

**EVALUATION OF CRANIOFACIAL
DIMENSIONS IN SAGITTAL AND TRANSVERSE
PLANE IN SUBJECTS WITH CLEFT LIP AND
PALATE- A CBCT STUDY**

DISSERTATION

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In the partial fulfillment of the requirements for the degree

**of
MASTER OF DENTAL SURGERY
In
ORTHODONTICS AND DENTOFACIAL ORTHOPAEDICS
By**

Dr. Sineen Khan

Under the guidance of

Dr. Shantanu Khattri

Professor

Department of Orthodontics and Dentofacial Orthopaedics

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LUCKNOW**

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Date: 5/3/25

GUIDE

Dr. Shantanu Khattri, Professor & Head
Department of Orthodontics and Dentofacial Orthopaedics BBDCODS, BBDO
Lucknow

CO-GUIDE

Dr. Sneha Lata Verma, Professor
Department of Orthodontics and Dentofacial Orthopaedics BBDCODS, BBDO
Lucknow

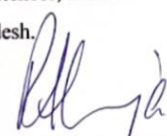
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**Dr. Shantanu Khattri, Professor & Head**Department of Orthodontics and Dentofacial
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BBDCCDS, BBDU

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Sineen Khan

Dr. Sineen Khan

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Date: 8/3/25

Place: BBD COLS



Dr. Sineen Khan

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LIST OF ABBREVIATIONS

S.NO	ABBREVIATED FORM	FULL FORM
1.	N	Nasion
2.	Se	Sella entrance
3.	S	Sella
4.	Co	Condylion
5.	Ba	Basion
6.	Ar	Articulare
7.	Go	Gonion
8.	ANS	Anterior Nasal Spine
9.	PNS	Posterior Nasal Spine
10.	Pog	Pogonion
11.	Gn	Gnathion
12.	M	Menton
13.	Lo	Frontozygomatic Suture
14.	Zy	Zygomatic arch point
15.	Nc	Nasal Cavity Point
16.	J	Jugale point
17.	Max6	Maxillary molar
18.	Mand6	Mandibular molar
19.	Ag	Antegonial notch

AIM: To evaluate and compare the cranio-facial dimensions in sagittal and transverse plane in surgically repaired cleft lip and palate patients and non cleft patients using CBCT images.

MATERIAL AND METHOD: 30 CBCT scans were collected from the Department of Plastic Surgery,KGMU based on the inclusion and exclusion criteria and were grouped as:**GROUP I (n=15)** included subjects with surgically repaired cleft lip and palate who came to the Department of Plastic Surgery,KGMU through Smile Train for orthodontic treatment;**GROUP II (n=15)**included non-cleft subjects from the Department of Plastic Surgery,KGMU.35 parameters(22 linear and 13 angular) were evaluated to assess craniofacial dimensions in sagittal,coronal and axial planes using Carestream CS 9300 imaging software.The data obtained was tabulated and subjected to statistical analysis using SPSS software.

RESULT:Significantly shorter anterior and posterior cranial base length with significantly increased cranial base angle was seen in Group I in comparison to Group II.Maxilla was restricted in all three planes with significantly shorter maxillary length Group I($44.047 \pm 1.1463\text{mm}$) < Group II ($48.513 \pm 1.6894\text{mm}$) also the posterior positioning of the maxilla was seen. Decrease maxillary width as well as maxillary molar width was observed in Group I than in Group II.Mandible was placed normally.Group I demonstrated increased vertical dimensions with tendency towards clockwise rotation in comparison to Group II .A tendency towards concave profile and skeletal Class III pattern was seen in Group I.The restricted maxillary growth was also reflected in retruded and upright maxillary incisors in Group I.

CONCLUSION: Noticeable horizontal asymmetry for the maxilla in all three planes (sagittal, coronal and axial) with significant overall vertical asymmetry in sagittal plane in surgically repaired cleft subjects was observed.This must be considered while planning treatment for cleft subjects.

Key words: Cleft lip and palate,craniofacial dimensions,cone beam computed tomography.

Most common congenital anomaly, cleft lip and palate have an aesthetic concern along with various functional disturbances of feeding, hearing, speech, respiration and dentofacial development and treatment requires a multidisciplinary approach.¹

Cleft lip occurs due to incomplete fusion of the lateral nasal process and the maxillary process during 5th-12th week of intrauterine life and could be unilateral or bilateral whereas cleft entailing the palate can be a result of failure of fusion of the palatal shelves.² Types of oral clefts differ by location (i.e. lip, palate or both) and extent (i.e. complete or incomplete; soft palate only or soft or hard palate). Cleft lip and palate has high prevalence in American Indians (3.74 per 1000) followed by Japanese (2.68 per 1000) and the Chinese (1.92 per 1000).³

The clinical presentation of craniofacial region of CLP patients significantly affects all three planes, i.e. Sagittal, Vertical and Transverse plane.⁴ The abnormal features associated with CLP patients are deficient mid face development resulting in class III malocclusion, retrognathic maxilla, maxillary transverse deficiency causing posterior cross bite and anterior cross bite. Dental abnormalities such as hypodontia (usually the maxillary lateral incisors and canines), supernumerary teeth, ectopic, malformed teeth and delayed eruption of teeth are also found in cleft lip and palate patients.⁵ In these patients, dental and skeletal problems require different orthodontic interventions during deciduous dentition to late permanent dentition to achieve functionally optimum occlusion and best possible aesthetics.

Attempts to salvage these malformations start early in life with surgical procedures for lip repair which include Tennison-Randall technique and Millard rotation advancement technique. The palatal repair follows later and is done using two-stages, commonly by Von Lagenbeck procedure or a Veau-Wardill-Kilner pushback operation.⁶ There are various treatment protocols which are followed across the world defining the timing of these surgical procedures namely IOWA protocol, OSLO

protocol,AIIMS protocol,American Cleft Protocol and Eurocleft study etc.According to these protocols lip repair should be performed at 3-4 months of age followed by repair of the hard and soft palate at 12-14 months of age.⁷

Krogman⁸stated that conservative surgery of lip and palate if properly timed with minimum mucoperiosteal involvement does not encourage deviant maxillofacial growth and also a catch up growth has also been observed postoperatively.Lip and palate surgery contributes dramatically to cosmetic and functional rehabilitation of the patient. However, the timing and technique of the surgical repairs for lip and palate are a controversial issue and it is still doubtful whether the surgical procedures carried out to close the defect has an impact on future growth of maxilla and mandible. Surgeons believe that early palate repair is associated with better speech results but according to **Ortiz-Monasterio et al**⁹, **Bishar a et al**¹⁰, **Mars and Houston**¹¹ and **Capellozza et al**¹² early repair tends to produce severe dentofacial deformities as maxillary deficiency. However, **Isiekwe and Sowemimo**¹³, and **Yoshida and Nakamura**¹⁴ claimed that maxillary deficiency in cleft individuals was an intrinsic primary defect. **Ross and Williams et al**¹⁵ identified that factors affecting the craniofacial growth in patients with cleft lip and palate includes intrinsic developmental malformations(morbidity), iatrogenic factors(post surgical effects) and functional distortions.

Few cephalometric studies have evaluated the transverse and sagittal morphology of patients affected by cleft lip and palate. **Abuhijleh et al(2014)**¹⁶ conducted a cephalometric study to compare the craniofacial morphology and asymmetry before, during, and after puberty within and between patients with unilateral complete cleft lip and palate (UCLP) and a non-cleft group. For all measurements, asymmetry on the horizontal plane in UCLP group was more significant than that on the vertical plane. **Athanasiou et al (1991)**¹⁷studied the transverse dentofacial morphology and growth of 64 surgically treated children of cleft lip and palate by means of a frontal proportional cephalometric analysis and found significantly increased ratios of the

inner orbital width to the interorbital width and of the width of the nasal cavity to the interorbital width. **Alexandr a I. Holst et al(2009)¹⁸** in a cephalometric study investigated whether the craniofacial vertical and sagittal jaw relationship in patients with cleft lip and palate (CLP) differed from that of age matched non cleft controls, before and after the pubertal growth spurt. The results revealed that despite a measured skeletal class I in both male and female patients with cleft lip and palate regardless of cleft type, there was a slight tendency towards a skeletal class III.

These lateral cephalometric studies are of less significance for the patients affected by CLP because of superposition of bilateral craniofacial structures and difficulty in landmark identification. In comparison to 2D techniques CBCT provides more accurate skeletal,dental and volumetric measurements because, in 3D CBCT regional anatomy is shown in a series of cross- sectional axial images unobstructed by other anatomic features (**Suri et al 2008¹⁹** , **Suleyman Kutalmis et al 2017¹**,**Anuraj S Kochar 2021²⁰**). Requisite for comprehensive treatment in CLP patients requires treatment in both the sagittal and transverse dimensions because in the end, a symmetrical morphological outcome is desired. There is a paucity of studies which have focused on measuring both the transverse and sagittal parameters of patients affected with repaired CLP.

Hence, the present study was conducted to evaluate the craniofacial morphology of surgically repaired CLP patients in sagittal and transverse plane using CBCT and to evaluate the iatrogenic effects of surgical procedures on the morbid anatomy.

AIM:

To evaluate and compare the cranio-facial dimensions in sagittal and transverse plane in surgically repaired cleft lip and palate patients and non cleft patients using CBCT images.

OBJECTIVES:

- 1.To evaluate the cranio-facial dimensions in sagittal plane in surgically repaired cleft lip and palate patients and non-cleft patients using CBCT.
- 2.To evaluate the cranio-facial dimensions in transverse plane in surgically repaired cleft lip and palate patients and non-cleft patients using CBCT.
- 3.To compare the cranio-facial dimensions of surgically repaired cleft lip and palate patients with non-cleft patients in sagittal plane.
- 4.To compare the cranio-facial dimensions of surgically repaired cleft lip and palate patients with non-cleft patients in transverse plane.

Graber TM (1949)⁴ studied the developmental characteristics of cranio-facial region in cleft subjects by taking cephalograms of 33 cleft palate patients who were in age range of 4 to 30 years. The cases were selected at random including operated, un-operated and orthodontically treated cases. Lateral cephalograms were taken into 3 positions namely: wide open, physiologic rest, and at occlusion. PA cephalograms were taken in to two positions namely: physiologic rest and at occlusion. They concluded that maxilla in cleft palate and cleft lip cases is deficient not only in its antero-posterior and lateral growth but also in vertical growth. There is marked freeway space in cleft palate individuals when compared to normal. Mandibular growth is apparently normal in surgically repaired patients. There is excessive lingual inclination of lower incisors. The orthodontic treatment in surgically repaired cases does not necessarily stimulate basal bone development and require indefinite retention.

Aduss H (1971)⁶⁸ through a longitudinal study, studied the craniofacial growth in complete unilateral cleft lip and palate patients and compared it with normal children. His sample consisted of 71 patients out of which 50 males and 21 females with complete unilateral cleft lip and palate. Lateral cephalograms were taken each consecutive year from the 4th-year onwards. By comparing the measurements obtained from the tracings of lateral cephalograms, he found that the Gonial angle was larger and anterior cranial fossa was more elevated. But the pattern of growth and development in the cleft sample remained the same as that of non-cleft children.

Badarch J et al (1979)⁶⁹ studied the relationship between lip pressure and its effect on facial growth. Their sample consisted of 62 white rabbits which were divided into four groups. Group I had 15 un-operated rabbits, Group II has 16 rabbits, in which cleft were created with no repair, Group III had 16 rabbits with surgically created cleft of lip, alveolus and palate and repaired by Millard Rotation Flap. Group IV had 15 rabbits with surgically created cleft of lip alveolus and palate and repaired by Badarch technique. By measuring the lip pressure through hydraulic transducer system, he

concluded that there was significant increase in lip pressure in group II with significant maxillary growth inhibition.

Dahl E (1979)⁷⁰ evaluated the transverse maxillary growth in combined cleft lip and palate subjects by inserting implants bilaterally at the Infrazygomatic crest in 3 boys with bilateral cleft and 2 with unilateral cleft. Annual PA cephalograms were taken and were correlated with somatic growth curves and body height growth curves. He concluded that growth curves for the transverse palatal growth were inhibited in these patients.

Dahl E et al (1982)³⁰ compared the craniofacial morphology in infants with incomplete cleft lip and palate and infants with isolated cleft palate. Their sample consisted of 30 infants with incomplete cleft lip and 30 infants with cleft palate. Lateral, frontal and Axial projections were taken before surgery. By comparing the measurements obtained after evaluating the radiographs, they found that cleft palate group showed short Anterior Cranial Base Length, short Maxilla, reduced Posterior Maxillary Height, reduced Mandibular Length, narrow naso-pharyngeal and oropharyngeal airway, whereas the cleft lip group had larger inter-orbital distance and symmetry deviations in the anterior part of the maxilla.

Nakasima A, Ichinose M (1983)⁷¹ studied the differences in craniofacial morphology between the parents of 251 children with cleft lip and palate and normal controls. The sample was divided in to three groups: patients with cleft lip and palate (CLP), patients with cleft lip and patients with cleft palate. The control group included 110 males and 110 females with an average age of 23.5 years. By comparing the Lateral Cephalograms of the two groups, they inferred that the Head Length, antero-posterior length of Maxilla, Upper Anterior Facial Height and Upper Posterior Facial Height were significantly shorter in parents of cleft lip and palate, but both Lower Anterior Facial Height and Lower Posterior Facial Height were significantly increased. These vertical dimension measurements resulted in significantly higher ratios of Upper

Facial to Lower Facial Height in anterior area and also in posterior area. The cranial base angle was more obtuse than that of control group. In parents of CP children only 3 measurements namely Upper Anterior Facial Height, Upper Posterior Facial Height and ratio of upper to lower facial height proved to be significantly different when compared with that of parents of CL children.

