"EVALUATION OF CERVICAL SPINE POSTURE OF ADULTS IN DIFFERENT SKELETAL MALOCCLUSIONS IN NORTH KARNATAKA POPULATION: A CROSS-SECTIONAL CEPHALOMETRIC STUDY"

By

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REG. NO. II0219006

Dissertation

Submitted to

KAHER, Belagavi, Karnataka

In partial fulfilment of the requirements for the degree of

MASTERS OF DENTAL SURGERY

IN

ORTHODONTICS AND DENTOFACIAL ORTHOPAEDICS

(BRANCH – V)

Under the Guidance of

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ORTHODONTICS AND DENTOFACIAL ORTHOPAEDICS

KLE VISHWANATH KATTI INSTITUTE OF DENTAL SCIENCES,

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2019 – 2022

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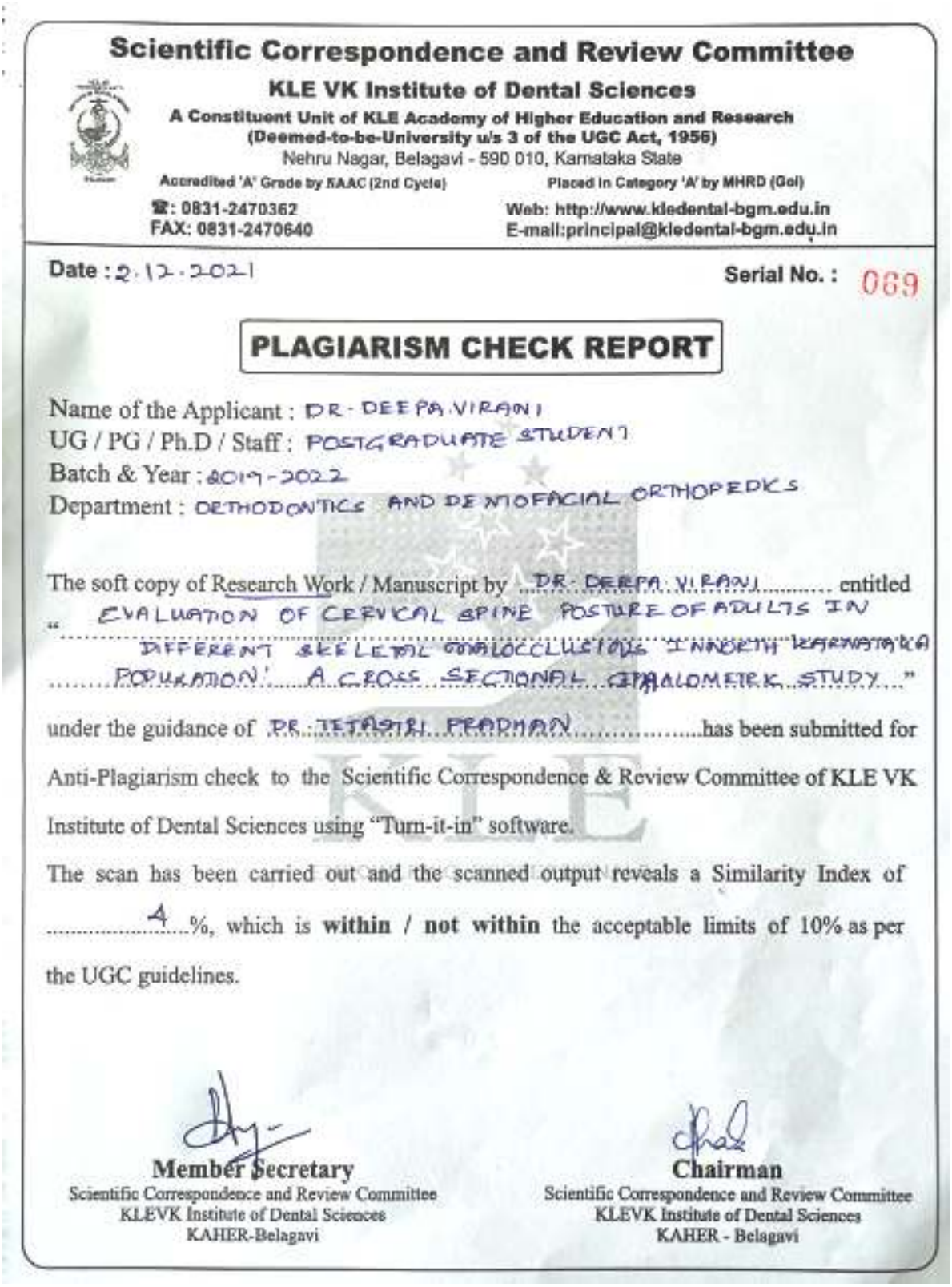

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Acknowledgement

First and foremost, I would like to thank God Almighty for giving me the strength, knowledge, ability and opportunity to undertake this research study and to persevere and complete it satisfactorily. Without his blessings, this achievement would not have been possible.

In my journey towards this degree, I have found a teacher, a friend, an inspiration, a role model and a pillar of support in my Guide, Dr. Tejashri Pradhan MDS, Professor and Head, Department of Orthodontics and Dentofacial Orthopaedics, KLE Academy of Higher Education and Research, (KAHER) KLE V. K. Institute of Dental Sciences, Belagavi. She has provided her heartfelt support to me at all times and has given me invaluable guidance, inspiration and suggestions in my quest for knowledge. She has given me all the freedom to pursue my research, while silently and non-obtrusively ensuring that I stay on course and do not deviate from the core of my research. I gratefully acknowledge the pertinent criticism, pragmatic suggestions and advice given to me through my time as a postgraduate student. Her passion for the subject, vast knowledge, calm and composed nature and skill are all standards to hope to breach someday. Without her able guidance, I would not be where I am today, and I shall eternally be grateful to her for her assistance.

I am highly obliged to Dr. Alka Kale MDS, Principal, Dr. Anjana Bagewadi Vice-principal, KAHER's KLE Vishwanath Katti Institute of Dental Sciences, KLE University, Belagavi, for providing the academic support and letting me avail facilities and infrastructure of the institution.

I have great pleasure in acknowledging my gratitude to my respected teachers Dr. K M Keluskar MDS, PHD Professor, Dr. Roopa Jatti MDS Professor, Dr. Rohan Hattarki MDS Reader, Dr. Anand Badavannavar MDS Reader, Dr. Amit Nilgar MDS Reader, Dr. Trupti Sadhunavar MDS Lecturer, Dr. Devyani Desai MDS Lecturer, Dr. Adithi MDS Lecturer and Dr. Pravin Mandaki MDS Lecturer, of Department of Orthodontics and Dentofacial Orthopaedics for their constant guidance and above all their inspirational support at all times.

I sincerely thank all my postgraduate colleagues Dr. Preethi, Dr. Pranavi, Dr. Sanjyot, Dr. Akin and Dr. Charles for the modest help, words of encouragement and confidence that kept me motivated. I thank them for reinsuring me, that the fire keeps burning and for being there at times when I required them the most. They propelled me on the course of not only my thesis but also through the three years of my post-graduation. Their support, encouragement and credible ideas have been great contributors to the completion of my thesis.

Special heartfelt thanks to my seniors, Dr. Ana and Dr. Poojit for always being there for me no matter what in unexplainable ways through the ups and downs of these three years, constantly motivating and supporting me.

I take this opportunity to show my gratitude to all my seniors- Dr. Susmita Dr. Yatin, Dr. Pooja, Dr. Ann, Dr. Aarti, and my juniors- Dr. Shreya, Dr Namit, Dr. Tanvi, Dr. Riddhi, Dr. Aravind, Dr. Sagar, Dr. Anwesha, Dr. Sreenidhi, Dr. Arzoo, Dr. Akansha, Dr. Sumedh and Dr. Shubham for their constant support and motivation that helped me do my work with maximum enthusiasm.

It would be inappropriate if I omit to mention the name of my closest friend Dr. Shaima, who has been there for me through all my ups and downs. I would like to thank her for being the core of my support system, a pillar of strength, especially at times when I needed it the most.

I acknowledge all my friends and well-wishers, whom I have not mentioned above for their cooperation and support whenever needed.

I am very much indebted to this department and extend my appreciation to all the non-teaching staff of the department for their able assistance.

I would like to thank Dr. Sathiya Priya for helping me with the statistics involved in my thesis.

I would like to acknowledge the work of Mr Arun and Mr Anand, Library Xerox Centre, for the excellent formatting, printing and binding of my thesis.

My acknowledgement would be incomplete without thanking the biggest source of my strength- my Family. The blessings of my grandparents, late Mrs. Sarladevi and late Mr. Nenumal Virani, Mrs. Sheela and late Mr. Ramchand Chhattani, my parents Mrs. Rekha and Mr. Chandrakumar Virani, and the love and care of my siblings, Mr. Bhushan and Mrs. Amrita Virani, Mr. Rohit and Mrs. Pooja Virani who have unconditionally supported me and made a tremendous contribution in helping me reach this stage in my life. I thank them for putting up with me in difficult moments persuading me to follow my dream of getting this degree. This would not have been possible without their unwavering and unselfish love and support given to me at all times. They are my confidantes, without whom umpteen things would never have materialized. Thank you for all that you have done, through

all these years. Thank you for being the core of my support system, a pillar of strength to me, especially at times when I needed it the most. I present this thesis as an unassertive tribute to all their love, affection, dreams and strong principles, which they have instilled in me.

Thank you one and all.

Dr. DEEPA VIRANI

LIST OF ABBREVIATIONS

OPT	-	Odontoid Process Tangent
CVT	-	Cervical Vertebral Tangent
ANS	-	Anterior Nasal Spine
PNS	-	Posterior Nasal Spine
NSL	-	Nasion Sella Line
PP	-	Palatal Plane
MP	-	Mandibular Plane
HOR	-	True Horizontal line
ANOVA	-	Analysis of variance
CSP	-	Cervical Spine Posture

ABSTRACT

Introduction: The cervical spine posture is dependent on interactions within the musculoskeletal system and physiologic growth processes and there is a close anatomic relationship between the cervical spine and the craniofacial morphology. Graber suggested that the anatomy and position of the upper cervical vertebrae was closely linked with craniofacial development. A concise and comprehensive understanding of the coordinating mechanisms which render to normal craniofacial development is of importance for the diagnosis and treatment planning.

