Relationship between crown-root angulation (collum angle) and lower lip line of maxillary central incisors in class 1 bimaxillary protrusion, class 2 division 1 and division 2 malocclusions-A CBCT study and Lateral Cephalogram Study

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Abstract-

Objectives: The purpose of this study was to assess relationship between crown root angulations of maxillary central incisors and lower lip line (a CBCT study and lateral cephalometric study).

Methods: A set of 30 conventional lateral cephalograms and CBCT were selected and divided into three groups of 10 each based on the type of malocclusion presented: Class II, division 2 (group 1); Class II, division 1 (group 2); and Class I (group 3). The collum angle of the maxillary central incisor was measured, and the lower lip line was recorded.

Results: Analysis of variance (ANOVA) revealed that the mean collum angle was statistically significantly different in the three groups. The mean collum angle was greatest in Class II, division 2 malocclusion (group 1). ANOVA and chi square test showed that the mean collum angle is significantly increased when the lower lip is in between the middle third and cervical third ($P < .05$) of the central incisor. Also variations in magnitude of the collum angles traced on the lateral cephalograms and CBCT was not significant.

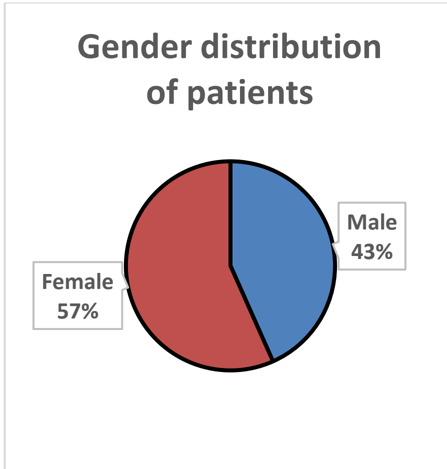
Conclusion: change in magnitude of the collum angle with the change in the lower lip line suggest a probable etiologic role of the lower lip line in the development of the collum angle. Non-significant difference between the evaluation of collum angle from lateral cephalogram vs CBCT shows that the two dimensional cpehalometric readings can be reliable in daily practice making the treatment more cost effective.

Key words: collum angle, lower lip line, CBCT, lateral cephalogram

I. INTRODUCTION

T.C. White, J.H. Gardeiner and B.C. Leighton defined Malocclusion as “A condition where there is a departure from the normal relation of the teeth to other teeth in the same arch and to teeth in the opposing arch.”[1] There are many classifications that are used widely out of which two of the most commonly used are “The Angle System (given by Edward Angle, 1899-1907), and “The Simon System (given by Simon, 1922). Angle lists and classifies all the diagnosis of malocclusion into three comprehensive divisions, and subdivisions. Out of which Angle Class II, division 2 malocclusion shows certain unique characteris tics such as presence of a deep overbite, classical arrangement of maxillary central and lateral incisors, Class II or end-on molar relationship,retroclined mandibular incisors, high lower lip line, increased perioral muscle activity, and extraoral features such as a large nose and prominent chin, as- sociated with a short lower anterior facial height. One important feature of Class II, division 2 malocclusion is the excessive palatal bending of the crown of maxillary central incisors. This retroclination of maxillary incisors has been seen in the lateral cephalogram as an increasedangulation between the long axis of the crown and the root. This angle was named the collum angle by Andreasen[2] in 1930. Quite a few hypotheses have been proposed for this classical appearance of the incisors. . In 1969 Taylor[3] gave an extensive description of thevariations in the morphology of the maxillary central incisor, stating that therelation of the crown and root varies considerably as both parts are subjectedto variations in curvature. In lateral cephalograms, the long axis of the incisor is recorded as the line passing through the incision superius (the midpoint of the cutting edge of the most prominent part of the central incisor) and the apex.[4] The sagittal relationship of the jaws also plays a major role in the de- velopment of the retroclination of maxillary incisors. In a neutro-occlusion, the contacts between the anterior teeth are established earlier than in distoclusion, and therefore there are more chances for lingual tipping of maxillary central in- cisors and mandibular anterior crowding.[5] Another hypothesis is based on the hyperactivity of the lower lip and increased coverage of the maxillary incisorsby the lower lip.[6] In a typical Class II, division 2 malocclusion, the maxillary cen-tral incisors are retroclined, whereas the lateral incisors are proclined. The hy-peractivity of the firm labial curtain has been attributed to relapse in most Class II, division 2 malocclusions. The sparing of lateral incisors has been explainedby the cervical positioning of the lateral incisor when compared with the central incisor. According to functional matrix theory,[7] soft tissue determines the hard tissue growth. If this can be applied in the present situation, the hyperactive high lower lip might have influenced the development of the collum angle. This study therefore was carried out to investigate the magnitude of the col- lum angle present in Class II, division 2 malocclusion in comparison with the collum angle present in Class II, division 1 and Class I malocclusion. The study also attempted to investigate the relationship of change in its magnitude with variations in the lower lip line. This study also highlights the influence of soft tissues surrounding the dental arches on the position of the teeth. Of the forces from the soft tissues, those from the tissues in the passive resting state are believed to be more important than the forces exerted upon the teeth during various functions such as speech and swallowing.