Bishara SE et al (1985)⁴⁵ studied the dento-facial relationship of 50 individuals with cleft lip and palate who were in the age range of 7 to 50 years. The sample was divided in to three groups: namely, un-operated unilateral cleft lip and alveolus (UCLA), un-operated unilateral cleft lip and palate (UCLP), un-operated bilateral cleft lip and palate (BCLP). The three groups were compared by means of lateral cephalograms and the dental casts. They found significant differences amongst the three groups. UCLP and BCLP subjects had relatively steeper mandibular plane associated with shorter posterior facial height and relatively long anterior facial height. Individuals with UCLA did not show similar trends. In addition, the persons with bilateral cleft lip and palate had Significant reduction in maxillary inter-canine width. This could be attributed to various degrees of medial arch collapse of both segments. In individuals with unilateral cleft lip and alveolus (UCLA), cleft segment has a tendency to rotate medially, resulting in canines with an edge-to-edge and sometimes in crossbite. The skeletal relationship of the mandible to the cranial base does not seem to be significantly influenced by the presence of cleft of primary palate. In UCLP, the cleft segment in the maxillary arch had shown various degrees of medial arch collapse, resulting in increased incidence of crossbite and BROPHY's Syndrome in the premolar area (that is maxillary premolar with overjet). The combined effects of both lip and palate surgery cause the maxilla to be relatively retrusive. The incidence of both the posterior and anterior crossbites had increased in these patients as a result of lip and palatal surgery. In BCLP, they found various degrees of maxillary protrusion because of no restraining effect from the lip. The palatal surgery had increased the incidence of crossbite in posterior segments.

Sandham A, Cheng L (1988)³³ did a study in order to find the variations in cranial base and its angulation in patients with cleft palate. Their sample consisted of 30 children (17 males, 13 females) with cleft lip and palate (experimental group). Control group had 61 patients without cleft lip and palate. The lateral cephalograms of both the experimental group and the control group were taken and compared. By comparing the findings amongst the two groups, they failed to find any significant difference in its length and angulation.

Athanasίου et al (1990)⁵ assessed the transverse dentofacial morphology and growth of 36 caucasian children with bilateral cleft lip and palate selected from the files of Lancaster Cleft Palate Clinic. The lip was repaired in two stages at the age of approximately three months, using a triangular flap method in most of the patients and a *Millard* rotation-advancement method in the others and hard and soft palate was operated on by Veau Wardill Kilner or von Langenbeck procedure. Comparison of the variables of the cleft group was made with the normal dimensions as obtained from the Bolton cephalometric templates. These groups were studied by means of a frontal proportional cephalometric analysis and compared at the ages 3, 8 and 12 years. The ratio of the width of the nasal septum to the interorbital width was significantly higher in the cleft group than in the Bolton normals at all three ages ($p < 0.01$ three and eight years, $p < 0.05$ at twelve years). The ratio of the width of the skeletal base of the maxilla to the interorbital width (was significantly lower ($p < 0.01$) at the age of three years as well as at the age of eight years ($p < 0.05$) in the cleft subjects. There was no significant difference, however, at the age of twelve years between the Bolton normals and the cleft group. The ratio of the maxillary intermolar width to the interorbital width and the ratio of the maxillary intermolar width of the skeletal base of the maxilla were both significantly lower ($p < 0.01$) at the ages of three and eight years in the cleft group. There were no significant differences, however, at the age of twelve years between the Bolton normals and the cleft group. The ratio of the mandibular intermolar width to the interorbital width was not significantly different from the Bolton normals at the age of three and twelve years. At the ages of eight

however, the cleft group presented significantly lower ratios ($p < 0.05$) than the normal dimensions. Following orthodontic treatment between the ages of seven to twelve years, the maxillary intermolar width of the treated subgroup was significantly larger than in the untreated subjects.

Badarch et al (1990)⁴³ studied cases of unilateral cleft lip and palate; it was stated for the first time that lip repair must be considered equally serious cause of mid-facial growth disturbance as palate repair. His conclusion were based on the basis of the observations of mid facial growth during the period between lip repair (performed between 5 and 6 months of age and palate repair between 4 and 6 years of age) in which 44 infants underwent lip repair the mean age of 4 years with all surgeries carried out by same surgeon. 148 normal infants were taken as control the study lasted until patient was 24 months of age at which time palate was repaired. Periodic measurements of lip pressure beginning at the 2 months of life revealed that lip pressure remained significantly higher during the study in infants with cleft lip. He stated that persistent higher lip pressure must be considered as an important cause of growth disturbance.

Mars M, Houston WJB (1990)¹¹ investigated the effect of surgery on sixty Sri Lankan males with unilateral cleft and palate who were over 13 years of age at the time of study by means of cephalometry and dental study models. The sample was categorized in to three groups: one group was totally un-operated, the second group had lip repair but not palatal repair, and the third had lip and palate repair both and they were compared with 23 healthy non-cleft Sri Lankan males over 13 years of age. The results had shown that subjects who had no surgery had a potential for normal maxillary growth in unilateral cleft lip and palate subjects. Lip surgery without palatal surgery does not significantly interfere with antero-posterior maxillary growth. Palatal surgery carried out at conventional times may severely affect antero-posterior growth of maxilla. UCLP subjects have relatively small retro positioned mandibles, regardless of whether they had surgery or not. They concluded that lip surgery had a

negligible effect on antero-posterior maxillary growth but palatal surgery had significantly restricted the antero-posterior growth.

Molsted K,Dahl E(1990)³⁵ studied the craniofacial asymmetry of the maxilla in children with complete unilateral cleft lip and palate in 31 children that were compared to a group of 24 children with incomplete clefts.Using 32 variables on postero-anterior cephalometric radiographs. There were no differences in cranial width(UCLP 147 ± 0.768 ; CL 146 ± 1.165) or interorbital width(UCLP 103 ± 0.585 ; CL 102 ± 0.837) between two groups. Only a positional deviation and a change of arch shape of the maxillary segment on the cleft side was observed. At the dentoalveolar level a decrease in maxillary width (UCLP 54 ± 0.780 ; CL 57 ± 0.908)and maxillary height (UCLP 47 ± 0.767 ; CL 49 ± 0.894)were observed towards the cleft side in the UCL group. Pronounce asymmetry was related to the anterior part of the maxilla and the nasal septum in UCLP patients. The inferior border of the bony part of the nasal septum was deviated towards cleft side.The anterior nasal spine and the midpoint between the upper central incisors were deviated towards non cleft side, but to a different degree indicating a vertical tilting of the premaxillary region.

Athanasίου et al (1991)¹⁷ assessed the transverse dentofacial morphology and growth of 64 caucasian children selected from the files of Lancaster Cleft Palate Clinic operated on by Veau Wardill Kilner or von Langenbeck procedure for clefting of the hard and soft palate and 72 caucasians normal children from the University of Michigan.Both these groups were studied by means of a frontal proportional cephalometric analysis and compared at the ages 3- 4, 8- 9 and 12 years. The comparison of the cleft palate and normal samples at the three periods indicated that the ratios of the inter orbital width and width of the nasal cavity were significantly higher in cleft patients than in the normal group at three ages.The ratio of the width of the maxilla to the inter orbital width was significantly higher in the cleft group at ages of 8-9 and 12 years, but not at the age of 3-4 years.The ratio of the maxillary inter

molar width to the mandibular inter molar width was significantly lower in the cleft group at the specified three ages.

Siegel M et al (1991)⁷² studied the relationship between premaxillary size and number of adjacent oro-nasal capsular components and correlated mid-facial components in normal and cleft lip and palate human fetal sample. The sample consists of 29 human fetuses (20 normal and 9 with complete cleft lip and palate). They compared their gestational age by sitting height and foot length and head modulus against Streeter developmental growth curves. The fetal heads were processed for histologic examination and the images were digitized and three-dimensional computer reconstruction of structural length/or structural areas for the nasal septum, nasal capsule, Premaxilla and tongue were calculated for each specimen. Of the five predictor variables of Premaxillary length examined, septal length was found to explain 90 to 93 percent of the variance in normal and cleft Premaxillary length from 8 to 21 weeks postmenstrual age. They also concluded that the Septal traction model is a more precise and explanatory model for early mid-palate growth than matrix model.

Horsewell B, Gallup B (1992)³¹ conducted a retrospective study to compare four cleft lip and palate groups (cleft lip and alveolus, UCLP, BCLP and isolated cleft palate) with a non cleft group using three cranial base dimensions on lateral cephalograms. Both the groups had a age range of 7-18 years with no documentation of other craniofacial abnormalities. Anterior cranial base length, posterior cranial base length and cranial base angle were evaluated. The results obtained showed no significant difference in the cleft lip and alveolus group and non control group in three dimensions. Anterior cranial base length and posterior cranial base length were generally reduced in the unilateral (ACB: 70.1±3.8mm, PCB: 39.9±2.5) and bilateral cleft lip and palate cases (ACB: 69.1±4.1mm, PCB: 42.0±2.2) and isolated cleft palate cases (ACB: 68.2±3.1mm, PCB: 41.6±0.9) in most of the growing periods, particularly

after age 8-9 years as compared to control group(ACB:73.4 $\pm$ 2.5mm, PCB:43.6 $\pm$ 2.2) at 10 years of age and onwards. The cranial base angle showed no similar findings in all groups in this study.

Capellozza L et al (1993)¹² studied the craniofacial morphology in 26 white un-operated individuals with complete unilateral cleft lip and palate. Their sample consisted of 13 males and 13 females with complete unilateral cleft lip and palate. Lateral cephalograms of the selected individuals were taken and compared with a control group of normal individuals without cleft lip and palate. The persons with missing teeth were excluded from the experimental sample so as to rule out the effect of loss of teeth on lower facial height. They concluded that the linear measurements were more conclusive if proportional comparisons were made between normal persons and cleft patients. In the cleft group, the Cranial Base is morphologically similar to that of the non-cleft group, however, it was reduced in length, the Maxilla was also found to be smaller and more protruded. The mandibular plane angle is increased and is probably linked to changes in the Gonial angle. The increased Gonial angle was accompanied by a smaller mandibular body length and ramus height. The antero-posterior position of maxilla in the cleft group was similar for both sexes, which was more protruded at the alveolar level in the cleft group.

Raghavan R et al (1994)³ studied the craniofacial pattern of parents of children having cleft lip and/or cleft palate anomaly in which the craniofacial patterns of 38 sets of parents who had children with cleft lip and/or cleft palate anomalies (experimental group) were compared with the 24 sets of parents of healthy (non-cleft) children (control group). The results showed that the parents in the experimental group exhibited a distinct craniofacial morphology, the cranial base angle was more obtuse. The upper anterior facial height (N-ANS) and total anterior face height (V-Gn) was decreased. Anterior nasal spine (ANS) and maxillary alveolar process (A) were positioned more anteriorly and superiorly in the experimental group which contributed to significant increase in palatal length and anterior steeping of palatal

plane. The counter clockwise rotation of mandible was shown by significant decrease in Gonial angle. Parents in the experimental group also tended to have faces which were smaller in both transverse and vertical dimensions.

Ras F et al (1994)⁷³ studied the facial left right dominance in patients with cleft lip and palate. Their sample consist of 32 children with who had operated cleft lip and palate on left side and 17 children with operated cleft lip and palate on right side with a mean age of 7 years. And control sample consist of 80 children without craniofacial anomalies. Through stereo photogrammetry they demonstrated that individuals without craniofacial anomalies show facial left sided dominance in transverse direction and facial right sided dominance in sagittal direction. Individuals with operated cleft lip and palate, the facial dominance on the non-affected (non-cleft) side in the vertical and sagittal direction is observed.

Smahel Z, Mullerova Z (1994)³² through a longitudinal study, studied the facial growth in 32 males with complete unilateral cleft lip and palate and who underwent primary periosteoplasty. They were examined at the age of 10 and 15 years. The lateral cephalograms were obtained and the results were compared with the development of face in longitudinal study of 20 males with same type of cleft who were operated with a primary bone graft. The group with periosteoplasty showed marked proclination of the upper dento-alveolar component with the restoration of positive over jet as compared with persistent anterior cross bite in males with bone grafts. The lower jaw showed a larger retrusion, The individuals with bone grafts at the ages of 10 and 15 years were characterized by a larger posterior rotation of the mandible. The growth of the maxilla did not differ significantly in between the series. In both the groups there was a marked reduction in the growth of maxillary depth and upper anterior facial height. An increasing mandibular protrusion and maxillary retrusion resulted in an impairment of sagittal jaw relations and in the flattening of the face both of which occurred in almost all the patients.

Honda B et al (1995)⁷⁴ longitudinally studied the craniofacial growth in subjects with cleft lip and palate. Their sample consisted 75 patients which was divided in to 3 groups, one with unilateral cleft lip and alveolus (UCLA), second group consisted of complete unilateral cleft lip and palate (UCLP) and third group had patients with isolated cleft palate (CP). Facial form at age of 8 years in patients with clefts were compared with those of 33 non-cleft subjects. They had taken serial lateral and frontal cephalograms obtained just before lip repair at 4 months or palatoplasty at 2 years and at 4 and 8 yrs. of age. By comparing the cephalograms they found wider upper facial width before lip repair which in UCLP patients diminished slightly following surgery but the condition persisted up to 8 years of age. Less forward growth of maxilla was found in subjects who received palatoplasty and a larger vertical growth increment in anterior maxilla occurred in UCLP patients. Posterior maxillary height no significant differences in its growth increments among patients with clefts, but shorter posterior maxillary height in UCLP patients continued. Linear dimensions of mandible did not differ among cleft subjects but a large inter-condylar width, a larger gonial angle and slightly retruded mandible in CP patients and UCLP patients suggested a compensation of the mandible to wider and retroclined incisors.

Kyrkanides S et al (1995)⁶⁰ retrospectively studied the postsurgical asymmetries of the naso-maxillary skeleton in unilateral cleft lip and palate patients. The study comprised of 36 complete cleft lip and palate subjects, along with 36 non-cleft subjects. Skeletal asymmetry, deviations of the anterior nasal spine and premaxilla were compared by chronological age and skeletal maturation in cleft subjects and control cases was assessed. Results indicated that skeletal asymmetry in UCLP and controls peaks during pubertal growth spurt. The anterior nasal spine and nasal septum always tended to deviate towards the non-cleft side of the nasal cavity, although individual variations exist. Cleft subjects were found to be more asymmetric than non-cleft subjects to a statistical significant degree.

