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Visual Acuity: An Eye Parameter to Predict Craniofacial Skeletal Malocclusion

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Abstract

Objectives: The study deals with the identifying correlations between visual acuity and Class I vs Class II skeletal pattern. **Methods:** A total of seventy subjects were enrolled in the study with age ranging from 11-29 years. Using ANB angle, they were equally divided in two groups (Class I, Class II). Visual acuity of each subject were measured and correlated with each group. Descriptive statistics was compiled and comparison between the groups was made using t-test and Mann-Whitney U test followed by Pearson's correlation. Level of statistical significance was set at $p \leq 0.05$. **Findings:** The mean age difference between Class I and Class II samples was -0.74 and not statistically significant, indicating that the samples for both categories were of comparable ages. On comparison of visual acuity of right eye, there were 22.7% subjects with myopia in Class I compared to 77.3% in Class II, and this difference in proportion was statistically significant (ES=0.429). In left eye, 25.0% of Class I subjects had myopia, whereas 75.0 % in Class II, and this difference in proportion was also statistically significant (ES=0.328). Positive Pearson's correlation was found between ANB and Visual acuity of right eye (r=0.165). **Novelty:** This study concludes that Class II skeletal pattern subjects have more tendency to develop myopia. Further research involving other eye parameters are required to understand the cause-effect relationship.

Keywords: Eye; Visual Acuity; Malocclusion; Opthalmology; Stomatognathic system

1 Introduction

The neural crest is an exceptionally pluripotent entity that has a pivotal function in the development of the cranial region in vertebrates[(1)]. The concept of the "fourth germ layer" has been frequently referenced in scientific literature, mostly due to its notable characteristics, including pluripotency and migratory tendencies[(2)]. The cranial neural crest cells (NCCs) undergo explicit differentiation into a range of cell types, including as osteocytes, chondrocytes, smooth muscle cells, stromal cells, endothelial cells in the cornea, and odontoblasts[3]. On this basis, it could be stipulated that the development /defects in craniofacial system may influence the ocular system and vice versa.

Moss's functional matrix theory, which describes the role of specific matrices in the formation of craniofacial structures, includes the orbital cavity as a key example; the theory also shows how the orbital cavity is intimately connected to the maxillary bone[4]. This implies a potential correlation between the two entities.

Pax-6 is an essential transcription factor that plays a pivotal role in the embryonic development of both ocular and dental structures. The gene is commonly known as the "master control gene" for the development of the eye[5,6]. However, its impact extends beyond eye development and encompasses other facets of embryonic development, such as the development of teeth[7]. This observation suggests the possibility of a link between two structures that arise from the same gene expression.

The anatomical linkage between the visual organ and the masticatory muscles occurs via the deep fascia of the orbit, known as Tenon's fascia, which connects with the cranial fascia of the skull. This cranial fascia, in turn, connects with the temporal fascia and subsequently with the deep fascia of the neck. Fascial tissue has contractile components that modulate force transmission and generation[8]. The orbicularis oculi muscle, the levator palpebrae superioris, and finally the superficial musculoaponeurotic system (SMAS) are all connected by the Tenon's capsule[9]. SMAS is further connected to epicranial aponeurosis and subsequently to the cervical ligament. It is also linked to the superficial fascia that envelops the platysma muscle at its anterior aspect[10]. Thus, the fascial hypothesis posits that the fascia, due to its capacity for real-time response, can account for both structural alterations within systems and changes in bioelectrical tensions explaining the musculo-tendinous connections exists between visual apparatus and stomatognathic system[8].

The interconnections between the visual organ and the stomatognathic system have also been elucidated, encompassing neuronal, myofascial, and biochemical processes. The material reviewed in study strongly supports the existence of a clear relationship between the visual organ and the stomatognathic system[8].