Therefore, this study was undertaken:

- To assess the cervical spine posture in Class I skeletal malocclusion
- To assess the cervical spine posture in Class II skeletal malocclusion
- To assess the cervical spine posture in Class III skeletal malocclusion
- To compare the cervical spine posture between Class I, Class II, and Class III skeletal malocclusions
- To develop cephalometric norms for cervical spine posture in the North Karnataka population

Materials and methods: The study was a descriptive cross-sectional cephalometric study conducted on 186 patients with Class I, II, and III skeletal malocclusions who were reported to the Department of Orthodontics and Dentofacial Orthopaedics, KLE Academy of Higher Education and Research, (KAHER) KLE V.K Institute of Dental Sciences, Belagavi, and three other colleges in the North Karnataka region (Dharwad, Bagalkot, Gulbarga). Pre-treatment lateral cephalogram of patients was traced manually, sagittal skeletal parameters, cervical spine posture, craniocervical posture, maxillary and mandinular plane inclination, cervicohorizontal angles were entered

and scrutinized using SPSS (Statistical Package For Social Sciences Cooperation, Chicago USA) version 25. Further, descriptive and inferential analysis was done to reach a final conclusion.

Results: The mean value of OPT-CVT for the samples were 3.98 ± 2.20 in Class I, 4.29 ± 2.78 in Class II and 3.15 ± 1.91 in Class III. The values for NSL-OPT were 99.37 ± 7.49 in Class I, 100.81 ± 6.03 in Class II and 97.47 ± 6.41 in Class III and for NSL-CVT were 103.68 ± 7.39 in Class I, 103.95 ± 5.43 in Class II and 101.44 ± 6.05 in Class III. The mean value for PP-OPT among the three groups is statistically different (0.024*). The maxilla is distally inclined to the upper cervical vertebrae in the Class III group. The mean value for PP-CVT among the three groups is not statistically significant (0.117). The maxilla is distally inclined to the upper cervical vertebrae in the Class III group. The mandibular plane inclination to the upper and middle cervical segment was statistically different in all three groups (0.000* and 0.002* respectively).

Conclusion: Cervical spine posture differs in various sagittal skeletal malocclusion. It was straighter in the Class III group compared to the Class I and Class II group. The head posture was extended in the Class II group and it was flexed in the Class III group suggesting forward inclination of the head on the cervical column. The maxillary and mandibular base inclination on the cervical column was found to be different in various skeletal malocclusions. The concept of 'Functional and postural competency' cannot be overlooked in orthodontics. An important consideration should be given to cervical spine posture in Orthodontics diagnosis and treatment planning as it may affect craniofacial development.

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INTRODUCTION

The spine has three curvatures i.e., cervical, thoracic, and lumbar curves.

Proper curvature and positioning of these three curves are important to maintain a healthy normal spine. Many researchers have stated that the cervical spine is closely related to craniofacial morphology as they both have the same origin.

Cervical spine posture is related to various factors:

- **The body** i.e., ethnic group[1], gender[2], age[3] and height[4]
- **Craniofacial morphology**[5] especially mandibular divergence[3], size of the mandible[6], and facial shape[7]
- **Functional elements** like nasorespiratory function[8], temporomandibular disorder[9]
- **Orthodontic treatment** like the use of appliances for correction of sagittal jaw relationship[10].

Hence, it is not irrational to expect that cervical spine posture might be associated with different skeletal malocclusion.

An enhanced understanding of the musculoskeletal system and cervical spine is of paramount importance as it contributes to the normal growth of craniofacial structures. Several researchers have found an association between the two which is critical for a better diagnosis and treatment planning of morphological and functional disorders in the musculoskeletal system.[5]

According to a study conducted by Graber[11], the upper and lower cervical columns have different origins. The upper cervical column is closely associated with

craniofacial development. However, the lower cervical vertebrae are linked to the rest of the cervical column. This was in accordance with the study conducted by Hellsing et al[3] where he established that there is no correlation between cervical lordosis and thoracic kyphosis emphasizing the correlation between the cervical spine and craniofacial development.

Schwartz[12] in 1926 proposed a correlation between head posture and malocclusion. His hypothesis was based on the sleep position with extended head posture in children with upper respiratory obstruction. This change in the posture in patients with obstruction of the airway can lead to the development of malocclusion, especially Class II malocclusion. A similar observation was reported by Gresham and Smithels[13] who concluded that subjects with poor neck posture are more prevalent to develop Class II malocclusions and an increase in the vertical development of the face compared to subjects with good neck posture.

Woodside et al[14] also proposed a similar association between the development of malocclusion and airway obstruction. They concluded that subjects with swelling of the nasal mucosa leading to impaired breathing had more chances of developing lower anterior crowding compared to normal breathers.

Solow and Talgren[5] have suggested that when the head is extended in relation to the cervical column the anterior facial height is increased, the sagittal jaw dimensions are reduced and the mandible has a steep inclination, whereas, when the craniocervical posture is flexed, the anterior facial height is shorter, sagittal jaw dimensions are larger and mandible has a less steep inclination.

In a study conducted by Solow and Siersbaek-Nielsen[15,16], it was demonstrated that changes in the growth of the cervical spine are associated with changes in the growth pattern of facial morphology and therefore craniocervical angles to some extent can help in the prediction of facial development.

A concise and comprehensive understanding of the coordinating mechanisms which render to normal craniofacial development is of importance for the diagnosis and treatment of morphological and functional disturbances in the masticatory system and adjoining regions. A factor that may be of relevance in this connection is the relationship between craniofacial morphology and cervical posture.

Changes in Cervical posture can affect the mandibular path of closure, mandibular rest position, and discomfort in masticatory muscle activity. The masticatory muscles are said to be affected by increased gravitational forces on the head. Unfortunately, the influence of the cervical spine on the maxillomandibular structure is frequently ignored. The orthodontist should consider correlating the relationship of the cervical spine when rest position and mandibular movement are assessed before treatment. When all the elements that affect the mandible function are in adequate association with each other, the masticatory system ascertains maximum efficiency with a minimal expenditure of energy.[17]

Various researchers over the last century have pursued to affirm a relationship between poor spinal posture, pain, diminished function, and/ or disability. Regardless, the longevity of interest by health researchers in the measurement and analysis of human posture, and its impact on the supporting structures, there is still much to be discovered.

The different cephalometric analyses carried out resulted in a set of norms against which patients and their need for orthodontic treatment were assessed. However, most of these analyses were carried out on a particular population such as Ricketts studied the Caucasian population, whereas Sushner did a study on the black population. Owing to the diverse population of India, it is necessary to consider the ethnic differences present and introduce cephalometric norms about the various ethnic groups and formulate an orthodontic treatment plan after consideration of the cervical spine posture and craniofacial morphology. Therefore, this study was planned to set the norms for the North-Karnataka population.

AIM AND OBJECTIVES

AIM:

- To evaluate and compare the cervical spine posture of adults in skeletal class I, II, and III patients in the North Karnataka population.

OBJECTIVES:

- To assess the cervical spine posture in Class I skeletal malocclusion
- To assess the cervical spine posture in Class II skeletal malocclusion
- To assess the cervical spine posture in Class III skeletal malocclusion
- To compare the cervical spine posture between Class I, Class II, and Class III skeletal malocclusions
- To develop cephalometric norms for cervical spine posture in the North Karnataka population

REVIEW OF LITERATURE

- **Tauhedd et al, (2019)[18]** conducted a study to determine 'cervical spine posture' in various sagittal skeletal malocclusions on 63 subjects using their lateral cephalometric radiographs and found a statistical difference between various sagittal 'skeletal malocclusions' for the 'cervical spine posture'. They observed that the cervical column was significantly straighter in skeletal Class III subjects than in skeletal class I subjects
- **D'Attilio et al, (2005)[19]** in their study on 120 children who were divided into 3 groups based on their skeletal class, checked the postural variables. A statistically significant lower 'cervical lordosis angle' was observed in skeletal class III group compared to children in skeletal class I and II. They established that head extension upon the spinal column was significantly higher in skeletal class II when compared to the other groups i.e skeletal class I and II.
- **Solow and Tallgren, (1976)[5]** examined 120 Danish male students of age 22-30 years and described the 'Craniofacial morphology by 42 linear and angular parameters, and postural association by 18 angular parameters'. A statistically significant association was observed between craniofacial morphology and head posture.
- **Kamal et al, (2019)[20]** evaluated pre and post-functional treatment cephalograms of sixty subjects. Three skeletal and seven cervical vertebral parameters were compared between the study group, where a twin-block functional appliance was given, and a control group. A significant difference was observed among pre and post-functional SNB, ANB, and SN-OPT angles. They concluded that TB causes the cervical posture to be more upright.

- **Tecco et al, (2005)[10]** compared the cervical spine posture of 20 Caucasian female children who were given Frankel appliance with 20 untreated class II controls. They reported that the cervical lordosis angle was significantly higher in patients where Functional appliance was given as compared to the control group at the end of the treatment
- **Solow and Tallgren, (1977)[21]** conducted a study on 120 Danish males of age 22-30 years and evaluated the association between the cervical column, head position, and dentoalveolar morphology. A positive correlation was discovered between the head posture and the cervical column with anterior maxillary and mandibular dentoalveolar heights and with the inclination of maxillary and mandibular occlusal planes. No associations were discovered between craniocervical angulation and dentoalveolar prognathism or incisor inclination.
- **Hellsing et al, (1987)[7]** evaluated the association amidst craniofacial morphology, head position, and cervical curvature in '125 children, 63 boys, and 62 girls equally divided into 3 age groups of 8, 11, and 15 years of age'. The systematic effects of gender and age were set aside in the statistical analysis and it was established that a straighter cervical curvature, evaluated from the 2nd to the 6th vertebrae was related to the head extension to the 2nd cervical vertebra, an increased mandible inclination, and increased anterior facial height. It was also observed that there was an association between increased cervical lordosis and extension of head characterizing a compensatory cervical spine curvature with an altered centre of gravity of the craniofacial complex.
- **Huggare, (1991)[22]** used lateral cephalograms of 78 young adults to evaluate the corelation among the anatomy of the 1st cervical vertebra, dentofacial build, and the atlas, with either a very high or a low atlas dorsal arch, were assessed about

the head position, dentofacial anatomy and cervicovertebral. Each group consisted of 22 women and 17 men of the high and low dorsal arch.

- **Wenzel et al, (1989)[23]** conducted a study to assess the role of the mandible to head posture and airway space by evaluating patients before and after surgical correction of mandibular prognathism. The sample consisted of lateral cephalograms of 52 individuals with the prognathic mandible. Orthodontic adjustments were carried out in all the participants of the study prior to mandibular osteotomy Changes in head posture and airway space were assessed by paired t-test. A mean increase in the posture of the head of 2.7 degrees ($p < 0.001$) and a mean reduction in airway space of 2.3 mm ($p < 0.001$) was observed.
- **Miralles et al, (2016)[24]** conducted a study to determine the effect of the increase in the occlusal vertical dimension using an orthodontic appliance on craniocervical relationships and the position of the cervical spine. The total sample size was 30 children, 15 in each group (a study group and a control group) presenting with malocclusion. An Orthodontic appliance was given to the children in the study group to correct the crossbite. No treatment was given to the children in the control group. A significantly forward position of the cervical spine was observed in the study group using cephalometric analysis. Though, no difference was seen in the control group.
- **Aglarci, (2019)[25]** conducted a study to evaluate the response of twin-block functional appliances on the cervical spine posture. He evaluated 21 patients with skeletal Class II malocclusion (11 females, 10 males; 13.31 ± 0.92) with retrognathic mandible. Cephalometric analysis was done to observe the CSP changes after treatment. He discovered that advancement of the mandible by twin

block therapy resulted in the upper segment of the cervical spine to be inclined backward and the lower segment to be inclined forward.