Ozturk Y, Cura Nil (1995)³⁹ conducted a study to assess the craniofacial morphology of children with and without unilateral cleft. 20 Turkish UCLP children and 20 non cleft children at the age range of 7 to 15 years were selected for this study from the Department of Orthodontics, Istanbul. Lateral cephalograms were evaluated on the basis of linear and angular measurements for possible differences in the craniofacial morphology. In UCLP patients the linear measurements were similar to those of control group. The cranial base angle was enlarged in UCLP (126 ± 6.90 degree) as compared to control group (122 ± 4.12 degree). The SNA angle was smaller (UCLP 75 ± 4.19 degree, control 79 ± 2.75 degree) and the maxillary length was shorter (UCLP 46 ± 4.13 mm, control 50 ± 3.33 mm) in the cleft children than in the non cleft children. Gonial angle was increased in the cleft group (UCLP 130 ± 6.73 degree, control 125 ± 7.96 degree) along with total anterior facial height (UCLP 113 ± 7.65 mm, control 107 ± 8.84 mm) and a backward rotation with a vertical growth pattern was seen.

Laspos CP, Kyrkanides, Talents RH, Moss ME, Subtenly JD (1997)⁷⁵ retrospectively studied the mandibular asymmetry in patients with unilateral cleft lip and palate (UCLP) in relation to chronologic age and in relation to lower facial asymmetry. Their sample consisted of 34 individuals with unilateral cleft lip and palate (UCLP) and 142 normal individuals without clefts formed the control group. They had analyzed the frontal and oblique cephalometric radiographs and divided the sample into three groups (6-10, 11-14, and 15 or greater) and compared it with controls. By comparing they inferred that there was no significant difference in mandibular asymmetry as compared with the controls. In addition, no significant correlation was found between mandibular asymmetry and lower facial asymmetry. They concluded that the degree of mandibular asymmetry was not a contributing factor to craniofacial asymmetry, rather cranial base/temporal region anomalies may be responsible for lower facial asymmetry.

Filho LC, Normado ADC, Silva Filho OG (1998)⁵² studied the isolated influences of cheiloplasty (lip surgery) and palatoplasty (palate surgery) on facial growth. Their sample consisted of 93 male subjects who were divided into 3 groups: Group I had 35 patients without surgical intervention. Group II had 23 subjects with operated lip, Group III had 35 individuals operated palate along with lip. By comparing the lateral cephalograms of the three groups he inferred that no significant difference between operated lip and operated palate group. Comparing the non-operated group with operated lip group significant retrusion of the maxilla was noticed. There were no changes in the mandibular morphology and growth direction between any of the groups. Comparing the height amongst the groups, the only significant difference was the increased facial height in the group with operated lip and palate.

Suzuki A et al(1999)⁷⁶ studied the maxillary arch width growth changes prior to the time of cheiloplasty up to 4 years of age. Serial dental casts were obtained and measured in 95 children with unilateral cleft lip and palate. The sample was divided into 4 groups with one group comprising of unilateral cleft lip and alveolus (CLA), second group comprised of unilateral cleft lip and palate (UCLP) and third group comprised of bilateral cleft lip and palate (BCLP) fourth group of isolated cleft palate (CP) patients. They concluded that prior to cheiloplasty, the growth of maxillary buccal segments showed lateral displacement. The premaxilla in BCLP subjects is protruded. Cheiloplasty influenced maxillary anterior arch width but not the posterior arch width. The surgery had caused the posterior displacement of premaxilla in BCLP subjects. Palatoplasty affected the growth of the maxillary arch in transverse dimension. They also concluded that a variety of growth patterns observed in the patients (e.g. increasing or decreasing of maxillary arch dimensions) suggested that maxillary arch dimensions were affected not only by surgery, but also by other factors such as genetic facial patterns and severity of cleft.

Levitt A, Long RE, Trotman CA (1999)⁷⁷ by means of a retrospective longitudinal study, they intended to study the effects of alveolar bone grafting in patients with cleft lip and palate. Their sample consisted of 97 patients who had received bone grafts and 138 patients who had not received grafts during surgery. The lateral cephalograms were taken before surgery and after surgery. By comparing the measurements from the lateral cephalograms, they concluded that there were no negative effects seen in patients who had received secondary alveolar bone grafting.

Kyrkanides S, Klambani M and Subtelny JD (2000)⁷⁸ investigated the development of cranial base and facial skeletal asymmetry on frontal cephalometric radiographs in individuals with 164 UCLP patients and compare them with 64 noncleft controls. Medial and lateral cranial base asymmetries were analyzed on frontal cephalometric radiographs relative to three developmental stages which indicated an average cranial base asymmetry at the level of the foramen rotundum(sphenoid bone) to be less than 1mm and that measured at the lateral cranial base(temporal bone) to be less than 2mm in the UCLP and non cleft group. Dentoalveolar structures of UCLP patient also appeared to correlate with the development of lower facial asymmetries.

Da Silva Filho OG, Neto JV, Filho LC, Freita JA (2003)⁴⁴ studied the influence of lip repair on Craniofacial Morphology of patients with Complete Bilateral Cleft Lip and Palate. Their sample consisted of 60 individuals which were divided into two groups. The first group comprised of 30 un-operated adult male patients with complete BCLP with an average age of 21 years. The second group comprised of 30 patients with an average age of 21 years 7 months, which had been operated only on the lip prior to 2 years of age. By comparing the lateral cephalograms amongst the groups, they concluded that cranial base shows enough stability and remains uninfluenced by the lip surgical reconstruction. Premaxilla was retro-positioned during growth because of lip repair only, and without any palate repair and is premaxilla is clockwise rotated, with the center of rotation close to the anterior nasal

spine. The palatal plane angle was not influenced by lip repair. The Cephalometric values referring to the mandible (SNB, Ar-Go-Me, Co-Gn, SN-Go-Gn) showed no alteration after lip repair. The upper anterior face height (SN-ANS) was increased probably because of the premaxillary downward and backward rotation following lip repair. Total anterior face height (N-Me) was also significantly greater following lip repair but cannot be attributed to the same rotational change in the ANS. The incisors were lingually tipped by the action of lip repair, and thus the overjet was reduced. Therefore, the influence of lip repair in the mid-face relates to the retroclining of the premaxillary alveolar region and the upper incisors. They had suggested that the lip repair had significant influence on the certain areas of the craniofacial complex mainly the premaxilla and upper incisors. Such an effect on projected premaxillary growth is usually beneficial except when exceeding lip pressure, unfavorable growth pattern or both repositioned mid-facial profile beyond acceptable sagittal limits.

Yoon YJ (2003)⁷⁹ retrospectively studied the association of transverse craniofacial asymmetry between children with unilateral cleft lip and palate (UCLP) and their parents and compared it with affected children and their non-cleft parents. They hypothesized that parental transverse craniofacial asymmetry is a risk factor associated with the development of asymmetry in children with UCLP. A total of 64 children-parent sets of data (32 child biological mothers, 32 child-biological fathers) were included. Subject's records included postero-anterior cephalometric radiographs. The side of parental nasal asymmetry was significantly associated with the side of cleft in their children. For the majority of parents with children suffering from a left cleft, nasal width was larger on the left, compared with the right side. They concluded that unilaterally increased naso-maxillary width in parents may play a key role in the development of ipsilateral palatal clefting in their offspring, therefore underscoring the importance of craniofacial form as a genetic etiologic factor in the genesis of clefting. Better understanding of the role of craniofacial form in cleft development will ultimately allow for the assessment of risk for cleft lip and palate.

Schneiderman et al(2009)⁴¹ assessed a group of 6 patients surgically treated with unilateral cleft lip and palate and 7 normal young adults using CBCT and measurements of 18 parameters were made in sagittal plane. The groups were matched in age and sex for both the groups. Significant differences were obtained in the maxillary region in palatal length ($p=0.034$), anterior palatal thickness ($p=0.050$) and overall sagittal maxillary length ($p=0.032$). The body of maxilla and maxillary height remained unaffected.

Matsuda A, Suda N, Motohashi N, Tsuji M, Ohyama K (2006)⁸⁰ examined the variation in the skeletal characteristics and the treatment outcomes of five Japanese Robin sequence cases. Patients with Robin sequence commonly exhibited upper airway obstruction and concomitant feeding difficulty, mandibular retrognathia/or micrognathic. The primary pathogenic event is that the tongue interferes with the fusion of palatal shelves and obstructs the upper airway. Patients with Robin sequence had significantly steep mandibular planes with lingually incisors in both arches. All the cases showed a significantly shorter ramus length but the mandibular body was short only in two cases all had moderate or severe crowding in both arches.

Shetye PR, Evans CA(2006)⁸ carried out a retrospective study to determine whether maxillary deficiencies observed in the cleft patients result from intrinsic defects or surgical intervention early in life. Lateral cephalograms of 30 adults (22 males and 8 female) nonsyndromic patients of Indian origin from Karnataka state were taken who had an untreated complete unilateral cleft lip and palate. The control group consists of 30 lateral cephalograms of normal geographically similar Indian individuals (15 males and 15 females) with Class I molar relationship, normal overjet and overbite with full complement of teeth present and ranging in age between 18 and 25 years. In unoperated adult cleft lip and palate patients, the cranial base angle was increased by 5.6 degree with reduction in anterior cranial base length by 2.6mm. The maxilla was found to be normal in size and somewhat prognathic (SNA was increased by 1.85 degree) in position than control. Both the maxillary and mandibular incisors were

relatively upright. The mandible was smaller in size by 4.45mm and posteriorly positioned (SNB was reduced by 2.9 degree) in the CUCLP patients. Potential for normal growth of the maxilla exists in patients with CUCLP. They also concluded that the disturbance of maxillary growth in surgically operated cleft patients was primarily due to the surgical intervention.

Alexandra I. Holst et al(2009)¹⁸ conducted a retrospective observational study to investigate whether the craniofacial vertical and sagittal jaw relationship in patients with 52 unilateral and 21 bilateral cleft lip and palate differed from that of age matched 53 noncleft controls, before and after the pubertal growth spurt. In patients with cleft lip and palate, the MP-SN(38 ± 7 degree) and SN-Gn (71 ± 4 degree) were significantly increased in UCLP patients whereas, Jaraback index was smaller in control. Similarly in BCLP patients ANB was 5 ± 4 degree and Wits appraisal 3.2 ± 3.7 indicated distal jaw bases relationship. The maxillary retrognathism became more remarkable with increasing age; whereas, the retrognathic position of the mandible became less pronounced as compared with controls. Reduced posterior midfacial height, a common prepubertal finding in patients with unilateral cleft lip and palate ($p=0.002$). Increased total anterior facial height was found in bilateral cleft lip and palate compared to control group ($p=0.002$). So in conclusion, patients with cleft lip and palate treated according to a standardized treatment concept had adequate craniofacial jaw relationships after puberty. Despite a measured skeletal class I in both male and female patients with cleft lip and palate regardless of cleft type, there was a slight tendency towards a skeletal class III.

Ebn LZ, Zam NA, Othman SA (2010)⁸¹ investigated the craniofacial morphology of Malay children with repaired unilateral cleft lip and palate and compared with the non-cleft children. Twenty Malay children with repaired unilateral cleft lip and palate (12 boys, 8 girls) with a mean age of 10.5 years were compared with 20 normal children (8 boys and 12 girls) with a mean age of 9.72 years (controls). By comparing the lateral cephalograms, they found significant differences amongst the groups. The

Cranial Base Angle was more acute. The Maxilla was reduced and shorter with class III skeletal relation as compared to the unoperated control group. The maxillary incisors were less proclined and interincisal angle was more obtuse. There were no differences in the facial height; also the Naso-labial Angle was more obtuse in patients with repaired cleft lip and palate. The upper lip was also retrusive than the E line in surgically treated group as compared with control group.

Wolfgang Zemmann et al (2010)⁴⁷ compared the sagittal facial growth in 54 children with unilateral cleft lip and palate treated with different surgical protocols at two different centres. A first evaluation had been carried out at the age of 6 years, now the patients have been re-evaluated at the age of 10 years. Children from both the centres received the same presurgical orthopaedics. Orthodontic treatment was carried out in centre 1, while children in centre 2 had no orthodontic intervention until the investigation. Growth of the facial skeleton in the sagittal plane was analyzed on lateral cephalograms. The results showed that there was considerably normal sagittal facial growth in patients who received orthodontic treatment, (ANB 2.9 ± 2.3 degree) with tendency of forward growth of the mandible. In patients without orthodontic treatment there was a slight decrease in sagittal maxillary and mandibular growth with unchanged intergnathic relation (ANB 3.6 ± 1.5 degree). There was no statistically significant difference in sagittal growth between the centres.

Abuhijleh et al (2014)¹⁶ conducted a study to compare the craniofacial morphology and asymmetry before, during, and after puberty within and between patients with unilateral complete cleft lip and palate (UCCLP) and a non-cleft group. 59 Turkish patients of age between 6-22 years were selected from Ankara University, Turkey. The control group comprised of 77 Turkish children of age 8-20 years. Lateral and frontal cephalograms were used to examine the craniofacial morphology. In the UCCLP group, the posterior cranial base length (42 ± 0.65 mm) and total cranial base length (100 ± 1.01 mm) were significantly shorter at all skeletal periods when compared to control (44 ± 0.69 mm and 103 ± 0.97 mm respectively), the maxilla was significantly

retruded and posteriorly rotated, and the mandible was significantly smaller and inferoposteriorly rotated. The upper anterior facial height (50 ± 0.64 mm in UCCLP and 52 ± 0.57 mm in control group) and posterior facial height (41 ± 0.67 mm in UCCLP and 46 ± 0.67 mm in control group) were significantly reduced for UCCLP. On postero-anterior cephalograms the nasal width was significantly higher (30 ± 0.54 mm in UCCLP and 26 ± 0.57 mm in control group). For all measurements, asymmetry on the horizontal plane was more significant than that on the vertical plane. Asymmetries in the UCCLP group were mostly detected during puberty. In UCCLP patients, the cranial base, maxilla, and mandible were affected on the sagittal plane during all growth periods.