Most studies have only highlighted the relationships between dental malocclusion and various ocular defects such as myopia, hypermetropia, astigmatism, strabismus and convergence disorders. It was found that individuals with class II dental malocclusion had a higher prevalence of myopia[11]. The occurrence of convergence defects was found to be equally prevalent in both Angle Class I and Class II malocclusion. Subjects that exhibited unilateral cross-bite and midline deviation had a notably higher frequency of ocular motility disorders[12]. Similarly, subjects with astigmatism had a statistically significant correlation with cross bite[13]. On the other hand, no correlation was found with strabismus and hypermetropia[14]. None of the studies have compared cranio-facial skeletal malocclusion with ocular defects and therefore this study aims to provide an insight into this association.

Thus, the aim of this study is identifying correlations between Visual acuity and Skeletal Class I vs Class II Malocclusion.

2 Methodology

Total of 96 subjects were examined, out of that 70 subjects (35 males; 35 females; mean age 17±3.17 years) with range from 11-29 years were enrolled in the study at Teerthanker Dental College and Research Center. The study was approved by the ethics committee of Teerthanker Dental College (TMDCRC/IEC/19-20/PhD1). The study was registered under Clinical Trial Registry- India before collection of samples (CTRI/2020/07/026624). Informed consent was obtained from all the subjects before any clinical research was conducted. Data from all subject databases, including Lateral Cephalograms, were collected from the Dept. of Orthodontics.

- Inclusion Criteria
  - Subjects having Class I or Class II skeletal Pattern.
  - Subjects of age group 11-29 years.
- Exclusion criteria
- Subjects having any facial deformity or syndrome.
- Subjects with history of Orthognathic/Plastic Surgery/Eye surgery.\
- Subjects with Temporomandibular disorders.
- Subjects with any underlying systemic disease that could affect their vision or facial development.
- Non cooperative patient.

For each subject, following cephalometric parameters were used:

- **ANB angle**- This is an angle formed between N-A line and N-B line at point N. Range for Skeletal Class I Malocclusion – 0° to 4°; Class II > 4° (Figure 1)

The subjects were then referred to the Dept. of Opthalmology at Teerthanker Mahaveer Medical College and Research Centre to obtain eye test variable by a single Opthalmologist.

- **Visual Acuity (VA)**: Snellen chart was used to measure visual acuity. It is printed with eleven lines of block letters. Following the first line, each row has increasing numbers of letters with decreasing sizes. Each subject took the test by covering one eye and reading out the letters from a distance of 6 meters. Normal vision has a visual acuity of 6/6.

Ophthalmic variable (visual acuity) were then compared and correlated with orthodontic parameter (ANB) of the respective subjects.

2.1 Statistical analysis

The data was entered into Microsoft Excel and analyzed using SPSS package 22.0 for relevant statistical comparisons. Repeatability was tested on 20 randomly selected subjects examined at least 2 weeks after the initial examination. Cohen's kappa coefficient was calculated to determine the reliability of determining each malocclusion in the 2 evaluation periods. Descriptive statistics was compiled and comparison between the groups was made using Mann Whitney U test followed by p value. The effect size, Phi coefficient, which ranges from 0 to 1 was used. Higher values indicate a stronger correlation between the two variables. Level of statistical significance was set at $p \leq 0.05$.

3 Results and Discussion

When participants were distributed based on their gender, it was found that out of 35 participants having CLASS I 23(65.7%) were male and 12(34.3%) were female and this difference in proportion was not statistically significant whereas in CLASS II 12(34.3%) were male and 23(65.7%) were female and this difference in proportion was also not statistically significant (Table 1). This states that based on gender, subjects were equally distributed in both groups.

Table 1. Gender wise Distribution of Participants

		Frequency	Percent	p
	Male	23	65.7	
CLASS I	Female	12	34.3	0.91
	Total	35	100	
	Male	12	34.3	
CLASS II	Female	23	65.7	0.91
	Total	35	100	

The samples for both groups were equivalent in terms of age, as shown by the mean difference between Class I and Class II samples being -0.74 and not statistically significant (Table 2).

