CEPHALOMETRIC EVALUATION OF POSITION OF MANDIBULAR CONDYLE, GLENOID FOSSA AND HYOID BONE IN ANGLE'S CLASS II DIVISION 2 MALOCCLUSION AFTER MANDIBULAR UNLOCKING

Dissertation

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In

ORTHODONTICS AND DENTOFACIAL ORTHOPAEDICS

By

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DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation entitled ***"CEPHALOMETRIC EVALUATION OF POSITION OF MANDIBULAR CONDYLE, GLENOID FOSSA AND HYOID BONE IN ANGLE'S CLASS II DIVISION 2 MALOCCLUSION AFTER MANDIBULAR UNLOCKING"*** is a bonafide and genuine research work carried out by me under the guidance of **Dr. Rohit Khanna,** Professor, Department of Orthodontics and Dentofacial Orthopaedics, Babu Banarasi Das College Of Dental Sciences, Babu Banarasi Das University, Lucknow, Uttar Pradesh.

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AIMS AND OBJECTIVE:- To evaluate and compare the position of mandibular condyle, glenoid fossa and hyoid bone in Angles Class II Div 2 malocclusion before treatment and after mandibular unlocking.

MATERIAL AND METHODS:- Digital lateral cephalograms of 30 subjects (mean age of 17yrs 7 months) were obtained, one before initiating treatment and another after unlocking of the mandible. Measurements were divided in two groups, pre-treatment measurements was considered as Group I, where as measurements taken after unlocking of mandible was included in Group II. 12 parameters (5 linear and 7 angular) were evaluated in each Group with the help of Nemoceph software and compared for mandibular condyle (Co-S⊥ on FHP, Gf-Co, S-N-D angle, S-N-Ar angle, S-Ar-Go angle and Ar-Go-Me angle), glenoid fossa (Gf-S⊥on FHP) and hyoid bone position (C3- Hy, Hy- Point D, C3-Hy-Point D angle, Hyoid plane angle). The statistical analysis was done by using SPSS Version 15.0 Statistical Analysis Software.

RESULTS:- After unlocking of the mandible glenoid fossa was shifted anteriorly by 0.74mm, but it was statistically insignificant change. Significant anterior movement of the condyle (0.87mm) and increase in joint space (0.53) was observed after unlocking of the mandible. Insignificant increase in the distance between 3rd cervical vertebrae to hyoid and hyoid to center of mandibular symphysis was observed. Hyoid bone position was positioned anteriosuerior as observed by reduced hyoid plane angle (26.97±4.02˚ to 25.55±2.44˚) and increase hyoidale angle (165.27±8.85˚

to 166.74±8.47˚) after unlocking of the mandible. Statistically significant changes were also found for S-N-D (73.63±2.89˚ to 74.08±3.23˚) and Articulare angle (143.33±6.33˚ to 144.65±7.01˚).

CONCLUSION:- The glenoid fossa and mandibular condyle was positioned more anteriorly after mandibular unlocking leading to increase in joint space between the Glenoid fossa and mandibular condyle. Hyoid bone was also tend to positioned anteriosuperiorly after unlocking of mandible in Class II Div 2 malocclusion patients.

KEY WORDS:- Mandibular condyle, Glenoid fossa, Hyoid bone, Angle Class II Div 2 malocclusion.

Skeletal malocclusion is a set of human craniofacial morphological characteristics that occurs either due to deficiency or due to increase in volume or proportion of skeletal bases in all the three planes of space that is sagittal, vertical or transverse plane. The malocclusion in sagittal plane was classified by Angle constitutes Class I, Class II Div I, Div II and Class III malocclusion.[1] Enlow and McNamara[2] (1973) stated that the cranial floor is the foundation on which the human face develops and demonstrated that the dimension of middle cranial fossa considerably influences the relationship between the naso-maxillary complex and the mandible. Relationship of the mandible to cranial base influances both sagittal and vertical facial disharmonies.

Spatial orientation of the glenoid fossa and malocclusion is likely to play important role in the establishment of different craniofacial pattern during growth. Kokitch[3] (1987) found that relative change in position of glenoid fossa can occur as a result of local remodeling or as a result of spatial repositioning of the entire temporal bone. In comparisons to Class I and Class III patients, Class II patients had more posterior positioning of glenoid fossa resulting in retrognathic mandible as stated by Baccetti.[4]

Andreson and Popovich[5] had also noted that in Class II malocclusion the mandible had a more posterior position under the cranium and there was a more open flexure of cranial base. Features of Class II Div 2 malocclusion include retroclined incisors, backward path of closure and functional retrusion of mandible. Deep bite, high lip line, deep mento-labial sulcus, and prominent chin, a decreased effective length of mandible and competent lips are also present.[6]

The glenoid fossa determines the posterior/superior limit of the mandible; it holds important implications for mandibular displacement. In Class II Div. 2 malocclusion mandible is locked against glenoid fossa that determines posterior-superior limit of mandibular condyle. The mandibular condyle serves as the primary focus of functional orthopaedic therapy to stimulate or restrict the mandibular growth. As mandible is postured forward with myofunctional appliance that is stretching of functional matrix (lateral pterygoid and soft tissue) related to condyle resulting in deposition of bone on posterior and superior aspect of the condyle.[7] On unlocking of mandible, it moves forward initiating growth of condyle in backward direction. Both condylar growth and fossa displacement must be evaluated to fully understand mandibular growth changes occurring with or without therapy. Glenoid fossa remodeling both sagitally and vertically was studied with respect to myofunctional therapy by Preeti Bhattacharya.[8]

Hyoid bone is a U shaped bone which developed from the second and third brachial arches and the posterior one third of the tongue. It located in the anterior midline of the neck, at the level of the third vertical vertebrae and forms the anterior bony boundary of the pharynx.[9, 10] The importance of the hyoid bone lies in its unique anatomic relationships. It has no bony articulations but provides attachment for muscles, ligaments, and fascia of the pharynx, mandible, and cranium. There are two major groups of muscles attached to this bone suprahyoid (Digastric muscle, Stylohyoideus, Mylohyoideus and Geniohyoideus) and the infrahyoid (Sternohyoideus, Sternothyreoideus, Thyreohyoideus and Omohyoideus). These muscles rely on the hyoid bone for their actions and have certain very important functions. The suprahyoid muscles (mylohyoid and genohyoid) depress the mandible by contracting against a fixed hyoid platform, the absence of which may seriously impair mandibular opening. The digastric muscles increase the antero-posterior dimension and the oropharynx during deglutition, while the posterior belly of the digastric and the stylohyoid muscle act to prevent regurgitation of food after swallowing. Other infrahyoid muscles tend to depress the larynx and hyoid bone, after they have been drawn up with the pharynx in act of deglutition.[11] Brodie[12] points out that as man assumed an upright posture the head had to be balanced on the vertebral column. This is attained by equal anterior and posterior muscle tension relative to the occipital condyles. For the accomplishment of anterior muscle tension to maintain delicate cranial balance and posture, the hyoid bone plays an important and active part. [13]

As mandible had anatomically attached to hyoid bone via various suprahyoid muscles and fascia, hence hyoid position varies because of anterio-posterior position of the mandible. The hyoid bone position was lower in Class III malocclusion than in Class I and Class II malocclusions in relation to the anterior cranial base (SN plane) and the Frankfort plane in the vertical plane.[14] Retrognathic mandible may also lead to infero-posterior displacement of the hyoid bone as studied by Khanna et al.[15] Inferior posterior displacement of hyoid bone might affect the tongue posture in oral cavity and stretching of the pharyngeal wall, because hyoglossus muscle and middle constrictor muscle of the pharynx take their attachment from greater horn of hyoid bone. Thus it appears that, as the mandible is moved posteriorly in relation to the other craniofacial structures, the tongue and the hyoid bone do not follow this movement in a similar manner. Otherwise it would encroach upon the vital oropharyngeal and laryngeal spaces. As a functional compensation, the hyoid bone and related structures are guided to an inferior position to avoid compromising the airway space. This suggests that stability and patency of the pharyngeal airway are primary factors in the hyoid bone positioning and anterio-posterior position of mandible is a secondary factor for hyoid bone positioning (Battagel et al).[16]

If the hyoid bone is in the same position before and after orthodontic treatment the soft tissue must still be in same balance, thus possibly reducing the chance of relapse from these soft tissue forces. If the hyoid position is altered how a longer retention period than normal may be indicated as studied by Bibby.[13] In Class II div 2 patients, the path of closure is more backward, demonstrating functional retrusion. From initial contact to full occlusion condylar rotation is both rotatory and translatory up and backward (post shift). As soon as mandible is unlocked in such cases by correction of axial inclination of maxillary incisors, mandible slides downward and forward there by opening the bite as well as improving the sagittal relationship. The change in condylar position, glenoid fossa and hyoid bone is anticipated as the result of the translation of mandible. Mandibular condyle, glenoid fossa and hyoid bone position was recorded by various parameter measured on lateral cephalogram.

Considering this, the present study was designed to evaluate and compare the changes in position of mandibular condyle, glenoid fossa and hyoid bone after unlocking of mandible in Class II div 2 malocclusion cases on lateral cephalogram.

Aim:-

To evaluate and compare the changes in position of mandibular condyle, glenoid fossa and hyoid bone in patients with Class II Div 2 malocclusion after unlocking of mandible.

Objectives:-

1. To evaluate the position of mandibular condyle, glenoid fossa and hyoid bone in patient with Class II Div 2 malocclusion on lateral cephalogram.

2. To evaluate the position of mandibular condyle, glenoid fossa and hyoid bone in patient with Class II Div 2 malocclusion after unlocking of mandible on lateral cephalogram.

3. To compare the position of Glenoid fossa, mandibular condyle and hyoid bone in patient with Class II Div 2 before and after unlocking of mandible.

Blair SE (1952)[1] conducted a study for a cephalometric roentgenographic appraisal of the skeletal morphology malocclusion. Lateral cephalogram of 40 Class I, Class II Div I, Class II Div II patients were taken. The conclusion seen was a high degree of variability of facial skeletal pattern within the groups. The mean skeletal pattern of Class II Div 2 malocclusion, compared with Class I, Class II Div 1, difference in a more acute gonial angle, decrease effective length of mandible and more forword position of anterior outline of both mandible and maxilla.

King EW, Albuquerque MN (1952)[17] studied the pharyngeal growth using serial cephalometric radiography on 24 male and 26 females with the help of a Boadbent Bolton cephalometer. Records were taken at three months, six months, one year, annually till six years and then biennially from 6 to 16 years they found that the that dimensional increase of the nasopharynx by the growth at the spheno-occipital junction was shown to be minimized by forward growth of the anterior arch of the atlas. From 3 months to 16 years the antero-posterior growth between the atlas and the posterior nasal spine amounted to only 3.8 mm in males and 2.6 mm in females. The distance between the hyoid bone and the cervical vertebrae was constant until puberty when the hyoid bone moved forward slightly, growth in length of the pharynx was continuous for the age period studied with a slight pre-pubertal spurt in the females and a slight post pubertal spurt in males. He concluded that changes in head position of the same person lead to changes in the position of hyoid. When head is extended backward the hyoid bone moves back and when the head is moved downward the hyoid moves forward.

Durzo AC, Brodie GA. (1962)[18] conducted a study on growth behavior of the hyoid bone. For this study the material consisted of five longitudinal cephalometric series with age range from 2 to 17 years. The lateral cephalogram were taken at different intervals of growth periods. The result showed that hyoid bone took posterior position in mandibular retrognathism and concluded that the position of hyoid bone antero-posteriorly depended on relative length of those muscles running to it from base of cranium bilaterally and from region of mandibular symphysis.

Graber LW. (1978)[9] studied the alteration in hyoid bone position on pre and post lateral cephalograms of 30 Class III malocclusion patients with mandibular prognathism. All patients were treated with orthopaedic chin cup therapy and they found that with increased posterior movement of mandible there is an increased movement of hyoid bone position and associate structures in an inferior direction. This result lack of encroachment on the pharyngeal passage suggesting that stability and patency of pharyngeal airway is a primary factor in hyoid positioning.

Biby R.E. and Prestone C.B. (1981)[13] introduced a cephalometric analysis for the hyoid bone position known as hyoid triangle which relate the hyoid bone to the vertebrae and the mandible. This triangle was formed by joining the retrognathion, hyoidale and C3. This analysis was applied to pretreatment lateral cephalometric radiograph of 54 samples (28 males and 26 females) with mean age of the male as 12.5 years and of the female as 13 years the sample were limited to class I malocclusion with no significant abnormality in vertical dimension. The vertical, horizontal, and angular anatomic relations of the hyoid bone were computed using hyoid triangle and hyoid plane angle. It was found that the hyoid triangle allows determination of hyoid bone position in three directions, since it is not dependent on a cranial reference plane. The bony pharynx at the level of PNS and hyoidale was found to have the same anerio-posterior dimensions. No sexual dimorphism in hyoid bone position was found.

Luder HU (1981)[19] conducted a longitudinal cephalometric study on 12 boys and 13 girls with Class II, Div 1 malocclusion treated with activators. The findings were compared with an untreated control group of 24 boys and 15 girls. The children were aged about 9 years at the start of the investigation and they were treated, or observed, for about two years. He found significant differences in the growth increments of control boys and control girls, the sexes were treated statistically as separate groups. Mandibular growth was found to be altered by activator therapy; in the boys growth was increased and redirected posteriorly while in the girl's growth was only redirected. The results as a whole support the concept of the activator as an appliance which transduces elastic soft tissue forces to the skeletal and dental units.

Erickson L.P, Hunter W.S (1985)[20] conducted a study to evaluate Class II Div 2 treatment and mandibular growth and position. Cephalograms of 34 subjects (14 male and 20 female) were taken with Class II Div 2 malocclusion with no previous history of orthodontic treatment, the entire treated sample were divided in three groups. Group I treated with extraction and Group II were treated by conventional class II method Group III was treated similarly as Group II, but with the inclusion of bite plate. Growth was evaluated by matching each treated subject with an untreated subject. The amount of growth in treated subjects was significantly greater than in the untreated controls, with a mean difference of approximately 1.5mm/year. The mandible grew forwardly significantly in treated subjects than in control group. The pretreatment size and subsequent growth of the mandible in the female extraction group was slightly less than for the other two treatment groups, but the differences were not statistically significant.

Agronin K.J, Kokic V.G. (1987)[4] conducted a study to evaluate displacement of the glenoid fossa. The sample was comprises of 175 orthodontically treated patients and evaluated to determine the change in position of articulare. The sample was arbitrarily subdivided according to the direction of facial growth during treatment measured at pogonion. The cephalograms were superimposed on anterior cranial base and a Cartesian coordinate system was devised to measure changes in the position of articulare over time. The results were clearly showed that articulare is displaced posteriorly and inferiorly during craniofacial development with treatment. Significant differences in the amount of displacement were noted between groups. Patients with vertical growth patterns showed significantly greater posterior displacement of articulare than patients with horizontal growth patterns. Because articulare represents the point of intersection of the temporal bone and the neck of the condyle, this investigation suggests that the temporal bone and glenoid fossa are displaced posteriorly during facial development with treatment and that the amount of displacement can affect mandibular position.