Yi Xu et al(2014)⁴⁶ analyzed the craniofacial morphology in subjects with unrepaired UCLP at childhood(5-7years),adolescence(12-14 years)and adulthood(>18 years) to evaluate the effect of non surgical protocols.Lateral and frontal cephalograms were used consisting of 106 non-syndromic UCLP patients compared to 102 age matched normal subjects and various parameters were analyzed in both the groups.UICP patients in childhood showed a shortened cranial basal length; reduced bony nasopharyngeal height; short maxillary depth and height with a posterior positioned maxilla and an increased width of the nasal cavity, maxilla and orbit; and a shortened mandibular length and height. UICP patients in adulthood showed a normal nasopharyngeal and mandibular morphology. However, the patients in this subgroup still showed a shortened cranial basal length, and short maxillary depth and anterior height with increased width of the nasal cavity, maxilla and orbit.Craniofacial morphology and growth in patients with UICP were significantly affected by nonsurgical factors. Growth of the cranial base and upper face were absolutely reduced, while growth of the bony nasopharynx and mandible were only postponed.

Arezoo Jahanbin et al(2015)⁸² conducted a study to evaluate the cranial base and facial morphology of cleft lip and palate patients with individuals with no cleft.32 individuals were taken out of which 9 patients were with no cleft,14 were with

unilateral cleft lip and palate and 9 with bilateral cleft lip and palate were taken. The average age for all groups was 18.71 ± 2.1 years. CBCT of the patients was taken and anatomic landmarks were traced in the midsagittal, coronal and axial planes. The craniofacial height and width related parameters were assessed among the three groups. SNA ($p=0.048$), SNB ($p=0.005$), S-N-Pog ($p=0.007$), N-ANS ($p=0.013$) were significantly decreased in BCLP than in controls. SNB and SNPog was significantly smaller in the UCLP patients as compared with controls.

Celikoglu M. et al (2015)⁸³ carried out a retrospective study to evaluate the mandibular dental, alveolar, and skeletal transversal widths in patients affected by unilateral (UCLP) 29 patients and bilateral (BCLP) cleft lip and palate 18 patients and to compare the findings with a well-matched normal occlusion sample 28 patients. Mandibular dental (intercanine and -molar), alveolar (intercanine and -molar), and skeletal (bigonial width) transversal measurements were performed using CBCT. In patients affected by UCLP and BCLP had statistically significantly lower intercanine alveolar widths (35 ± 2.45 mm in UCLP, 33 ± 4.64 mm in BCLP and 37 ± 1.67 mm in control) and larger intermolar dental (51 ± 3.69 mm in UCLP, 49 ± 6.46 mm in BCLP and 46 ± 2.3 mm in control) and alveolar widths (62 ± 3.91 mm in UCLP, 60 ± 8.09 mm in BCLP and 56 ± 2.38 mm in control) compared with the normal occlusion group. However, the patients affected by UCLP and BCLP had similar mandibular dental, alveolar, and skeletal transversal widths. This shows the importance of using individualized arch wires according to the pre treatment arch widths of the patients affected by UCLP and/or BCLP.

Patricia Bittencourt Dutra dos Santos et al (2015)⁸⁴ compared the maxillary arch widths of patients with UCLP and different inter arch relationships (GOSLON Yardstick index). Two samples of dental casts were selected for this study, 104 patients with complete UCLP and 40 non cleft casts of Class I patients. Anterior and mid sections of maxillary arch width were significantly smaller in UCLP compared to the control group (UCLP 28 ± 4.29 mm and control 34 ± 1.08 mm). The maxillary

permanent molar width was similar in patients with and without cleft(UCLP 49 ± 4.41 mm and control 49 ± 3.64 mm). No inter group differences were observed for mandibular arch widths. So, it was concluded that the operated UCLP patients with more severe sagittal discrepancies tend to show more severe transverse maxillary arch deficiencies.

Kutalmis S. et al(2016)¹ conducted a study to evaluate the transverse craniofacial morphology of 20 adolescent patients with unilateral cleft lip and palate and to compare the findings with non cleft group (30 patients) using retrospective CBCT scans from Erciyes University,Turkey.A total of 25 skeletal and dental tissue landmarks were identified for frontal cephalometric analysis.Patients affected by UCLP had statistically significant, smaller interorbital width (89 ± 4.16 mm)maxillary width(58 ± 5.77 mm) ,maxillary intermolar width(52 ± 4.83 mm), and upper face height compared with the control group. Conversely, distance between the anterior nasal spine to the incisor superior frontale (ANS-isf) was significantly greater in the UCLP group(29 ± 5.19 mm) than in the control group(26 ± 3.99 mm). Moreover, alveolar cleft width had significant effect on Cr-ANS and the ANS-isf measurements.

Goruku Coskuner et al(2020)⁶ conducted a cross sectional study to assess the transverse craniofacial dimensions of patients with 80 unilateral cleft lip and palate and compare those dimensions with those of 80 non cleft individuals aged between 7-14 years. The study identified the correlation between the nasal and maxillary transverse widths of patients with UCLP on postero-anterior cephalometric radiographs.Results showed that thebizygo matic,(UCLP 128 ± 8.89 mm and control 132 ± 6.88 mm) maxillary skeletal (UCLP 64.50 mm and control 68.00 mm)and molar(UCLP 57 ± 4.40 mm and control 61 ± 4.21 mm), mandibular molar(UCLP 57 ± 4.40 mm and control 61 ± 4.21 mm), and antegonial widths(UCLP 84 ± 7.15 mm and control 87 ± 5.73 mm) in the UCLP group were significantly less than those in the control group.No significant difference was observed in the interorbital and nasal

width. As maxillary skeletal and dental widths presented a correlation with nasal width, a decrease in nasal width must be noted when maxillary constriction is noted.

Kochhar A. Singh et al(2020)¹⁹ assessed the extent of maxillary arch collapse on the cleft and the non cleft sides in the same individual with UCLP. A total of 31 children were selected and bilateral landmarks from the mid sagittal plane was evaluated using CBCT for both frontal and axial views. A significant reduction of transverse position of pyriforme (cleft side 7 ± 2.26 mm and non cleft side 5.3 ± 1.504 mm) and alveolar crest above the maxillary first molar (cleft side 11 ± 2.716 mm and non cleft side 13 ± 3.685 mm) were discerned in frontal analysis on the cleft side. In the axial view, the zygomatic arch, malar, porion and alveolar crest at the molar region showed no significant difference whereas, the alveolar crest at the premolar region on the cleft and non cleft side showed significant reduction (cleft side 7 ± 3.875 mm and non cleft side 9 ± 3.931 mm).

S. Rawat et al(2024)⁵¹ assessed skeletal and dental characteristics using lateral cephalograms among BCLP patients and control patients. Fifty patients including 25 with BCLP and 25 without BCLP aged 10-18 years were taken and evaluated on Nemoceph software. Skeletal and dental parameters were evaluated and the results showed significant differences in the SNA ($p=0.710$), SNB ($p=0.259$), ANB ($p=0.195$). Among the dental parameters the interincisal angle and upper incisor to A-Pog also showed a significant mean difference ($p=0.0001$). Hence noticeable sagittal discrepancies were obtained between the two groups.

This study was conducted in the Department of Orthodontics and Dentofacial Orthopaedics, BBDCODS, Lucknow with an aim to evaluate and compare the cranio-facial dimensions in sagittal and transverse plane in surgically repaired cleft lip and palate patients and non cleft patients using CBCT.

30 CBCT scans were collected from the Department of Plastic Surgery, KGMU based on the inclusion and exclusion criteria and were grouped as: GROUP I (n=15) included subjects with surgically repaired cleft lip and palate who came to the Department of Plastic Surgery, KGMU through Smile Train for orthodontic treatment; GROUP II (n=15) included non-cleft subjects from the Department of Plastic Surgery, KGMU.

The approval was taken from the Ethical Committee of Babu Banarasi Das College of Dental Science, BBDU, Lucknow before conducting the study.

Inclusion criteria

For surgically repaired cleft lip and palate patients

1. Patients should have completed minimum 14 years of chronologic age anticipating maxillary growth is over.
2. Patients with non-syndromic complete cleft lip and palate that are surgically repaired.

For non-cleft patients

1. Patients should have completed minimum 14 years of chronologic age anticipating maxillary growth is over.
2. Patients with good facial aesthetics, Class I molar relationship and full complement of teeth till second molar.
3. Patients with no craniofacial anomalies or syndromes.
4. Patients should not have undergone any surgical or orthodontic treatment.

Exclusion criteria

1. Patients with severe facial asymmetries due to reasons other than cleft.

2. Patients with missing or malformed teeth other than lateral incisor and canine.
3. Patients with history of any other surgical procedure other than CLP repair.

Based on the inclusion and exclusion criteria 30 CBCT images were collected and divided into two groups:

GROUP I comprised of 15 CBCT scans of surgically repaired cleft lip and palate patients who came to the Department of Plastic Surgery, KGMU through Smile Train for orthodontic treatment.

GROUP II comprised of 15 CBCT scans of non-cleft patients from the Department of Plastic Surgery, KGMU.

These scans were uploaded on laptop and converted into the appropriate format using DICOM file. The assessment of craniofacial dimensions was done on the Carestream CS 9300 imaging software.

To assess craniofacial dimensions in both the groups 22 linear and 13 angular parameters were measured in sagittal, coronal and axial view respectively obtained from CBCT images using Carestream CS 9300 imaging software. To maintain the uniformity in locating the landmarks, identification of all landmarks were carried out by the same operator. The measured data was tabulated and subjected to appropriate statistical analysis and results were obtained.

MATERIALS

1. CBCT machine used for obtaining CBCT image was Carestream CS 9300. The field of view of the machine Carestream CS 9300 was 17 X 13.5cm, where the source current was 2 to 15 ampere and voltage was recorded 60-90 Kv with a duration of scan 12 seconds. (Figure 1a)

Specification of CBCT Machine:

Scanning time : 12-28 seconds

Tube Voltage : 60-90 Kv

Exposure time : 12 seconds

Voxel size : 90-500 μm

Field of view : 5x5, 8x8, 10x5, 10x10, 17x6, 17x11, 17x13.5 cm

X-ray source current : 2-15 Ampere

Focal Spot : 0.5

Scanning mode: Continuous and pulse

Tube Current : 327 Ma

Reconstruction: Less than 2 minutes



Figure 1a- Carestream CS 9300 CBCT machine

2.CBCT images of surgically repaired cleft lip and palate patients and non-cleft patients (control group) were taken.(Figure 1b)

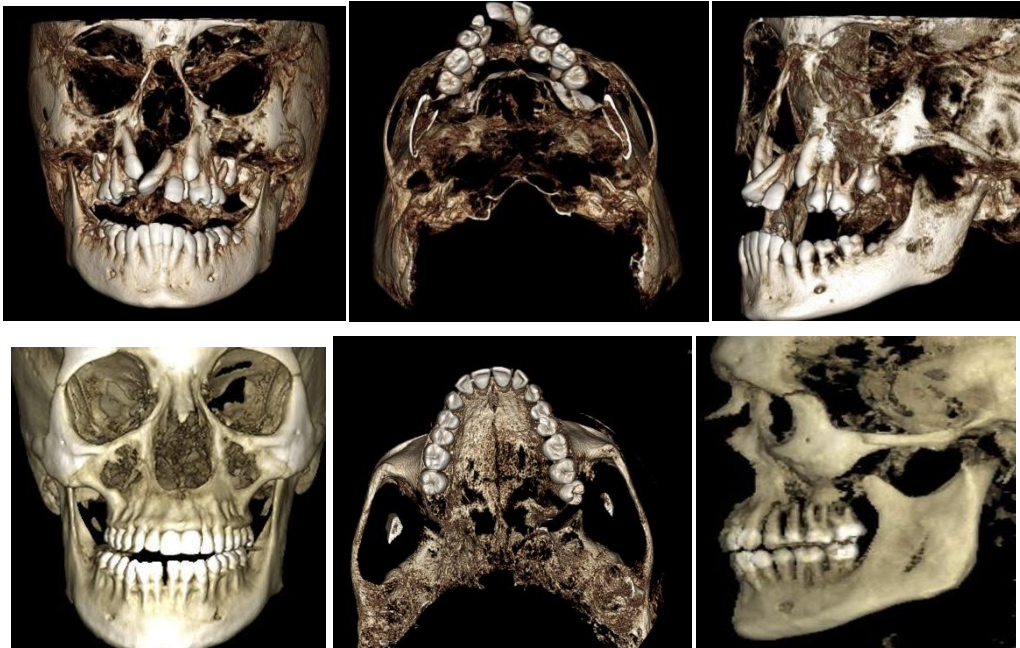


Figure 1b-CBCT scans of surgically treated cleft lip and palate patient and non cleft patient.

3.DICOM file was used for the conversion of CBCT scans into the required format for measurement.

