Relationship between Human Eye and Different Divergence of Skeletal Class I Pattern: A Correlative Study

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ABSTRACT

Introduction: All the systems in the body are interconnected to form a single structural unit. Scientific evaluations of potential correlations between the stomatognathic system and the eye are based on different scientific approaches. The development of the eye and the stomatognathic system begins at approximately the same time, that is, during the 3rd and 4th week of intrauterine life. Some of the recent studies have shown that the various genes and growth factors involved in the eye formation play an important role in the development of the stomatognathic system also.

Aims and objectives: The aim of the present study is to correlate the normal human eye variables with the different growth patterns.

Materials and methods: A total of 150 samples were selected. The sample selected for the study ranged in the age group from 18 to 24 years. Individual were subjected to radiographs (lateral cephalograms) and various eye tests. The subjects were divided into horizontal, average, and vertical growth patterns on the basis of the Go-Gn-SN angle.

Results: Positive correlation was found between visual acuity and mandibular plane angle among the average growth pattern, and negative correlation was found between visual acuity and mandibular plane angle among the horizontal growth pattern. So, the present study concludes that there is a correlation between the human eye variables and the growth patterns, and thus malocclusion can be anticipated on this basis.

Keywords: Divergence, Eye, Pax-6, Pax-9, Skeletal pattern.

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INTRODUCTION

All the systems in the body are interconnected to form a single structural unit. Scientific evaluations of potential correlations between the stomatognathic system and the eye are based on different scientific approaches. Some recent studies have shown that the various genes and growth factors involved in the eye formation play an important role in the development of the stomatognathic system also.^{1,2}

In this study, patterns of horizontal, average, or vertical growth were diagnosed from the lateral cephalograms. These growth patterns were correlated with the visual acuity, corneal diameter, corneal thickness, axial length, retinal nerve fiber layer thickness, and intraocular pressure of each patient.

MATERIALS AND METHODS

The 150 samples were selected. Good-quality lateral cephalograms of 150 patients were obtained based on the following criteria:

Inclusion Criteria

- Subjects of age group 18–24 years having a class I skeletal pattern
- Subjects should not have any facial deformity or syndrome

Exclusion Criteria

- Subjects having class II and class III skeletal pattern
- Subjects with history of orthodontic, orthognathic, or plastic surgery
- Subjects with history of eye surgery

Sampling Method

The subjects were divided into three groups:³

- Group I—Horizontal growth pattern Go Gn-SN angle = 25–29

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- Group II—Average growth pattern Go Gn-SN angle = 30–34
- Group III—Vertical growth pattern Go Gn-SN angle = 35–39

Methodology

The standardized lateral cephalogram of each patient was obtained.

The cephalometric landmarks were identified: angle between point A-Nasion-point B (ANB), beta angle, and mandibular plane angle.

The subjects were then referred to a renowned eye institute with academic interest. Different eye test variables were established and identified by a qualified ophthalmologist.

Eye test variables taken were the following:

Visual Acuity⁴

During an eye test, ophthalmologists use eye charts to measure how well you see in the distance, compared with other human beings. The standard placement of the eye chart is on a wall that is 20 feet away from your eyes. Vision is considered "normal" when there is a 20/20 vision (or 20/20 visual acuity), that is, a letter can be read at 20 feet.

Corneal Diameter⁵

The corneal diameter (CD) is the limbus-to-limbus distance, and clinically both the horizontal and vertical dimensions are regarded as important.

Corneal Thickness⁶

Corneal thickness measurements are indicative of the metabolic status of the cornea, as they provide an index of corneal hydration. Such measurements give valuable information on the physiological status of the cornea and its changes associated with disease, trauma, and hypoxia.

Axial Length⁷

The axial length is the distance from the corneal surface to an interference peak corresponding to the retinal pigment epithelium. A majority of axial length elongation takes place in the first 3–6 months of life and a gradual reduction of growth over the next 2 years, and by 3 years the adult size is attained.

Retinal Nerve Fiber Layer (RNFL)⁸

Optical coherence tomography is a relatively new noncontact imaging technique that has been developed to assess tissue thickness with micrometer scale sensitivity.

Intraocular Pressure (IOP)⁷

In human eyes in particular, the axial length undergoes daily fluctuations of some 15–40 μm , with a mean period of approximately 21 hours. Although diurnal fluctuations in axial length have been observed in many species, the underlying physiologic control mechanisms are unknown.

Various scans obtained during investigation were shown in Figure 1 and interpreted in Figure 2.