Woodside D.G, Metaxas A, and Altuna G. (1987)[21] investigated the remodeling changes in the condyle and glenoid fossa following a period of progressively activated and continuously maintained mandibular advancement using the Herbst appliance. The sample consisted of 6 female and one male cynomolgus (Macaca fascicularis) monkeys; one was juvenile (24 to 36 months), five were adolescent (36 to 48 months), and one was adult (male 70 to 80 months). Activated Herbst appliances were placed in five experimental animals; two adolescents wore inactivated appliances. Progressive mandibular advancement was achieved by adding stops to the telescopic arms of the appliance, with the total activation reaching 7.0 to 10.0 mm, dependent upon the length of the treatment phase. This mandibular advancement produced extensive remodeling and anterior relocation of the glenoid fossa, which contributed to anterior mandibular positioning and altered jaw relationships. This glenoid fossa remodeling contributes to anterior mandibular positioning and altered jaw relationships. Proliferation of condylar tissues and increased mandibular length following continuous and progressive mandibular protrusion may be age and sex related, and was seen only in the juvenile primate. Adolescent primates in the permanent dentition prior to third molar eruption did not show any condylar response. After continuous protrusion, proliferation of the posterior part of the fibrous articular disk splinted the condylar head eccentrically in the glenoid fossa. Skeletal jaw relationship may be altered by both glenoid fossa remodeling and condylar extension in young primates, thereafter by glenoid fossa relocation. This result may be related to age, sex, and the amount of mandibular protrusion.

Gianelly AA. (1989)[22] conducted a study to determine the Condylar position and Class II deep-bite with no overjet malocclusion. The positions of the condyles in 19 click-free persons with Class II malocclusions characterized by a bite depth greater than 50%, no overjet, and an interincisal angle of greater than 140° were compared with the positions of the condyles in 21 control subjects (Class II molar relation, overbite is less than 50% and interincisor angle less than 140˚). Average condylar position in both groups was concentric and no significant differences between groups were found. In addition, no significant correlation was noted when condylar position was related to bite depth.

Demisch A, Ingervall B, and Thuer U. (1992)[23] conducted a study to evaluate the effect of the treatment of Angle Class II Div 2 malocclusion was studied in 22 children by x-ray cephalometry and by recording the relation between the retruded and the intercuspal mandibular positions. The relation between the retruded (RCP) and the intercuspal (ICP) mandibular positions were recorded with wax bites and dental casts mounted in a modified gnathothesiometer. The anteroposterior distance between retruded and intercuspal was large before the start of the treatment. The relation between the retruded and the intercuspal mandibular positions before the start of the treatment is also in accordance with previous results. The development of this relation during the different phases (Phase I- Removable plate used for proclination of upper incisors and deep bite correction and Phase II- Activator for the correction of the distal occlusion) of the treatment is also logical. No finding in this study supports the view that the mandible is posteriorly displaced in Angle Class II, Div 2 malocclusion and tends to reposition anteriorly when the steep upper incisor position and the deep bite are corrected. This conclusion is valid as a general statement for a group of persons with Angle Class II, Div 2 malocclusion but may not hold true for single persons.

Baccetti T, Antonin I, Franchi L, Tonti M, Tollaro I. (1997)[3] conducted the study to evaluate glenoid fossa position in different facial types. Cephalometric study was carried out on a sample of 180 subjects (90 males and 90 females, aged 7–12 years) who were combined to form three groups (60 subjects each) according to skeletal sagittal relationships and three groups (60 subjects each) according to skeletal vertical relationships. Cephalometric analysis comprised both sagittal and vertical measurements for the assessment of the position of the glenoid fossa in relation to surrounding skeletal structures. As for sagittal measurements, TMJ position was more posterior in skeletal Class II when compared with skeletal Class III in the vertical plane; the position of the glenoid fossa relative to basicranial structures was more caudal in low angle subjects when compared with subjects with normal or high angle vertical relationships. Both basicranial structures and the posterior nasal spine may be used as reference structures for the assessment of vertical position of the glenoid fossa in diagnosis and treatment planning.

Pancherz H, Zeiber K, Hoyer B. (1997)[24] compared dentoskeletal morphology in 347 Class II Div 1 and 156 Class II Div II malocclusion by lateral cephalometric radiographs. Children at the ages 8-10 years and 11-13 years were evaluated. The result of the study revealed marked variations in the variables. Further they concluded that except for the position of the maxillary incisors no basic difference in dentoskeletal morphology of Class II Div I and Class II Div II exists.

Buschang HP, Pinto S. (1998)[7] conducted a study to evaluate age and gender differences in the growth of the mandibular condyle and displacement of the glenoid fossa. They found that the condyle grew between 0.8 and 1.3 mm posteriorly and between 9.0 and 10.7 mm superiorly over the 4-year periods, the articulare landmark showed significantly more posterior and superior growth than the condylion landmark. Relative to the cranial base reference structures, the fossa was displaced between 1.8 and 2.1 mm posteriorly and between 1.0 and 1.8 mm inferiorly. The articulare showed significantly more inferior movement than the condylion. Boys showed significantly greater superior condylar growth during adolescence than during childhood. The glenoid fossa demonstrated greater posterior and inferior displacement during adolescence than during childhood.

Battagel JM, Johal A, L'Estrange PR, Croft CB Kotecha B. (1999)[16] examined the alterations in airway and hyoid position in response to mandibular advancement in subjects with mild and moderate obstructive sleep apnea (OSA). Pairs of supine lateral skull radiographs were obtained for 13 female and 45 male, dentate

Caucasians. Males and females were analyzed separately. In males, mean mandibular protrusion at the tip of the lower incisor was 5.3 mm, increasing its distance from the posterior pharyngeal wall by 6.9 mm. Movement of the hyoid showed extreme inter-subject variability, both in the amount and direction. In relation to the protruded lower jaw, the hyoid became closer to the gonion by 6.9 mm and to the mandibular plane by 4.3 mm. With respect to the upper face, a 1.3 mm upward and 1.1 mm forward repositioning was seen. The percentage alterations in airway dimensions matched or bettered the mandibular advancement. The minimum distances behind the soft palate and tongue improved by 1.0 and 0.8 mm, respectively. Despite their smaller faces, females frequently showed greater responses to mandibular protrusion than males.

Mattos JM, Palomo JM, Ruellas AC, Cheib LP, Eliliwi M, Souki QB (2000)[25] conducted a study to test the null hypothesis that the positions of the glenoid fossae and mandibular condyles are identical on the Class I and Class II sides of patients with Class II subdivision malocclusion. Distances from the glenoid fossa and condyles were calculated in pretreatment cone beam computed tomographic scans of 82 patients: 41 with Class II and 41 with Class II subdivision malocclusions. Patients with Class II malocclusion displayed a symmetric position of the glenoid fossa and condyles with no statistically significant differences between sides whereas patients with Class II subdivision showed asymmetry in the distance between the glenoid fossae and anterior cranial base or sella turcica, with distally and laterally positioned glenoid fossa on the Class II side. Male patients had greater distances between glenoid fossa and anterior cranial fossa. The condylar position relative to the glenoid fossa did not differ between the two malocclusion groups or between males and females. The null hypotheses were rejected. Patients with Class II subdivision malocclusion displayed asymmetrically positioned right and left side glenoid fossa, with a distally and laterally positioned Class II side, although the condyles were symmetrically positioned within the glenoid fossa.

Eggensperger N, Smolka K, Johner A, Rahal A , Iizuka T (2004)[26] determined the long-term changes in hyoid bone position and pharyngeal airway size after mandibular advancement, including evaluation of the relationship between length of suprahyoidal musculature and skeletal relapse. Cephalometric follow up of 15 patients for 12 years, who underwent mandibular advancement surgery was taken and the results were obtained were. The final position of the hyoid bone was more posterior than it had been preoperatively. Suprahyoidal musculature continuously lengthened from pre-operatively to 12 years post-operatively. Total skeletal relapse at B-point and pogonion correlated significantly with postoperative stretch of suprahyoidal musculature. The upper and middle pharyngeal airways were narrower than their preoperative values.

Azumi Y, Sugwara J, Takahashi I, Nagasaka H, Kawamura H. (2004)[27] conducted a study to evaluate the condylar position, condylar morphology, and temporo-mandibular joint symptoms in patients with severe skeletal Class II malocclusions. The records of 13 patients who had undergone bilateral mandibular lengthening and/or midline mandibular widening were analyzed. Pre and post-operative positional changes of the mandibular condyle in the glenoid fossa, the axial rotation of the condylar head, and the temporo-mandibular joint symptoms was evaluated. Most of the condyles were displaced in an upward and backward direction in the glenoid fossa; the amount correlated with the amount of mandibular lengthening. Resorption was observed in 20% of condyles; the incidence of the resorption correlated with incidence of preoperative articular disk displacement and with the amount of condylar displacement.

Katsavrias GE, Voudouris CJ (2004)[28] undertook a study to determine the contribution of glenoid fossa modification in the correction of skeletal Class II malocclusions. Lateral tomograms of 35 patients (18 boys and 17 girls) between the ages of 7.96 and 15.06 years were used. The results of this study demonstrated that there are no positive radiographically depictable contributions from glenoid fossa modification for the correction of skeletal Class II malocclusions treated with mandibular protrusive appliances (activators). In addition, no statistically significant differences were found between right and left sides denoting relative symmetry.

Katsavrias GE, Halazonetis DJ (2005)[29] conducted a study for the purpose of investigation of the shapes of the condyle and the glenoid fossa in patients with Class II Div 1, Class II Div 2, and Class III malocclusions in 189 patients (109 Class II Div 1, 47 Class II Div 2, and 33 Class III). Condylar and fossa shapes were found to be different between the groups where as shape variability of the fossa was related to inclination of the eminence and fossa height. Shape variability of the condyle was mainly related to inclination of the condylar head. The Class III group had a more elongated and anteriorly inclined condylar head and a wider and shallower fossa and the condyle was closer to the roof of the fossa. The Class II div 2 differed only in the position of the condyle in the fossa, which was situated more anteriorly in the Class II Div 1 group.

Giuntini V, Toffol D.L, Franchi L, Baccetti T. (2008)[30] conducted a study to access the position of glenoid fossa in 30 subjects (16 male,14 female with mean age 9yrs) in mixed dentition with class II malocclusion associated with mandibular retrusion and normal skeletal vertical relationships. Each subject's lateral cephalograms were traced by the same operator and checked by another operator for landmark location Computer assisted cephalometric analysis was carried out by means of a digitizer and software. The position of glenoid fossa was evaluated according to its distance from sella from pterygo-maxillary fissure and from fronto-maxillary suture and it was compared in subjects with Class II malocclusion and 37 subjects with normal occlusion (18 male,19 female; mean 9.5yrs). The conclusion derived was that a posterior position of the glenoid fossa is possible diagnostic anatomic feature of Class II malocclusion associated with mandibular retrusion and an effective measurement to evaluate glenoid fossa with the craniofacial relationship is the cephalometric distance from glenoid fossa to the franto-maxillary suture.

Bustani AA, Al-Joubori AK, Saloom FH (2008)[31] assessed the skeletal or dental outcomes of treating moderate-severe skeletal Class II Div 1 malocclusion by the activator. The sample consisted of pre and post treatment records (cephalometric radiographs) of 11 Iraqi adolescent patients (7 females 10-11 years old, and 4 males 12-13 years old). The results showed significant skeletal and dental changes that reflected significant improvements in the cardinal features of Class II (overjet, overbite, ANB angle, and lower anterior facial height).

Tsarudis SC, Pancherz H. (2008)[32] evaluated the effective temporomandibular joint (TMJ) changes (the sum of condylar modeling, glenoid fossa modeling, and condylar position changes within the fossa), and their influence on chin position in patients with a Class II Div 1 malocclusion treated orthodontically with a multibracket appliance and Class II elastics (Tip-Edge) and orthopedically with a fixed functional appliance (Herbst). Two groups of successfully treated subjects were evaluated: Tip-Edge (n-24) and Herbst (n-40). Results obtained were in comparison with the Herbst and control groups, the Tip-Edge group exhibited less favorable sagittal effective TMJ growth and chin position changes necessary for skeletal Class II correction.

Sheng MC, Lin LH, Yu Su, Tsai HH (2009)[33] the objective of this study was to test the hypothesis that there are no developmental changes in the pharyngeal airway depth and hyoid bone position from childhood to adulthood in normal Taiwanese persons. Lateral cephalometric radiographs of 239 normal Taiwanese (132 females and 107 males; aged 7–27 years) were separated into three stages according to dental age. They analysed that the pharyngeal airway depth increased from the mixed dentition stage to the permanent dentition stage in both genders. There was sexual dimorphism in the lower pharyngeal airway depth. The hyoid bone position showed an obvious difference in the permanent dentition stages between genders. The vertical position of the hyoid bone was associated with the mandibular morphology and position, but the relationship in males was reversed compared with that in females.

Khanna R, Tikku T, Sharma V. P, (2011)[15] conducted a cephalometric study to compare the pharyngeal dimension in Angles Class I normal (46 patients- 25 males and 21 females) and Angles Class II Div 1 samples(46 patients- 25 males and 21 females), and correlate it with the dento-skeletal parameters in both the groups. Group A were having Class I molar relation with ideal occlusion while Group B consisted of subjects with Class II Div 1 malocclusion. Each Group consisted of 25 males and 21 females. After statistical analysis the result showed that Angles Class II Div 1 samples with retrognathic mandible showed an inferio-posterior displacement of hyoid bone. The positional alteration of hyoid was prevalent in skeletal malrelation rather than dentoalveolar malocclusion.

Jena AK, Duggal R (2011)[34] conducted a study to test the hypothesis that there is no difference in hyoid bone position among subjects with different vertical jaw dysplasia's. 71 North Indian adult male and female subjects in the age range of 15 to 25 years were selected for the study. Based on the vertical growth pattern of the face, subjects were divided into Group I (24; subjects in whom both Frankfort mandibular plane angle [FMA] and basal plane angle measured 20 to 25 degrees), Group II (17 subjects in whom both FMA and basal plane angle measured <15 degrees), and Group III (30 subjects in whom both FMA and basal plane angle measured >30 degrees). The conclusion obtained was that the anteroposterior position of the hyoid bone was more forward in subjects with short face syndrome. The vertical position of the hyoid bone was comparable among subjects with different vertical jaw dysplasias. The axial inclination of the hyoid bone closely followed the axial inclination of the mandible.

Wigal TG, **Dischinger T, Martin C, Razmus T, Gunel E, Ngan P (2011)**[35] determine the condyle/glenoid fossa changes in 21 Class II patients with a mean age of 8.4 years and Class II division 1 malocclusion treated consecutively with the edgewise crowned Herbst appliance in the early mixed dentition period. At the completion of the fixed appliance therapy, the net change in overjet and molar relationship was reduced to 3.0 and 2.2 mm, respectively. Most of the remaining corrections were caused by restraint in the maxillary growth. No significant differences were found in the position of the condyle and remodeling of the glenoid fossa compared with the controls.

Verma G, Tandon P, Nagar N, Singh GP, Singh A (2012)[36] evaluated the position of hyoid bone in 40 Angles Class II Div I treated subjects with Twin block appliance. The subjects were classified in to three groups: group I (hypodivergent, SN-MP: <31° (27°-30°), n=15), group II (normodivergent, SN-MP: 31°-34°, n=15), and group III (hyperdivergent, SN-MP: >34° (35°–38°), n=10) Pre and post lateral cephalograms were taken and traced manually. The results obtained were hyoid bone shifted significantly (P<0.01) forward in horizontal dimension in all three groups, although it was highest in group III and there was no significant difference amongst the groups. In vertical dimension, hyoid bone shifted in upward direction in all three groups; and, the shift was significant (*P*<0.01) only in group I and there was a significant difference between group I and rest of the two groups.