Also the reliability of two dimensional tracing of lateral cephalogram is checked by comparing it with three dimensional readings obtained from CBCT. The sample of the study included lateral cephalograms of patients undergoing orthodontic treatment in the Department of Orthodontics in the Faculty of Jaipur Dental College, India. The samplewas categorized into three groups. Group 1 included patients with Class II, division 2 malocclusion; group 2 included patients with Class II, division 1 mal- occlusion; and group 3 had individuals with Class I malocclusion. The total sample size was 30, with 10 in each group. Since Class II, division 2 malocclusion has a low prevalence in the general population, a sample size of about 10 for group 1 could be achieved. To maintain the equality in the sample size, the sample size was made same in groups 2 and 3.Out of the 30 patients, 13 were male and 17 were female



The lateral cephalograms were categorized based on the following inclusion and exclusion criteria using the certain cephalometric parameters and study casts.

Inclusion criteria

1. For Class II, division 2 malocclusion included Angle Class II or end-on molar relationship, Class II, division 2 incisor relationship, and ANB angle greater than 4 degrees.
2. For Class II, division 1 malocclusion, inclusion criteria included Angle Class II or end-on molar relationship, Class II, division 1 incisor relationship, and ANB angle greater than 4 degrees.
3. For Class I malocclusion (bimaxillary protrusion), the criteria for inclusion was Angle Class I molar relationship, Class I incisor relationship, and ANB angle less than or equal to 4 degrees.
4. Permanent dentition
5. completely developed root
6. No apparent bending and No absorbing
7. Intact contour of the crown and no apparent abrasion.
8. Moderate crowding, and no apparent rotation in anterior teeth
9. No caries, filling, restoration history and periodontitis in anterior teeth.
10. No orthodontic, functional orthopedic treatment, cleft lip palate, and orthognathic surgery history.
11. No oral bad habit, occlusion interference, swallowing and respiratory disorder, and facial or spinal abnormalties.
12. Clear imaging by CBCT.
13. Patients with both hyperdivergent and hypodivergent growth patterns were included.
14. Patients with missing molars and those with supernumerary or missing anterior teeth were excluded from the study.

Exclusion criteria

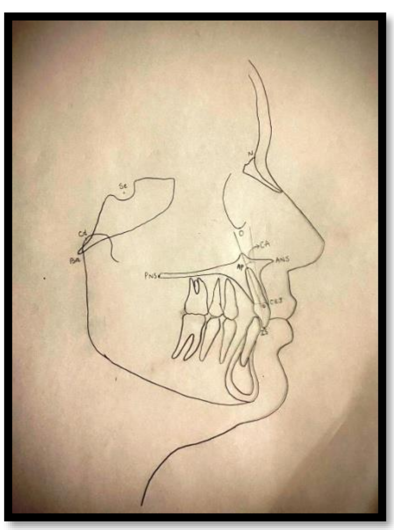
1. Subjects that had orthodontic treatment earlier
2. Subjects whose lateral caphalometric radiographs were of poor quality or those for whom measurements were of poor quality or those for whom measurements were not easily readable were excluded.
3. Anterior root with periapical lesions or apparent bending, containing embedded supernumerary teeth in alveolar bone.

4. Crown with obvious abrasion.
5. Mild to severe crowding, or obvious rotation in anterior teeth.
6. Caries, filling or restoration treatment, or periodontitis leading to loosening in anterior teeth.
7. With orthodontic, functional orthopedic treatment, cleft lip palate, and orthognathic surgery history.
8. With oral bad habit and the mandibular located in functional and unstable position, or jaw cyst, cancer, injury, and abnormalities.
9. Blurring image by CBCT.

The lateral cephalograms were taken with standardized criteria. All the lateral cephalograms were taken with subjects in centric occlusion with lips reposed in the same cephalostat and in standardized position. The cephalograms were developed and fixed under standardized conditions. The lateral cephalograms were traced by a single operator on acetate paper to eliminate interexaminer error. The maxillary central incisor was traced with concern to exactly reproduce theanatomical details of the teeth, and tracings and measurements were performed by same person after 14 days to assess the magnitude of processing error. The landmarks were verified by another operator and any disagreement resolved. The lateral cephalometric analysis included measurement of the collum angle of the maxillary central incisors and recording the position of the lower lip line.