- **McAviney, (2005)[26]** assessed the presence of a functionally normal cervical lordosis and also investigated the correlation of functionally normal cervical lordosis and the amount of forward posture with neck complaints. Cervicogenic symptoms were more likely to be seen in patients with lordosis of 20^{O} or less. A statistically significant correlation was observed between cervical pain and lordosis of 0^{o} or less. Lordosis of 0^{o} or less was 18 times more in a patient with complaint of cervical pain when compared to a patient with non-cervical complaint. He found a statistically significant correlation between lordosis $<20^{O}$ and cervical pain. A clinically normal range for cervical lordosis is 31^{O} to 40^{O}.
- **Solow and Nielsen, (1992)[16]** conducted a study on 34 children (16 girls and 18 boys) to evaluate if head posture and cervical spine posture can predict the growth changes of the craniofacial structures using lateral cephalogram of samples taken on two occasions before orthodontic treatment. The mean age was 9.9 years at time 1 and 12.7 years at time 2. Correlation coefficients were analysed among 11 postural variables and growth rate in 36 structural variables at time 1. A statistically significant correlation was observed indicating that a small cranio-cervical angle and backward inclination of upper cervical vertebra was related to horizontal growth pattern due to reduction in backward displacement of TMJ, large maxillary growth in length, increased facial prognathism, and larger than average true forward rotation of the mandible. A large cranio-cervical angle is associated with vertical growth pattern due to large backward displacement of the TMJ, reduced growth in length of the maxilla, reduced facial prognathism, and less than average true forward rotation of the mandible.

- **Ohnmei et al, (2014)[27]** evaluated cephalograms of 64 patients with a class II malocclusion who were given functional appliance for mandibular advancement. Linear and angular parameters were used to assess the changes in the cervical spine posture before and after mandibular advancement. They concluded that upper cervical spine position straightened significantly post-treatment, cervical spine position changes with treatment in skeletal Class II malocclusion.

MATERIALS AND METHODS

STUDY DESIGN

A descriptive cross-sectional cephalometric study was conducted on patients with Class I, II, and III skeletal malocclusions.

SOURCE OF DATA

The study was done on cephalograms of patients who were treated in the Department of Orthodontics and Dentofacial Orthopaedics, KLE Academy of Higher Education and Research, (KAHER) KLE V.K Institute of Dental Sciences, Belagavi, and at three other colleges in the North Karnataka region (Dharwad, Bagalkot, Gulbarga).

INCLUSION CRITERIA

Patients satisfying the following criteria were included:

- North-Karnataka population
- Age between 18-25 years at the time when cephalogram was taken
- Permanent dentition with all the teeth present (excluding third molars)
- No history of orthodontic treatment
- No missing teeth in both the arches
- Both males and females

EXCLUSION CRITERIA

Patients with the following criteria were excluded:

- Any trauma or injury to the cervical spine
- Any syndromes or congenital abnormalities
- Any systematic disease
- History of orthognathic surgical treatment
- History of extracted or missing permanent teeth

SAMPLE SIZE ESTIMATION

The sample size for the study was calculated as 62 subjects in each group (Class I, II, and III) with a total of 186 subjects, based on the formula:

$$N = \frac{2\,(S)^2\,(Z\ 1\text{-}\alpha/2 + Z\ 1\text{-}\beta)^2}{d^2}$$

Where standard deviation,

S1 in the 1st group= 1.67

S2 in the second group= 2.06

d is the detectable mean difference= 1.21

$Z_{1-\alpha}$ =1.96 at 5% α error

$Z_{1-\beta}$ = 1.682 at 5% β error

Power = 95%

So, the estimated sample size was 62 per group, which made the sample size 186 in total

PERMISSIONS OBTAINED

- Institutional ethical clearance.
- Waiver of Informed consent form.

TOTAL BUDGET

- Material cost: Rs. 600
- Equipment cost: Rs. 1400
- The cost incurred during the investigation: Rs. 8000
- The cost incurred for statistical analysis: Rs. 2000
- Total cost: Rs. 12000

FUNDING DETAILS:

- No funding from any external source was required to conduct the study.
- I, Dr.Deepa Virani took up the financial responsibility of my research and bore all the expenses incurred during the study.

METHODOLOGY

The cervical spine posture in three different classes of malocclusion was assessed on patients reporting to the Department of Orthodontics and Dentofacial Orthopaedics KLE Academy of Higher Education and Research, (KAHER) KLE V. K. Institute of Dental Sciences, Belagavi, and three other colleges in North Karnataka. A total of 186 patients were evaluated using the pre-treatment lateral cephalogram.

Standardized lateral cephalograms taken in natural head position, with teeth in centric occlusion and lips in relaxed position were collected.

⇩

Acetate sheet was placed on top of the radiograph and the soft tissue, hard tissue and cervical spine landmarks were traced on the sheet.

⇩

Skeletal malocclusion were classified based upon the ANB angle and Wits value which indicates the positional relationship of the maxilla and mandible.

⇩

The patients were categorized into three classes:
Class I, Class II and Class III skeletal malocclusion.

⇩

To evaluate the cervical spine posture two tangents were drawn to the 2^{nd} and 4^{th} cervical vertebrae called odontoid process tangent and cervical vertebrae tangent, respectively.

Anatomic landmarks used in the study are:

1) **Nasion (N)**- The most anterior point of the frontal nasal suture in the mid-sagittal plane.

2) **Sella (S)**- The geometric center of the pituitary fossa.

3) **Point A (Subspinale)**- The most posterior midline point in the concavity between the ANS and the prosthion (the most inferior point on the alveolar bone overlying the maxillary incisor).

4) **Point B (Supramentale)**- The most posterior midline point in the concavity of the mandible between the infradentale (the most superior point on the alveolar bone overlying the mandibular incisors) and Pogonion (Pog).
5) **CV2tg**- The tangent point of OPT on the odontoid process of the second cervical vertebra.
6) **CV2ip**- The most posteroinferior point on the corpus of the second cervical vertebra.
7) **CV4ip**- The most posteroinferior point on the corpus of the fourth cervical vertebra.
8) **Anterior nasal spine (ANS)**- The anterior tip of the sharp bony process of the maxilla at the lower margin of the anterior nasal opening.

9) **Posterior nasal spine (PNS)**- The posterior spine of the palatine bone constituting the hard palate.

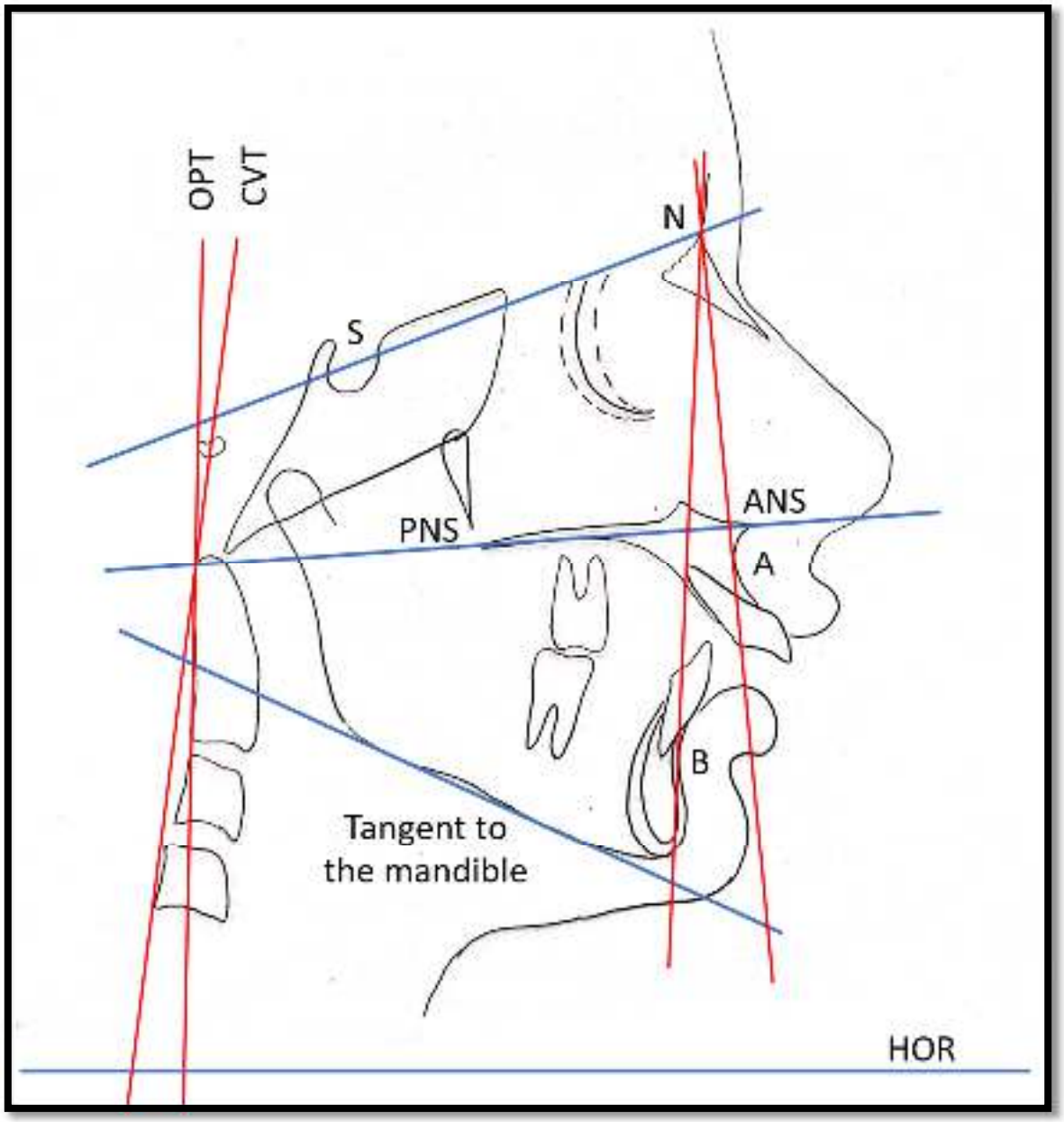
Reference lines used are:

1) **Odontoid process tangent**- The posterior tangent to the odontoid process through CV2ip
2) **Cervical vertebral tangent**- The posterior tangent to the odontoid process through CV4ip.
3) **Nasion-sella line**- The line through N and S.
4) **Palatal plane**- The line through the anterior nasal spine and posterior nasal spine.
5) **Mandibular plane**- The tangent to the lower border of the mandible.
6) **True Horizontal line (HOR)**- The line perpendicular to Vertical.