Deljo E, MFilipovic M, Babacic R, Grabus J (2012)[37] proposed a study to find the relationship among hyoid bone to the cranial base, mandible, and cervical part of vertebrae. 30 profile teleroengen images of patients aged 17-18 years (male and female) were used. The subjects were divided into 3 groups based on their ANB angle. The first group was ortognathic patients with ANB angle values, from 1 to 4°. The second group included patients with distal jaw relationship, that is, whose values of ANB-angle were greater than / or 5°. The third group consists of patients with ANB-angle value of 0 or negative. The result found was that the position of hyoid bone is not constant, but depends on the maxillo-mandibular anterior posterior relationships. Length of hyoid bones and greater horns of hyoid bone differs with respect to the sagittal malocclusion. In relation to the cranial base and maxillary bones flat position of the hyoid bone is highly correlated. A positive correlation was found with relation to the cervical vertebra, while the dependence is determined in relation to the steep mandibular plane.

Bhattacharya P. Raju S.P, Gupta A, Agrawal K.D. (2013)[8] conducted the study to evaluate the glenoid fossa changes in response to twin block appliance therapy**.** The study was conducted on pre and post-teatment cephalograms of 30(15 males and 15 females) myofunctionally treated, Angles Class II Div 1 patients mean age was 12.8 years for male and 10.15 years for females and mean treatment duration 10±1.46 months for males and 10.15±2.59 for females. All the cephalograms were traced and analysed for four linear variables to access to glenoid fossa changes and nine linear, five angular parameters to access to change in craniofacial morphology. The glenoid fossa was found to be relocated sagitally as well as vertically. Mandibular length was increased with simultaneous forward positioning of mandible.

Miranda JM, Valencia SM, Mir FC, Sampen AP, Guillen AL (2013)[38] compared the condylar position in patients with different anteroposterior sagittal skeletal relationships through a cone beam computed generated tomography (CBCT) imaging generated space analysis. A retrospective study was conducted on 45 adult patients between age range of 18-35 years. The upper distance of the condyle to the glenoid fossa was found smaller in the Class II and Class III as compared to the Class I group. The anterior distance of the condyle to the articular eminence showed significant differences when comparing the Class I with the Class II and class III groups. No statistically significant difference was noted in the posterior condylar distance between the groups. Spatial differences existed for the condylar position in relation to the glenoid fossa for skeletal Class I, Class II, and Class III, but these spatial differences may not be clinically relevant.

Jose P. N, Mary L, Mogra S, Rangrajan S, Shetty S, Shetty S. V. (2014)[10] conducted the study on hyoid bone position to ascertain any correlation with pharyngeal airway space in skeletal Class I, II, and III malocclusions. McNamara's airway analysis was carried out to assess the upper and lower airway width and hyoid triangle analysis by Bibby and Preston was carried out to determine the position of the hyoid bone. A positive correlation was found between the lower airway and horizontal distance from hyoid bone to the retrognathion in Class I skeletal pattern with average growth pattern.

Amayari M, Saleh F, Sahed M. (2014)[14] conducted the study to evaluate the change in the position of hyoid bone in relation to facial skeleton. For this 65 lateral cephalograms were taken between the age of 12 to 17 year with a mean age of 14 yrs and then tracing was done. The samples were divided in to Class I, II and Class III group taking Class I as control group. After cephalometric analysis the conclusion derived was significant difference in the angular measurement of the hyoid bone in relation to the anterior cranial base (S-N plane) where the hyoid bone moved backward in Class II malocclusion cases in the sagittal plane with no significant changes in linear measurement. Linear measurement showed a significant difference among the control and study group where hyoid bone position was lower in Class III malocclusion cases than in Class I and Class II malocclusion.

Tekale PD, Vakil KK, Sun Nagmode LS, Vakil KJ (2014)[39] investigated the hyoid bone position and the head posture using lateral cephalograms in subjects with skeletal Class I and skeletal Class II patterns. Lateral cephalograms of 40 subjects (20 skeletal Class I pattern; 20 skeletal Class II pattern) were traced and analyzed. The position of hyoid bone was found closer to the cervical vertebra horizontally in skeletal Class II subjects when compared with skeletal Class I subjects. In males, the hyoid bone position was closer to the cervical vertebra horizontally both in skeletal Class I and skeletal Class II subjects.

Ulusoy C, Bavbek NC, etal. (2014)[40] conducted a study to evaluate the airway dimensions and changes in hyoid bone position following class II functional therapy with activator. Lateral cephalograms of 16 patients (8 girls, 8 boys, mean age 11.36±0.77 yrs) who were treated with activator and 19 patients (11 girls, 8 boys, mean age 12.14±0.65 yrs) who served as control were used for linear, angular and area measurements regarding airway track and hyoid bone. During treatment nasopharyngeal height and nasopharyngeal area increased and hyoid bone moved downward and forward. During retention period nasopharyngeal and oropharyngeal area increased. H-SN and C3-H distances increased. Hyoid bone position exhibited significant changes. The increases in C3-H in long-term was more in the activator group than control. In growing Class 2 patients with mandibular deficiency and airway track without obstructions, functional appliance treatment provided favourable effects on nasopharyngeal and oropharyngeal area throughout the retention period.

Coskuner HG, Ciger S (2014)[41] aimed to assess three-dimensional changes in the temporomandibular joint positions and mandibular dimensions after correction of dental factors restricting mandibular growth in 14 patients each with Class II division 1 (group I) and Class II division 2 (group II) malocclusions. The results shown that the mandibular dimensions increased in both groups, although mandibular positional changes were also found in group II. There were no differences in the condylar position within the mandibular fossa or the condylar dimensions. They stated Class II malocclusion can be partially corrected by achieving an ideal maxillary arch form, particularly in patients with Class II Div 2 malocclusion.

Cacho A, Ono T, Kuboki T Martin C (2015)[42] compared the relationship between the temporomandibular joint (TMJ) condyles and the temporal fossa by means of tomography before and after the orthodontic correction. 26 consecutively treated Class II, division 1 patients (19 boys and 7 girls with an average pre-treatment age of 11 years) who underwent orthodontic treatment by means of an activator appliance were taken and the result obtained was that there was no difference in the joint space measurements in any direction. Comparisons between the right and left condyles were not significantly different.

Hegde SS, Revankar AV, Patil KA (2015)[43] evaluated the condylar position in patients with different skeletal sagittal malocclusion patterns. Pretreatment lateral cephalometric radiographs of 112 subjects (both males and females) were categorized into three classes (Class I, Class II, Class III) based on their ANB angulation and studied for N-S-Ar (saddle angle), S-Ar-Go (articular angle), S-Ar (posterior cranial base length). They concluded that there is no significant difference in condylar position in different skeletal malocclusion patterns. N-S-Ar and S-Ar-Go angles show a negative correlation in any skeletal malocclusion pattern.

Rizk S, Kulbersh VP, Qawasmi RA, (2016)[44] compare the Changes in the oropharyngeal airway of Class II patients treated with the mandibular anterior repositioning appliance. Twenty Class II white patients (mean age, 11.76± 1.75yrs) treated with the MARA followed by fixed appliances were matched to an untreated control sample by cervical vertebrae maturation stage at pretreatment (T1) and posttreatment (T2) time points. Cone beam computed tomography scans were taken at T1 and T2. Dolphin 3D imaging software was used to determine oropharyngeal airway volume, dimensions, and anteroposterior hyoid bone position. Oropharyngeal airway volume, airway dimensions, and A-P position of the hyoid bone increased significantly with functional appliance treatment. SNA and ANB decreased significantly in the experimental group (P 0 .05). Changes in SNB and Sn-GoGn failed to reach statistical significance. They concluded Functional appliance therapy increases oropharyngeal airway volume, airway dimensions, and anteroposterior hyoid bone position in growing patients.

Kumar S, Arshad F, Nahin J, Lokesh NK, Riyaz K (2017)[45] tested the hypothesis that there is no difference in hyoid bone position among individuals with different growth patterns before and after treatment. 40 pre and post lateral cephalogram of patients in the age group of 20-27 years were grouped. On analysis statistically significant correlation was observed in the pre- and post-treatment values of dentofacial structures and hyoid bone, but no significant correlation was found in position of the hyoid bone in the normodivergent and hyperdivergent groups. No change was seen in position of the hyoid bone in normodivergent and hyperdivergent groups.

This cephalometric study was conducted in the Department of Orthodontics and Dentofacial Orthopaedics, Babu Banarasi Das College of Dental Sciences, Lucknow to evaluate cephalometric changes in the position of mandibular condyle, glenoid fossa and hyoid bone in patients with Angle's Class II Div 2 malocclusion before and after unlocking of mandible.

MATERIALS:

Sample-

Sample for the present study comprised of 30 patients with age range of 10-25 years. The data were collected either from the records of the patients with Angle's Class II Div 2 malocclusion who had completed their treatment or were undergoing fixed orthodontic treatment in the Department of Orthodontics and Dentofacial Orthopaedics, Babu Banarasi Das College of Dental Sciences, Lucknow. Two lateral cephalograms one before initiating orthodontic treatment and one after unlocking the mandible was obtained either from the selected patient record file or for the patient undergoing orthodontic treatment, pretreatment lateral cephalogram was taken from the case file and lateral cephalogram taken after mandibular unlocking lateral cephalogram was taken again. Figure 1 shows frontal and lateral intraoral photograph of representative sample after unlocking of mandible. Similarly Figure 2 show lateral cephalogram of the patient before and after unlocking of mandible.

Figure 1- (A&B) frontal & lateral view of pre-treatment photograph

(C&D) frontal & lateral view after unlocking of mandible

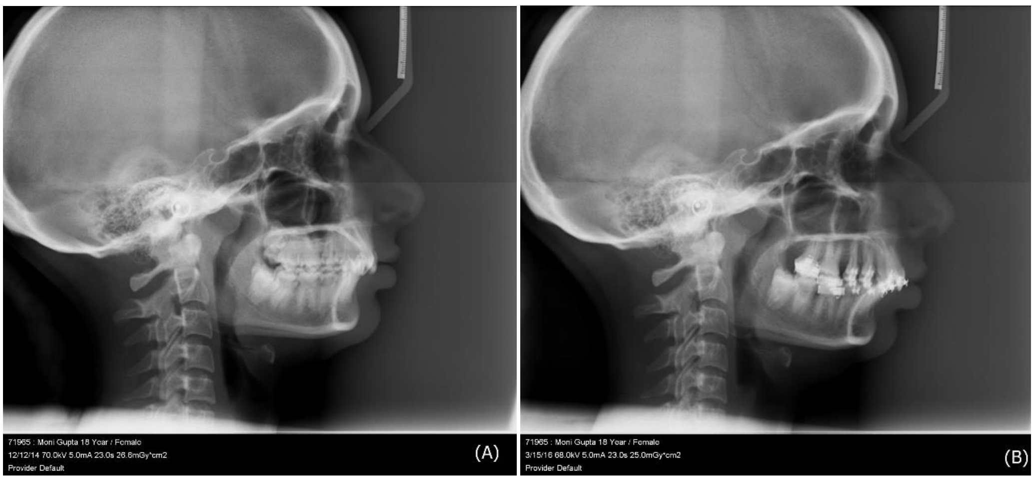


Figure 2-(A) Pre-treatment lateral cephalogram **(B)** Cephalogram after

unlocking of mandible.

Criteria for sample selection:-

The sample was selected according to following criteria:

Inclusion criteria-

1. Patients with Angle’s Class II Division 2 malocclusion in whom unlocking of mandible had been accomplished after initial alignment and levelling. Patients with age range 10-25 years.
2. No evidence of morphological aberration in mandibular condyle, glenoid fossa and hyoid bone as seen on lateral cephalogram and OPG.
3. No significant medical history.

Exclusion criteria-

1. Patient with no evidence of unlocking of mandible as seen on the study model taken after initial alignment and levelling.
2. History of trauma in maxillofacial region.
3. Skeletal asymmetry in maxillo-facial region.
4. Previous history of maxillofacial surgery.

Approval was taken from the Ethical and Research Committee of Babu Banarasi Das College of Dental Sciences, BBDU, Lucknow. A signed informed consent was obtained from each subject as per guidelines of the University.

Sample distribution:-

Two cephalograms of each patient were obtained from record file of 24 patients who met the inclusion criteria. Lateral cephalogram of 6 patients were undergoing orthodontic treatment were repeated after initial alignment and leveling when mandible was unlocked. Thus total sample constituted of 60 lateral cephalograms that were divided in two Groups.

Sample was divided in two Groups (Table 1)

i- Pre-treatment lateral cephalograms- (Group I)

ii- Lateral cephalograms after unlocking mandible- (Group II)

Table -1: Distribution of sample in Groups

Sample (Lateral cephalograms)	**Group I** Pre-treatment lateral cephalograms	**Group II** Lateral cephalograms after unlocking of the mandible
N = 60	**N = 30** Mean age (17yrs 7months)	**N = 30** Mean age(18yrs 1 months)

<u>Materials</u>:-

1. **Material used for obtaining lateral cephalogram:**
   - A. **Soft copy of lateral cephalograms:** Two lateral cephalograms (Fig.2 A&B) of each patient saved in CD- ROM were taken from record files of 24 patients.
   - B. **Lateral cephalogram of 6 subject undergoing orthodontic treatment:** Pretreatment lateral cephalogram was taken from record file and lateral cephalogram repeated after unlocking of mandible by cephalostat machine.
   - C. **Cephalostat machine:** Planmeca proline XC cephalostat (Finland) machine

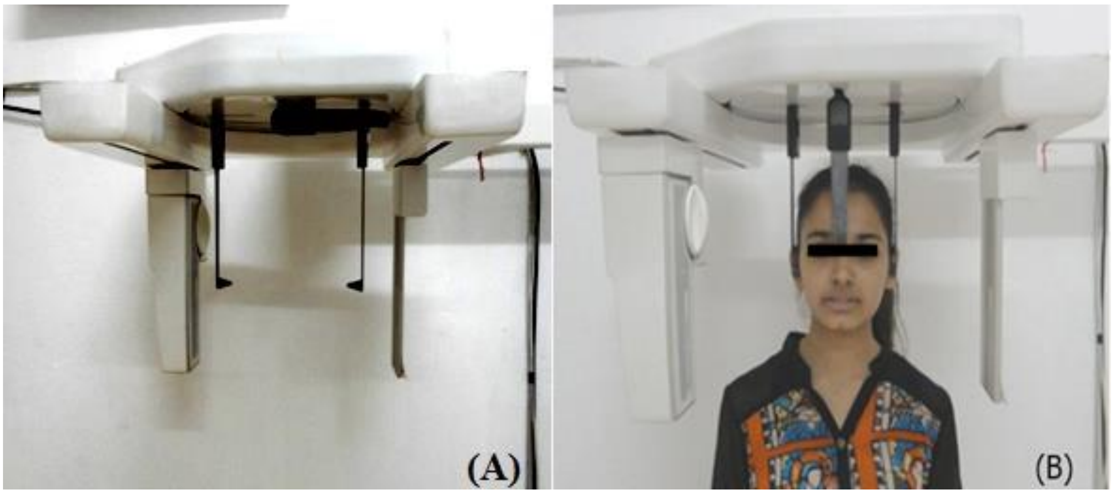


Figure 3: Materials used in the study **(A)** Cephalostat machine for taking lateralcephalogram **(B)** Patients position while taking lateral cephalogram in the cephalostat machine

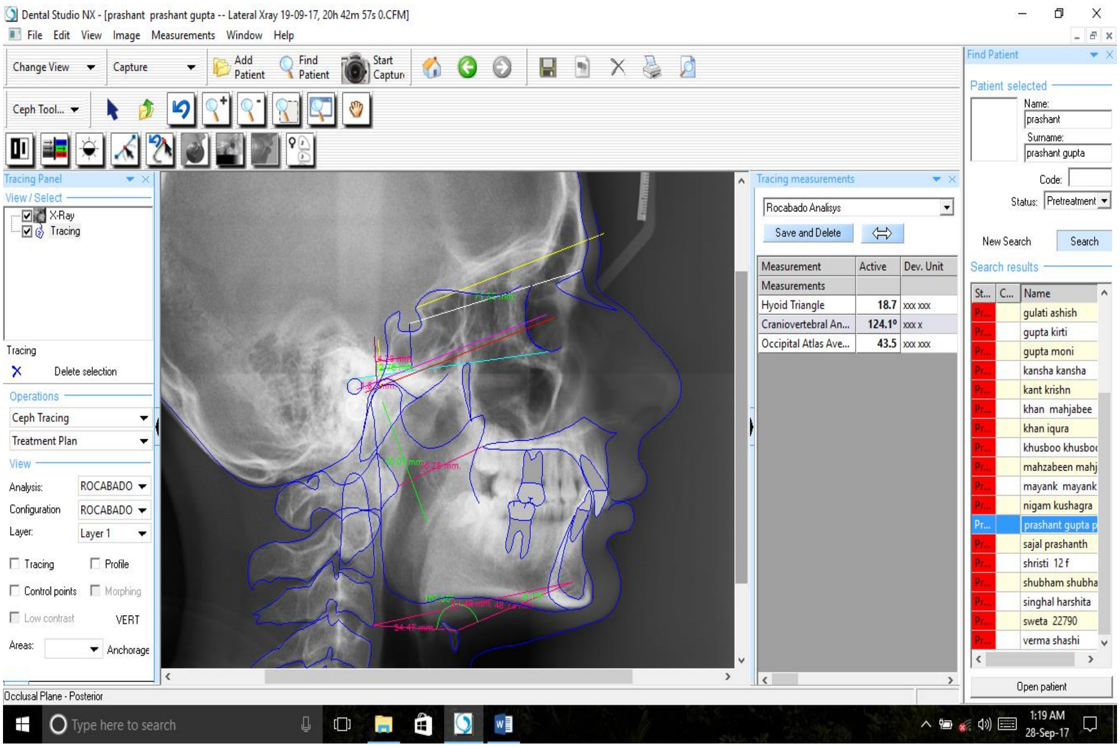


Figure 4: Cephalometric tracing using Nemoceph software

(Fig.3 A&B) was used to take digital lateral Cephalograms of selected subjects. The exposure was set at 68 KV, 5 mA and exposure time of 2.3 second and receptor was placed at a distance of 6.0 inches.