STATISTICAL ANALYSIS

The data obtained were subjected to statistical analysis.

The statistical analysis was done using Statistical Package of Social Science. Data comparison was done by applying specific statistical tests to find out the statistical significance of the comparisons. Quantitative variables were compared using mean values and qualitative variables using proportions. Significance level was fixed at $p < 0.05$.

RESULTS

Table 1 illustrates descriptive statistics for optical parameters for group I. The mean corneal diameter of the left eye was slightly higher than the right. The mean corneal thickness of the right eye was slightly higher than the left. The mean axial length of the right eye was slightly higher than the left. The mean RNLF of the right eye was slightly higher than the left. The mean IOP of the right eye was slightly higher than the left.

Table 2 illustrates descriptive statistics for optical parameters for group II. The mean corneal diameter of the left eye was slightly higher than the right. The mean corneal thickness of the right eye was slightly higher than the left. The mean axial length of the right eye was slightly higher than the left. The mean RNLF of the right

Table 1: Descriptive statistics for optical parameters for group I

	Minimum	Maximum	Mean	Std. deviation
Visual acuity RT	0.0000	0.0000	0.000000	0.0000000
Visual acuity LT	0.0000	0.1760	0.017600	0.0533361
Corneal diameter RT	10.90	12.69	11.8468	0.48110
Corneal diameter LT	10.81	12.80	12.0356	0.48401
Corneal thickness RT	450	604	537.88	52.057
Corneal thickness LT	454	598	537.12	47.709
Axial length RT	21.63	24.55	23.3376	0.70960
Axial length LT	21.00	24.30	23.3194	0.86634
RNFL RT	78	110	100.34	8.270
RNFL LT	79	111	100.32	8.326
IOP RT	10	18	14.36	2.238
IOP LT	10	17	13.66	2.309

Table 2: Descriptive statistics for optical parameters for group II

	Minimum	Maximum	Mean	Std. deviation
Visual acuity RT	0.0000	0.3010	0.016580	0.0588661
Visual acuity LT	0.0000	0.3979	0.022039	0.0725589
Corneal diameter RT	11.00	13.58	11.9902	0.50838
Corneal diameter LT	11.00	13.00	12.0948	0.47594
Corneal thickness RT	450	608	539.00	41.528
Corneal thickness LT	452	611	536.14	41.750
Axial length RT	21.81	24.83	23.5388	0.79004
Axial length LT	21.00	24.80	23.5346	0.84260
RNFL RT	78	110	97.74	9.120
RNFL LT	80	110	97.32	9.410
IOP RT	12	18	13.94	2.045
IOP LT	10	18	13.26	2.146

Table 3: Descriptive statistics for optical parameters for group III

	Minimum	Maximum	Mean	Std. deviation
Visual acuity RT	0.0000	0.5440	0.036295	0.1019236
Visual acuity LT	0.0000	0.6990	0.043047	0.1112065
Corneal diameter RT	10.99	13.58	11.8400	0.53919
Corneal dia LT	11.00	12.70	11.8708	0.37218
Corneal thickness RT	454	590	535.98	30.178
Corneal thickness LT	456	590	536.12	31.277
Axial length RT	21.73	25.10	23.5351	0.77267
Axial length LT	21.50	25.15	23.5139	0.85975
RNFL RT	85	111	95.53	8.352
RNFL LT	83	115	93.08	7.958
IOP RT	10	18	13.41	1.779
IOP LT	10	16	12.88	1.752

Fig. 1: Scan

eye was slightly higher than the left. The mean IOP of the right eye was slightly higher than the left.

Table 3 illustrates descriptive statistics for optical parameters for group III. The mean corneal diameter of the left eye was slightly higher than the right. The mean corneal thickness of the left eye was slightly higher than the right. The mean axial length of the right eye was slightly higher than the left. The mean RNLF of the right eye was slightly higher than the left. The mean IOP of the right eye was slightly higher than the left.

Table 4 illustrates the Pearson correlation matrix between dental and optical parameters among group I, which shows negative

correlation between visual acuity of the left eye and mandibular plane angle, beta angle, and ANB angle.

Table 5 illustrates the Pearson correlation matrix between dental and optical parameters among group II, which shows positive correlation between visual acuity of the left eye and mandibular plane angle.

Table 6 illustrates the Pearson correlation matrix between dental and optical parameters among group III, which shows no statistically significant correlations between dental and optical parameter correlation to be found. Although there was statistically significant correlation was found within the optical as well as dental parameters.