Parameters used in the study:

1) ANB angle
2) Wits appraisal
3) OPT-CVT
4) NSL-OPT
5) NSL-CVT
6) PP-OPT
7) PP-CVT
8) MP-OPT
9) MP-CVT
10) OPT-HOR
11) OPT-CVT

Figure 1. Landmarks and planes used for analysis.



INSTRUMENTS AND MATERIALS

- Pre-treatment lateral cephalograms
- Acetate matte sheets
- Lead pencil (0.35 mm)
- Scale
- Set squares
- Protractor
- View box

STATISTICAL ANALYSIS

The statistical analysis was done using SPSS VERSION 25.0. Continuous variables were represented by mean± sd/median (range) The Kruskal Wallis test was used to compare the mean between the three study groups. The statistical significance was kept at a p-value less than 0.05.

RESULTS

- This study was done to evaluate and compare the cervical spine posture of adults in skeletal class I, II, and III patients in the North Karnataka population between the age group of 18-25 years.

- A total of 186 subjects were divided into 3 groups based on the ANB angle and Wits appraisal.

Table 1: Descriptive mean and standard deviation for Class I

Parameters	N	Minimum	Maximum	Mean	Std. Deviation
ANB	62	0	3	1.79	.847
Wits appraisal	62	-1	3	1.63	1.090
OPT-CVT	62	0	12	3.98	2.206
NSL-OPT	62	86	115	99.37	7.493
NSL-CVT	62	88	118	103.68	7.390
PP-OPT	62	75	110	91.94	7.147
PP-CVT	62	81	109	94.37	5.962
MP-OPT	62	99	127	114.45	7.500
MP-CVT	62	95	125	110.34	7.542
OPT-HOR	62	76	110	93.58	6.378
CVT-HOR	62	74	100	89.42	5.653

Table 1 shows descriptive mean and standard deviation for all the parameters in Skeletal Class I group

Table 2: Descriptive mean and standard deviation for Class II

Parameters	N	Minimum	Maximum	Mean	Std. Deviation
ANB	62	4	11	6.03	1.717
Wits appraisal	62	2	9	4.35	1.577
OPT-CVT	62	0	13	4.29	2.784
NSL-OPT	62	86	112	100.81	6.035
NSL-CVT	62	91	112	103.95	5.430
PP-OPT	62	75	104	93.39	7.846
PP-CVT	62	80	113	96.40	7.303
MP-OPT	62	94	130	114.56	7.923
MP-CVT	62	91	126	109.95	8.525
OPT-HOR	62	80	106	95.66	7.140
CVT-HOR	62	75	105	91.39	7.201

Table 2 shows descriptive mean and standard deviation for all the parameters in the Skeletal Class II group

Table 3: Descriptive mean and standard deviation for Class III

Parameters	N	Minimum	Maximum	Mean	Std. Deviation
ANB	62	-10	-1	-4.56	2.386
Wits appraisal	62	-17	-1	-6.77	3.861
OPT-CVT	62	0	8	3.15	1.915
NSL-OPT	62	83	113	97.47	6.419
NSL-CVT	62	88	116	101.44	6.053
PP-OPT	62	76	107	90.03	6.111
PP-CVT	62	80	106	96.53	7.688
MP-OPT	62	98	130	108.50	9.091
MP-CVT	62	92	125	105.35	9.117
OPT-HOR	62	76	106	91.56	9.109
CVT-HOR	62	75	106	88.37	9.733

Table 3 shows descriptive mean and standard deviation for all the parameters in the Skeletal Class III group

Table 4: Comparison of malocclusion classes (I, II, III) with different parameters by Kruskal Wallis test

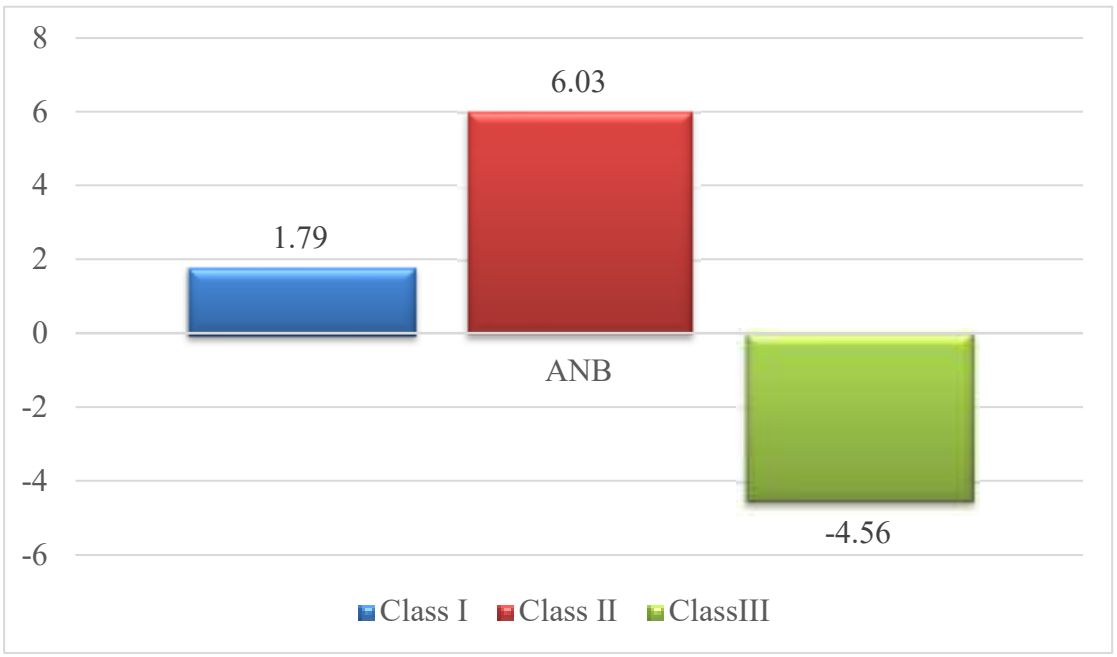
	Groups	N	Mean ± SD	P-VALUE
ANB	Class I	62	1.79 ± 0.84	**0.000***
	Class II	62	6.03 ± 1.71	
	Class III	62	-4.56 ± 2.38	
Wits appraisal	Class I	62	1.63 ± 1.09	**0.000***
	Class II	62	4.35 ± 1.57	
	Class III	62	-6.77 ± 3.86	
OPT-CVT	Class I	62	3.98 ± 2.20	0.074
	Class II	62	4.29 ± 2.78	
	Class III	62	3.15 ± 1.91	
NSL-OPT	Class I	62	99.37 ± 7.49	**0.007***
	Class II	62	100.81 ± 6.03	
	Class III	62	97.47 ± 6.41	
NSL-CVT	Class I	62	103.68 ± 7.39	**0.024***
	Class II	62	103.95 ± 5.43	
	Class III	62	101.44 ± 6.05	
PP-OPT	Class I	62	91.94 ± 7.14	**0.024***
	Class II	62	93.39 ± 7.84	
	Class III	62	90.03 ± 6.11	

PP-CVT	Class I	62	96.53 ± 7.68	0.117
	Class II	62	96.40 ± 7.30	
	Class III	62	94.37 ± 5.96	
MP-OPT	Class I	62	114.45 ± 7.50	**0.000***
	Class II	62	114.56 ± 7.92	
	Class III	62	108.50 ± 9.09	
MP-CVT	Class I	62	110.34 ± 7.54	**0.002***
	Class II	62	109.95 ± 8.52	
	Class III	62	105.35 ± 9.11	
OPT-HOR	Class I	62	93.58 ± 6.37	**0.011***
	Class II	62	91.56 ± 9.10	
	Class III	62	95.66 ± 7.14	
CVT-HOR	Class I	62	89.42 ± 5.65	0.079
	Class II	62	88.37 ± 9.73	
	Class III	62	91.39 ± 7.20	

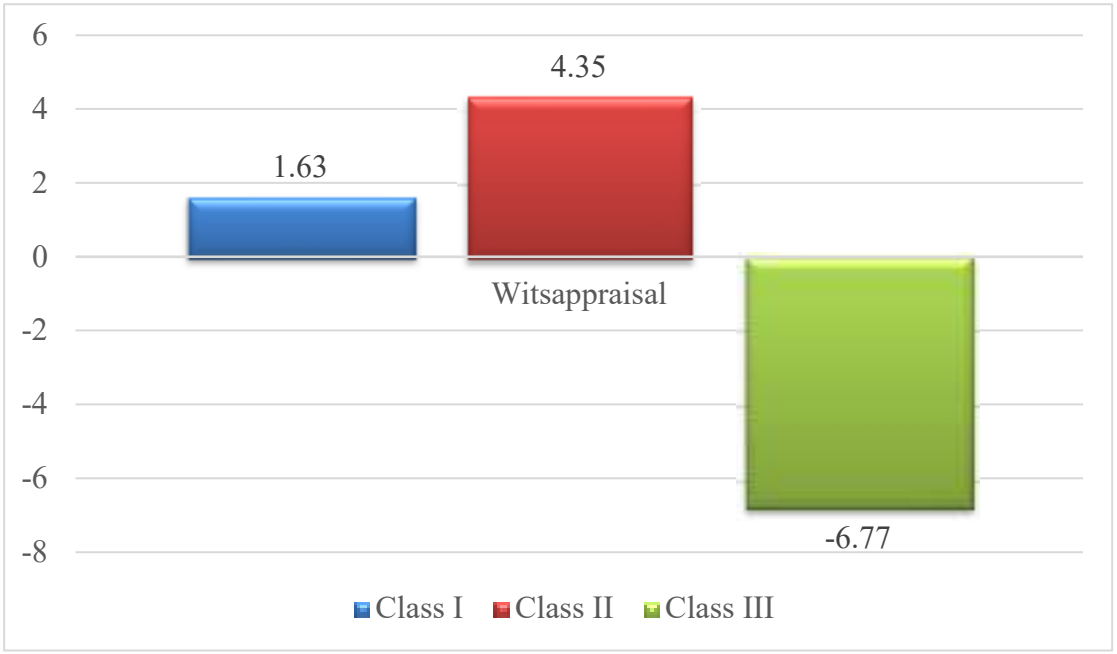
The statistical significance was kept at a p-value less than 0.05.