2. Nemoceph software: Nemoceph software (Dental studio 6.0) was used to trace the identified landmarks (Fig. 4).

METHODS:-

Both pretreatmentlateral cephalogramsand lateral cephalograms taken after unlocking of mandible were transferred to a computer loaded with Planmeca software, from where the digital lateral cephalogram were saved in bitmap file and taken in CD ROM. The soft copies of all lateral cephalograms were transferred to Nemotec software program (Dental studio-NX, version 6.0).

The images were calibrated by identifying two crosshairs 10 mm apart. The image enhancement feature of the software, like brightness, contrast adjustment and magnification were used as needed to identify individual cephalometric landmarks as precisely as possible. The cephalometric landmarks were marked with the help of mouse/cursor. Once all the landmarks were marked, these landmarks were again adjusted and corrected for accurate measurements. All angular and linear measurements were done on tracing with the help of the software (Fig. 4). The data so obtained was subjected to statistical analysis.

Landmarks used in study:- (Fig. 5)

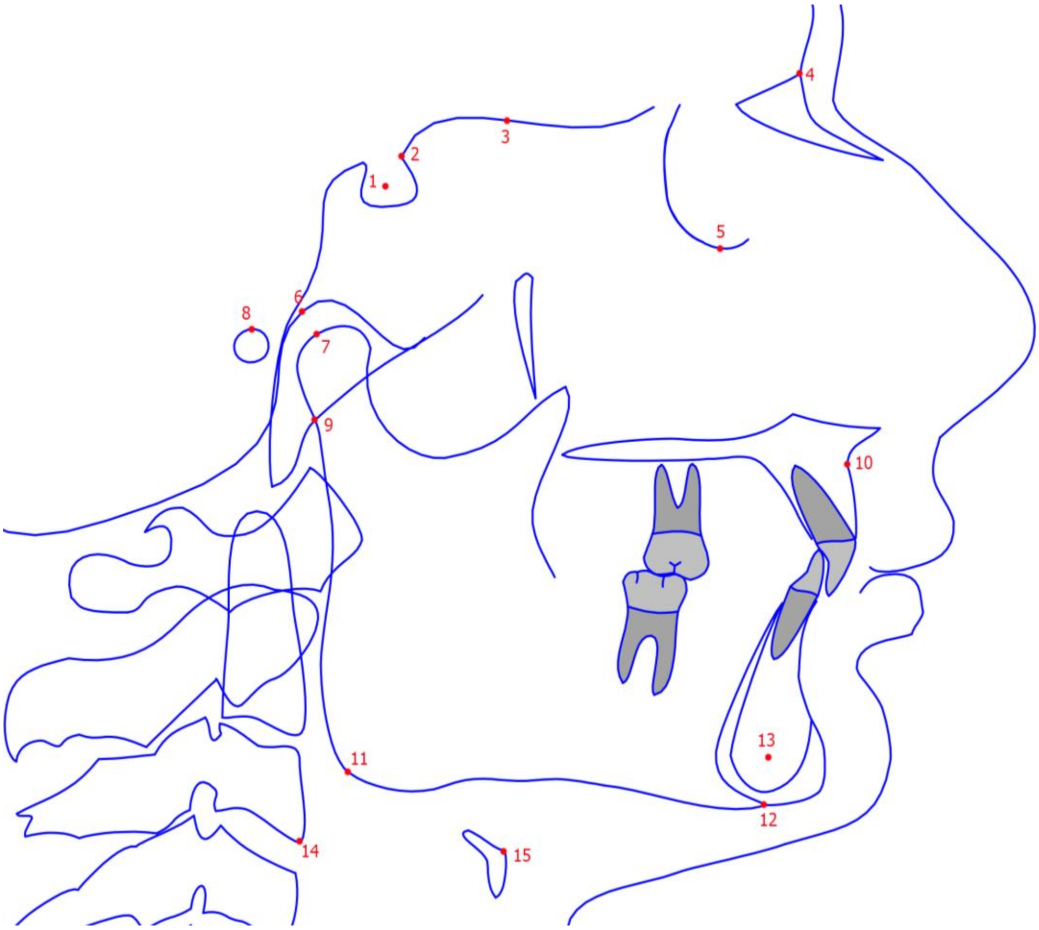
1. **Sella (S):** Sella is the midpoint of the sella turcica or hypophyseal fossa or pituitary fossa.

2. **Point T**: Point T is the most superior point of the anterior wall of sella turcica (Viazis, 1991).
3. **Lamina Cribrosa:** The nerve fibers forming the optic nerve exit the eye posteriorly through a hole in the sclera that is occupied by a mesh-like structure called the lamina cribrosa. It is formed by a multilayered network of collagen fibers that insert into the scleral canal wall.
4. **Nasion (N):** Nasion is most anterior point of fronto-nasal outline in the mid line.
5. **Orbitale (Or):** The lowest point inferior bony margin of the orbit.
6. **Glenoid fossa (Gf):** Most superior and posterior point on the bony contour of the temporal bone at the root of the zygomatic arch that receives the condyle of the mandible.
7. **Condylon (Co):** A point on the condylar head in contact with and tangent to the ramus plane.
8. **Porion (po):** It is the midpoint on the upper edge of the porus acusticus extrenus located by means of the metal rods on the cephalometer.
9. **Articulare (Ar):** A point at the junction of the posterior border of the ramus and the inferior border of cranial base (occipital bone).
10. **Point A:** Point A is deepest point on the curved bony outline between anterior nasal spine and prosthion.
11. **Gonion (Go):** A point on the curvature of the angle of the mandible located by bisecting the angle formed by lines tangents to posterior ramus and inferior border of mandible.
12. **Menton (Me):** The lowest point on the symphyseal shadow of the mandible seen on a lateral cephalogram.

13. **Point D:** Located by inspection as the center of body of the mandibular symphysis seen on lateral cephalogram.
14. **C3**: The point at the most inferior anterior position on the third cervical vertebra.
15. **Hyoidale (Hy):** The most superior, anterior point on the body of the hyoid bone.

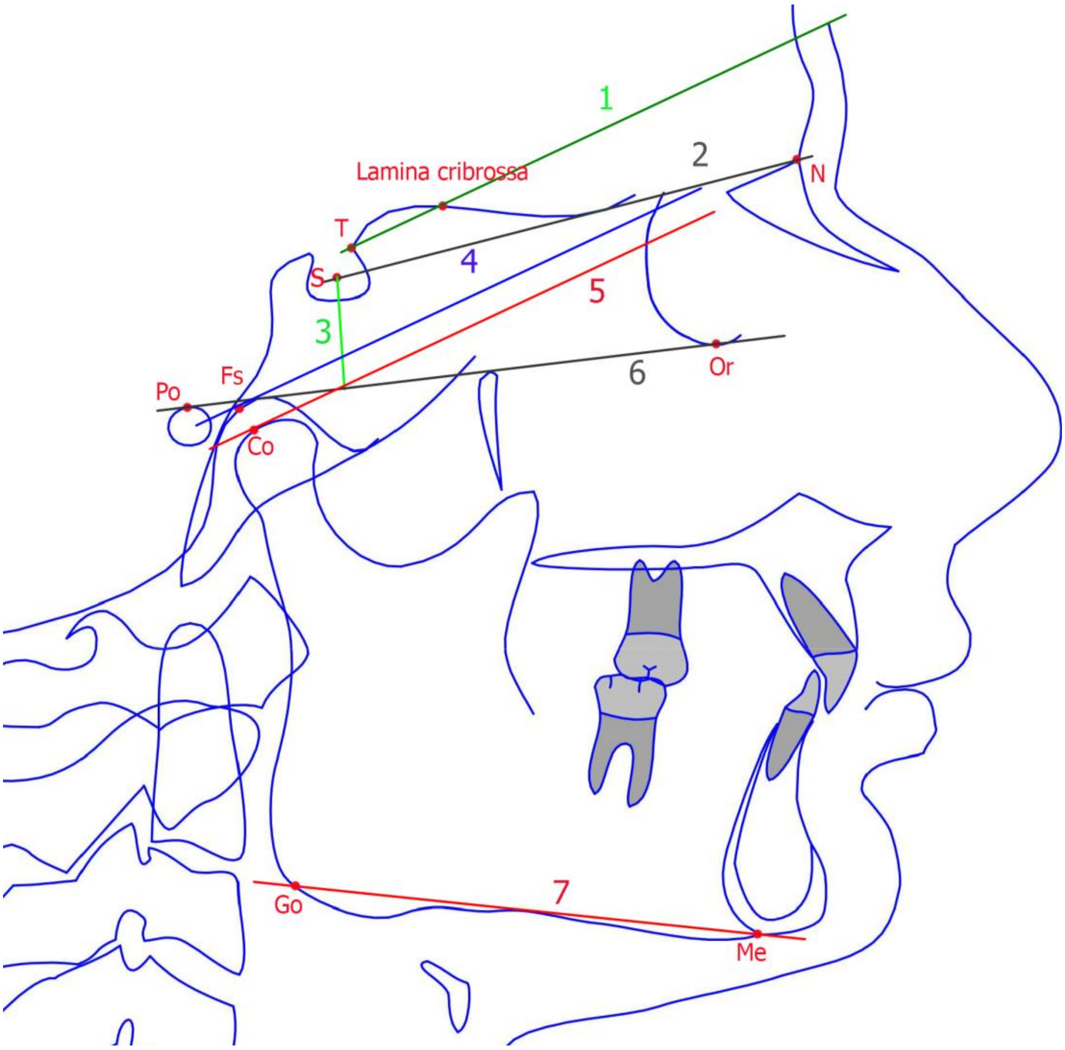
Reference planes used in study:- (Fig. 6)

1. **SBL (Stable Basicranial Line):** SBL is a line passing through point T and tangent to the lamina cribrosa of the ethmoid bone (Tollaro *et al*., 1995a, 1995b).
2. **SN plane**: The SN plane is drawn between sella (S) to nasion (N).
3. **S⊥ on FHP:** Perpendicular line drawn from sella(S) on Frankfort horizontal plane (FHP).
4. **Fs-SBL parallel plane:** Point Fs is the point on the superior margin of the glenoid fossa where a line parallel to SBL lies tangent to the superior curvature (Baccetti).
5. **Co-SBL parallel plane:** Point Co is the point on the superior margin of the mandibular condyle where a line parallel to SBL lies tangent to the superior curvature (Baccetti).
6. **Frankfort plane (**Porion to Orbitale**):** The Frankfort horizontal plane which extends from upper margin of external auditory meatus to lowest point on the infraorbital ridge was essentially called as Yon Ihering line (1872).
7. **Mandibular plane (Me-Go):** The mandibular plane is drawn between menton and gonion (Down's).



1. Sella
2. Point T
3. Lamina cribrosa
4. Nasion
5. Orbitale
6. Glenoid fossa
7. Condyle
8. Porion
9. Articulare
10. Point A
11. Gonion
12. Menton
13. Point D
14. C3
15. Hyoidale

Figure 5- Cephalometric Landmarks used in this study



1. SBL plane (T to lamina cribrosa)
2. SN plane
3. S⊥ FHP
4. Fs-SBL parallel plane
5. Co-SBL parallel plane
6. Frankfort plane
7. Mandibular plane

Figure 6- Reference planes used in study

<u>Assessment of Glenoid fossa position</u>:-

Linear measurements (in mm)-

Gf-S ⊥ on FHP- The linear distance from point Gf to S perpendicular on FHP (Fig. 7).

<u>Assessment of mandibular condyle position</u>:-

Linear measurements (in mm)- (Fig. 8)

1. **Co-S ⊥ on FHP -** The linear distance from point Co to S perpendicular on FHP.
2. **Gf- Co-** The linear distance from point Gf to Co.

<u>For overall mandibular position</u>:-

Angular measurements- (Fig. 9)

1. Saddle angle (N-S-Ar): The angle formed by joining Nasion, Sella and Articulare is an assessment of the relationship of anterior and posteriolateral cranial base.