Table 2. Illustrates age wise comparison between Class I and Class II skeletal pattern

	CLASS	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t	df	p
Age	CLASS I	35	17.0000	3.17156	.53609	-.74286	-.892	68	.375
	CLASS II	35	17.7429	3.76784	.63688				

On Comparison between VA Rt and Class I & Class II based on ANB Angle, there were 5 (22.7%) participants in Class I based on ANB who had myopia, compared to 17 (77.3%) participants in Class II who had myopia, and this difference in proportion was statistically significant (ES=0.429) (Table 3, Figure 1). Among participants in Class I based on ANB, 30 participants (62.5%) had normal VA Rt, while in Class II 18 participants (37.5%) had normal VA Rt (Table 3).

When distribution of VA -Lt for Class I was done it was found that 29(82.9%) had normal vision whereas in Class II, 20 (40 %) had normal VA Lt. Among participants in Class I based on ANB 5(25.0%) had Myopia and in Class II 15(75.0 %) had myopia and this difference in proportion was statistically significant (ES=0.358) (Table 4).

When overall correlation between ANB was done with VA-Rt, VA-Lt it was found that there was a significant positive correlation between ANB and VA-Rt ($p<0.05$, $r=0.272$) whereas correlation between VA-Lt and ANB was not statistically significant ($r=0.165$) (Table 5, Figure 2). This states that on increasing ANB angle, there is increase in visual acuity of right

Table 3. Comparison between VA Rt Values and Class I & Class II based on ANB Angle

			VA-Rt							Total	Mann Whitney U Value	p
			6*6	6*9	6*12	6*18	6*24	6*36	6*60			
ANB	CLASS I	N	30	2	1	0	2	0	0	35	383.500	.001 ES= 0.429
		%	62.5	33.3	50.0	0.0	40.0	0.0	0.0	50.0		
	CLASS II	N	18	4	1	1	3	4	4	35		
		%	37.5	66.7	50.0	100.0	60.0	100.0	100.0	50.0		
Total		N	48	6	2	1	5	4	4	70		
		%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		

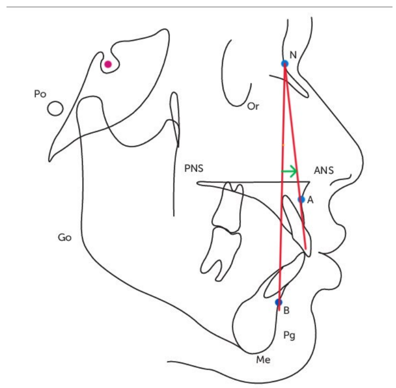

Fig 1. ANB Angle in Cephalometric tracing

Table 4. Comparison between VA Lt Values and Class I & Class II based on ANB Angle

			VA-Lt							Total	Mann Whitney U Value	p
			6*6	6*9	6*12	6*18	6*24	6*36	6*60			
ANB	CLASS I	N	29	1	1	1	3	0	0	35	443.500	.014 ES= 0.358
		%	82.9	2.9	2.9	2.9	8.6	0.0	0.0	50.0		
	CLASS II	N	20	3	2	1	3	2	4	35		
		%	57.1	8.6	5.7	2.9	8.6	5.7	11.4	50.0		
Total		N	49	4	3	2	6	2	4	70		
		%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		

eye. Increase in visual acuity is suggestive of Myopia. Thus, it can be stated that Class II individuals have more chances of developing Myopia.

Table 5. Overall Correlation of ANB with Eye Parameters

		VA-Rt	VA-Lt
ANB	Pearson's Correlation Coefficient r	.272	.165
	p value	.022	.171

This result is comparable to that of study, which discovered a higher prevalence of myopia (19.4%) in Class II Division 1 malocclusion and participants in Class I who were not visually impaired (45.3%)[(11)]. In a similar vein, Class II molar relation showed a higher prevalence of myopia (40.69%), according to Hegde et al.[(15)]. In a different investigation, Gupta G et al[(16)] discovered a positive correlation (r =0.349) between visual acuity and mandibular plane angle in the Class I average growth pattern but a negative correlation (r =-0.350) in the horizontal growth pattern. According to Caruso et al[(17)] the percentage of participants with fusional amplitudes with convergence less than the cut-off value (83.3%) and the prevalence of exodeviations (78.3%) are both statistically substantially higher in the molar class II subjects.