Table 4 shows the mean values of the different parameters for the three groups, Class I, Class II, and Class III. The difference between the values for all the parameters between the three groups was found to be statistically significant except OPT-CVT, PP-CVT and CVT-HOR.

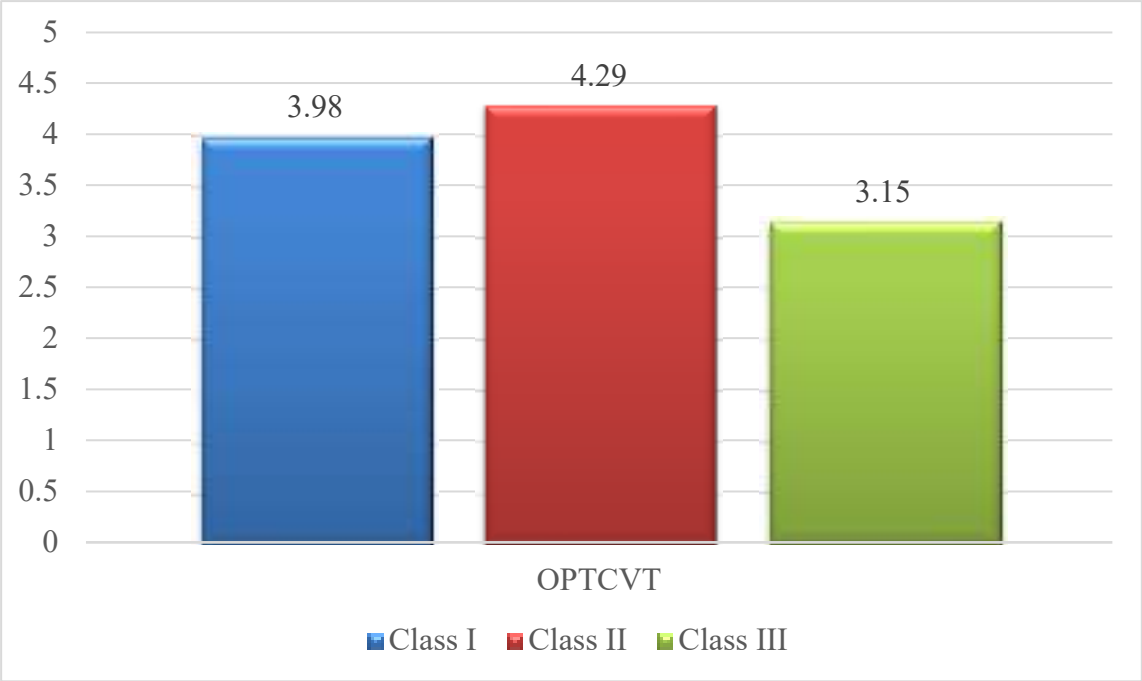
Graph number 1: Comparison of mean ANB between the three groups.



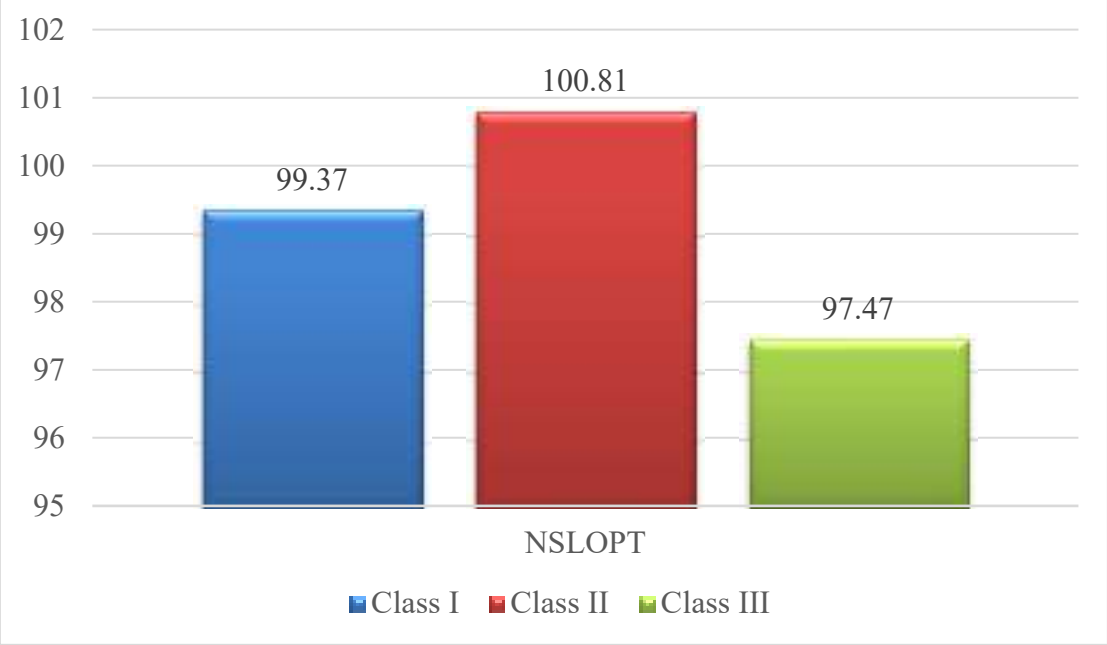
Graph number 2: Comparison of mean Wits appraisal between the three groups.



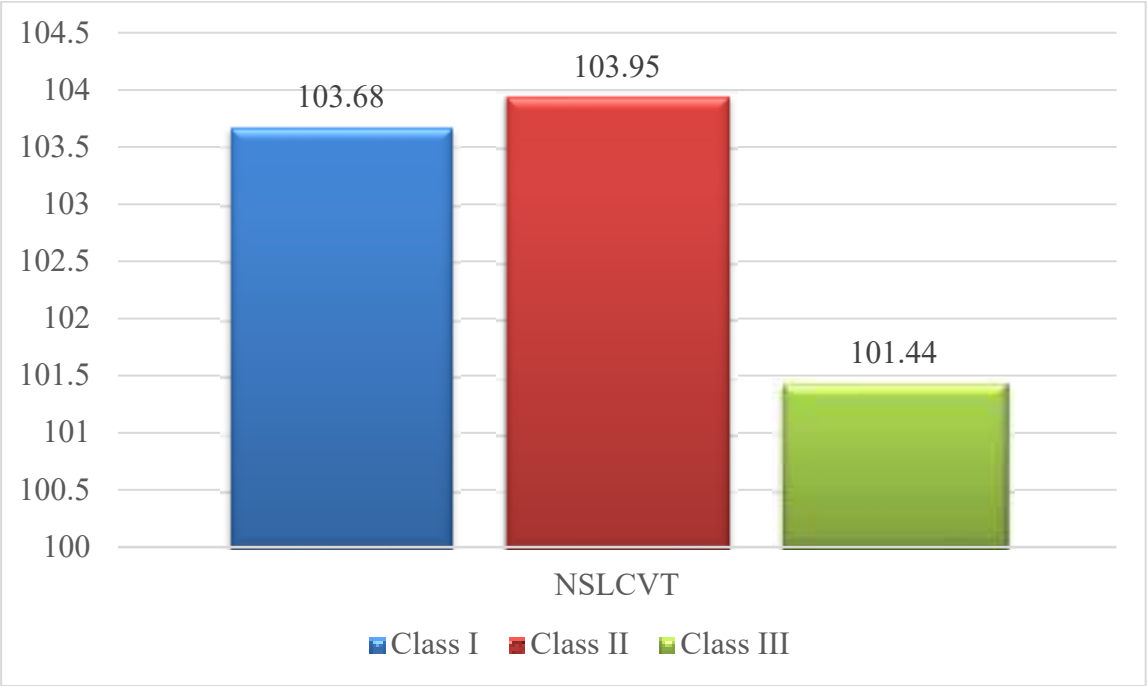
Graph number 3: Comparison of mean OPT-CVT between the three groups.



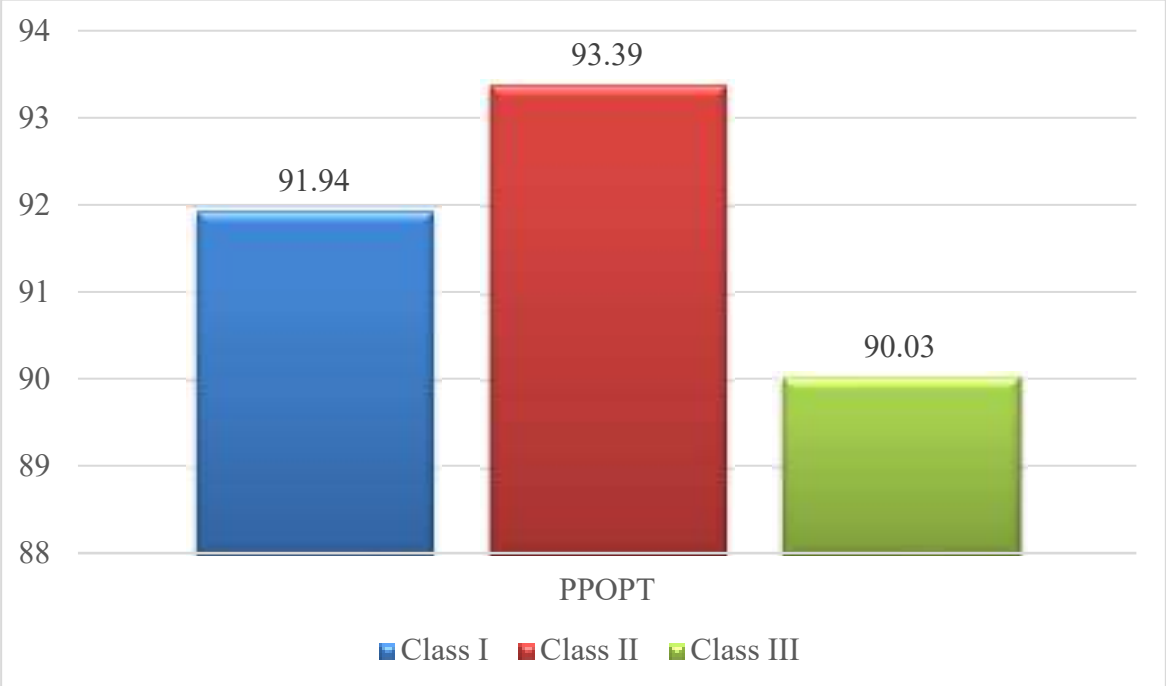
Graph number 4: Comparison of mean NSL-OPT between the three groups.