4.Carestream CS 9300 imaging software. (Figure 1c)



Figure 1c-Carestream CS 9300 Software

METHODOLOGY

- CBCT scans of surgically repaired cleft lip and palate patients and control group patients were taken using Carestream CS 9300 CBCT machine. The scans were taken in natural head position with the Frankfort plane parallel to the floor and lips relaxed. Natural head position is a standardized and reproducible orientation of head that was attained by asking the patients to rest their chin on a small support shelf. A universal bite block was placed between the patient's teeth. Relaxed lip was achieved by giving direct instructions to the patient. (Figure 2a)



Figure 2a-Patient positioned on CBCT machine for a scan

- CBCT scans obtained were uploaded on laptop and converted into the appropriate format using DICOM file.
- The image enhancement feature of the CS 9300 imaging software like brightness, contrast adjustment and magnification were used to identify individual landmarks as precisely as possible. The landmarks were marked with the help of cursor. (Figure 2b)

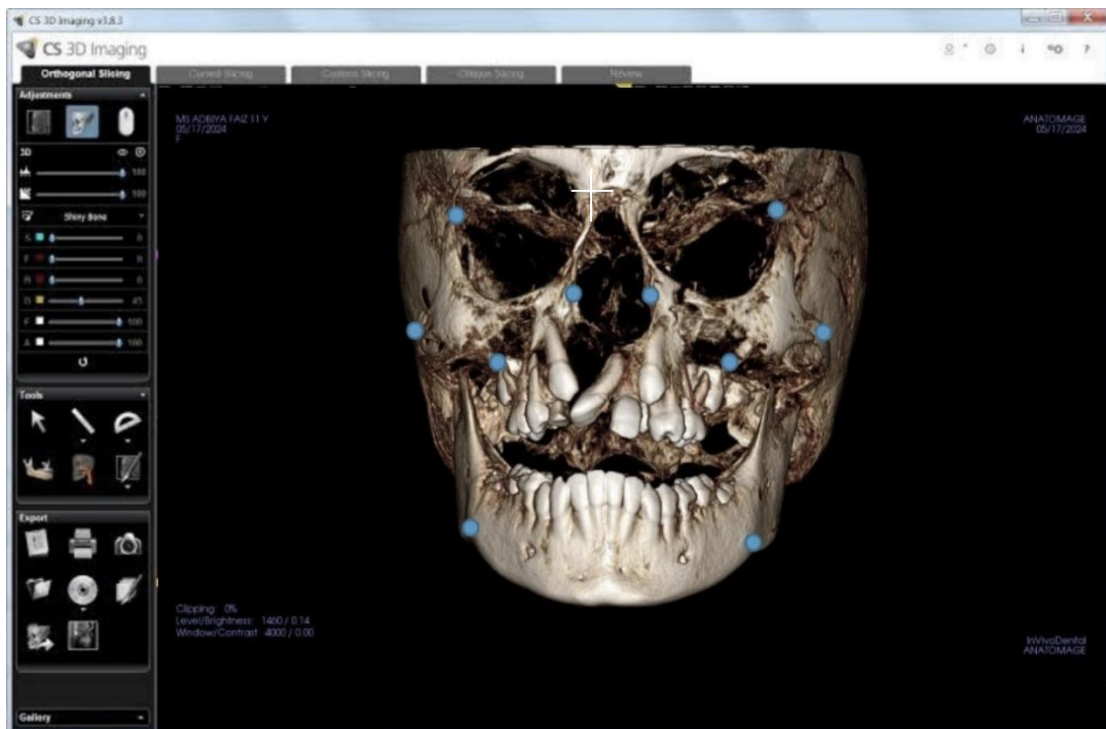


FIGURE 2b-Landmarks identification on CS 9300 3D imaging software

- 35 parameters(22 linear and 13 angular) were measured in sagittal,coronal and axial views using CS 9300 imaging software.To maintain the uniformity in locating the landmarks,identification of all landmarks were carried out by the same operator.The measured data was tabulated and subjected to appropriate statistical analysis and results were obtained using SPSS software.

POINTS AND LANDMARKS USED IN THE STUDY

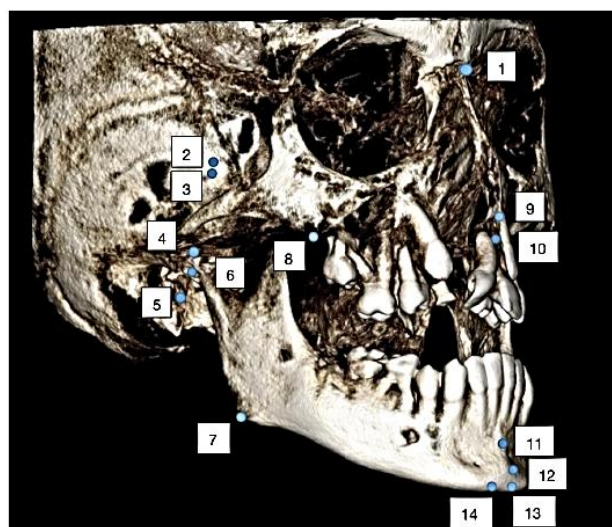
(SAGITTAL PLANE)

The following reference points and landmarks as seen in sagittal plane were used in the present study. **(Figure 3)**

1.**Nasion (N):** The most anterior point of the fronto nasal suture in the median plane **(Downs 1948).**²¹

2.**Sella (S):** The point representing the midpoint of sella turcica **(Downs 1948).**²¹

- 3.**Point A (Subspinale):** The most deepest point in the midline on the premaxilla between the anterior nasal spine and prosthion(the most inferior point on the alveolar bone overlying the central incisor)(**Downs 1948²¹, Steiner 1953²²**).
- 4.**Anterior Nasal Spine (ANS):** Tip of the bony anterior nasal spine, in the median plane (**Bjork 1947²³**).
- 5.**Posterior Nasal Spine(PNS):** The tip of the posterior spine of the palatine bone in the hard palate(**Bjork 1947²³**).
- 6.**Point B(Supramentale):** The most posterior midline point in the concavity of the mandible between the most superior point on the alveolar bone overlying the mandibular incisors(Infra Dentale) and pogonion(**Downs 1948²¹,Steiner 1953²²**).
- 7.**Menton (Me):** The lowest point on the symphyseal shadow in norma lateralis (mandible)(**Downs 1948²¹**).
- 8.**Pogonion(Pog):** The most anterior point on the contour of the chin(**Downs 1948²¹**).
- 9.**Gnathion(Gn):** A point located by taking the midpoint between anterior(Pogonion) and Inferior (Menton) points of bony chin(**Steiner 1953²²**).
- 10.**Gonion(Go):** A point on the curvature of the angle of the mandible located by bisecting the angle formed by lines tangent to the posterior ramus and inferior border of the mandible(**Downs 1948²¹**).
- 11.**Articulare (Ar):** A point at the junction of the posterior border of the ramus and inferior border of the cranial base (occipital bone)(**Ricketts 1952²⁴**).
- 12.**Basion(Ba):** The lowest point on the anterior rim of foramen magnum in the mid sagittal plane (**Ricketts 1952²⁴**).
- 13.**Sellion (Se):** It is the midpoint at the entrance of pitutary fossa (**Burstone 1978²⁵**).
- 14.**Condylion(Co):**The highest point on the mandibular condyle.(**Ricketts 1952²⁴**).



CBCT SCAN IN SAGITTAL PLANE

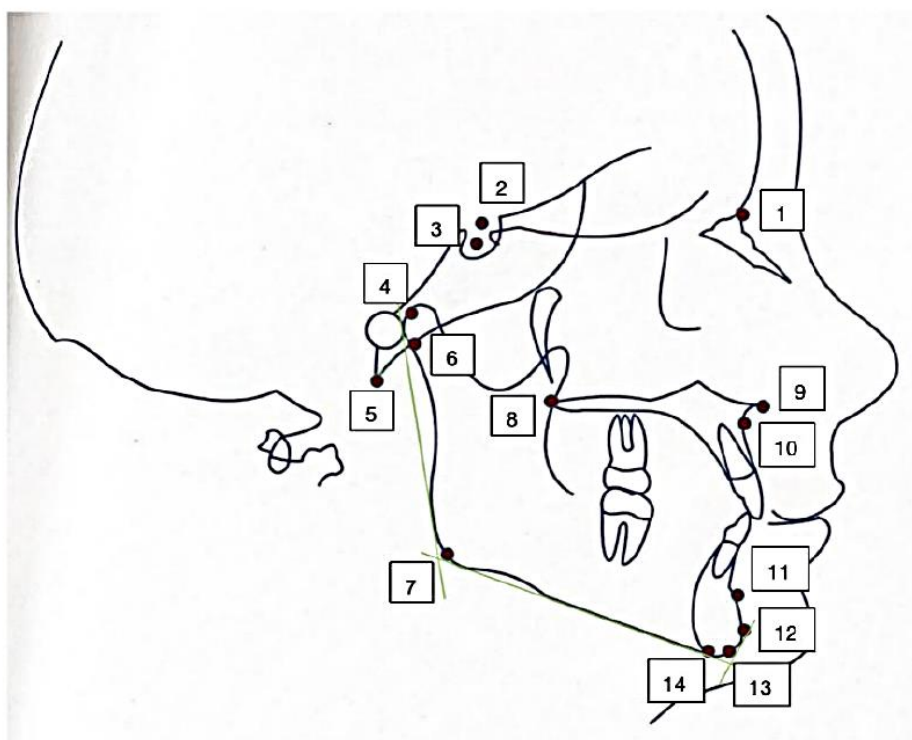


FIGURE 3-2D REPRESENTATION OF LANDMARKS IN SAGITTAL PLANE

- | | | |
|----------------------|------------------|------------------|
| 1.Nasion(N) | 6.Articulare(Ar) | 11.Point B |
| 2.Sella entrance(Se) | 7.Gonion(Go) | 12.Pogonion(Pog) |
| 3.Sella(S) | 8.PNS | 13.Gnathion(Gn) |
| 4.Condylion(Co) | 9.ANS | 14.Menton(Me) |
| 5.Basion(Ba) | 10.Point A | |

POINTS AND LANDMARKS IN USED IN THE STUDY**(CORONAL PLANE)**

The following reference points and landmarks as seen in coronal plane were used in the present study.(Figure 4)

1.(LoR/LoL point): The innermost point on the medial margin of the fronto-zygomatic suture. It is marked as LoR for right side and LoL for left side.(Grummons DC 1987²⁶)

2.Zygomatic arch(ZyR/ZyL point): The outermost (lateral) point of the zygomatic arch. It is marked as ZyR for right side and ZyL for left side. (Grummons DC 1987²⁶)

3.Nasal Cavity(NcR/NcL point): Point on the lateral surface of the nasal aperture at its maximum convexity.It is marked as NcR for right side and NcL for left side.(Ricketts 1952²⁴).

4.Jugular process(JR/JL point): Highest point of the alveolar process of maxilla at the intersection of the midline of the maxillary tuberosity of the maxilla and zygomatic buttress.It is marked as JR for right side and JL for left side.(Grummons DC 1987²⁶)

5.Antegonial point(AgR/AgL): Point located at the greatest concavity of the antegonial notch of the mandible. It is marked as AgR for right side and AgL for left side.(Ricketts 1952²⁴).

6.Maxillary molar (Max6R-Max6L): Most lateral point of the permanent first maxillary molar parallel to the occlusal plane.It is marked as Max6R for right side and Max6L for left side.

7.Mandibular molar(Mand6R-Mand6L): Most lateral point of the permanent first mandibular molar parallel to the occlusal plane.It is marked as Mand6R for right side and Mand6L for left side.

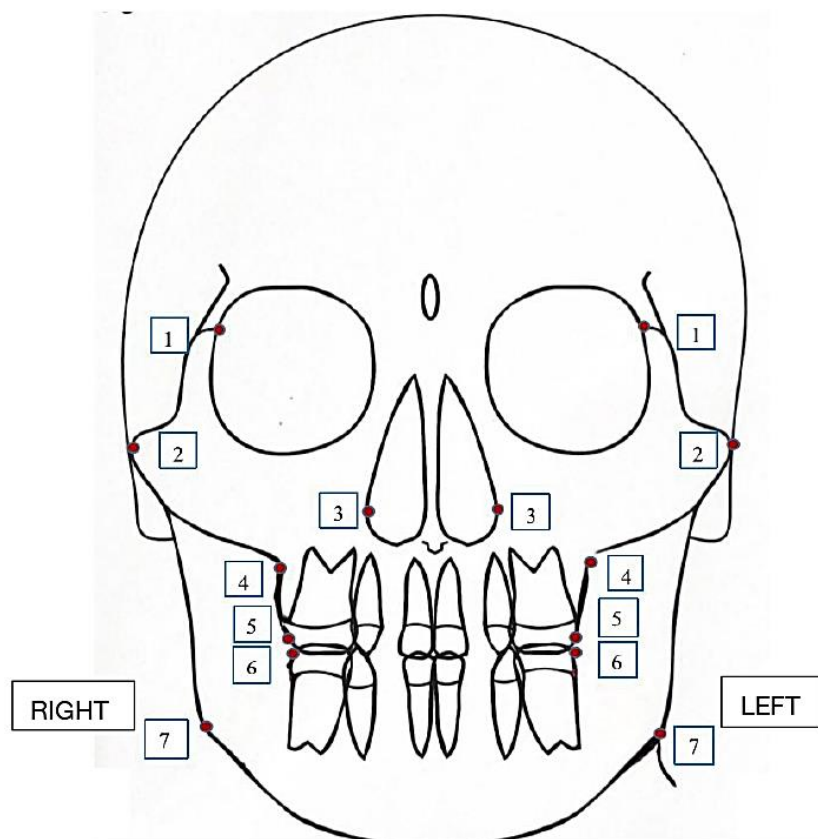
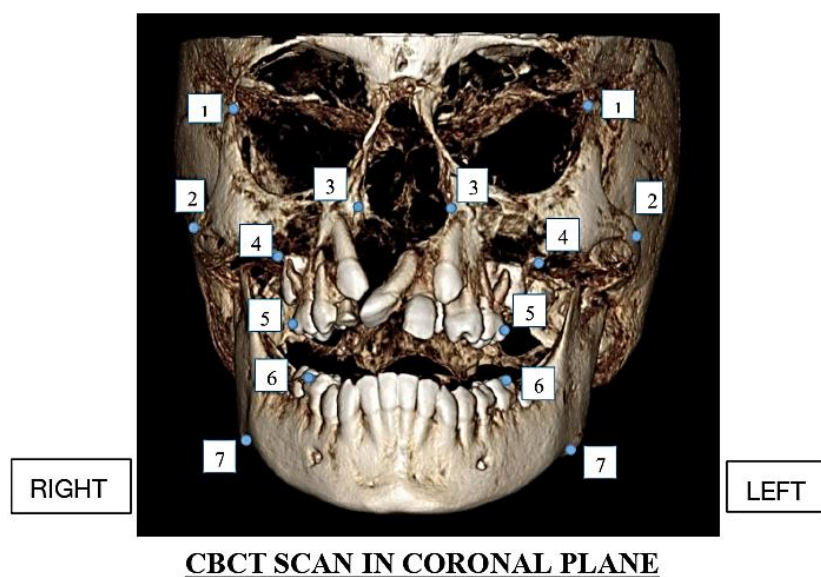


FIGURE 4-2D REPRESENTATION OF LANDMARKS IN CORONAL PLANE

- | | |
|------------------------------------|------------------------------------|
| 1. Frontozygomatic suture(LoR,LoL) | 5. Maxillary molar(Max6R,Max6L) |
| 2. Zygomatic arch point(ZyR,ZyL) | 6. Mandibular molar(Mand6R,Mand6L) |
| 3. Nasal cavity point(NcR,NcL) | 7. Antegonial notch(AgR,AgL) |
| 4. Jugale point(JR,JL) | |

POINTS AND LANDMARKS IN USED IN THE STUDY**(AXIAL PLANE)**

The following reference points and landmarks as seen in different axial planes were used in the present study.(Figure 5)

1.Zygomatic arch(ZyR/ZyL point): The outermost (lateral) point of the zygomatic arch. It is marked as ZyR for right side and ZyL for left side. **(Grummons DC 1987²⁶)**

2.Jugular process(JR/JL point): Highest point of the alveolar process of maxilla at the intersection of the midline of the maxillary tuberosity of the maxilla and zygomatic buttress.It is marked as JR for right side and JL for left side.**(Grummons DC 1987²⁶)**

3.Maxillary molar (Max6R-Max6L): Most lateral point of the permanent first maxillary molar parallel to the occlusal plane.It is marked as Max6R for right side and Max6L for left side.

