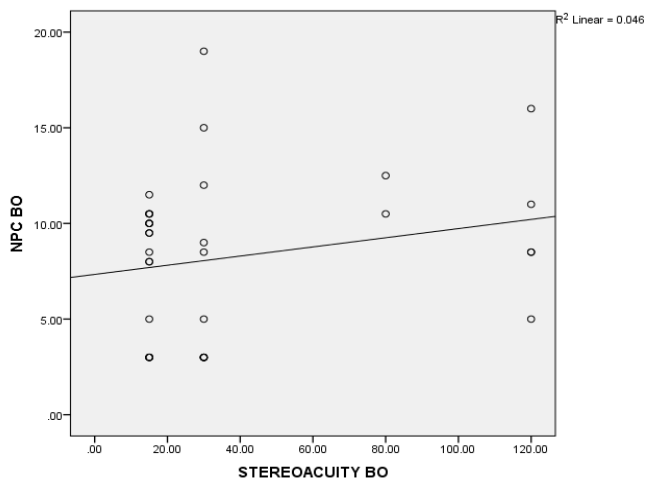Fig. 5:- Graphical representation of Base IN NPC and stereo acuity



`Fig; 6:- Graphical representation of Base –IN NPC and stereo acuity

## V.    DISCUSSION

Sam Otabor Wajuihian, Rekha Hansraj (2018) reported that the mean stereo acuity of those with vergence anomalies was significantly better than that of those with either refractive errors or accommodative anomalies ($p = 0.02$)3. The mean stereo acuity of cases of accommodative anomalies was significantly reduced compared to those without such anomalies. Similarly, the mean stereo acuity of cases with vergence anomalies was significantly reduced compared to those without vergence anomalies ($p = 0.02$). Also, Nick fogt and Ronald Jones (1997) studied the spatial characteristics of the changes in retinal correspondence produced by forced convergence. The results indicated that binocular stress from forced convergence induces a small but significant change in retinal correspondence. When a small central point of regard was used as the fusion target the changes in retinal correspondence occurred only within about 3* of the fixation point.4

Similarly, Philip W. laird, Sarah R. Hatt, 2007, by experimentally inducing exodeviations in normal subjects found that stereo acuity was reduced at the point of first fusion in most subjects, and that this was not associated with reduced binocular visual acuity. Studies of increasing convergence stress have reported reduced levels of stereo acuity and proposed that small shifts in retinal correspondence can occur without disrupting Panum's fusional process.5

We want to explore the possible associations of forced vergence with stereo acuity, by comparing NPC in normal, induced convergence and induced divergence and finding out the stereo acuity in above three conditions in a sample of 35 students. The idea is to understand, weather near point of convergence changes will affect stereo acuity. For the study we tried to increase the NPC by base out prism and reduce the NPC by base in prism, and there by finding the stereo acuity in induced conditions. The major finding of this study is that the mean value of normal NPC is higher than the mean value of BI NPC which is statistically significant, whereas the mean value of NPC base-out is higher than the mean value of base-in NPC which is statistically significant, but the mean value of BO NPC is higher than the normal NPC which is statistically not significant.

Also, the mean value of stereo acuity Base-in is higher than the mean value of normal stereo acuity which is not statistically significant. But the mean value of stereo acuity Base-out was higher on comparison with mean value of normal streoacuity and was not statistically significant. Whereas, mean value of stereo acuity base-out is higher than the mean value of stereo acuity base-in and also not statistically significant. Additionally, the Base-out NPC and Base-out stereo acuity shows a moderate positive correlation and is also not statistically significant, whereas normal NPC and normal stereo acuity, Base-in NPC and Base-in stereo acuity shows poor positive correlation and is not statistically significant.

## VI.    LIMITATIONS;

The standard Von Graefe technique is used to assess heterophoria and FV in some studies which would have allowed for consistency in approach. But we have used prism bar as a preferred tool in a screening, where setting as it is quicker and allows for easy viewing of eye movements and it is easier for school-aged children to perform and understand in terms of their instructions. Also we have excluded moderate to severe phoria conditions, as the study is basically interested in understanding the normal deviations with stereo acuity.

There are some studies which correlated forced vergence with refractive error, accommodation, ARC and phorias, where there were significant changes in stereo acuity has been reported.

Also in this study we have preferred to use only TNO stereo book to assess stereo acuity and push up method to assess NPC.

## VII. CONCLUSION;

1. There was a poor positive correlation between normal NPC and normal stereo acuity, Base in NPC and Base in stereo acuity, which is not significant, where the value of one parameter increases then the value of another parameter also increases. There was a moderate positive correlation between Base out NPC and Base out stereo acuity but it is not statistically significant.

2. Since there was a poor positive correlation between normal, induced divergence and stereo acuity and moderate positive correlation between induced convergence and stereo acuity, there are chances of changes in stereo acuity clinically in convergence related anomalies more compared to divergence related anomalies.

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