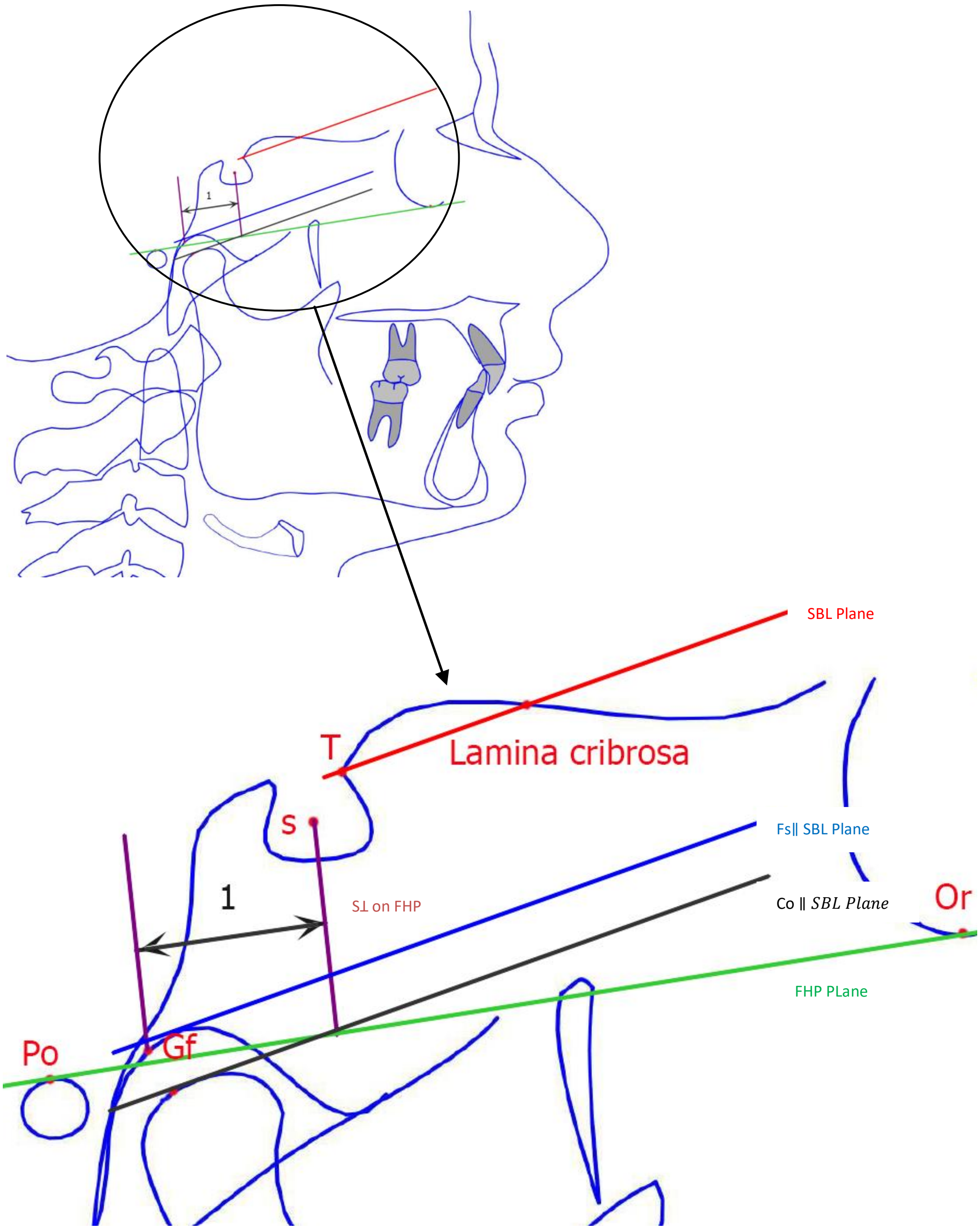
2. Articulare angle (S-Ar-Go): The angle is constructed by joining sella, articulare and gonion.

3. Gonial angle (Ar-Go-Me): The angle formed by tangents of body of the mandible and posterior border or ramus.

4. S-N-D: the angle formed between sella-nasion plane and nasion-point D plane.

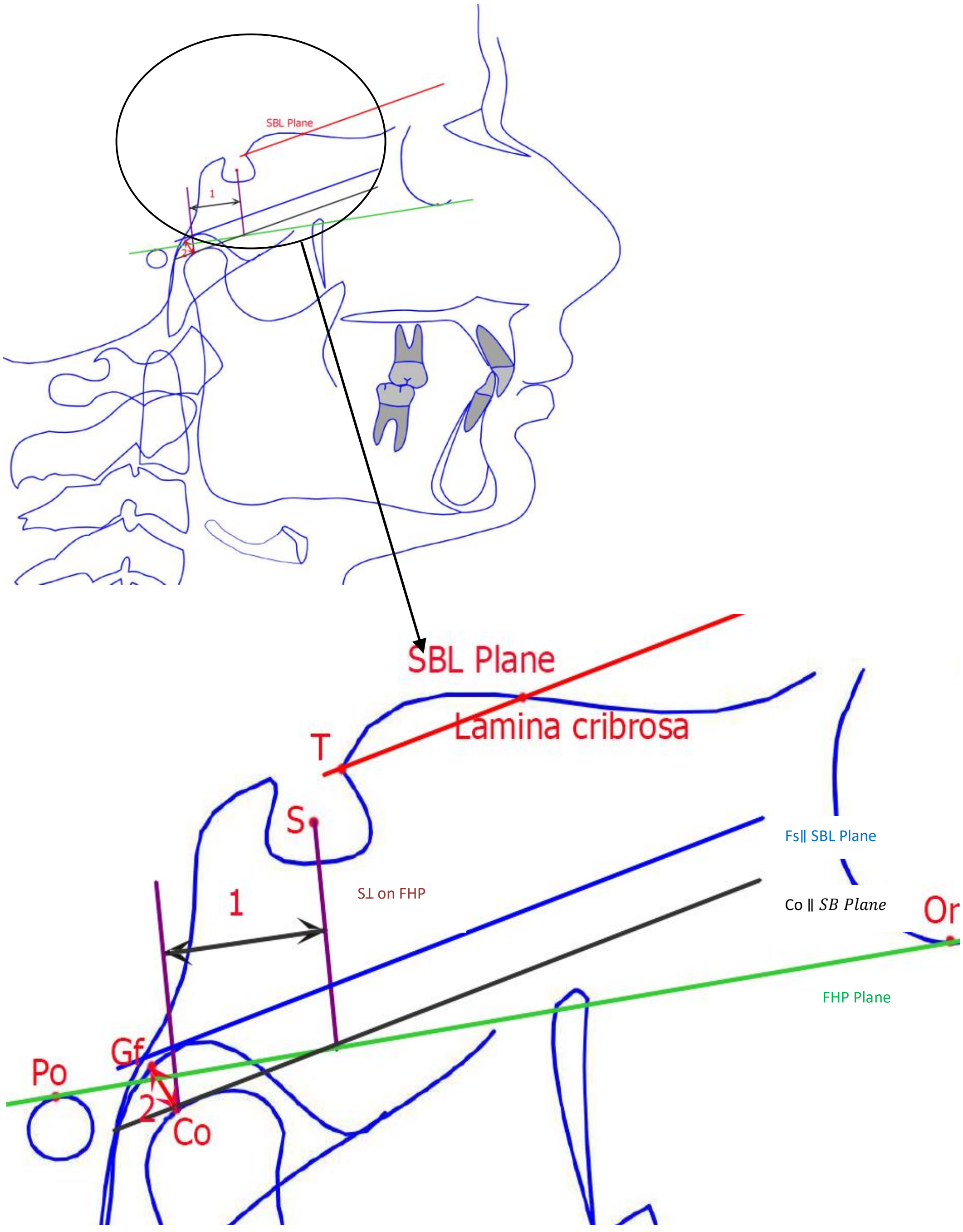
<u>Maxillary basal bone position</u>:-

S-N-A: The angle formed with sella-nasion plane and the line joining nasion and point A (Fig. 9).



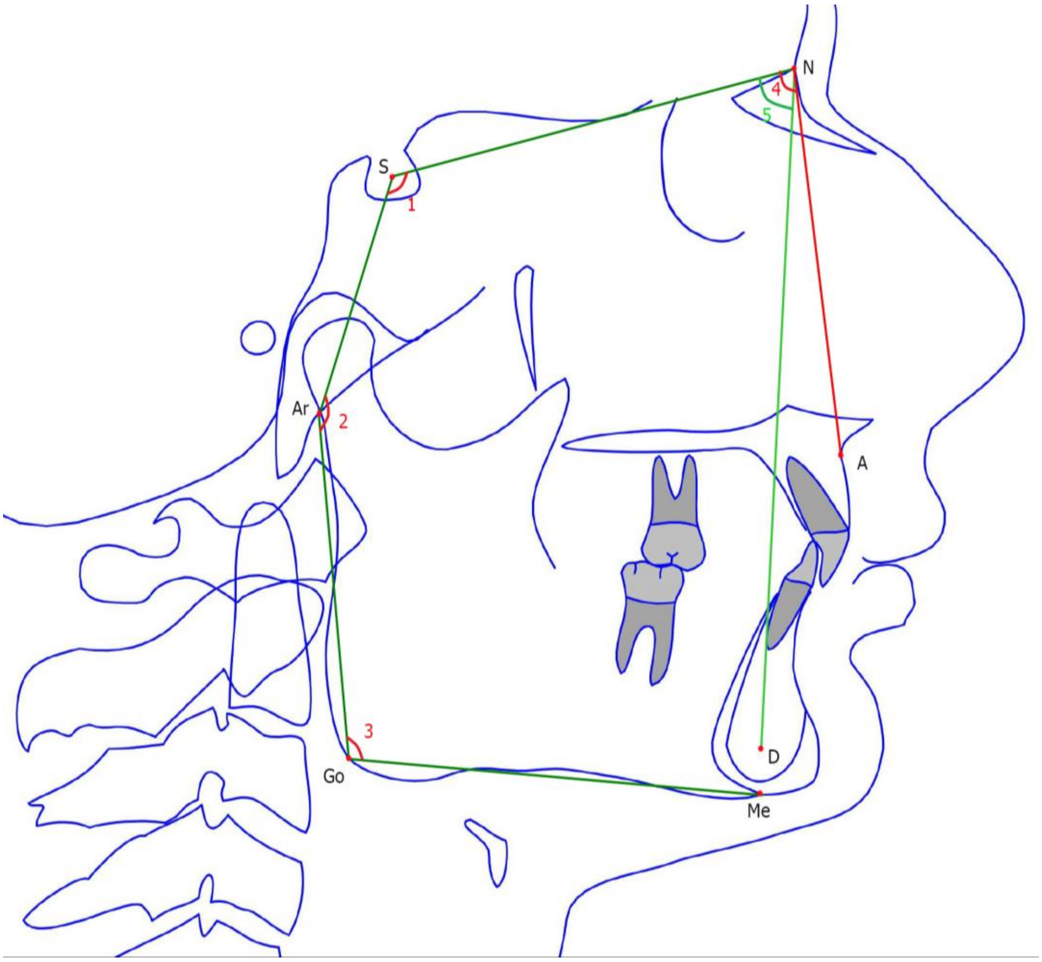
1. Gf-S⊥ on FHP

Figure 7- Linear measurement for assessment of glenoid fossa position



1. Co - S ⊥ on FHP
2. Gf- Co

Figure 8- Linear measurement for assessment of condyle position



1. Saddle angle (N-S-Ar)
2. Articulare angle (S-Ar-Go)
3. Gonial angle (Ar-Go-Me)
4. S-N-A
5. S-N-D

Figure 9- Angular measurement for assessment of overall mandibuar position and maxillary basal bone

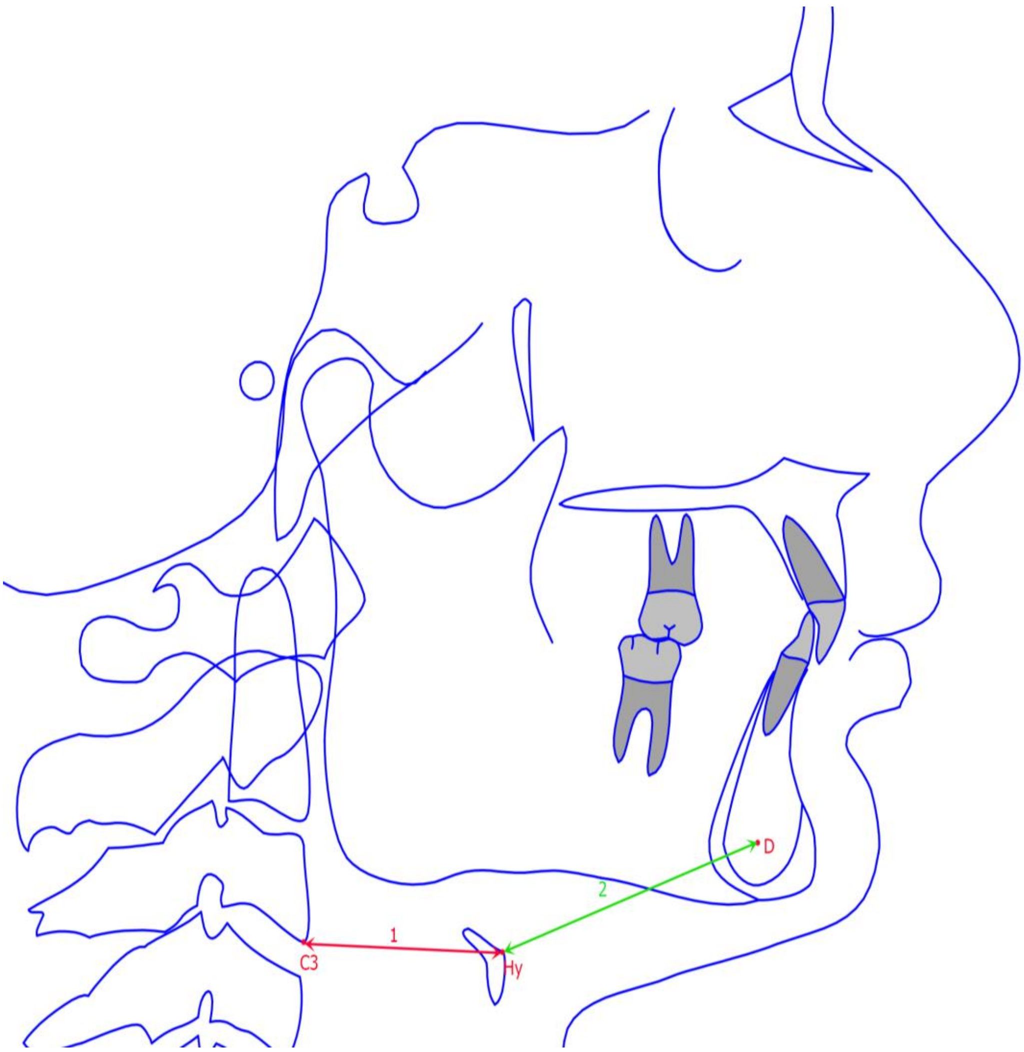
Assessment of hyoid bone position:-

Linear Measurements: (Fig. 10)

1. **C3-Hy (C3-Hy):** Formed by joining most inferior-anterior point on the third cervical vertebrae to most superior, anterior point on the hyoid bone.
2. **Hyoidale-Pt. D (Hy-D):** Line connecting most superior anterior point on the hyoid bone to center of mandibular symphysis.