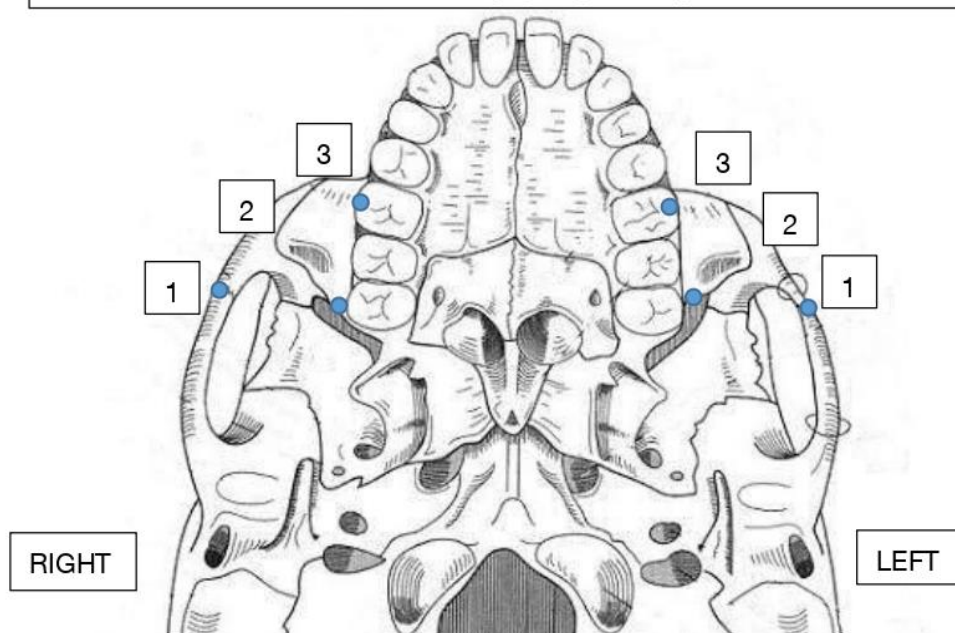
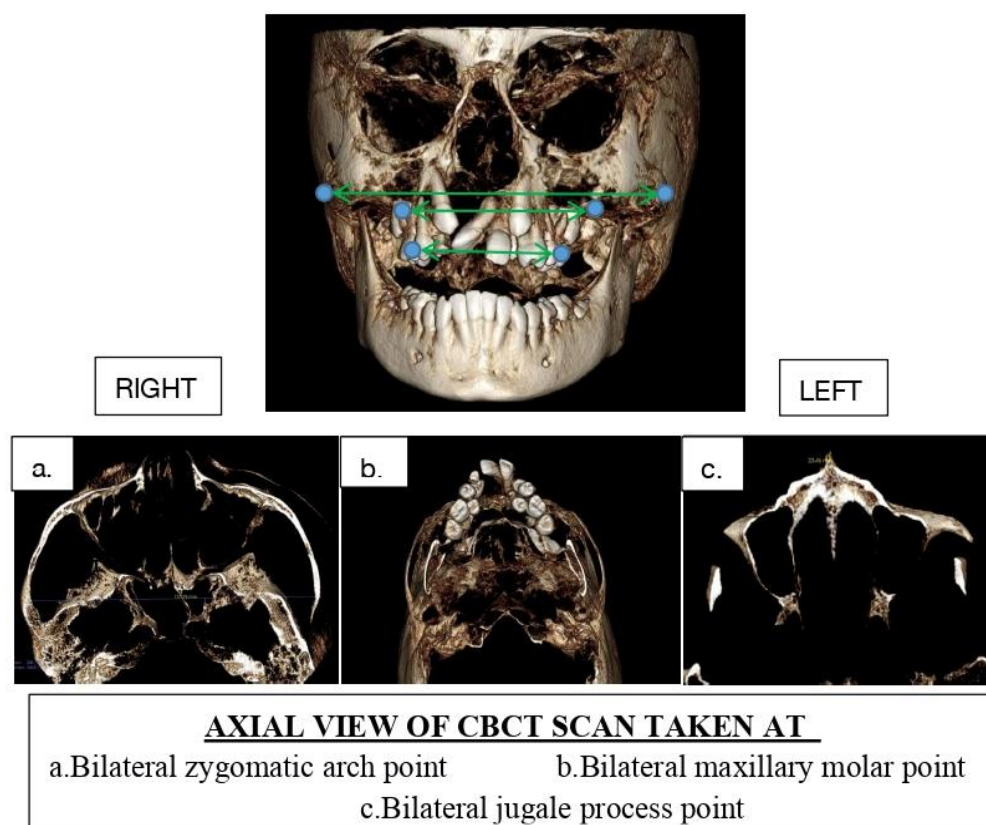


FIGURE 5-2D REPRESENTATION OF LANDMARKS IN AXIAL PLANE

1. Zygomatic arch point (ZyR, ZyL)
2. Jugale point (JR, JL)
3. Maxillary molar (Max6R, Max6L)

PARAMETERS MEASURED IN SAGITTAL PLANE

Based on the landmarks mentioned above the following linear and angular measurements were made using CS 9300 imaging software.(Figure 6)

(i). SKELETAL PARAMETERS**A. LINEAR MEASUREMENTS(Figure 6a)**

- 1.**Anterior Cranial Base Length (N-Se):** Linear distance between Nasion(N) and Sella entrance(Se).
- 2.**Posterior Cranial base length(S-Ba):** Linear distance between Sella(S) and Basion(Ba).
- 3.**Maxillary Length(PNS-ANS):** It is measured as linear distance between the posterior nasal spine(PNS) and anterior nasal spine(ANS).
- 4.**Ramus Length(Co-Go):** Linear distance between Condylion(Co) and Gonion(Go).
- 5.**Corpus length(Go-Gn):** Linear distance between Gonion(Go) to Gnathion(Gn).
- 6.**Mandibular Length(Co-Gn):** Linear distance between Condylion(Co) and Gnathion(Gn).
- 7.**Total Anterior Face Height(N-Me):** Vertical linear distance between Nasion(N) and Menton(Me).
- 8.**Total Posterior Face Height(S-Go):** Vertical linear distance between Sella(S) and Gonion(Go).
- 9.**Lower Anterior Facial Height(ANS-Me):** Vertical linear distance between Anterior nasal spine(ANS) and Menton(Me).
- 10.**Jaraback Ratio:** Ratio of Total posterior face height and Total anterior face height.

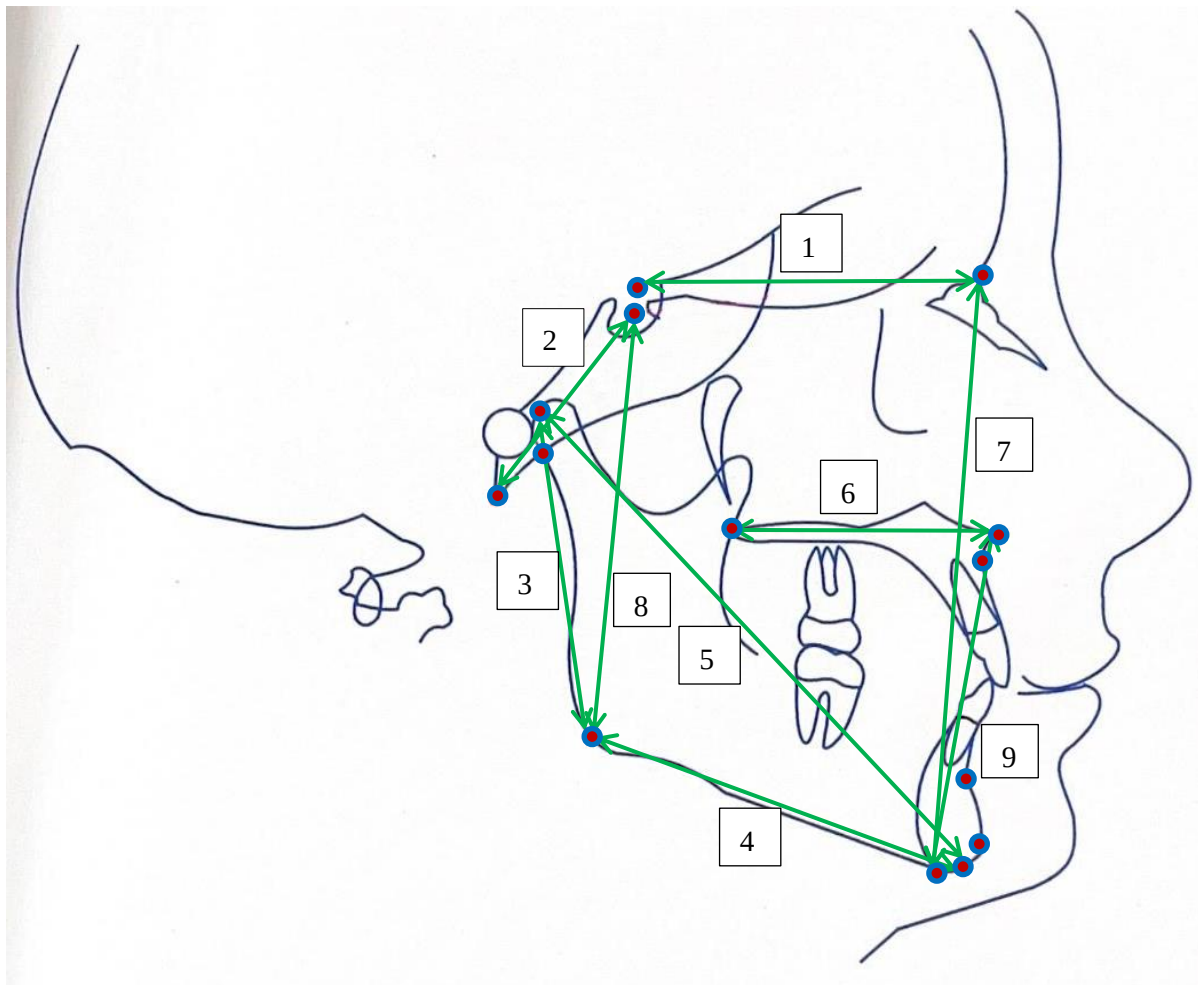


FIGURE 6a -SKELETAL PARAMETERS (LINEAR) MEASURED IN SAGITTAL PLANE

- | | |
|--|---------------------------------------|
| 1. Anterior cranial base length(N-Se) | 6. Maxillary length(ANS-PNS) |
| 2. Posterior cranial base length(S-Ba) | 7. Total anterior face height(N-Me) |
| 3. Ramus length(Co-Go) | 8. Total posterior height(S-Go) |
| 4. Corpus length(Go-Gn) | 9. lower Anterior face height(ANS-Me) |
| 5. Mandibular length(Co-Gn) | |

B. ANGULAR MEASUREMENTS(Figure 6b)

- 1.**Cranial Base Angle(N-S-Ba):** Angle formed between Sella-Nasion line and Sella-Basion line.
- 2.**SNA:** Angle formed between Sella-Nasion plane and a line joining Nasion to Point A.
- 3.**Angle of convexity(N-A-Pog):** Angle formed between Nasion-Point A and Point A to Pogonion.
- 4.**SNB:**Angle formed between Sella-Nasion plane and a line joining Nasion to Point B.
- 5.**ANB:** Angle formed between Sella-Nasion plane and a line joining Nasion to Point A and Nasion to Point B.
- 6.**Saddle Angle(N-S-Ar):** Angle formed between line joining Nasion-Sella and Sella to Articulare.
- 7.**Articular Angle(S-Ar-Go):** Angle formed between line joining Sella-Articulare and Articulare-Gonion.
- 8.**Gonial Angle(Ar-Go-Me):** Angle formed between line joining Articulare-Gonion and Gonion-Menton.
- 9.**Bjork Sum:** Measured as a sum of three angles-Saddle Angle(N-S-Ar),Articular Angle(S-Ar-Go) and Gonial Angle(Ar-Go-Me).