Measurement of collum angle and recording of lower lip line

Measurement of collum angle involved measurement of the long axis of the root and the crown. The measurement method used was based on the oneused by Delivanis and Kuftinec[11] in 1980. The longitudinal axis (L) of the incisoris defined as a line passing through the midpoint of the cutting edge or abrasion face of the incisor and the radiographic apex of the root. The radiographicapex of the root is marked as point Ap. The midpoint between the lingual andfacial projections of the cementoenamel junction is marked as point D. The longitudinal axis of the root (RL) is represented by a line passing through land-marks Ap and D. The longitudinal axis of the crown (CL) is the line connectingpoint incision superius (IS) and point D. The angle between the lines Ap-D and D-IS was recorded as the collum angle



The study carried out on the CBCT scans of three classifications of the angles malocclusions and different skeletal patterns was selected from the archives of the Department of Oral Medicine and Radiology of Jaipur Dental College, Maharaj Vinayak Global University in the patients who were undergoing orthodontic treatment . The CBCT images of 30 patients were selected as the criteria presented. CBCT images were obtained using CS 8200 3D CBCT (Carestream Dental LLC, Atlanta, GA), with the same exposure settings - tube current: 4mA (pulsed mode), tube voltage: 90 kV, voxel dimensions: 150μmx150μmx150μm, and scanning time: 20 seconds. During scanning, patients should parallel the interpupillary line and Frankfurt plane to the ground, and the facial midline coincided to the median reference line of the machine, with central occlusion and no swallow. The data from the 3D Scanner X-rays were recorded in DICOM (Digital Imaging and Communication in Medicine) format and processed using CS 3D Imaging (Carestream) software.Firstly for the horizontal view, the horizontal line located rightly at the frontal edges of the bilateral ramus, and the vertical line was perpendicular to it and passed through the center of the incisive canal (Fig1.).Then for the coronal view, the vertical line should be parallel to the mid-sagittal reference line at crista galli (Fig2.).

Lastly for the sagittal view, the horizontal line connecting the anterior nasal spine to the posterior nasal spine should be parallel to the bottom of the monitor (Fig3.). Then, the median sagittal tomographic images of incisors in labio-lingual direction were adjusted to capture using the Arch Section tab. Thus, the median one of the five images in sagittal direction was selected for angular measurement (Fig4-5.). The thickness of sectional slices was 2.0 mm with the interval set at 0.1 mm.

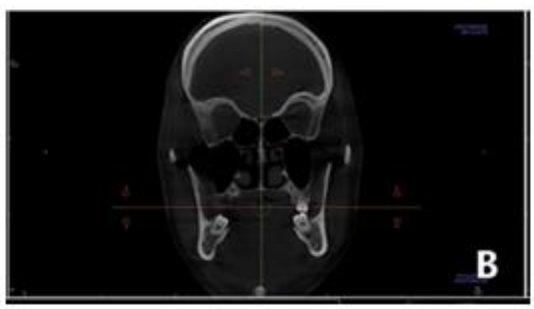


Fig. 1 The horizontal view

Fig.2 The coronal view

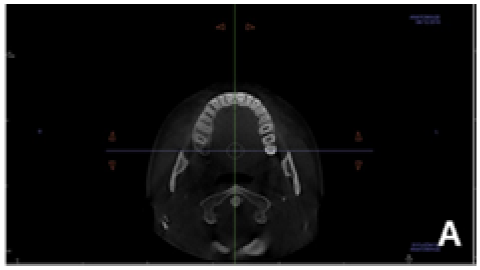


Fig.3 The sagittal view

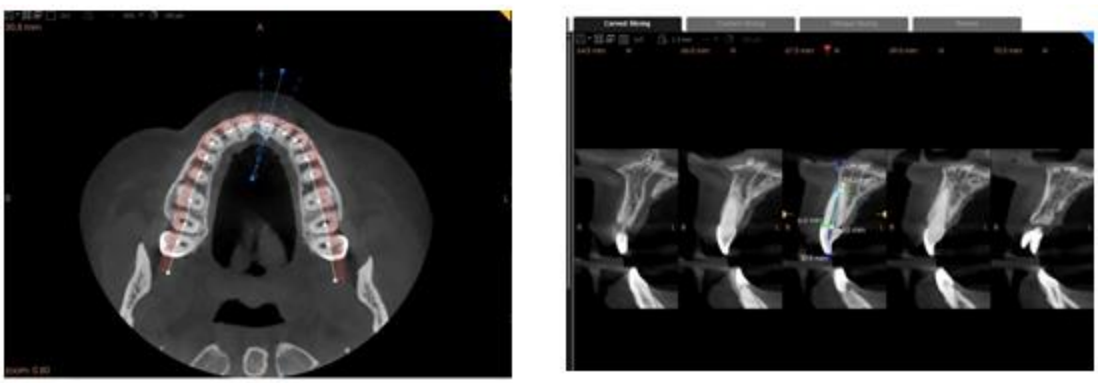


Fig.(4-5) The median sagittal views were established with five layers, interval 0.10 mm, and the middle one was the measuring image