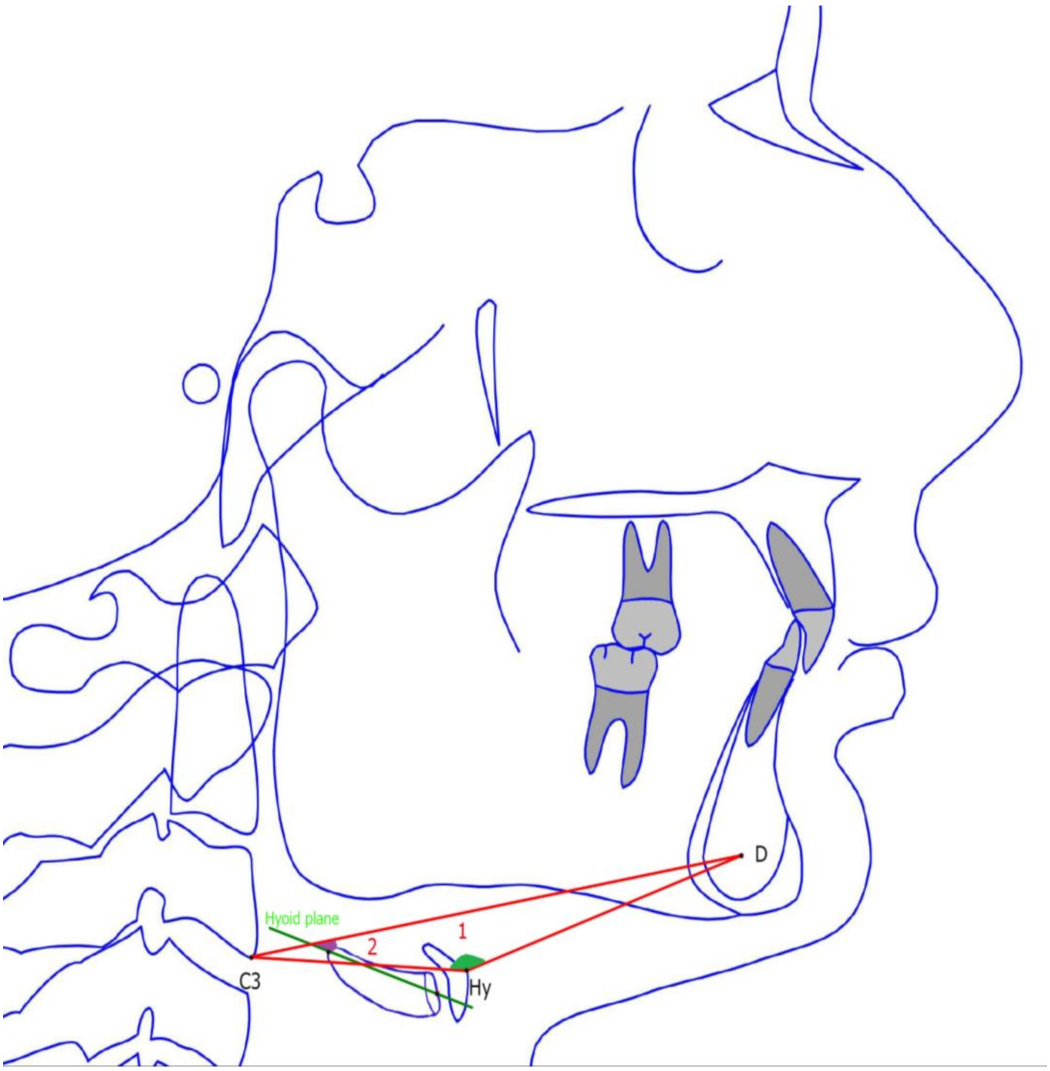
Angular Measurements: (Fig.11)

1. **Hyoidale angle (C3-Hy-D):** The angle formed by C3-Hyoidale plane and Hyoidale- point D line. The angle formed superiorly by two planes is read as hyoidale angle.
2. **Hyoid plane angle:** Formed by intersection of long axis of greater horn of hyoid with C3-Point D line.



1. C3-Hy (Bibby)
2. Hyoidale-Pt. D (Rohit khanna)

Figure 10- Linear Measurements for assessment hyoid bone position



1. C3-Hy-Point D
2. Hyoid plane angle

Figure 11 - Angular Measurements for assessment hyoid bone position

STATISTICAL TOOLS EMPLOYED

The statistical analysis was done using SPSS (Statistical Package for Social Sciences) Version 15.0 statistical Analysis Software. The values were represented in Number (%) and Mean±SD.

The following Statistical formulas were used:

1. Mean: To obtain the mean, the individual observations were first added together and then divided by the number of observation. The operation of adding together or summation is denoted by the signΣ.

The individual observation is denoted by the sign X, number of observation denoted by n, and the mean by $\overline{X}$.

$$\overline{\mathrm{X}} = \frac{\Sigma \mathrm{X}}{\text{No. of observations (n)}}$$

2. Standard Deviation: It is denoted by the Greek letterσ. If a sample is more than 30 then.

$$\sigma = \sqrt{\frac{\Sigma(X - \overline{X})^2}{n}}$$

When sample in less than 30 then.

$$\sigma = \sqrt{\frac{\Sigma(X - \overline{X})^2}{n-1}}$$

3. Student 't' test: To test the significance of two means the student 't' test was used

$$t = \frac{\overline{X}_1 - \overline{X}_2}{S\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

where $S^2 = \frac{(N_1 - 1)SD_1^2 + (N_2 - 1)SD_2^2}{N_1 + N_2 - 2}$

where $\overline{X}_1$, $\overline{X}_2$ are means of group 1 and group 2

N_1, N_2 are number of observation group1 and group 2

SD_1, SD_2 are standard deviation in group1 and group 2

4. **Level of significance**: "p" is level of significance

$p > 0.05$	Not significant
$p < 0.05$	Significant
$p < 0.01$	Highly significant
$p < 0.001$	Very highly significant

The present study was conducted to evaluate and compare the position of glenoid fossa, mandibular condyle and hyoid bone in Class II Div 2 patient before treatment and after unlocking of mandible by comparing 5 linear and 7 angular parameters on digital lateral cephalograms with the help of Nemoceph software.

A total 30 subjects, in the age range of 10-25 years (Mean age of 18.11±4.26 years) were recruited for the study (Table 1). The measurements were divided in two groups Group I (Before treatment) and Group II (After unlocking of mandible).

Table 1: Distribution of sample in Groups

Sample (Lateral cephalograms)	**Group I** (Pre-treatment)	**Group II** (After unlocking of the mandible)
N = 60	**N = 30** Mean age (17yrs 7months)	**N = 30** Mean age(18yrs 1months)

Group I- Pretreatment measurements of glenoid fossa, mandibular condyle, and hyoid bone of 30 subjects.

Group II- Measurements of glenoid fossa, mandibular condyle and hyoid bone after unlocking of mandibular of 30 same subjects.

Table 2: Descriptive statistics of different linear (millimeter) and angular (degree) parameters of glenoid fossa, mandibular condyle and hyoid bone position in Group I and Group II.

		Group I (Pre-treatment)		**Group II** (After unlocking of the mandible)	
	Parameters	**Mean**	**SD±**	**Mean**	**SD±**
Glenoid fossa (Linear measurements)	Gf-S⊥on FHP	15.00	2.55	14.26	2.61
Mandibular condyle (Linear measurements)	Co-S⊥on FHP	12.90	3.02	12.03	2.79
	Gf-Co	2.25	0.52	2.78	0.54
Overall mandibular position (Angular measurements)	S-N-D	73.63	2.89	74.08	3.23
	N-S-Ar	126.71	5.23	126.37	5.20
	S-Ar-Go	143.33	6.63	144.65	7.01
	Ar-Go-Me	118.65	8.58	119.41	8.44
Hyoid bone (Linear measurements)	C3- Hy	32.04	4.43	32.99	4.19
	Hy- Point D	40.37	4.99	41.12	5.20
Hyoid bone (Angular measurements)	C3-Hy-Point D	165.27	8.85	166.74	8.47
	Hyoid plane angle	26.97	4.02	25.55	2.44
Maxillary basal bone position (Angular measurements)	S-N-A	81.83	3.17	81.26	2.89

Table 2 shows overall mean and SD± values of various linear (millimeter) and angular (degree) parameters of glenoid fossa, mandibular condyle and hyoid bone position. In Group I glenoid fossa position (Gf-S⊥ on FHP) showed mean values of (15.00±2.55mm), where as condylar position (Co-S⊥ on FHP) mean value of (12.90±3.02mm). Gf-Co mean value of (2.25±0.52mm). Angular measurements to assess the condylar position showed SND with mean value of (73.63±2.89˚), saddle angle (N-S-Ar) (126.71±5.23˚), articulare angle (S-Ar-Go) (143.33±6.63˚) and gonial angle (Ar-Go-Me) (118.65±8.58˚). For the hyoid bone position linear measurements showed mean values for C3-Hy (32.04±4.43mm) and Hy-Point D (40.37±4.99). Angular measurements mean values for C3-Hy-D (165.27±8.85˚). For hyoid plane angle Group I was found mean value of (26.97±4.02˚). SNA in group I was found (81.83±3.17˚).

When measurements of different parameters in Group II, glenoid fossa position (Gf-S⊥ on FHP) showed mean values of (14.26±2.61mm), where as condylar position (Co-S⊥on FHP) mean value of (12.03±2.79mm). Gf-Co mean value of (2.78±0.54mm). Angular measurements to assess the condylar position showed SND with mean value of (74.08±3.23˚), saddle angle (N-S-Ar) (126.37±5.20˚), articulare angle (S-Ar-Go) (144.65±7.01˚) and gonial angle (Ar-Go-Me) (119.41±8.44˚). For the hyoid bone position linear measurements showed mean values for C3-Hy (32.99±4.19mm) and Hy-Point D (41.12±5.20mm). Angular measurements mean values for C3-Hy (166.74±8.47˚). For hyoid plane angle Group II was found mean value of (25.55±2.44˚). SNA in group II was found (81.26±2.89˚).

Table 3: Comparison of Mean±SD values of linear (in mm) parameter for glenoid fossa position in Group I (pretreatment) vs. Group II (after unlocking of the mandible).

Parameters measured for glenoid fossa (Linear measurements)	**Group I** (Pre-treatment)		**Group II** (After unlocking of the mandible)		
	Mean	**SD±**	**Mean**	**SD±**	**P value**
Gf-S⊥on FHP	15.00	2.55	14.26	2.61	0.259

* p > 0.05 Not significant, p <0.05Significant, p <0.01 Highly significant, p <0.001 Very highly significant

Table 3 shows comparison of mean and SD± values of linear parameters for glenoid fossa in Group I and Group II. Group I showed higher mean values for Gf-S⊥ on FHP (15.00±2.55mm) than Group II (14.26±2.61mm). The difference between Group I and Group II was statistically non significant (p =0.259).

Table 4: Comparison of Mean±SD values of various linear parameters (in mm) for mandibular condyle position in Group I (pretreatment) vs. Group II (after unlocking of the mandible).

Parameters measured for mandibular condyle (Linear measurements)	**Group I** (Pre-treatment)		**Group II** (After unlocking of the mandible)		
	Mean	**SD±**	**Mean**	**SD±**	**P value**
Co-S⊥on FHP	12.90	3.02	12.03	2.79	0.001*
Gf-Co	2.25	0.52	2.78	0.54	0.001*

* P > 0.05 Not significant, p <0.05Significant, p <0.01 highly significant, p <0.001 Very highly significant

Table 4 shows comparison of mean and SD± values of linear parameters for mandibular condyle position in Group I and Group II. For Co-S⊥on FHP Group I showed higher mean value (12.90±3.02mm) as compared to Group II (12.03±2.79mm) and difference was statistically significant (p= 0.001). Glenoid fossa to condyle distance (Gf-Co) in Group I was lesser (2.25±0.52mm) as compared to group II (2.78±0.54mm) and this difference was statistically significant (p= 0.001).

Table 5: Comparison of Mean±SD values of various angular (in degree) parameters of mandibular position in Group I (pre-treatment) vs. Group II (after unlocking of the mandible)

Parameters measured for mandibular position (Angular measurements degree)	**Group I** (Pre-treatment)		**Group II** (After unlocking of the mandible)		
	Mean	**SD±**	**Mean**	**SD±**	**P value**
S-N-D	73.63	2.89	74.08	3.23	0.003*
N-S-Ar	126.71	5.23	126.37	5.20	0.143
S-Ar-Go	143.33	6.63	144.65	7.01	0.012*
Ar-Go-Me	118.65	8.58	119.41	8.44	0.214

* $p > 0.05$ Not significant, $p < 0.05$Significant, $p < 0.01$ Highly significant, $p < 0.001$ Very highly significant

Table 5 shows comparison of mean and SD± values of angular parameter for overall mandibular position in Group I and Group II. For SND in Group I showed lesser mean (73.63±2.89mm) as compared to group II (74.08±3.23mm) and the difference was statistically significant (p=0.003). Saddle angle (N-S-Ar) in Group I showed higher mean value (126.71±5.23˚) than group II (126.37±5.20˚) but the difference was statistically non significant (p=0.143). Articulare angle (S-Ar-Go) was observed more Group II (126.71±5.23˚) as compared to group I (143.33±6.63˚) difference was statistically significant (p=0.012). No significant difference was found for gonial angle (Ar-Go-Me) for Group II (119.41±8.44˚) and Group I and Group (118.65±8.58˚).

Table 6: Comparison of Mean±SD values of various linear parameters (in mm) for hyoid bone position in Group I (pretreatment) vs. Group II (after unlocking the mandible)

Parameters measured for hyoid bone (Linear measurements)	**Group I** (Pre-treatment)		**Group II** (After unlocking of the mandible)		
	Mean	**SD±**	**Mean**	**SD±**	**P value**
C3- Hy	32.04	4.43	32.99	4.19	0.083
Hy- Point D	40.37	4.99	41.22	5.20	0.082

* $p > 0.05$ Not significant, $p < 0.05$ Significant, $p < 0.01$ Highly significant, $p < 0.001$ Very highly significant

Table 6 shows comparison of mean and SD± values of various linear parameters for the hyoid bone position in Group I and Group II. For C3-Hy Group II showed higher value(32.99±4.19mm) as compared to Group I (32.04±4.43mm) and difference was statistically non significant(p=0.083). Hyoidale to Point D (Hy-D) distance in Group II was higher (41.22±5.20) as compared to Group I (40.37±4.99) and the difference was statistically non significant(p=0.082).

Table 7: Comparison of Mean±SD values of various angular (in degree) parameters for hyoid bone position in Group I (pretreatment) vs. Group II (after unlocking of the mandible).

Parameters measured for hyoid bone (Angular measurements)	**Group I** (Pre-treatment)		**Group II** (After unlocking of the mandible)		
	Mean	**SD±**	**Mean**	**SD±**	**P value**
C3-Hy-Point D	165.27	8.85	166.74	8.47	0.202
Hyoid plane angle	26.97	4.02	25.55	2.44	0.064

* p > 0.05 Not significant, p <0.05Significant, p <0.01 Highly significant, p <0.001 Very highly significant

Table 7 shows comparison of mean and SD values of angular parameters for the hyoid bone position in Group I and Group II. C3-Hy-D angle was found increased in Group II (166.744±12.09˚) after unlocking of the mandible, where as hyoid plane angle in Group II (25.55±2.44˚) was decrease, although the difference between two groups was statistically non significant for both the parameters.

Table 8: Comparison of Mean±SD values of angular parameter for maxillary basal bone position in Group I (pre-treatment) vs. Group II (after unlocking of the mandible).

Parameter measured for maxillary basal bone (Angular measurements)	**Group I** (Pre-treatment)		**Group II** (After unlocking of the mandible)		
	Mean	**SD±**	**Mean**	**SD±**	**P value**
S-N-A	81.83	3.17	81.26	2.89	0.192

* p > 0.05 Not significant, p <0.05Significant, p <0.01, Highly significant, p <0.001 Very highly significant

Table 8 shows comparison of mean and SD± values for SNA angle for assessing the change in maxillary position in reference to cranial base. Group I (81.83±3.17˚) and Group II (81.26±2.89˚) statistically non significant changes was observed for SNA angle between the Groups.

Malocclusions are the result of various combinations of underlying dental and skeletal disharmonies that involve several different component of craniofacial region. The morphological variations of the cranial base along with glenoid fossa position effects the anterioposterior positioning of the jaws which ultimately influences the sagittal and vertical facial disharmonies. In Angle's Class II, Div 2 malocclusion (retroclination of the upper incisors in combination with a deep bite) mandible is supposed to be placed posteriorly and during functional movements or during closure from the rest position into the intercuspal position, the mandible is trapped by the steep upper incisors and forced backwards.[23] The presumed posterior mandibular displacement is, however, thought to be favorable for the Orthodontic treatment of the malocclusion. It is assumed that when the retroclination of the upper incisors and the deep bite are corrected the mandible will spontaneously move forward into a more anterior intercuspal position and thereby simplify the Orthodontic correction of the distal occlusion.[46]

The concept of a posterior mandibular displacement in Class II, Div 2 malocclusion is controversial and not supported by evidence for or against. Baccetti et al,[3] Katsavrias et al,[28] Giuntini et al[30] and Swann et al,[47] in their studies observed that Class II malocclusion presented with a significantly more distal position of the glenoid fossa and mandibular condyle. Agronin[48] studied the cephalometric change in position of articulare (glenoid fossa) during growth and compared in Orthodontically treated patients in different growth patterns. They concluded that changes in the spatial orientation of the glenoid fossa and temporal bone may have an effect on mandibular position. Wallis[49] compared Class I, Class II, Div 1 and Class II, Div 2 individuals and found that the posterior cranial base was larger and a "typical" mandible form in Class II, Div 2 case with relatively more acute gonial and mandibular plane angles, shorter lower anterior face height, and excessive overbite. The result of the some studies argues against the assumption of posterior mandibular displacement in Class II, Div 2 malocclusion. Gianelly et al,[22] compared the condylar position in Class II cases with steep incisors and a deep bite with Class II cases without these characteristics and found no evidence of an abnormal condyle position in the steep incisor/deep bite and their findings was supported by Pullinger et al,[50] who also not found any relationship between deep bite and condyle position.