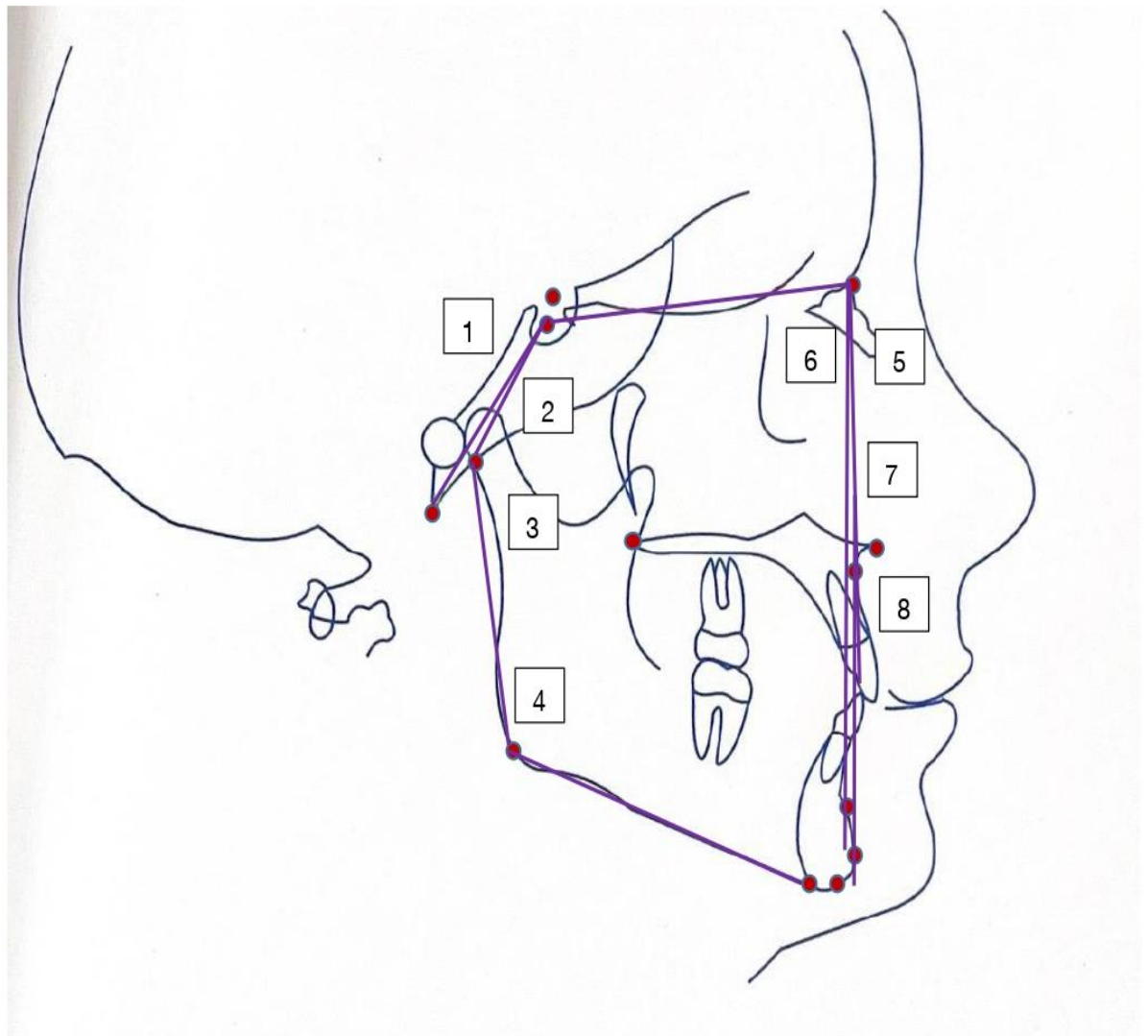


FIGURE 6b-2D SKELETAL PARAMETERS (ANGULAR) MEASURED IN SAGITTAL PLANE

- | | |
|-------------------------------|--------------------------------|
| 1. Cranial base angle(N-S-Ba) | 5. SNA |
| 2. Saddle angle(N-S-Ar) | 6. SNB |
| 3. Articular angle(S-Ar-Go) | 7. ANB |
| 4. Gonial angle(Ar-Go-Me) | 8. Angle of convexity(N-A-Pog) |

(ii). **DENTAL PARAMETERS**(Figure 6c)

A. LINEAR MEASUREMENTS

1.Maxillary Incisor protrusion(U1 to A-Pog): Linear distance between tip of the maxillary central incisor and a line joining Point A and Pogonion(A-Pog line).

2.Mandibular Incisor protrusion(L1 to A-Pog): Linear distance between tip of the mandibular central incisor and a line joining Point A and Pogonion(A-Pog line).

B. ANGULAR MEASUREMENTS

1.Maxillary Incisor Inclination(U1 to A-Pog): Angle formed between tip of the maxillary central incisor and a line joining Point A and Pogonion(A-Pog line).

2.Mandibular Incisor Inclination(L1 to A-Pog): Angle formed between tip of the mandibular central incisor and a line joining Point A and Pogonion(A-Pog line).

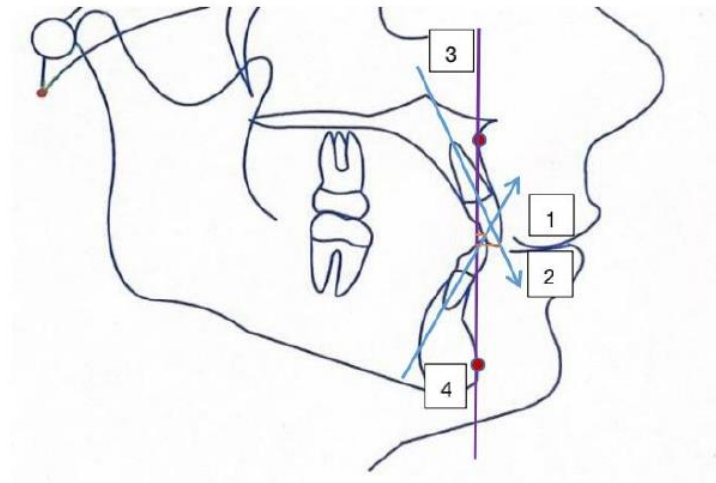


**FIGURE 6c-DENTAL PARAMETERS(LINEAR AND ANGULAR)
MEASURED IN SAGITTAL PLANE**

(LINEAR)

- 1.Upper incisor to A-Pog Protrusion(U1 to A-Pog)
- 2.Lower incisor to A-Pog Protrusion(L1 to A-Pog)

(ANGULAR)

- 3.3.Upper incisor to A-Pog Inclination(U1 to A-Pog)
- 4.Lower incisor to A-Pog Inclination(L1 to A-Pog)

PARAMETERS MEASURED IN CORONAL PLANE

Based on the landmarks mentioned above the following linear and angular measurements were made using CS 9300 imaging software.(Figure 7)

(i). SKELETAL PARAMETERS(Figure 7a)**A. LINEAR MEASUREMENTS**

- 1.**Interorbital width(LoR-LoL):** Linear distance between the LoR and LoL.
- 2.**Facial width(ZyR-ZyL):** Linear distance between the ZyR and ZyL.
- 3.**Nasal width(NcR-NcL):** Linear distance between the NcR and NcL.
- 4.**Maxillary width(JR-JL):** Linear distance between the JR and JL.
- 5.**Antegonial width(AgR-AgL):** Linear distance between the AgR and AgL.

B. ANGULAR MEASUREMENTS

- 1.**Postural Symmetric Right(ZyR-AgR-LoR):** Angle formed between line joining ZyR to AgR and AgR to LoR.
- 2.**Postural Symmetric Left(ZyL-AgL-LoL):** Angle formed between line joining ZyL to AgL and AgL to LoL.

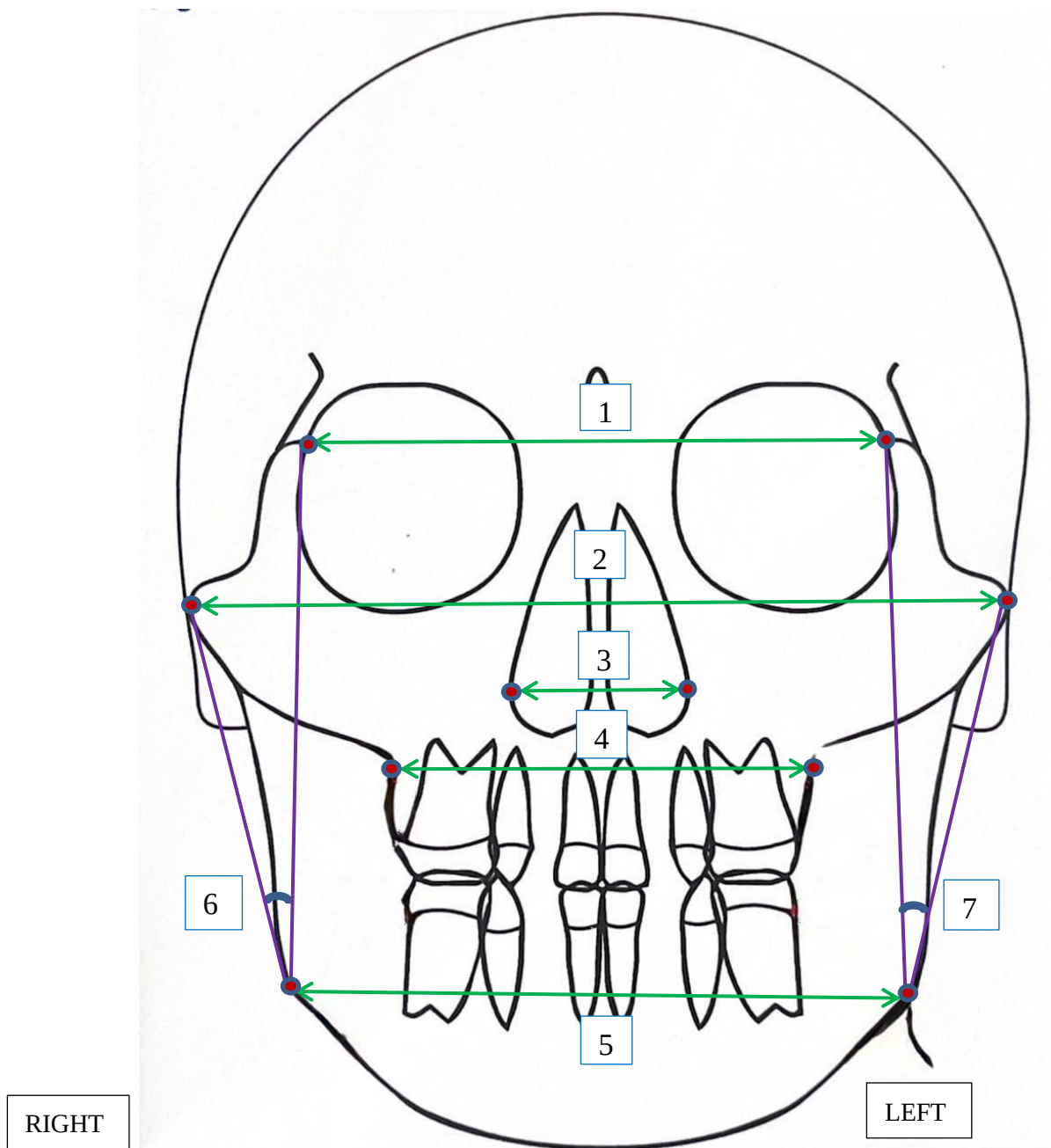


FIGURE 7a -SKELETAL PARAMETERS (LINEAR AND ANGULAR) MEASURED IN CORONAL PLANE

(LINEAR)

1. Interorbital width(LoR-LoL)
2. Facial width(ZyR-ZyL)
3. Nasal width(NcR-NcL)
4. Maxillary width(JR-JL)
5. Antegonial width(AgR-AgL)

(ANGULAR)

6. Postural Asymmetry Right(ZyR-AgR-LoR)
7. Postural Asymmetry Left(ZyL-AgL-LoL)

(ii). **DENTAL PARAMETERS**(Figure 7b)

A. LINEAR MEASUREMENTS

1.**Maxillary molar width(Max6R-Max6L)**:Linear distance between the maxillary Max6R and Max6L.

2.**Mandibular molar width(Mand6R-Mand6L)**:Linear distance between the maxillary Mand6R and Mand6L.