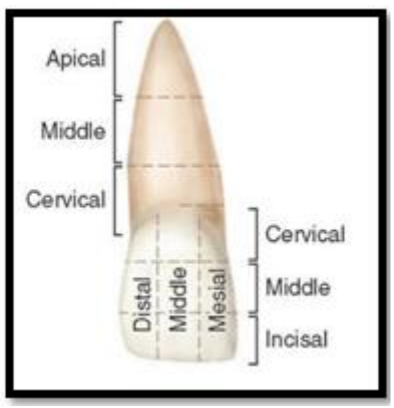
Marker and measurement in CBCT

The measuring images were marked and measured via AutoCAD (Autodesk, San Rafael, CA) as follows . “CEJ” (Green Colour) represented the labial or lingual cementoenamel junction. Point A was the incisor superior, and point R was the root apex.The straight line “AO” represented the long axis of the crown (Blue Colour), and “RO” was the long axis of the root (Yellow Colour). “Collum angle (CA)” (Light Blue Colour) was an acute angle between the line RO and reverse extension line AO(fig). When line RO located lingual side to the extension line, the CA was defined as a positive value; otherwise, the labial side was negative.

Error in measurements

- To assess the intra-observer and inter-observer error, repeated measurements performed on all the samples were measured by two operators on two occasions at a 2-week interval and analyzed with Student's t test for paired samples adopting an α-level of 0.05.
- The mean values calculated by combining the measurements of both operators were used for inter-group difference analysis.
- The technical error of measurement (TEM) was assessed with the formula.
- in which $\mathrm{TEM} = \sqrt{\sum d_i^2/2n}$ di was the difference between the first and second measurement on the ith sample and n was the whole sample number.

The lower lip line was measured by noting the vertical third of the crown ofthe central incisor (incisal [I], middle [M], or cervical [C]) with which the vermillion border of lower lip was in contact. The data was recorded and was subjectedto statistical analysis. Analysis of variance (ANOVA)was used to test the statistical significance of the difference in the collum angle in the three groups.



The χ^2 test was performed to compare the percentage of the various categories of lip linepresent in the three groups and test the statistical significance of the lower lip line influencing the collum angle.

II. RESULTS

In lateral cephalogram

The mean collum angle in group 1 was 5 ± 3.92 degrees.The mean collum angle in group 2 was 4.7 ± 3.92 degrees, and in group 3 the mean was 14.9 ± 7.68degrees.

In CBCT

The mean collum angle in group 1 was 6.3 ± 4.11degrees.

The mean collum angle in group 2 was 4.4 ± 3.60 degrees, and in group 3 the mean was14 ± 6.52 degrees.

After comparing the values between CBCT and Lateral cephalogram using t test, P value was calculated to be 0.9848 which showed a non significant relationship, thereby making two dimensional as much as reliable for clinical diagnosis and treatment planning.

Age Interval	n = 30	In %
≤ 20	5	16.67%
20 - 22	6	20.00%
22 - 24	5	16.67%
24 - 26	8	26.67%
26 - 28	4	13.33%
28 - 30	2	6.67%

Table 1: Frequency distribution of age of patients

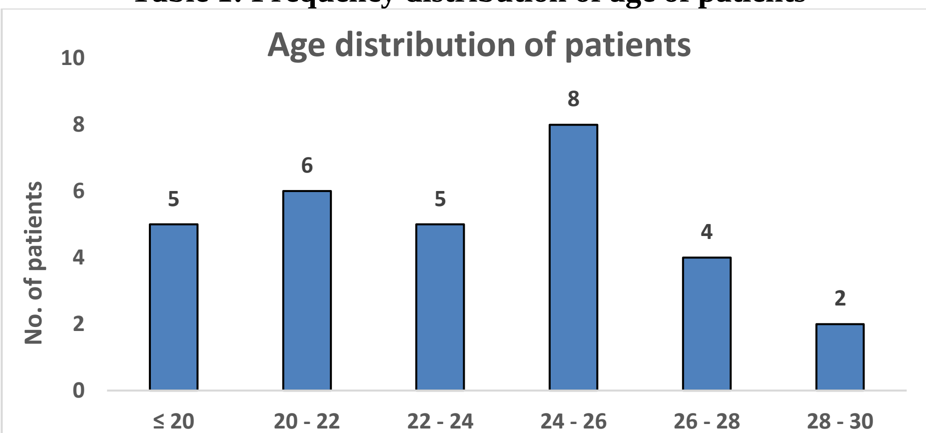


Table 2: Frequency distribution of gender of patients

Gender	n = 30	In %
Male	13	43.33%
Female	17	56.67%

Table 3: Group wise descriptive statistics of collum angle of both lateral Ceph & CBCT of patients

Variables		Minimum	Maximum	Median	Mean ± SD
Collum angle (Lateral Ceph)	**Class I BIMAX**	0	12	4	5 ± 3.92
	Class II DIV – 1	0	12	4.5	4.7 ± 3.92
	Class II DIV – 2	4	27	12.5	14.9 ± 7.68
Collum angle (CBCT)	**Class I BIMAX**	0	12	6.5	6.3 ± 4.11
	Class II DIV – 1	0	12	4	4.4 ± 3.60
	Class II DIV - 2	5	26	12.5	14 ± 6.52