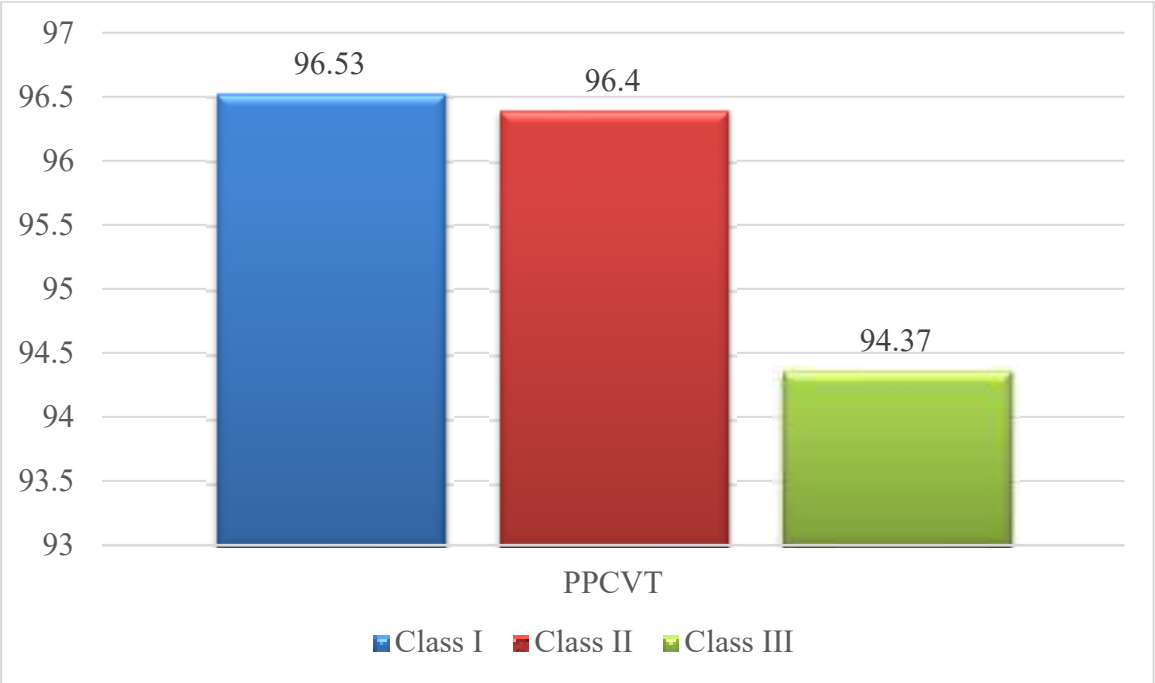
Graph number 5: Comparison of mean NSL-CVT between the three groups.



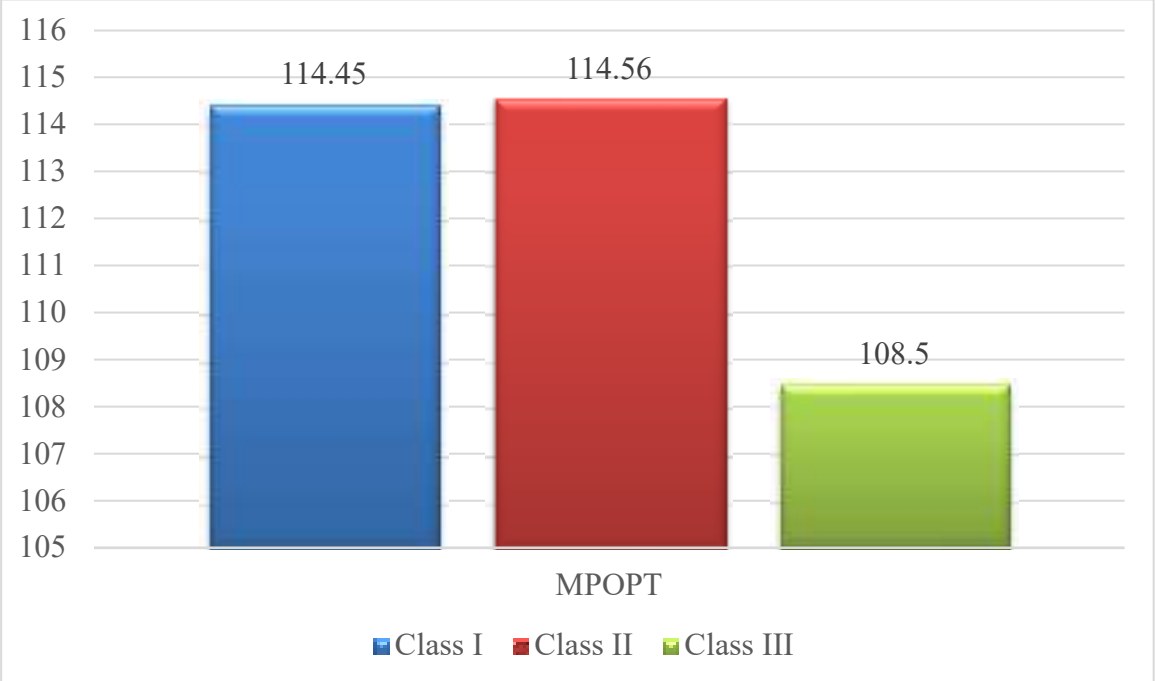
Graph number 6: Comparison of mean PP-OPT between the three groups.



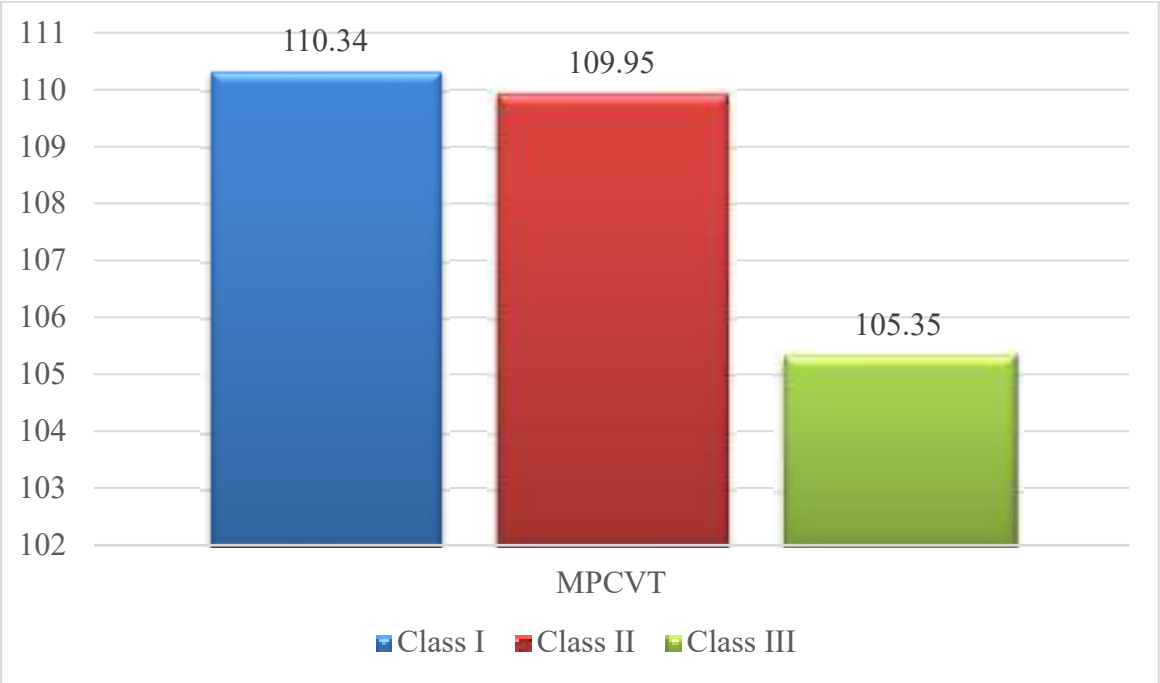
Graph number 7: Comparison of mean PP-CVT between the three groups.



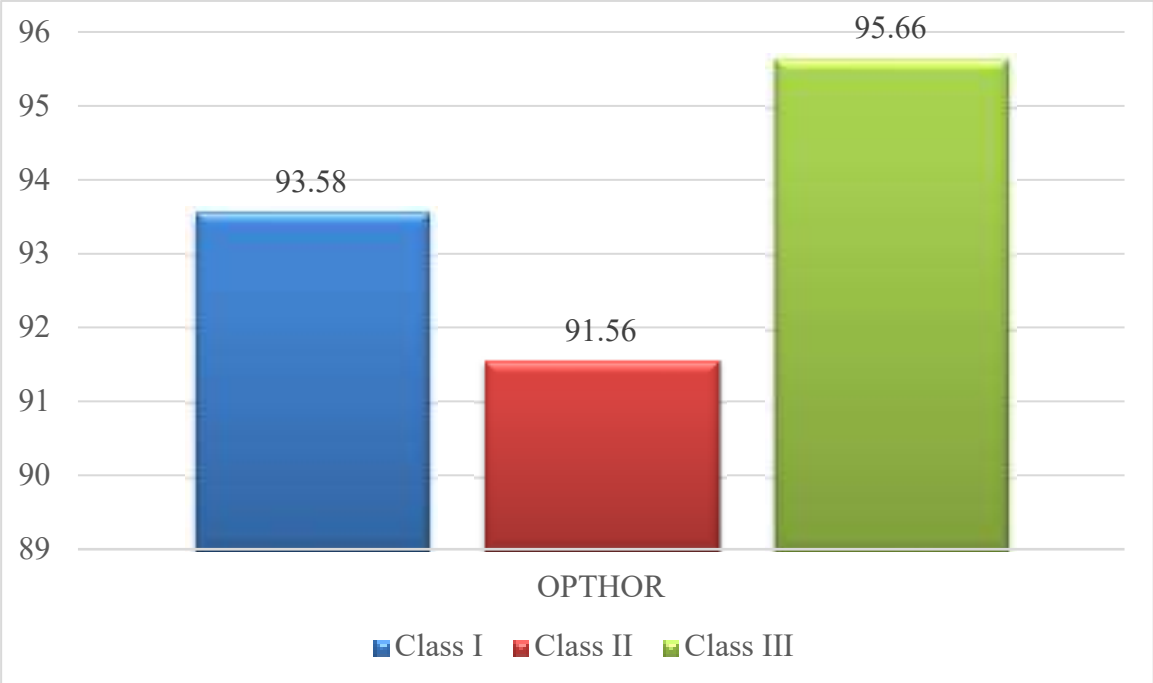
Graph number 8: Comparison of mean MP-OPT between the three groups.