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RAGINI BHARDWAJ RAGINI, 6/11/1993
ID P00012

Examination 1 of 17/12/16
Analysis 8, standardized
Biometry

Time: 5:09 PM
Duration: 2 Min

		OD Right eye	OS Left eye
Measuring mode	Mode	Phakic	Phakic
Axial length	AL	22.46 mm	⚠ 22.44 mm
Cornea thickness	CCT	523 µm	527 µm
Aqueous depth	AD	⚠ 2.75 mm	2.56 mm
Anterior chamber depth incl.	ACD	⚠ 3.27 mm	3.09 mm
Lens thickness	LT	⚠ 3.64 mm	-----
Retina thickness	RT	200** µm	200** µm
Flat meridian	K1	⊖ 45.03 D @ 43°	⊖ 43.68 D @ 168°
Steep meridian	K2	⊖ 45.89 D @ 133°	⊖ 44.74 D @ 78°
Astigmatism	AST	0.86 D @ 133°	1.07 D @ 78°
Keratometric index	n	1.3375	1.3375
White to White	WTW	11.35 mm	11.51 mm
Iris barycenter	IC	-0.37 / -0.14 mm	0.58 / -0.19 mm
Pupil diameter	PD	3.40 mm	3.16 mm
Pupil barycenter	PC	-0.24 / -0.05 mm	0.43 / -0.22 mm

* Value user-defined
** System constant
⊖ Significant difference between OD and OS
⚠ see detail printout
⊖ Analysis

LENSTAR
LS 900

EyeSuite™ Biometry, V2.2.0
LS 900, SN 2585, V 2.1.0

HS HAAG-STREIT
DIAGNOSTICS

Fig. 2: Interpretation of scan

DISCUSSION

Eye development is initiated by the master control gene Pax-6, a homeobox gene, and so is the stomatognathic system. The Pax-6 gene locus is a transcription factor for the various genes and growth factors involved in eye formation.^{2,9}

In an immunohistochemical study by Lei, the expression of Pax-6 was seen in various developmental stages of the tooth. At the bud stage and cap stage, Pax-6 was expressed in the central parts of the tooth buds/enamel organs and in the oral epithelia adjacent to the tooth germs.¹

As the various systems in the body are interconnected to form a single structural unit, a pathological condition in one area can also affect other areas. There are many known correlations

between the visual and motor system. The importance of visual function, particularly the paracentral peripheral field of view, in motor coordination, ambulation, and the maintenance of balance has been amply demonstrated. In line with current medical principles, which are moving toward a more holistic view of the human body, this study aims to investigate, in an interdisciplinary manner, the incidence of dental malocclusions together with posture and eye convergence disorders. This study was conducted to determine the clinical association between teeth malocclusions, wrong posture, and ocular convergence disorders. A total of 605 children attending at the 3rd, 4th, and 5th years of seven Genoa primary schools were examined. Each child underwent the following examinations: (i) dental/occlusal,

Table 4: Pearson correlation matrix between dental and optical parameters among group I

	Age	Mand plane	ANB	Beta angle	Visual acuity RT	Visual acuity LT	Corneal diameter RT	Corneal diameter LT	Corneal thickness RT	Corneal thickness LT	Axial length RT	Axial length LT	RNFL RT	RNFL LT	IOP RT	IOP LT
Age	1	0.100	0.235	0.064	-	-	0.132	0.118	0.211	0.172	0.115	0.253	-0.141	-0.059	0.000	0.057
Mandibular plane		1	0.063	0.233	-	-0.350*	-0.271	-0.126	0.104	0.092	0.186	0.020	0.002	-0.022	-0.139	-0.169
ANB			1	0.338*	-	-0.304*	-0.094	-0.223	0.049	0.033	-0.013	0.045	0.036	0.021	0.034	0.000
Beta angle				1	-	-0.353*	-0.169	-0.051	0.123	0.127	0.163	-0.021	-0.269	-0.238	-0.065	-0.062
Visual acuity RT					1	-	-	-	-	-	-	-	-	-	-	-
Visual acuity LT						1	-0.065	0.010	-0.064	-0.053	-0.060	0.016	0.222	0.302*	0.006	-0.038
Corneal diameter RT							1	0.688**	0.274	0.235	-0.047	0.125	-0.036	0.072	0.570**	0.592**
Corneal diameter LT								1	0.521**	0.494**	0.186	0.235	0.039	0.073	0.407**	0.398**
Corneal thickness RT									1	0.974**	-0.010	0.373**	0.015	0.025	0.437**	0.340*
Corneal thickness LT										1	-0.054	0.306*	-0.057	-0.049	0.389**	0.308*
Axial length RT											1	0.530**	0.096	0.081	-0.237	-0.428**
Axial length LT												1	0.099	0.222	0.272	-0.079
RNFL RT													1	0.857**	0.126	-0.043
RNFL LT														1	0.246	0.088
IOP RT															1	0.901**
IOP LT																1