Table 4: Comparing collum angle between lateral Ceph and CBCT of patients by using t-test

Collum angle	Collum angle	t - test	P – Value	Significance

(Lateral Ceph)	(CBCT)			
8.2 ± 7.146	8.23 ± 6.345	-0.019	0.9848	Not significant

Table 5: Comparing collum angle between lateral Ceph and CBCT of all class by using t-test

Variables		Mean ± SD	t - test	P - Value	Significance
Class I BIMAX	**Collum angle (Lateral Ceph)**	5 ± 3.92	-0.724	0.4783	All are not significant
	Collum angle (CBCT)	6.3 ± 4.11			
Class II DIV - I	**Collum angle (Lateral Ceph)**	4.7 ± 3.92	0.178	0.8604	
	Collum angle (CBCT)	4.4 ± 3.60			
Class II DIV - II	**Collum angle (Lateral Ceph)**	14.9 ± 7.68	0.283	0.7807	
	Collum angle (CBCT)	14 ± 6.52			

Table 6: Comparing collum angle of lateral (Ceph, CBCT) between class I BIMAX, class II DIV-1 & class II DIV-2 by using ANOVA

Angle	Class I BIMAX	Class II DIV-1	Class II DIV-2	ANOVA	P - Value	Significance
Collum angle (Lateral Ceph)	5 ± 3.92	4.7 ± 3.92	14.9 ± 7.68	11.272	0.0003	Both are significant
Collum angle (CBCT)	6.3 ± 4.11	4.4 ± 3.60	14 ± 6.52	10.727	0.0004	

Table 7: Comparing collum angle of lateral Ceph, CBCT between class I BIMAX & class II DIV-1 by using t-test

Angle	Class I BIMAX	Class II DIV - 1	t – test	P - Value	Significance
Collum angle (Lateral ceph)	5 ± 3.92	4.7 ± 3.92	0.171	0.8659	Both are not significant
Collum angle (CBCT)	6.3 ± 4.11	4.4 ± 3.60	1.1	0.2858	

Table 8: Comparing collum angle of lateral ceph, cbct between class I BIMAX & class II DIV-2 by using t-test

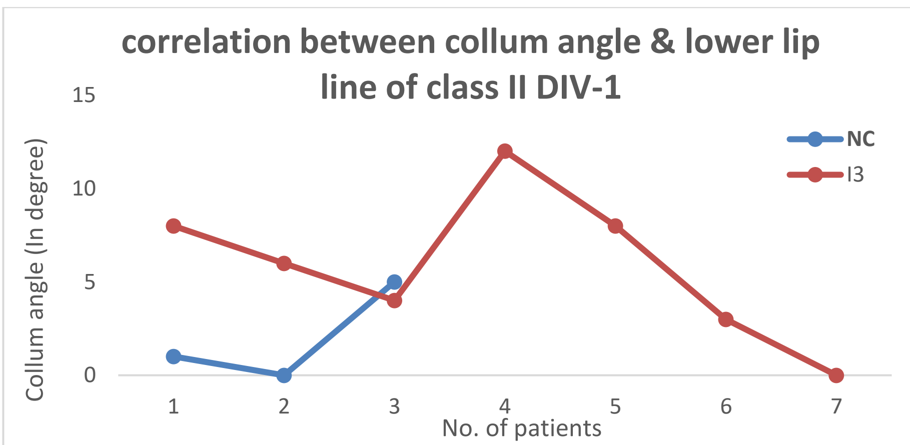
Angle	Class I BIMAX	Class II DIV - 2	t - test	P - Value	Significance
Collum angle (Lateral Ceph)	5 ± 3.92	14.9 ± 7.68	-3.631	0.003	Both are significant
Collum angle (CBCT)	6.3 ± 4.11	14 ± 6.52	-3.161	0.0065	

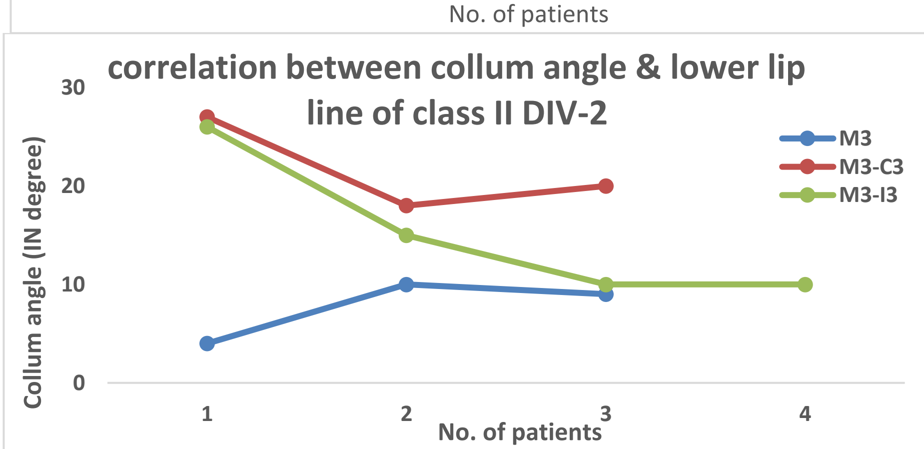
Table 9: Comparing collum angle of lateral Ceph, CBCT between class II DIV-1 & class II DIV-2 by using t-test