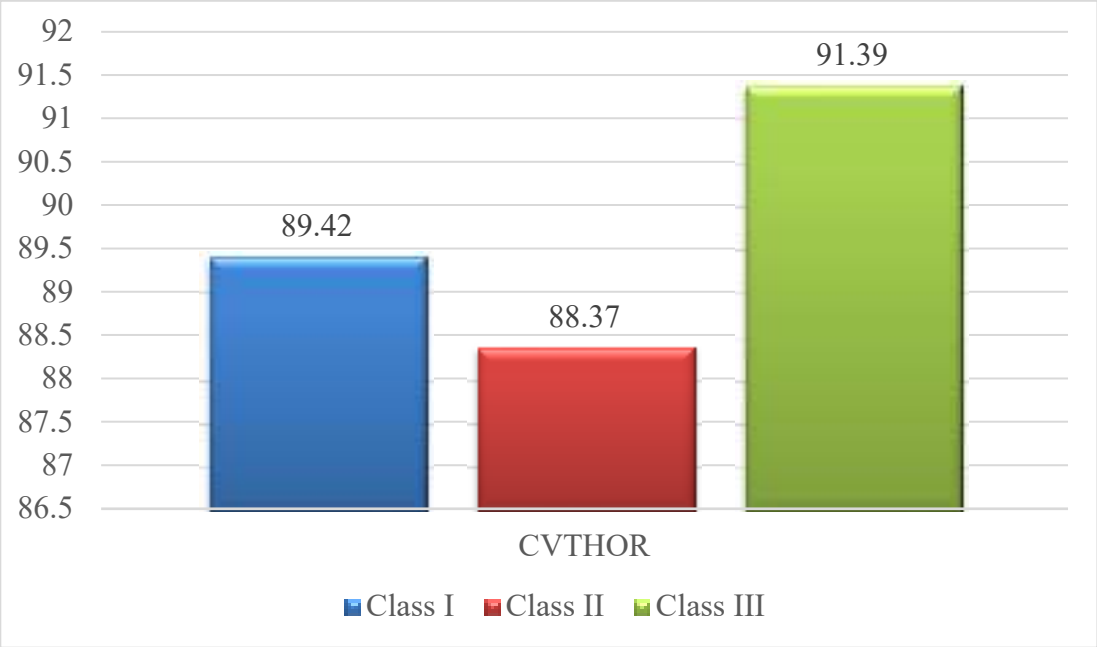
Graph number 9: Comparison of mean MP-CVT between the three groups.



Graph number 10: Comparison of mean OPT-HOR between the three groups.



Graph number 11: Comparison of mean CVT-HOR between the three groups.



1. **ANB angle (Graph 1):** The mean values for the samples were 1.79 ± 0.84 in Class I, 6.03 ± 1.71 in Class II and -4.56 ± 2.38 in Class III. It suggests the anteroposterior relation of the maxilla to the mandible. The mean value among the three groups is statistically significant (0.000*)
2. **Wits appraisal:** The mean values for the samples were 1.63 ± 1.09 in Class I, 4.35 ± 1.57 in Class II and -6.77 ± 3.86 in Class III. It suggests the anteroposterior relation of the maxilla to the mandible by taking the linear measurement. The mean value among the three groups is statistically significant (0.000*)
3. **OPT-CVT:** The mean values for the samples were 3.98 ± 2.20 in Class I, 4.29 ± 2.78 in Class II and 3.15 ± 1.91 in Class III. The cervical spine posture in Class III subjects was smaller compared to the other two groups suggesting that

subjects in the Class III group had a straighter cervical spine column. However, it was not statistically significant (0.074).

4. **NSL-OPT:** The mean values for the samples were 99.37 ± 7.49 in Class I, 100.81 ± 6.03 in Class II and 97.47 ± 6.41 in Class III. The mean value in Class III subjects was smaller suggesting forward inclination of the cranium on the 2nd cervical vertebrae. The value was increased in the Class II group suggesting extension of the head on the 2nd cervical vertebrae. The mean value among the three groups is statistically significant (0.007*)
5. **NSL-CVT**: The mean values for the samples were 103.68 ± 7.39 in Class I, 103.95 ± 5.43 in Class II and 101.44 ± 6.05 in Class III. The mean value in Class III subjects was smaller suggesting forward inclination of the cranium on the 4th cervical vertebrae. The value was increased in the Class II group suggesting extension of the head on the 4th cervical vertebrae. The mean value among the three groups is statistically significant (0.024*)
6. **PP-OPT**: The mean values for the samples were 91.94 ± 7.14 in Class I, 93.39 ± 7.84 in Class II and 90.03 ± 6.11 in Class III. The mean value among the three groups is statistically significant (0.024*). The maxilla is distally inclined to the upper cervical vertebrae in the Class III group.
7. **PP-CVT**: The mean values for the samples were 96.53 ± 7.68 in Class I, 96.40 ± 7.30 in Class II and 94.37 ± 5.96 in Class III. The maxilla is distally inclined to the upper cervical vertebrae in the Class III group. The mean value among the three groups is not statistically significant (0.117).
8. **MP-OPT**: The mean values for the samples were 114.45 ± 7.50 in Class I, 114.56 ± 7.92 in Class II and 108.50 ± 9.09 in Class III. It was observed that the mandibular inclination to the upper cervical segment was statistically significant

in all three groups (0.000*). The mean value was decreased in the Class III group compared to the groups Class I and Class II.

9. **MP-CVT**: The mean values for the samples were 110.34 ± 7.54 in Class I, 109.95 ± 8.52 in Class II and 105.35 ± 9.11 in Class III. It was observed that the mandibular inclination to the middle cervical segment was statistically significant in all three groups (0.002*). The mean value was decreased in the Class III group compared to the groups Class I and Class II.
10. **OPT-HOR:** The mean values for the samples were 93.58 ± 6.37 in Class I, 91.56 ± 9.10 in Class II and 95.66 ± 7.14 in Class III. The cervico-horizontal angle suggests the cervical inclination to the true horizontal plane. The mean value among the three groups is statistically significant (0.011*). The angle was increased in the Class III group suggesting a straighter inclination of the cervical column on the true horizontal plane.
11. **CVT-HOR**: The mean values for the samples were 89.42 ± 5.65 in Class I, 88.37 ± 9.73 in Class II and 91.39 ± 7.20 in Class III. The difference among the mean value of the three groups is not statistically significant (0.079)

DISCUSSION

Cervical spine posture is reported to be related to craniofacial morphology. The understanding of the cervical spine posture in different sagittal skeletal malocclusion is not clear, therefore this study was conducted for the orthodontist to know the importance of the coordinating mechanism for better diagnosis and treatment planning.

The maxillary and mandibular rotation during growth and development was described by Bjork and Skieller[28] as either forward or backward. The quadrant theorem of Guzay[29] explains the effect of cervical vertebral muscles on the development of vertical growth patterns. It explains that when the mandible is moved down it generates a pulling force which loosens the muscle around the second cervical vertebrae, similarly, when it is moved upward it tightens the muscles around C2. The muscle tension around C2 is aggravated when an individual with a vertical growth pattern closes the mandible.

Bjork[30] suggested that one of the important factors for head balance is the location of the foramen magnum line, where the center of mass of the head is situated. Brodie[31] explains that a change of the center of gravity of the head requires a compensatory curve in the cervical spine and a change in the neck muscle to maintain the head balance. Forsberg[32] concluded in an EMG study that cervical muscle activity decreases with the extension of the head.

All these studies suggest that there is a relationship between skeletal malocclusion and cervical spine posture. In different skeletal malocclusion, the position of the mandible varies and affects the pharyngeal airway space. Any

improvement in respiratory function may improve the cervical spine posture. Solow et al[33] conducted a study to evaluate the head posture in subjects with obstructive sleep apnoea and discovered that the craniocervical angle was 10 degrees larger in subjects with OSA when compared to subjects without OSA. Extension or flexion of the craniocervical angle can influence the development of the craniofacial morphology. Although, the cause-and-effect relationship has not been confirmed yet. Certainly, there is a mechanism that coordinates craniocervical posture and development of the face. Various researchers have reported muscular-neural connection to be responsible for this. Miralles et al[34] confirmed that a correlation exists between face and neck muscles by conducting a study on 15 healthy individuals where a significant increase in basal tonic EMG activity of the muscles of the neck was seen when varying the vertical dimension of occlusion to 45 mm of jaw opening. A 'Soft tissue stretching hypothesis' was proposed by Solow and Kreiborg[35] in 1977 which states that there is passive stretching of the soft tissue consisting of skin, muscles, and fascia when there is an extension of the head which has an impact on the development of the face. The stretching of the soft tissue exerts a force on the facial skeleton which hinders normal growth, especially the mandible. Hellsing and L'Estrange[36] provided evidence in regards to such forces. They placed a pressure transducer device on the labial surface of the upper central incisor of dental students. The students were asked to tilt their heads 5 degrees up from the natural head posture and then 5 degrees down. Several grams of pressure change was recorded when the head was tilted through 10 degrees. Such pressure variation through the head posture was enough to cause skeletal and dentofacial changes. Cervicospinal anomalies can influence the normal development of craniofacial structures.

Sagittal skeletal parameters: ANB and wits appraisal were used to divide the pre-treatment lateral cephalograms into three different groups i.e. Class I, Class II and Class III with 62 samples in each group. The difference between the mean of all the three groups for ANB and wits appraisal was statistically significant i.e ($p=0.000^{*)}$ suggesting that the anteroposterior relationship of maxilla to the mandible is different in all the three groups.

Cervical curvature: The mean value for OPT-CVT was 3.15 $\pm$ 1.91 in the Class III group, suggesting a straighter cervical column in Class III samples, as the angle was smaller compared to Class I and III groups. However, the difference was not statistically significant. The finding of our study was in accordance with the study conducted by Tauheed et al[18] where they concluded that sagittal skeletal malocclusions differ in their cervical postures, especially cervical curvature. They found that Skeletal Class III subjects have significantly straighter cervical columns than skeletal Class I subjects and statistically significant differences were found between the different skeletal malocclusions for the cervical curvature angle OPT/CVT ($p=0.025$). D'attilio et al[19] also reported similar results. Aglarci et al[25] conducted a study where they evaluated the effects of twin block on skeletal malocclusion and cervical spine posture, there was a statistically significant difference between pre and post-treatment ANB and OPT-CVT suggesting an improvement in the skeletal relationship and cervical spine posture. Ohnmeiß et al[27] also found similar results where sagittal skeletal relationship and cervical spine posture were improved post-functional appliance. Both of these studies suggest that cervical spine posture was improved as the mandibular position changed from Class II to Class I sagittal skeletal relationship.