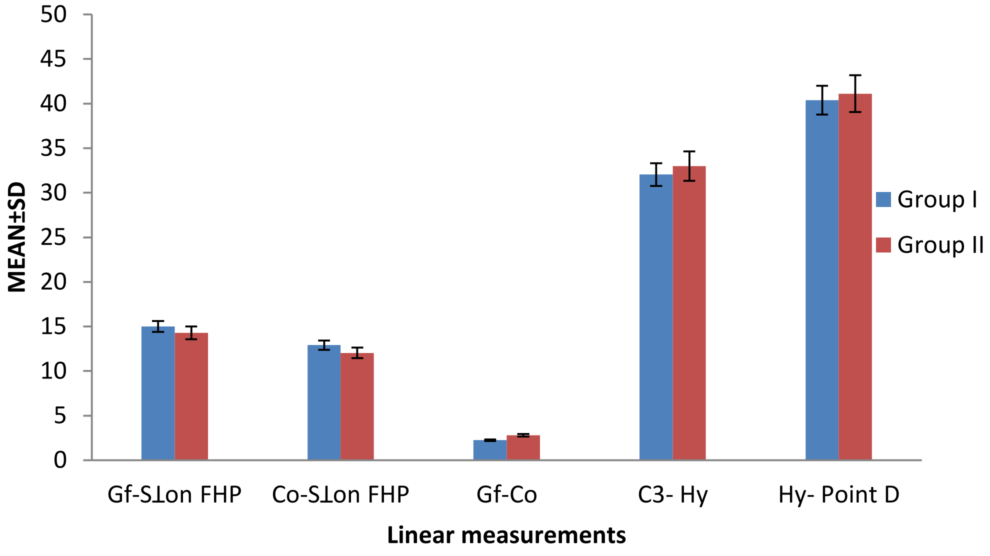
McNamara and Brudon[51] stated maxillary constriction as one of the most important cause of Class II malocclusion and relative constriction of the maxilla leads to mandibular retrusion. In Class II, Div 2 malocclusion mandible is restricted by retroclined upper incisors and the mandibular path of closure is more backward from initial contact to full occlusion, condylar rotation is both rotatory and translatory up and backward (post shift). Correcting the incisor inclination using appropriate mechanics in the early phase of treatment facilitates the spontaneous correction of Class II malocclusion by eliminating the factors restricting mandibular movement. Ricketts[52] theory states that progressive unlocking of the malocclusion is applicable to the treatment of Class II, Div 1 and Class II, Div 2 malocclusion. Spontaneous correction of Class II malocclusion may be achieved not through mandibular growth only but also through the elimination of occlusion interferences that enables the mandible to move forward to more comfortable position. Cleall and Begole (1982)[53] indicated that intrusion of incisors during initial phase of treatment may unlock the occlusion thus aiding in the correction. Erickson and Hunter[20] analyzed cephalometrically the Class II, Div 2 sample and found that mandible was repositioned anteriorly during the treatment.

Mandibular condyle is a well established mandibular growth site serve as the primary focus of functional Orthopaedic therapy to stimulate or restrict the mandibular growth.[54] Because the glenoid fossa determines the posterior superior limit of the mandible, it also has an important implication for mandibular displacement. Therefore both the condylar displacement and glenoid fossa changes must be evaluated to understand the effect of Orthodontic therapy.[7]

Hyoid bone is a key skeletal structure which maintains functions like breathing, swallowing, chewing, and head position because of insertion of the responsible muscles.[55] Hyoid bone is not fixed in space by bony articulations; hence its position is determined by muscles and ligaments which are attached to structures above and below it. The attachments of these muscles may affect the position of the hyoid bone by way of tongue movements and also through mandibular position.[13] Thus it may be influenced by the habits of tongue-thrusting and mouth breathing affecting the pharyngeal airway space. Patency of the respiratory tract is considered to be the main task of the hyoid bone. In various studies hyoid bone was related to the cranium and great variation was observed in its position even with slight movement of the head.[9,17,55-57] Ingervall[57] noticed the hyoid bone positions higher in postural position than in intercuspal position. According to Durzo and Broide[18] hyoid bone is positioned level opposite the lower portion of third cervical vertebrae and the upper position of the forth cervical vertebrae. Antero-posterior position of hyoid bone was dependent on the relative lengths of the muscles running to it and also on gravity acting on the larynx.[18,58] King[17] stated that the distance between the hyoid bone and the cervical vertebrae is constant until puberty. After studying the sample between 2 to 45 years of age Bench[58] concluded that the hyoid bone gradually descends from a position opposite to lower half of third vertebrae and upper half of fourth cervical vertebrae at the age of 3 year to a position opposite to fourth cervical vertebrae in adulthood. Comparisons have been made to evaluate the positional variation of the hyoid bone in subjects with different malocclusion groups and movement of the hyoid bone in concert with movement of the mandible, tongue, pharynx, and cervical spine were made. Grant and coworkers[59] observed constant hyoid bone position in all three Class I, II and III malocclusions. Contrary to this Duggal et al[34] found more forwardly placed hyoid bone in short face syndrome as compared to long face syndrome but the vertical position of hyoid was comparable in all vertical dysplasias. Khanna et al[15] found inferio-posterior displacement of hyoid bone in skelet al Class II, Div 1 malocclusion as compared to Class I malocclusion. Caylan and Oktay[60] observed that distance from hyoid to the cervical vertebrae was affected by change in ANB angle as it become smaller with increase in angle. Previous studies have evaluated the glenoid fossa, mandibular condyle and hyoid bone positional change in response to functional appliances in Class II, Div 1 or Class II, Div 2 cases, although no separate studies has been performed in Class II, Div 2 malocclusion patients to evaluate positional changes of glenoid fossa, mandibular condyle and hyoid bone after elimination of occlusal interference or after unlocking of mandible with fixed Orthodontic therapy.

Considering the above facts present cephalometric study was conducted on 30 patients in age range of 10-25 years with the aim to evaluate and compare the changes in position of mandibular condyle, glenoid fossa and hyoid bone after unlocking of the mandible in patients with Class II, Div 2 malocclusion. Two lateral cephalograms (one before initiating the treatment and another after unlocking of mandible) were collected either from the records of the patients with Angle's Class II, Div 2 malocclusion who had completed their treatment or were undergoing fixed Orthodontic treatment in the Department of Orthodontics and Dentofacial Orthopaedics, Babu Banarasi Das College of Dental Sciences, Lucknow. After placement of fixed Orthodontic appliance, once an acceptable maxillary arch width, U shape arch form and ideal incisor inclination were achieved; second lateral cephalogram was obtained to compare parameter selected for the study. 12 parameters (5 linear and 7 angular) were evaluated and compared with the help of Nemoceph software to evaluate the change in position of mandibular condyle, glenoid fossa and hyoid bone in Class II, Div 2 patient after unlocking of mandible. Nemoceph digital imaging software was used to measure the parameters as in the conventional method errors arise from radiographic acquision, landmark identification and measurements. Use of digital cephalometry also allows the operator to manipulate data on the computer thereby facilitating the complex analysis and organization.

The parameters analyzed were grouped and discussed as changes seen in position of glenoid fossa (Gf-S⊥on FHP), changes seen in mandibular condyle (Co-S⊥ on FHP, Gf-Co, S-N-D angle, S-N-Ar angle, S-Ar-Go angle and Ar-Go-Me angle.) and changes in hyoid bone position (C3- Hy, Hy- Point D, C3-Hy-Point D angle, Hyoid plane angle).



Bar diagram 1: Shows comparison of mean value for various linear parameters (in mm) in Group I and Group II

Change in glenoid fossa position:

Gf-S ⊥ on FHP- represents the position of glenoid fossa relative to sella (S) (Bar diagram 1 and Table 3). It was observed that Glenoid fossa (horizontal distance from Gf to S⊥ on FHP) was relocated anteriorly after unlocking of the mandible (Group II-14.26±2.61mm) as compared to pretreatment samples (Group I-15.00±2.55mm). The mean difference between Group I and Group II was about 0.74mm but it was statistically non-significant. Changes in the Glenoid fossa position may be attributed to the appositional growth of the glenoid fossa after forward displacement of condyle when restricting factor of the mandibular movement were removed by orthodontic therapy. The findings of the present study are supported by Wigal et al,[35] Bhattacharya et al,[8] Katsavrias et al,[28] and Baccetti et al.[3] Wigal et al[35] found the adaptive relocation of the glenoid fossa (OLp-GFP 1.6mm/yr) throughout (using Herbst appliance) the entire treatment but statistically non significant. Bhattacharya et al[8] evaluated effect of Twin block therapy in Class II malocclusion cases and concluded forward positioning of mandible leads to remodeling of glenoid fossa (Ar-Tvert 2.00±0.60mm). Woodside et al[21] and Bacetti et al[3] reported that the mandible advancement produced extensive remodeling and anterior relocation of glenoid fossa which contributed to anterior mandibular positioning and altered jaw positions. Pancherz[6] described the forward displacement of the articulare position of temporal bone fallowed by Herbst therapy in Class II occlusion. In progressive position of the mandible after unlocking may contribute to correction of Class II malocclusion by stimulating condylar growth or by remodeling of glenoid fossa in to a new position and thus changing the position of condyle in the fossa. The remodeling of the glenoid fossa has been demonstrated by TMJ roentogenograms by double contouring of the anterior surface of the post glenoid spine.[6,21] Voudouris[61] reported relocation of glenoid fossa anterioinferiorly to meet active condylar modification and to restore normal function during anterior orthopedic displacement of mandible. In contrast to the result of the present study Coskuner et al,[41] and Demisch[23] found no difference in relation to change in position of glenoid fossa after functional appliance therapy. Agronin,[4] Droel[62] and Anderson[5] showed greater than expected posterior fossa displacement during growth in Class II malocclusion as compared to Class I malocclusion.

Although animal studies reported that glenoid fossa remodeling and relocation occurs as an adaptation to anterior repositioning of the mandible.[21,63,64] The available human studies gives the contrary statements may be because the results of the human studies are confounded by posterior fossa displacement.[4,64,65]

Change in condyler position:

Co to S⊥ on FHP- Mandibular Condyle position was described by the change in the location of landmark condylion after unlocking the mandible. Horizontal distance from Co to S⊥ on FHP was measured (Bar diagram 1 and Table 4). Mandibular condyle was found positioned distally in pretreatment samples (Group I- 12.90±3.02mm) and forwardly displaced after unlocking of the mandible (Group II- 12.03±2.79mm). The mean difference (0.87mm) between Group I and Group II was found statistically highly significant. The findings of the present study are supported by Erickson and Hunter,[20] Coskuner et al,[41] and Demisch et al[23]. Coskuner et al[41] who found significant mandibular positional changes as well as significant increase in mandibular dimension with the forward movement of mandible in Class II, Div 2 patients (Pre-treatment Ar- Go 38.51±3.28mm, post-treatment Ar- Go 39.76±3.68mm) (Utility arch). Demisch and Ingervall[23] concluded that the mandible is posteriorly displaced in Angle Class II, Division 2 malocclusion (SNB 75.2±3.85˚) and tends to reposition anteriorly when the steep upper incisor position and the deep bite are corrected (SNB 75±4.3˚). Erickson and Hunter[20] analyzed 32 subjects with Class II, Div 2 malocclusion to identify any forward repositioning of the mandible during treatment as demonstrated by changes in Ba-Ar. They stated that unlocking the bite through routine treatment procedure enhances the forward growth of the mandible by an average of 1.5mm/year more than untreated subjects with Class II, Div 2 malocclusion. Results of the present study are in contrast to the study done by Baumrind et al.[66] who reported 1.5mm condylar growth and 1.2mm posterior fossa displacement in Class II patients aged between 8.4-10.6 years and concluded that condylar growth remain relatively constant between 8.5 and 15.5 years for both treated and untreated Class II patients. Buschang et al[7] evaluated age and gender difference in the growth of mandibular condyle and displacement of glenoid fossa in French Canadian patients using longitudional sample. They observed posterior (0.8mm - 1.3 mm) and superior (9.0 - 10.7 mm) growth of condyle in 4 years, whereas the fossa displaced posterior (1.8-2.1mm) and inferiorly (1-1.8mm).

Gf-Co- Position of the mandibular condyle (Co) relative to glenoid fossa (Gf) was represented by linear distance between glenoid fossa and mandibular condyle (Bar diagram 1 and Table 4). Linear measurement for glenoid fossa to mandibular condyle was found lesser in pretreatment sample (Group I 2.25±0.52mm) where as it increased about 0.53mm after unlocking of the mandible (Group II 2.78±0.54mm) and the difference was Statistically significant. It can be assumed from the results of the present study that the morphological alteration in joint space following the translocation of mandibular condyle is due to unlocking of mandible from its posteriosuperior position to the new adoptive modification in the Class II, Div 2 malocclusion. The findings of the present study were supported by Miranda et al[38] and Panchertz et al.[6] Miranda et al[38] stated distance between (GI) glenoid fossa to (CS) mandibular condyle (2.07±0.22mm) is less in Class II malocclusion as compared to Class I (3.02±0.58mm). Contrary to the findings of the present study Cacho et al[42] observed insignificant change in jont space after treatment of Class II malocclusion. In their study the neutral position of the condyle within the fossa, before treatment was 2.64±0.5810.35mm (posterior joint space) and it became 2.92±.086mm (posterior joint space) after treatment. They suggested that the effect should not be attributed to a forward mandibular position. Coskuner et al[41] found insignificant changes in post treatment anterior (0.986±0.012mm), superior (0.974±0.019mm), and posterior (0.946±0.017mm) joint spaces and the anteroposterior (0.957±0.037mm), and mediolateral condylar width

(0.973±0.016mm), as compared to the pretreatment measurements anterior (0.991±0.006mm), superior (0.975±0.020mm), and posterior (0.975±0.020mm) joint spaces and the anteroposterior (0.946±0.015mm) and mediolateral condylar widths (0.953±0.035mm), that indicating restrictions of the mandible in the transverse or sagittal plane do not affect the temporomandibular joint positions because of the high adaptability of this joint.

Change in hyoid bone position:

The hyoid bone which moves in unison with the translation the of mandible was observed in the present study by assessing linear measurement (C3- Hy and Hy-Point D) and angular measurement(Hyoidale angle and Hyoid plane angle) (Bar diagram 1 and Table 6). C_3 to Hyoid bone (Hy) and body of Hyoid (Hy) to mandibular symphyseal center (Point D) was found statistically non significant.

C3- Hy- represents the anterior position of the hyoid bone relative to third cervical vertebra (C3). It also represents the anterior bony body of the pharynx at a lower level. (Bar diagram 1 and Table 6). Statistically non significant difference was observed for linear measurements between third cervical vertebrae (C_3) to Hyoidale (Hy) although it was increased in Group II (32.99±4.19mm) as compared to Group I (32.04±4.43mm).