Angle	Class II DIV - 1	Class II DIV - 2	t - test	P - Value	Significance
Collum angle (Lateral Ceph)	4.7 ± 3.92	14.9 ± 7.68	-3.741	0.0025	Both are significant
Collum angle (CBCT)	4.4 ± 3.60	14 ± 6.52	-4.08	0.0011	

Table 10: Association between groups and location of lower lip line by using chi-square test

Group	NC	I_3	M_3	M_3-C_3	M_3-I_3	Chi-square	P - Value	Significance
Class I BIMAX	4	5	0	0	1	2.329	0.12697	Not significant
Class II DIV – 1	3	7	0	0	0			
Class II DIV - 2	0	0	3	3	4			





III. DISCUSSION

COLLUM ANGLE IN DENTISTRY

For evaluation of collum angle, it is apparent that its consequences may have several applications in dentistry where its major role concerns with the anterior esthetics. Relating it to restorative dentistry, when a post is placed, it may pose differently for the construction of core, if column angle is large that can in turn effect in retention. In regards to periodontics, root prominence, dehiscence and soft tissue esthetics may be effected. Also, when anterior implants are placed, the post of the implant is commonly placed parallel to longitudinal axis of the previous root. But, if the previous tooth had a large collum angle the crown must be restored as such the misalignment of the restoration is preserved. However, when such an abutment is used leading to the stress to be concentrated on the buccal side of the fixture can cause post-surgical tension in gingival causing recession & other unwanted cosmetic defect (Shen, 2012)[12]. Persistence of this post-surgical tension may even be problematic when a soft tissue graft is completed, causing the recession to return. In addition, increased abutment angulations have been shown to increase the magnitude of stress and strain in cortical bone (Clelland, 1995)[13]. This increase in stress generation is also seen in orthodontics with large collum angles in natural dentition. In Heravi's et al's study, retraction of Class II div 2 maxillary central incisors resulted in forces that were 1.18, higher than in the Class I maxillary incisors. However, when an intrusive force was applied, the teeth with larger collum angles demonstrated lower stress distribution to the periodontal ligament, (Heravi, 2013)[14]. Although the collum angle may have various effocts in dentistry, its application has been most frequently discussed in regards to orthodontics. Although colum angle is relevant in different aspects of dentistry but mostly the field of Orthodontics remains the largest platform to discuss about it.

COLUM ANGLE IN ORTHODONTICS

With the advent of the first fully programmed brackets Dr Lawerence Andrews revolutionized the field of orthodontics where development was based on six keys of normal occlusion in which he named crown inclination as the third key (Andrews, 1972)[15]. But realtion of root to crown wasn’t still discussed. The omission may have subsequently propogated the assumption that th elomgitudinal axis of the crown and root found a straight line (Harris, 1993)[16].

Although Andrews disregarded root inclination when developing the Straight Wire Appliance, the importance of root position is evident in the grading system developed by the American Board of Orthodontics (ABO). As the golden standard of orthodontics, the ABO has carefully selected root position as a paradigm in which Board Certified cases are graded upon. In assessing root position as a fundamental criterion, the ABO has noted its value in the treatment planning of cases.

ASESSMENT OF COLUM ANGLE IN CBCT VS LATERAL CEPH

A cephalometric analysis is a key element in orthodontic diagnosis. First introduced by Hofrath in Germany and Broadbent in the USA, this radiographic technique has been widely accepted as a standard tool for orthodontic treatment planning (Hofarth 1931, Broadbent 1931)[17,18]. Traditionally, the technique is performed on a 2D lateral cephalogram, which does not represent the full dimensions of the human face and also has disadvantages such as geometric distortion and superimposition of anatomical structures. In the past, a cephalogram with a long distance between X-ray source and mid-sagittal plane of the patient's face (3-4 m) was used. This type of machine allows more parallel X-ray beams, leading to less magnification of the images and possibly less radiation dose to the patient, when paired with sensitive image receptors [Bourraiu (2012)[19], Jacobs (1997)[20], Gijbels (2003)[21] Gonzolez (2004)[22]]. Today, most of the machines on