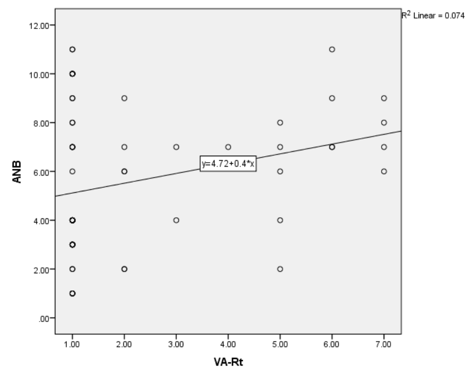

Fig 2. Positive correlation found between ANB and VA-Rt

Zielinski G et al. found negative correlation between refractive error and axial length of the eyeball; inferior rectus muscle and visual acuity [9]. Muscle thickness variations and electromyographic activity have been linked to refractive errors. Ocular length, retinal thickness, and choroidal thickness appear to be linked to bioelectrical activity in the temporalis anterior in women with myopia [10].

The visual function exhibits a strong interconnection with other functions that are directed towards the individual's orientation in the surrounding space. Within this context, several factors may be identified, such as the alignment of the head in relation to the cervical spine, which plays a crucial role in maintaining an erect posture. The establishment of these interconnections is facilitated by neurological connections, which also encompass the stomatognathic apparatus [18].

Vompi et al. [19] observed a significant correlation between temporomandibular disorders (TMDs) and visual impairment. The study identified correlations between oculomotor dysfunction and orthognathic alterations, namely those related to function or skeletal structure.

In the trigeminal system, proprioception is collected from both somitic structures and oculomotor muscles. The medulla intermedius is a tiny nucleus located in the perihypoglossal region of the brain stem. It is responsible for relaying information from the head and neck to the solitary tract nucleus, which in turn triggers autonomic reactions. Marchilli et al [20] concluded that the neural system and functional circuits directly link vision and dental occlusion.

Recent studies [4,17] have shown that the genes and growth factors involved in eye development also have a major impact on the development of the stomatognathic system. Lei's [7] immunohistochemistry analysis revealed that Pax-6 expression was present at different stages of tooth development. Pax-6 was expressed in the core regions of the tooth buds and enamel organs as well as in the oral epithelium next to the tooth germs at the bud stage and cap stage.

Skeletal pattern may indicate a distinct course of development of the structures connected to vision, according to Hegde et al. [15]. According to Vitale et al [21] vision defect that affects the postural system might also impact the formation of skeletodental structures, suggesting that the connection between vision defects and orthodontic malocclusion may be the result of a global developmental delay.

Although it should be noted that the presence/absence of any type of ocular motility or convergence defects was analysed as a parameter, not the specific defect type. Bollero et al. [12] study, which found no association between molar class alterations and ocular motility or convergence defects, is contrary to the current study. In contrast to this investigation, Monaco et al. [14] could not discover any links between strabismus and malocclusions. Some found no statistically significant correlation between the variables of eye and hair color, craniofacial structures of similar formation [4].

The main indicator of vision quality, visual acuity, is essential for overall health. Myopia appears to be influenced significantly in India by a variety of geo-biological factors, including genetics and a number of social ones. In a school-based study, participants aged 5 to 15 had a prevalence of myopia of 21.1% [22].

This study only explored a single eye parameter (visual acuity); additional parameters remain to be investigated. The inability to substantiate a cause-and-effect relationship in the observed association is a limitation of the present study; additional research is required to address these concerns.

4 Conclusion

It can be concluded that there is a positive correlation between visual acuity of right eye and skeletal class II malocclusion (r=0.272). This suggests that subjects having Skeletal Class II malocclusion are more prone to develop myopia. For a better understanding of the etiology, diagnosis, and treatment of malocclusions, it is important to take into account visual abnormalities, which are readily detected by a detailed medical history for standard orthodontic diagnostic records.

Although it is impossible to conclude from these facts that there is a direct causal relationship between them, we might surmise that such a relationship might exist. Additional research is necessary to get a definitive conclusion, which should involve incorporating a greater number of eye variables. As a result, a multidisciplinary approach and the involvement of numerous specialists are needed for the treatment of such diseases.

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