Craniocervical posture: It is determined by the angles NSL-OPT and NSL-CVT. The mean values for NSL-OPT and NSL-CVT were 100.81 ± 6.03 and 103.95 ± 5.43 respectively in the Class II group which was increased when compared to the other two groups, suggesting a more extension of the cranium on the cervical column. Whereas these angles were decreased in the Class III group suggesting a more forward head posture. The mean value among the three groups is statistically significant for both NSL-OPT (0.007*) and NSL-CVT (0.024*). In a study conducted by D'attilio et al[19] similar results were obtained. The curvature of the spine was increased with the greater extension of the head in the Class II group and the curve was more straightened with forward head posture in the Class III group.

Maxillary plane inclination on the cervical column: It is determined by the angles PP-OPT and PP-CVT. The maxillary plane is distally inclined on the upper and middle cervical vertebrae in the Class III group with a mean value of 90.03 ± 6.11 and 96.53 ± 7.68 respectively. The difference among the three groups is statistically significant for PP-OPT (0.024*). However, maxillary plane inclination on the middle cervical vertebrae is not statistically significant (0.117). The results that we obtained were in accordance with the study conducted by Solow and Tallgren[5] where they found a correlation between the small inclination of the maxillary plane to cervical column and short anterior facial height and prognathic mandible

Mandibular plane inclination on the cervical column: It is determined by the angles MP-OPT and MP-CVT. Similar to the maxillary plane inclination, the mandibular plane to the upper and middle cervical column is also distally inclined in the Class III group with a mean value of 108.50 ± 9.09 and 105.35 ± 9.11 respectively. The mean value among the three groups is statistically significant for

both MP-OPT (0.000*) and MP-CVT (0.002*). This was similar to the results acquired by D'Attilio et al[19] and Solow et al[5].

Cervicohorizontal angles: OPT-HOR and CVT-HOR indicate the cervical inclination to the true horizontal plane. The angles were smaller in the Class II group suggesting a forward inclination of the cervical column on the horizontal plane with a mean value of 91.56 ± 9.10 for OPT-HOR and 88.37 ± 9.73 for CVT-HOR. The angle was larger in the Class III group suggesting a straight cervical spine. The difference between the three groups for the OPT-HOR was statistically significant (0.011*), however, it was not statistically significant for the angle CVT-HOR (0.079). Tauheed et al[18] also didn't find any statistically significant difference in the cervico-horizontal angle between the three groups, but Alkofide[37] in his study found a statistically significant difference between the three groups. Both the researchers suggested a forward inclination of the cervical column in the Class II group and backward inclination in the Class III group which is in accordance with our study.

Solow and Sandham[38] in their study mention the correlation between temporomandibular disorders and craniocervical angles. They reported that craniocervical angles were 5-7 degrees larger in subjects with TMD problems with signs and symptoms of clicking and difficulty in opening the mouth. Symptoms of cervical spine disorders can overlap symptoms of Temporomandibular joint disorder, therefore careful observation is required during diagnosis and treatment planning and such patients should be referred to a physiotherapist for better analysis.

LIMITATIONS OF THE STUDY

- This study was conducted on a sample size of 186 subjects in the age group of 18-25 years. Even though we included both male and female subjects in our study, gender was not considered as a differentiating criterion in the present study.
- All the landmarks were estimated from lateral cephalometric films which provide information only in 2 dimensions and tracing was carried out manually.

FUTURE SCOPE

- A similar study can be done considering the gender of a larger sample to derive conclusive results.
- 3-dimensional comparative analysis of craniofacial growth and cervical spine posture of patients with different sagittal malocclusions can be evaluated using the CBCT imaging technique.
- Evaluation of cervical spine posture and craniofacial morphology in different facial patterns and the transverse discrepancy can also be carried out.
- A similar study on a large sample can be done longitudinally using sequential radiographs to see the changes in the cervical spine posture post-orthodontic treatment.

APPLICATIONS OF THE STUDY

Orthodontic diagnosis and treatment planning are largely dependent on cephalometric analysis. However, since most of the established norms of the cephalometric analysis are based on the Caucasian population, it is necessary to develop cephalometric norms specific to the North-Karnataka population. Based on the results achieved from the present study, the cervical spine posture was different in various sagittal skeletal malocclusions. There is an association between cervical spine posture and craniofacial morphology. Therefore, it is important for an orthodontist to carefully assess the cervical spine posture of the patients during diagnosis and treatment planning as it might affect the development of the craniofacial structures.

CONCLUSION

Cervical spine posture was evaluated for the different skeletal malocclusions, i.e., Class I, Class II and Class III in the North Karnataka population.

The following conclusions can be drawn from the present study:

- Cervical spine posture differs in various sagittal skeletal malocclusion. It was straighter in the Class III group compared to the Class I and Class II group.
- The head posture was extended in the Class II group and it was flexed in the Class III group suggesting forward inclination of the head on the cervical column.
- The maxillary and mandibular base inclination on the cervical column was found to be different in various skeletal malocclusions.
- The concept of 'Functional and postural competency' cannot be overlooked in orthodontics. An important consideration should be given to cervical spine posture in Orthodontics diagnosis and treatment planning as it may affect craniofacial development.

SUMMARY

The purpose of the study was to evaluate and compare the cervical spine posture in different sagittal skeletal malocclusions, i.e., Class I, Class II, Class III, in North-Karnataka population. The study was also aimed at developing cephalometric norms for the cervical spine posture in the study population. 186 lateral cephalograms were analyzed, with 62 in each of the three group which was categorized using ANB and wits appraisal. Cervical spine posture, craniocervical posture, maxillary and mandinular plane inclination, cervicohorizontal angles were assessed in all the three groups. Statistical analyses were performed for the different parameters to obtain mean values for each of the three groups, and their comparison was conducted by Kruskal Wallis test. There was no statistically significant difference in the cervical spine posture between Class I, Class II and Class III groups. The cervical spine posture was straighter in Class III group. The head was extended in Class II group and it was flexed in Class III group. The maxillary and mandibular base plane were distally inclined on the upper and middle cervical column in Class III group. There was forward inclination of the cervical column in Class II group and backward inclination in Class III group. An important consideration should be given to cervical spine posture in Orthodontics diagnosis and treatment planning as it may affect craniofacial development.

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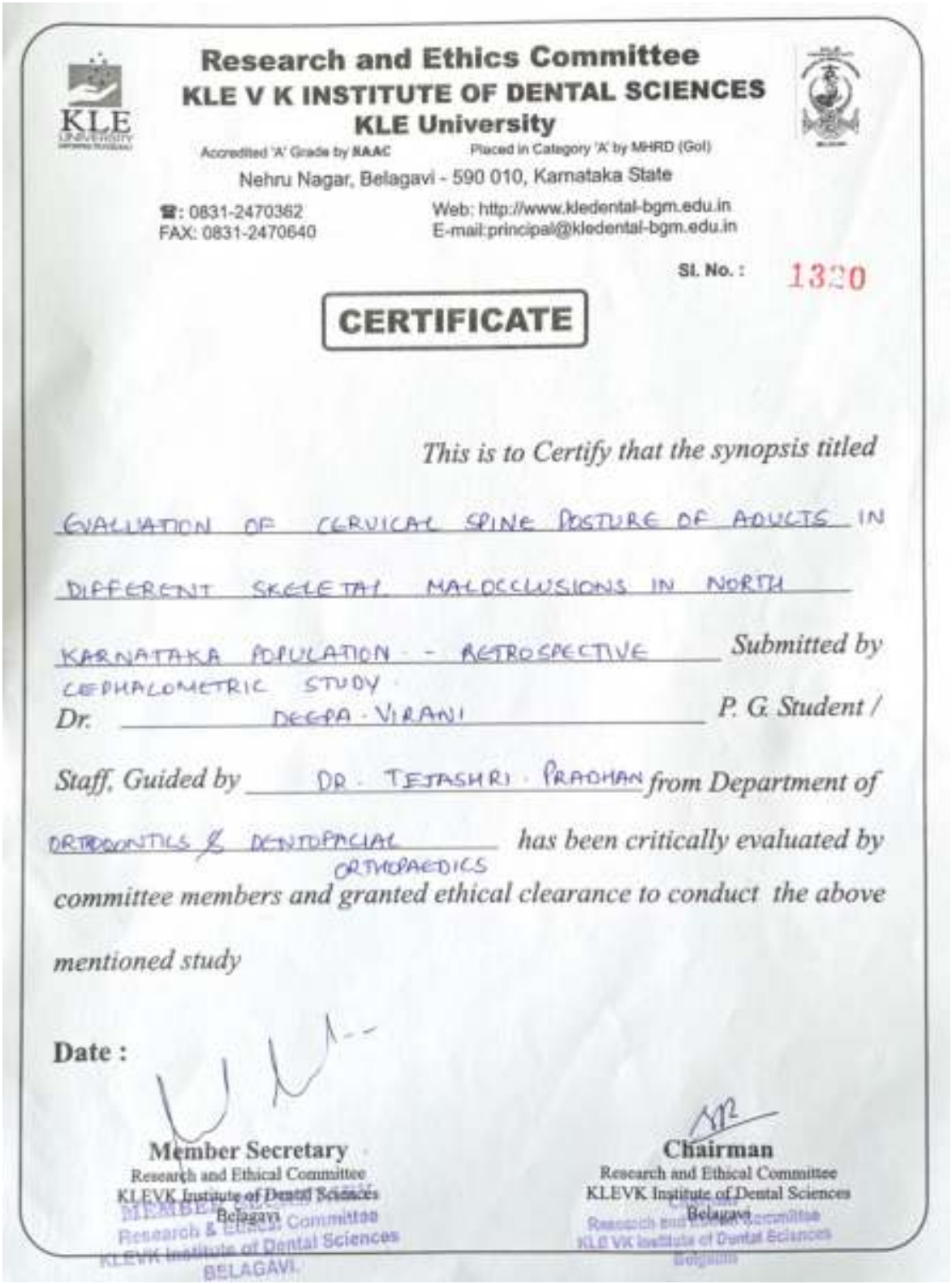
ANNEXURE I – ETHICAL CLEARANCE LETTER



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CERTIFICATE

This is to Certify that the synopsis titled

EVALUATION OF CERVICAL SPINE POSTURE OF ADULTS IN DIFFERENT SKELETAL MALOCCLUSIONS IN NORTH KARNATAKA POPULATION - A RETROSPECTIVE CEPHALOMETRIC STUDY *Submitted by*

Dr. DEEPA VIRANI *P. G. Student /*

Staff. Guided by DR. TEJASHRI PRADHAN *from Department of* ORTHODONTICS & DENTOFACIAL ORTHOPAEDICS *has been critically evaluated by committee members and granted ethical clearance to conduct the above mentioned study*

Date :

Member Secretary
Research and Ethical Committee
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Chairman
Research and Ethical Committee
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