the market combine panoramic and cephalometric radiographic options within one single device. The design of these machines is more compact, which allows for a 1.5 m distance between the X-ray source and the mid-sagittal plane of the patient's face (profit-2007).
CBCT is becoming exceedingly popular among orthodontists worldwide. Its applications vary from impacted and supernumerary tooth location to orthognathic surgery planning and surgical splint prototyping. Although few software systems currently have a 3D Cephalometric module, none of the existing modules have been tested or validated. It cannot be assumed that because a study validated CBCT measurements from a particular machine and soft-ware, this result can be extrapolated to all CBCT machines and all software, because they may be conceived differently.
In 2002, Lascala and coworkers™ compared 13 direct caliper measurements on 8 human skulls vs those made on a CBCT scan using MPR images (ie, axial, sagittal, and coronal sections) (Gribel 2011)[23]. They found that the CBCT images were systematically smaller than those made directly on the skull; these differences, however, were not statistically or clinically significant. It should be noted that this 2002 study used one of the first CBCT units (New Tom QR DVT 9000, Marburg, Germany) with a very low resolution and 2 mm slice thickness.
Hilgers and coworkers in 2005 compared direct measurements of the temporomandibular joint region vs those made on the MPR images of a CBCT scan(CAT) with 0.4 mm slice thickness of 25 dry skulls, and found that CBCT measurements were accurate and reproducible.
In analyzing the collum angles of the anterior teeth between molar classifications, it was found that the maxillary centrals showed significant differences between malocclusions. The mean value for the Class II div 2 group was 14 ± 7.68 degrees, whereas the individual mean for the Class I (5 ± 3.92^0), Class II div 1 (4.7 ± 3.92^0) in lateral ceph assessment and (14 ± 6.52^0), (6.3 ± 4.11^0), (4.4 ± 3.60^0) respectively. This suggests that a significantly larger collum angle is present in Class II div 2 malocclusions. The larger collum angles in the maxillary central incisors theoretically coincide with the retroclined maxillary central incisors unique to this malocclusion. Since only the Class II div 2 malocclusion was defined by the axial bending of the maxillary central incisors, the retroclination of the incisors provide aplausible explanation for the larger collum angles found in this malocclusion.
The manual measurements carried after tracing lateral cephalogram (2D) vs software generated measurements in CBCT (3D) showed some differences but were not significant.
When the comparisons were made between two different malocclusions in order to check for difference in colum angle, it was found that the difference between

a. class 1 bimax and class II div 1 was not significant
b. Class 1 bimax and Class II div 2 was significant
c. Class II div 1 and Class II div 2 was also significant.

The difference in the test of significance can be explained by the role of the position of lower lip.

ASSESSMENT OF ROLE OF LOWER LIP WITH COLUM ANGLEIN LATERAL CEPH

The influence of the forces exerted by the lips, cheeks, and tongue on positions of the teeth has been the subject of scientific debate. Most authors accept, as a basis, the equilibrium theory of tooth position (Weinstein et al., 1963; Proffit, 1978). Previous work on the relationship between tongue-lip pressures and tooth position has shown that the lips and cheeks, rather than the tongue, are the most important environmental determinants of tooth position; a second finding was that resting pressure and not functional pressure is the dominant factor (Lear et al., 1974; Proffit et al., 1975; Thier et al., 1999).

The discussion on the equilibrium of tooth position is closely related to the etiology of certain malocclusions. Class II, division 2 malocclusion, characterized by distocclusion of the buccal teeth and retroclination of some or all the upper incisors, is predominantly determined by hereditary factors (Christiansen-Koch, 1981; Schulze, 1993). Many clinicians have hypothesized that the upper incisor retroclination results from non-physiologically high lip pressure against these teeth. This suggests that the lips act as a local genetic factor in Class II, division 2 malocclusion. The finding in longitudinal cephalometric studies- that the retroclination occurs progressively during the intra-oral eruption period- may support this view (Fränkel and Falck, 1967; Fletcher, 1975). However, up to now, no experimental study has proven the impact of increased lip pressure on the upper central incisors in Class II, Division 2 malocclusion. The most likely reason for this is that, in previous investigations (Gould and Picton, 1968;
Luffingham, 1969; Thter and Ingervall, 1986), pressure measurements on the upper incisors were carried out at a single location only, and therefore, uneven pressure distribution on the crown had not been taken into account.

Another question which still needs to be resolved concerns the causes of increased resting lip pressure. These causes may include a high lip line relative to the upper incisors and/or hyperactivity of the peri-oral musculature, particularly the mentalis muscle (Brodie, 1953; Jarabak and Fizzell, 1972; Mills, 1973; Van der Linden, 1983). There is a strong clinical impression that the lips play a part in control of incisor angulation. The lower lip trapped behind the upper incisors in many subjects with a severe Class 1I division 1 malocclusion; lips apart at rest in many subjects with a milder Class II division 1 malocclusion, and the high lip line, frequently observed in Class II division 2 malocclusion, which often appears to be retroclining the upper central incisors while the lip traps the proclined maxillary lateral incisors, all strongly suggest an aetiological role for the lip.

These clinical impressions are by no means new but, although Desirabode in 1847 described the lips as one of the factors controlling incisor position, the relationship of the lower lip to the upper incisors was not examined in detail until Nicol (1954) in a study of the height of the lip line in 16 patients with deep overbite found that, in every case, the lower lip covered at least half of the upper incisor crown.