*Highly significant i.e., *p* value is less than 0.01**Moderately significant i.e., *p* value is less than 0.05**Table 5:** Pearson correlation matrix between dental and optical parameters among group II

	Age	Mand plane	ANB	Beta angle	Visual acuity RT	Visual acuity LT	Corneal diameter RT	Corneal diameter LT	Corneal thickness RT	Corneal thickness LT	Axial length RT	Axial length LT	RNFL RT	RNFL LT	IOP RT	IOP LT
Age	1	-0.036	-0.109	-0.119	0.113	0.006	0.117	0.243	0.133	0.153	-0.219	-0.034	-0.190	-0.276	0.167	0.290*
Mandibular plane		1	-0.219	-0.190	0.172	0.349*	0.144	-0.160	0.176	0.172	0.175	0.169	0.164	0.046	0.117	0.156
ANB			1	0.632**	-0.085	-0.114	0.060	-0.114	-0.037	0.031	-0.016	-0.048	-0.070	0.035	-0.153	-0.244
Beta angle				1	-0.058	-0.072	0.114	-0.004	-0.132	-0.110	-0.085	-0.126	-0.043	0.087	0.032	0.025
Visual acuity RT					1	0.781**	0.368**	0.058	0.025	0.063	0.162	0.121	0.077	0.012	-0.004	0.116
Visual acuity LT						1	0.368**	0.029	-0.012	0.006	0.211	0.224	0.082	0.019	-0.028	0.072
Corneal diameter RT							1	0.616**	0.089	0.119	0.118	0.266	-0.134	-0.126	0.130	0.152
Corneal diameter LT								1	0.229	0.188	0.003	0.196	-0.185	-0.182	0.237	0.200
Corneal thickness RT									1	0.971**	0.107	0.293*	-0.141	-0.258	0.460**	0.450**
Corneal thickness LT										1	0.096	0.326*	-0.156	-0.251	0.412**	0.403**
Axial length RT											1	0.648**	-0.011	-0.129	0.012	0.061
Axial length LT												1	-0.010	-0.052	0.223	0.263
RNFL RT													1	0.862**	0.010	-0.169
RNFL LT														1	0.047	-0.101
IOP RT															1	0.883**
IOP LT																1

*Highly significant i.e., *p* value is less than 0.01**Moderately significant i.e., *p* value is less than 0.05

Table 6: Pearson correlation matrix between dental and optical parameters among group III

	Age	Mand plane	ANB	Beta angle	Visual acuity RT	Visual acuity LT	Corneal diameter RT	Corneal diameter LT	Corneal thickness RT	Corneal thickness LT	Axial length RT	Axial length LT	RNFL RT	RNFL LT	IOP RT	IOP LT
Age	1	0.164	-0.065	-0.095	-0.226	-0.226	0.138	0.126	0.032	0.001	0.251	0.189	-0.069	-0.096	0.114	0.086
Mandibular plane		1	0.014	-0.100	-0.039	-0.039	0.086	0.043	-0.198	-0.185	0.037	-0.043	0.037	0.099	0.236	0.251
ANB			1	0.631**	-0.129	-0.171	0.060	-0.034	0.236	0.244	-0.164	-0.139	0.230	0.139	0.182	0.165
Beta angle				1	-0.021	-0.136	-0.022	-0.104	0.030	0.030	-0.170	-0.128	0.165	0.125	0.012	0.036
Visual acuity RT					1	0.767**	0.115	0.270	-0.220	-0.185	0.176	0.161	0.135	0.064	-0.055	-0.100
visual acuity LT						1	-0.080	0.020	-0.169	-0.131	0.153	0.127	-0.043	-0.015	-0.359*	-0.349*
Corneal diameter RT							1	0.710**	0.111	0.110	-0.054	-0.120	0.308*	0.145	0.186	0.242
Corneal diameter LT								1	-0.024	-0.060	0.118	0.160	0.100	-0.127	0.208	0.108
Corneal thickness RT									1	0.985**	-0.362*	-0.273	0.372**	0.098	-0.069	0.084
Corneal thickness LT										1	-0.398**	-0.317*	0.422**	0.164	-0.047	0.131
Axial length RT											1	0.946**	-0.262	-0.194	-0.157	-0.161
Axial length LT												1	-0.199	-0.200	-0.218	-0.207
RNFL RT													1	0.896**	-0.012	0.087
RNFL LT														1	-0.105	0.004
IOP RT															1	0.866**
IOP LT																1