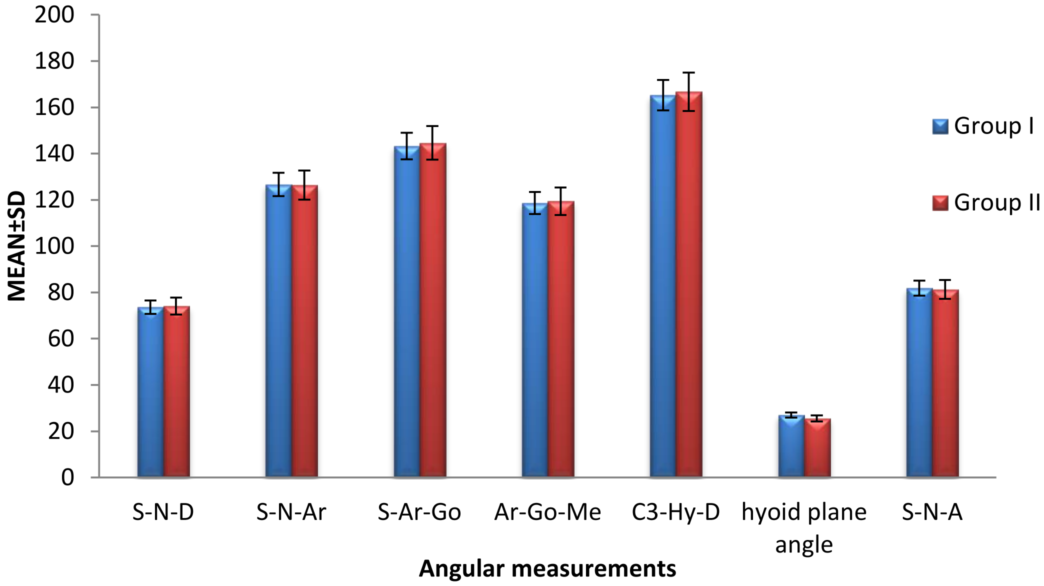
Increase in the distance between C_3 to Hy in the present study may be expected as a result of forward repositioning of the mandible due to unlocking. As the hyoid bone attached to the mandible through muscle change in mandibular position also change the position of hyoid bone, and furthermore movements due to forward movement of the mandible the hyoid bone also move anteriorly resulting in increased distance relative to third cervical vertebrae.

The findings of present study are supported by Verma et al[36], Battagel et al[16] and Khanna et al[15]. Verma et al[36] noted hyoid bone positioned more anteriorly after Twin block treatment (Hy-CL 49.80±8.9mm) in hypodivergent patients as compared to pretreatment (Hy-CL 46.80±3.2mm). Battagel et al[16] concluded position of hyoid bone (Hy-C5 37.2±6.2mm) was related to mandibular retrusion and after mandibular protrusion the distance was increased by 2.9mm. In retrognathic mandible an inferioposterior displacement of hyoid bone (C3-Hy 37±4.19mm) was found by Khanna et al[15], Duggal et al[34] suggested that hyoid bone closely followed the axial inclination of the mandible. Conflicting result was shown by study done by Kumar et al[45] who found the hyoid bone tends to move in a posterior and inferior direction but the difference between the pretreatment (32.69±1.38) and post-treatment (31.67±1.42) was statistically insignificant.

Hy- Point D- represents the position and movements of hyoid bone relative to point D (center of the body of mandibular symphysis) (Bar diagram 1 and Table 6). Non significant increase was observed between Group I (40.37±4.99mm) and Group II (41.22±5.20mm) for the distance between Hyoid bone to Point D. Literature suggests that the hyoid bone is positioned posteriorly in Angles class II malocclusion patients due to retrusion of mandible.[15] After unlocking of mandible translation of mandible occurs and lead o more forward position of hyoid bone, but the hyoid bone position is governed by the location of the mandible as well as by the tongue. It might be expected that a low hyoid would be associated with a tongue which had an extensive vertical component and which would be much more difficult to move forward in response to protrusion. Wide variation was found in both amount and direction of the response of the hyoid to mandibular protrusion. The findings of the present study was supported by Verma et al[36] who found that after functional appliance therapy hyoid bone move anteriorly along with mandible as it was repositioned forwardly by functional appliance. Result of the present study are contrary to Battagel et al[16] who recorded the hyoid bone position in reletion to both maxilla and mandible, as well as to the cervical spine and vallecula with respect to mandible they found hyoid bone moved forward coming closure to 3.4mm to point B after using mandibular protrusion appliance in obstructive sleep apnea patients. Amayeri et al[14] stated sagittal position of the hyoid bone in relation to the mandible (Hy-Rgn 38.63±7.69mm) in Class II malocclusion. Eggensperger et al[26] evaluated hyoid bone position in surgical treatment (Orthognathic surgery) of Class II malocclusion, and found significant anterior movement of hyoid bone by 1 mm.

Hyoidale angle (C_3-Hy-Point D) - The other angular finding was observed by increase in Hyoidale angle (C_3-Hy-D) (Group I 165.27±8.85˚ and Group II 166.74±8.47˚) as compared to but was well below statistical significance level.

Hyoid plane angle- Furthermore the hyoid plane angle depicting the evaluation of hyoid bone body to the greater horn was found to be statistically non significant difference (Group I 26.97±4.02˚and Group II 25.55±2.44˚) (Bar diagram 2 and Table 7). The observation shows the hyoid plane angle which is form from C_3 – Point D to long axis of hyoid bone, is reduced while unlocking of the mandible probably due to superior positioning of hyoid bone. It could be due to the muscular pull by Geniohyoid, Hyoglossus, Genioglossus and Anterior belly of digastric muscles generated secondarily to the anteriorly positioned mandibular symphysis post unlocking.



Bar diagram 2: Shows comparison of mean value for various angular (in degree) parameters in Group I and Group II

Change in Overall mandibular position:

SND angle -represents the position of the mandible relative to Sella, Nasion and Point D (S-N-D). It shows the position of mandible to cranial base (Bar diagram 2 and Table 5). Statistically significant difference was observed for angular measurement between Sella, Nasion and Point D although it was increased in Group II (74.08±3.23˚) as compared to Group I (73.63±2.89˚). Increase in the angle between cranial base to Point D may be expected as a result of forward repositioning of the mandible due to unlocking. The findings of present study are supported by Demisch et al.[23] Khanna et al.[15], Amayeri et al.[14] Demisch et al.[23] concluded that the mandible is posteriorly displaced in Angle Class II, Division 2 malocclusion (SNB 75.2±3.85˚) and tends to reposition anteriorly when the steep upper incisor position and the deep bite are corrected (SNB 75±4.3˚).

Saddle angle (N-S-Ar) - represents the position of the articulare relative to Sella and Nasion. Which is also known as the cranial base flexure angle helps determine the changes in the cranial base angulations (Bar diagram 2 and Table 5). Statistically non significant difference was observed for angular measurement between Nasion (N), Sella(S) and Articulare (Ar). Although it was decrease in Group II (126.37±5.20˚) as compared to Group I (126.71±5.23˚). Decreased saddle angle may be expected as a result of forward repositioning of the mandible due to unlocking. These findings were supported by Bustani et al.[31] Coskuner et al.[41] Bustani et al.[31] found decrease in the saddle angle pretreatment (128.7±0.927˚) was and it reduced in post treatment (127.47±1.0˚) in Class II, Div 1 malocclusion (Activator), and concluded the anterior displacement of the condyle with remodeling of the glenoid fossa. Coskuner et al.[41] found no significant changes in saddle angle before (124.86±6.51) and after unlocking (124.86±6.5) of the mandible probably due to highly adoptability of temporomandibular joint.

Articulare Angle (S-Ar-Go) - represents the position of the articulare relative to Sella and Gonion (Bar diagram 2 and Table 5). Statistically significant difference was observed for angular measurement between Sella (S), Articulare (Ar) and Gonion (Go) although it was decreased in Group II (143.33±6.33˚) as compare to Group I (144.65±7.01˚). Decrease in the articulare angle may be expected as a result of forward repositioning of the mandible due to unlocking. Many authors[8,19,31,41] found forward positioning of the articulare and decreased articulare angle after functional therapy secondarily to mandibular translocation by myofunctional therapy and deep bite correction (unlocking). Bustani et al.[31] found decrease in post-treatment (141.16±3.59˚) Articulare angle as compared to pretreatment (141.45±2.05˚) after using myofunctional appliance (Activator) in Class II, Div 1 malocclusion. Similar finding was found by Luder[19] decrease in post-treatment (138.0±5.5˚) Articulare angle as compared to pretreatment (136.4±6.3˚) after using myofunctional appliance (Activator).

Gonial angle (Ar-Go-Me) - represents the position of the gonion (Go) relative to articulare (Ar) and menton (Me) (Bar diagram 2 and Table 5). Statistically non significant difference was observed for gonial angle although it was decreased in Group II (119.41±8.4˚) as compared to Group I (118.65±8.59˚). This finding was supported by Bustani et al.[31] found decrease in post-treatment (127.2±3.26˚) gonial angle as compared to pretreatment (125.18±1.537˚) after using myofunctional appliance (Activator) in Class II, Div 1 malocclusion.

<u>Change in maxillary basal bone position:</u>

SNA angle- represents the position of the maxilla (Point A) relative to Sella (S) to Nasion (N). It shows the position of maxilla to cranial base (Bar diagram 2 and Table 8). Statistically non significant difference was observed for SNA angle although it was more in Group I (81.83±3.23˚) as compared to Group II (81.26±2.89˚).This finding was again supported by Bustani et al who found decrease in post-treatment (79.30±2.25˚) SNA angle as compared to pretreatment (81.30±1.34˚) after using myofunctional appliance (Activator) in Class II, Div 1 malocclusion which gives a restraining effect over the maxilla.

The results of the present study suggest that unlocking of the mandible in Class II, division 2 malocclusion cases leads to relocation of the glenoid fossa due to adaptive changes and forward positioning of the mandibular condyle. Significant morphological alteration in joint space was realized following the translocation of mandibular condyle due to unlocking of mandible from its posteriosuperior position to the new adoptive location. Statistically insignificant alteration in hyoid bone position was also observed when the steep upper incisor position and the deep bite are corrected and the mandible was unlocked.

The present study was conducted in Angle Class II, Div 2 malocclusion with a wide age range (10-25yrs) which include both growing and non growing patients. Future studies can be designated to evaluate and compare the glenoid fossa, mandibular condyle and hyoid bone positional alteration after unlocking of the mandible growing and non growing patients separately to demonstrate the difference in the growth response of glenoid fossa, mandibular condyle and hyoid bone after unlocking of the mandible among these patients.

The following conclusion can be drawn from the study.

1. Relative change in position of glenoid fossa was observed due to anterior remodeling secondary to relocation of mandibular condyle.
2. The significant anteriorly postured mandibular condyle was observed after mandibular unlocking, leading significant alteration of joint space in TMJ.
3. Hyoid bone was positioned more anteriosuperiorly as mandible translate forwardly after unlocking of mandible, although the difference was statistically non-significant.

Skeletal malocclusion is a set of human craniofacial morphological characteristics that occurs either due to deficiency or due to increase in volume or proportion of skeletal bases in all the three planes of space that is sagittal, vertical or transverse plane. The malocclusion in sagittal plane was classified by Angle constitutes Class I, Class II Div I, Div II and Class III malocclusion. Features of Class II Div 2 malocclusion include retroclined incisors, backward path of closure and functional retrusion of mandible. Deep bite, high lip line, deep mento-labial sulcus, and prominent chin, a decreased effective length of mandible and competent lips are also present.

Spatial orientation of the glenoid fossa and malocclusion is likely to play important role in the establishment of different craniofacial pattern during growth. Relative change in position of glenoid fossa can occur as a result of local remodeling or as a result of spatial repositioning of the entire temporal bone. The glenoid fossa determines the posterior/superior limit of the mandible; it holds important implications for mandibular displacement. In Class II Div. 2 malocclusion mandible is locked against glenoid fossa that determines posterior-superior limit of mandibular condyle. The mandibular condyle serves as the primary focus of functional Orthopaedic therapy to stimulate or restrict the mandibular growth. On unlocking of mandible, it moves forward initiating growth of condyle in backward direction.

Hyoid bone is a U shaped bone which developed from the second and third brachial arches and the posterior one third of the tongue. It located in the anterior midline of the neck, at the level of the third vertical vertebrae and forms the anterior bony boundary of the pharynx. The importance of the hyoid bone lies in its unique anatomic relationships. It has no bony articulations but provides attachment for muscles, ligaments, and fascia of the pharynx, mandible, and cranium.

As mandible had anatomically attached to hyoid bone via various suprahyoid muscles and fascia, hence hyoid position varies because of anterio-posterior position of mandible. The hyoid bone position was lower in Class III malocclusion than in Class I and Class II malocclusions in relation to the anterior cranial base (SN plane) and the Frankfort plane in the vertical plane. Retrognathic mandible may also lead to infero-posterior displacement of the hyoid bone as studied by Khanna et al. Inferior posterior displacement of hyoid bone might affect the tongue posture in oral cavity and stretching of the pharyngeal wall, because hyoglossus muscle and middle constrictor muscle of the pharynx take their attachment from greater horn of hyoid bone.

In Class II div 2 patients, the path of closure is more backward, demonstrating functional retrusion. From initial contact to full occlusion condylar rotation is both rotatory and translatory up and backward (post shift). As soon as mandible is unlocked in such cases by correction of axial inclination of maxillary incisors, mandible slides downward and forward there by opening the bite as well as improving the sagittal relationship. The change in condylar position, glenoid fossa and hyoid bone is anticipated as the result of the translation of mandible. Mandibular condyle, glenoid fossa and position were recorded by various parameters measured on lateral cephalograms.

Considering this, the present study was designed to evaluate and compare the changes in position of mandibular condyle, glenoid fossa and hyoid bone after

unlocking of mandible in Class II Div 2 malocclusion cases on lateral cephalograms of 30 patients in age range of 10-25 years. Two lateral cephalograms (one before initiating the treatment and another after unlocking of mandible) were collected from the records of the patients. Cephalograms was obtained to compare parameter selected for the study. 12 parameters (5 linear and 7 angular) were evaluated and compared with the help of Nemoceph software to evaluate the change in position of mandibular condyle, glenoid fossa and hyoid bone in Class II Div 2 patient after unlocking of mandible. Nemoceph software was used to measure the parameters.

The parameters were analyzed and compared for position of mandibular condyle (Co-S⊥ on FHP, Gf-Co, S-N-D angle, S-N-Ar angle, S-Ar-Go angle and Ar-Go-Me angle.), glenoid fossa (Gf-S⊥on FHP), and hyoid bone position (C3- Hy, Hy- Point D, C3-Hy-Point D angle, Hyoid plane angle). The mean values thus obtained were compared for mandibular condyle, glenoid fossa and hyoid bone position in pretreatment and after unlocking of mandible.

Based on the result of the study following conclusion were drawn.

1. Relative change in position of glenoid fossa was observed due to anterior remodeling, secondary to relocation of mandibular condyle.
2. The significant anteriorly postured mandibular condyle was observed after mandibular unlocking, leading significant alteration of joint space in TMJ.
3. Hyoid bone was positioned more anteriosuperiorly as mandible translate forwardly after unlocking of mandible, although the difference was statistically non-significant.

The present study was conducted in Angle Class II Div 2 malocclusion with a wide age range (10-25yrs) which include both growing and non growing patients. Future studies can be designated to evaluate and compare the glenoid fossa, mandibular condyle and hyoid bone positional alteration after unlocking of the mandible growing and non growing patients separately to demonstrated the difference in the growth response of glenoid fossa, mandibular condyle and hyoid bone after unlocking of the mandible among these patients.

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