Nicol (1955) using an x-ray technique found no correlation between the relationship of lip height and inter-incisal angle in normal and Class I subjects.

Ridley (1960)[24] concluded from a detailed clinical study of 105 Class II division 2 subjects that in every case the lower lip covered more than one third of the upper incisor crown.

Nicol (1963)[25] found very significantly greater lip coverage of the upper central incisor in 20 Class II division 2 cases than in the group of Class I cases previously reported.

It was suggested that variation in lip height occurred through all classes of malocclusion and that high lip line did not occur only in Class II division 2.

Mills (1973)[26] and Fletcher (1975)[27] confirmed the association of a high lip line with Class II division 2 malocclusion.

More recently the relationship of the lower lip to the upper incisors has been investigated with reference to orthodontic relapse in an attempt to determine where a retracted upper incisor should be placed in order to achieve stability. Orton (1966)[28] showed cases where relapse appeared to follow upper incisor retraction when these teeth had not been brought adequately within the control of the lower lip. He considered that it was important to eliminate the inter-incisal space at the end of treatment so that the lower lip could not catch below the upper central incisor and cause relapse. He believed that the zone of lip control was critically narrow and that the overjet difference between success and failure might be as small as I mm. Mills as well as van der Linden and Boersma found a significant correlation between the lower lip overlap on the upper incisor position, the interincisal angle, and the overbite. It can, therefore, be assumed that the high positioned lip retroclines the upper and lower incisors. The resulting large interincisal angle then causes the deep overbite due to the missing incisal support allowing the front teeth to erupt freely. In the present study the lip line recorded was either having no contact or the demarcations were on incisal third, middle third, between middle and cervical third or at between middle and incisal third. No contact of LLP was found in two groups clas 1 bimax and Class II div 1 incisal third contact was found on 5 subjects of class 1 bimax and 7 subjects of Class II dv 1. There was no contact of lower lip line on mesial third of CC in the three groups except for Class II div 2 where 3 subjects showed mesial third contact. Same was repeated in case of middle third to cervical third contact of LLP with CC. Whereas only 1 subject from class 1 bimax and 4 subjects from Class II div 2 developed the contact of LLP to CC Also after relating to the measured angulations of CA in different malocclusions, it was found that the change in the magnitude of the CA was remarkably increased in the cases of Class II div 2 malocclusions especially when the lower lip line fell between the mesial third and cervical third of the CC. The retroclination of all four upper incisor teeth can only take place if the lip line is high enough to involve the laterals and where these teeth are unsupported on their palatal side by the canines.(Fletcher 1975)[29].

Long-term post treatment stability of the occlusion is certainly also dependent on balanced muscle forces acting on the teeth. A lower lip coverage will challenge this balance. Is therefore, in the correction of Class II div 2 cases, it is necessary to retain the treatment result over a longer period of time to get a soft tissue adaptation. However, in comparison with the lip pressure in the other types of malocclusion, it seems unlikely that the incisor retroclination in the Class II div 2 cases is maintained by a strong upper lip force rather by lower lip pressure.

IV. LIMITATIONS OF THE STUDY

One of the major limitations in the study was that the sample size was less.

Second major limitation in this study was that a Class I normal occlusion group was not included in this study. Such a group would serve as a control in which all malocclusions could be compared. However, since records were extracted from the Department of Orthodontics and Dentofacial Orthopedics at the Jaipur dental college, Class I normal occlusions were not available. This is because patients with normal occlusions do not typically seek orthodontic treatment.

The third limitation to this study was the presence of artifacts on CBCT scans. Although most of the scans that had poor radiographic quality were screened out, there were scans included in the study where noise posed some issues. The "graining" effect on an image appears when the projection of images presents inconsistent attenuation values (Kincade, 2011). While radiation is scattered, it is produced in various directions and the detector records this in the form of pixels. Unlike the attenuation of x-ray beams with a specific path, the non-linear attenuation is recorded by an area detector as noise (Schulze 2011). This causes image degradation and reduces the human ability to accurately distinguish the points being measured. For example, in a single scan, noise can be apparent in different areas of the scan. The maxillary central incisor root apex may be clearly discernible, however, when the slice for the mandibular incisor is created, the root apex may be significantly less apparent. This graining effect was not uniform throughout the scans, causing room for error in the measurements.

V. CONCLUSION

The study concluded that:

1.The manual measurements carried after tracing lateral cephalogram (2D) vs software generated measurements in CBCT (3D) showed some differences but were not significant.

2.The mean colum angle of central inciors was significantly different in different malocclusions.

3.Palatal bending of the root seen in Class II div 2 malocclusion resulted in greater colum angle.

4.The amount of lower lip line's coverage at the different level of the clinical crown showed varied amount of colum angle change and the highest being when found at the level of middle third to cervical third.

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