*Highly significant i.e., p value is less than 0.01**Moderately significant i.e., p value is less than 0.05

(ii) orthoptic, and (iii) postural. Occlusal data concerned the presence of cross-bite, midline deviation with a mandibular shift, bad habits, and deep or open bite. Postural assessment involved frontal and lateral inspection, investigation during trunk flexion and ambulation, and note of any asymmetry in the lower limbs. The recorded orthoptic data included those pertaining to ocular dominance, a cover test, convergence, and the Brock string test. A prevalence of cases with an unphysiological gait was found in patients with overjet (14.70%) or overbite (14.87%), while the percentage of patients with normal occlusion who showed an unphysiological gait was 13.08%. Also, about 93.8 to 94.2% of children showed normal legs without dysmetry, with no difference in respect to the type of occlusion. Subjects with an open bite or deep bite showed a slightly different distribution of right or left dominant eyes. About 13% of children showed a pathological gait and, among them, vertical anomalies of occlusion (deep bite or open bite) were prevalent with respect to the other occlusal defects. The vertical dimension of occlusion revealed a slight relationship with the proper dominant eye. Postural, orthoptic, osteopathic, and occlusal variables were often clinically associated, and therefore these disorders appear to request a multidisciplinary medical approach for their treatment.¹⁰

Lin et al. conducted a study at Tufts University, School of Dental Medicine, and confirmed the relationship between head posture, mandibular position, and eye dominance. The purpose of this study is to assess the temporary eye dominance of children and the change relative to head posture and mandibular position. Twenty children were included in this study after the completion of the ophthalmological exclusion screening. All subjects had the sign of eye dominance screened with eye dominance tests. The mandibular position and the three-dimensional posture of head were recorded. The eye patches were applied over the dominant eye for 1 hour to achieve the effect of temporary eye dominance change for 10 children. Ten children had the same procedures except for the eye patch procedure. The reexaminations were performed at the end of 1-hour visit for both groups. Mandibular midline data revealed no change in both control and experimental groups. The transverse head postural change has been demonstrated by means of temporary eye dominance change. This study highlights several areas: the importance of clinical intervention in young children, the difference on transverse dimensional change, and the importance of the role of pediatric dentistry among interdisciplinary cooperation. Further investigation and early clinical intervention are encouraged.¹¹

In the present study, the skeletal class I growth pattern was assessed using the beta angle, and horizontal, average, or vertical growth patterns were diagnosed from the lateral cephalograms. These growth patterns were correlated with the visual acuity, corneal diameter, corneal thickness, axial length, retinal nerve fiber layer thickness, and intraocular pressure of each patient.

Correlation between the Dental and Ophthalmic Parameters

Group I: Horizontal Grower

A negative correlation is seen between the visual acuity of the left eye and the mandibular plane in group I, i.e., horizontal grower. By looking at the above correlation, we can anticipate some malocclusion in this type of grower but the type of malocclusion cannot be determined as we have not taken dental malocclusion

into consideration in our study. Thus, the visual acuity can serve as a basis for the determination of malocclusion in a horizontal grower.

Group II: Average Grower

A positive correlation is seen between the visual acuity of the left eye and the mandibular plane in group II, i.e., average grower. It was observed that by determining the visual acuity in an average grower, it can be assumed that some type of malocclusion may be present.

Group III: Vertical Grower

There was no statistically significant correlations between dental and optical parameters in group III. However, there was a statistically significant correlation that was found within the optical as well as dental parameters.

CONCLUSION

Positive correlation was found between visual acuity and mandibular plane angle among the average growth pattern, and negative correlation was found between visual acuity and mandibular plane angle among the horizontal growth pattern. So, correlation is present between dental and eye variables.

Hence, if the patient is referred from an ophthalmologist, then by analyzing the various eye variables and correlating them with the growth pattern of the patient, malocclusion can be forestalled.

In the future, it will serve as an excellent interdisciplinary approach to diagnosis and treatment planning.

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