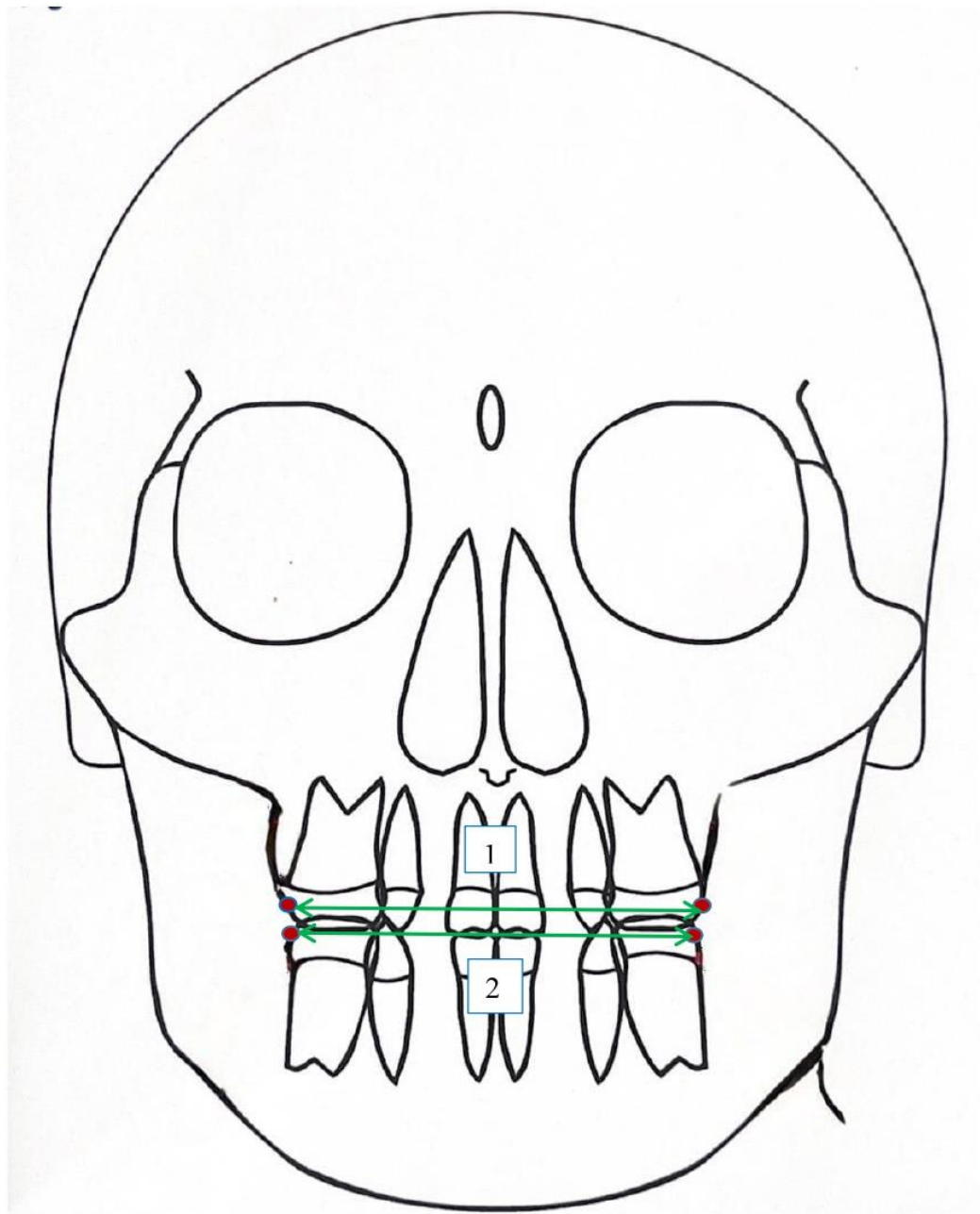


FIGURE 7b -DENTAL PARAMETERS (LINEAR) MEASURED IN CORONAL PLANE

- 1.Maxillary molar width(Max6R-Max6L)
- 2.Mandibular molar width(Mand6R-Mand6L)

PARAMETERS MEASURED IN AXIAL PLANE

Based on the landmarks mentioned above the following linear measurements were made using CS 9300 imaging software.(Figure 8)

(i). SKELETAL LINEAR MEASUREMENTS

1.**Facial width(ZyR-ZyL):** Linear distance between the ZyR and ZyL.

2..**Maxillary width(JR-JL):** Linear distance between the JR and JL.

(ii). DENTAL LINEAR MEASUREMENTS

1.**Maxillary molar width(Max6R-Max6L):**Linear distance between the maxillary Max6R and Max6L.

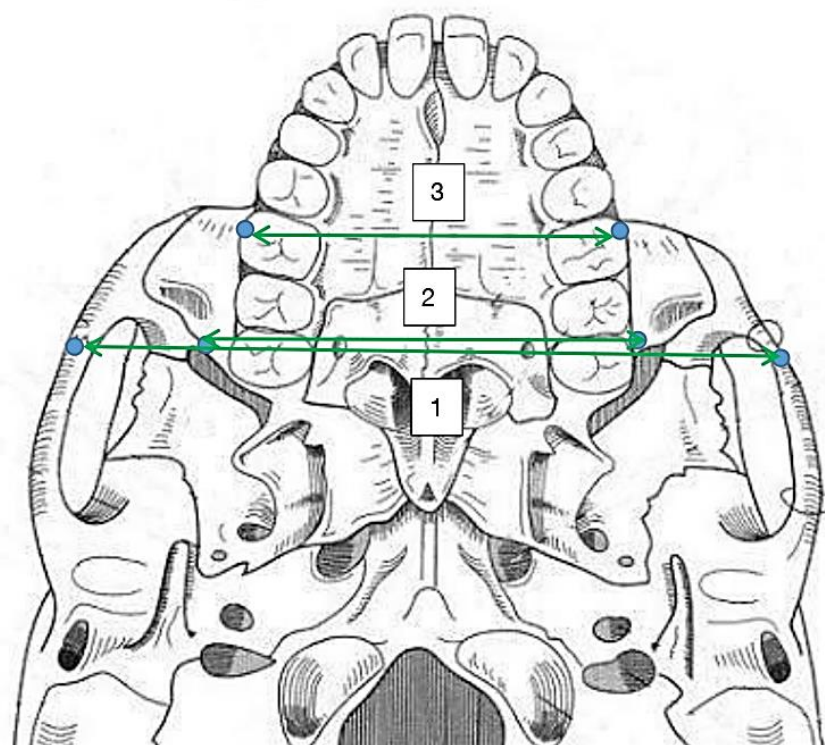


**FIGURE 8-SKELETAL AND DENTAL PARAMETERS (LINEAR) MEASURED
IN AXIAL PLANE**

(SKELETAL)

1.Facial width(ZyR-ZyL)

2.Maxillary width(JR-JL)

(DENTAL)

3.Maxillary molar width(Max6R-Max6L)

The present study was conducted in the Department of Orthodontics & Dentofacial Orthopaedics, Babu Banarsi Das College of Dental Sciences, Lucknow with an aim to evaluate and compare the cranio-facial dimensions in sagittal and transverse plane in surgically repaired cleft lip and palate patients and non cleft patients using CBCT.

Based on the inclusion and exclusion criteria CBCT images from 30 subjects were collected and divided into two groups:

GROUP I - 15 CBCT scans of surgically repaired cleft lip and palate patients.

GROUP II -15 CBCT scans of non-cleft patients.

These scans were uploaded on laptop and converted into the appropriate format using DICOM file. To assess craniofacial dimensions in both the groups 22 linear and 13 angular parameters were measured in sagittal,coronal and axial view respectively obtained from CBCT images using Carestream CS 9300 imaging software.The data obtained were recorded on Microsoft Excel sheet and subjected to Student t test for statistical analysis to determine the level of significance.

The result of the study are tabulated as follows:

Table 1: Descriptive statistics of Skeletal and Dental (Linear and Angular) parameters in Sagittal plane (Group I & Group II).

Table 2: Descriptive statistics of Skeletal and Dental (Linear and Angular) parameters in Coronal plane (Group I & Group II).

Table 3: Descriptive statistics of Skeletal and Dental (Linear) parameters in Axial plane (Group I & Group II).

Table 4: Inter-Group comparison of Skeletal and Dental (Linear and Angular) parameters in Sagittal plane using Student t test (Group I vs Group II).

Table 5: Inter-Group comparison of Skeletal and Dental (Linear and Angular) parameters in Coronal plane using Student t test (Group I vs Group II).

Table 6: Inter-Group comparison of of Skeletal and Dental (Linear) parameters in Axial plane using Student t test (Group I vs Group II).

TABLE 1 :Descriptive statistics of Skeletal and Dental (Linear and Angular) parameters in **SAGITTAL PLANE** (Group I & Group II).

S.NO	PARAMETERS		Group I Mean±Standard Deviation (N=15)	Group II Mean± Standard Deviation (N=15)
	<u>SKELETAL</u>			
	(LINEAR MEASUREMENTS)	ABBREVIATIONS	(in mm)	(in mm)
1.	Anterior Cranial Base Length	N-Se	66.627±1.9612	69.507±1.0687
2.	Posterior Cranial Base length	S-Ba	33.440±.8356	35.187±.2408
3.	Maxillary Length	PNS-ANS	44.047±1.1463	48.513±1.6894
4.	Ramus Length	Co-Go	57.427±1.2623	62.340±1.3282
5.	Corpus length	Go-Gn	71.560±1.2252	73.360±3.4694
6.	Mandibular Length	Co-Gn	114.47±1.356	117.93±1.335
7.	Total Anterior Face Height	N-Me	122.73±.961	120.60±1.404
8.	Total Posterior Face Height	S-Go	75.207±1.5083	78.880±.6450
9.	Lower Anterior Facial Height	ANS-Me	71.300±.1.0268	67.780±.9667
10.	Jaraback Ratio	S-Go/N-Me x 100	61.227±1.1380	65.467±.9116
	(ANGULAR MEASUREMENTS)		(in degrees)	(in degrees)
11.	Cranial Base Angle	N-S-Ba	130.60±1.454	128.07±1.033
12.	Maxillary Prognathism	SNA	77.113±1.2524	83.060±1.1044
13.	Mandibular Prognathism	SNB	76.580±.9719	80.833±1.119
14.	Skeletal Discrepancy	ANB	.6600±.88574	2.2227±.65317
15.	Angle of Convexity	N-A-Pog	-3.4173±.53940	4.4753±.55420
16.	Saddle Angle	N-S-Ar	122.07±1.163	122.40±1.404

17.	Articular Angle	S-Ar-Go	145.07 $\pm$ 2.052	145.87 $\pm$ 1.506
18.	Gonial Angle	Ar-Go-Me	126.60 $\pm$ 1.993	127.07 $\pm$ 1.033
19.	Bjork Sum		393.60 $\pm$ 1.549	394.73 $\pm$ 1.387
	<u>DENTAL</u>			
	(LINEAR MEASUREMENTS)		(in mm)	(in mm)
20.	Maxillary Incisor protrusion	U1 to A-Pog	2.9233 $\pm$.96304	6.2567 $\pm$.56343
21.	Mandibular Incisor protrusion	L1 to A-Pog	2.4960 $\pm$.56343	3.3447 $\pm$.86574
	(ANGULAR MEASUREMENTS)		(in degrees)	(in degrees)
22.	Maxillary Incisor Inclination	U1 to A-Pog	17.240 $\pm$.5026	30.860 $\pm$ 1.3426
23.	Mandibular Incisor Inclination	L1 to A-Pog	14.233 $\pm$.6532	17.467 $\pm$.6241

Table 1 depicts the descriptive statistics of Skeletal and Dental (Linear and Angular) parameters in Sagittal plane (Group I & Group II).

SKELETAL PARAMETERS

For linear measurements,

GROUP I

The mean value of anterior cranial base length was found to be (66.627 $\pm$ 1.9612mm) in Group I. The mean value of posterior cranial base length was (33.440 $\pm$.8356mm) in Group I. For maxilla significant change was obtained between the two groups, mean value of maxillary length was (44.047 $\pm$ 1.1463mm) in Group I. The linear measurements in the mandible with respect to the mean values showed ramal length (57.427 $\pm$ 1.2623mm) and mandibular length (114.47 $\pm$ 1.356mm) in Group I. The mean value of corpus length was (71.560 $\pm$ 1.2252mm) in Group I. Changes in the maxilla along with its effect on facial measurements was also anticipated. Group I had mean value for total anterior face height (122.73 $\pm$.961mm) and lower anterior face height

(71.300 $\pm$ 1.0268mm). The mean value of total posterior face height was (75.207 $\pm$ 1.5083mm) in Group I. Jaraback ratio for Group I was (61.227 $\pm$ 1.1380).

GROUP II

The mean value of anterior cranial base length was found to be (69.50 $\pm$ 1.0687mm) in Group II. The mean value of posterior cranial base length was (35.187 $\pm$ 1.2408mm) in Group II. For maxilla significant change was obtained between the two groups, mean value of maxillary length was (48.513 $\pm$ 1.6894mm) in Group II. The linear measurements in the mandible with respect to the mean values showed ramal length (62.340 $\pm$ 1.3282mm) and mandibular length (117.93 $\pm$ 1.335mm) in Group II. The mean value of corpus length was (73.360 $\pm$ 3.4694mm) in Group II. Changes in the maxilla along with its effect on facial measurements was also anticipated. Group II had mean value for total anterior face height (120.60 $\pm$ 1.404mm) and lower anterior face height (71.300 $\pm$ 1.0268mm). The mean value of total posterior face height was (67.780 $\pm$ 1.9667mm) in Group II. Jaraback ratio for Group II was (65.467 $\pm$ 1.9116).

.

The angular measurements, also followed a similar trend showing highly significant changes in the antero-posterior positioning of jaw bases.

GROUP I

The mean value of cranial base angle was (130.60 $\pm$ 1.454 degrees) in Group I. Depicting the maxillo-mandibular relationship with the cranial base, Group I showed values for SNA(77.113 $\pm$ 1.2524degrees), SNB(76.580 $\pm$ 1.9719degrees), ANB(.6600 $\pm$ 1.88574 degrees). The mean value of angle of convexity was (-3.4173 $\pm$ 1.53940degrees) in Group I. The mean values were seen in Group I as follows, Saddle angle(122.07 $\pm$ 1.163degrees), Articular angle(145.07 $\pm$ 2.052degrees) and Gonial angle(126.60 $\pm$ 1.993degrees). Bjork sum had a mean value (393.60 $\pm$ 1.549) in

Group I.

GROUP II

The mean value of cranial base angle was $(128.07 \pm 1.033 \text{ degrees})$ in Group II. Depicting the maxillo-mandibular relationship with the cranial base, Group II showed values for SNA($83.060 \pm 1.1044 \text{ degrees}$), SNB($80.833 \pm 1.1191 \text{ degrees}$), and ANB($2.2227 \pm .65317 \text{ degrees}$). The mean value of angle of convexity was $(4.4753 \pm .55420 \text{ degrees})$ in Group I. The mean values was seen in Group II as follows, Saddle angle($122.40 \pm 1.404 \text{ degrees}$), Articular angle($145.87 \pm 1.506 \text{ degrees}$) and Gonial angle($127.07 \pm 1.033 \text{ degrees}$). Bjork sum had a mean value (394.73 ± 1.387) in Group II.

DENTAL PARAMETERS

The **dental parameters** showed linear and angular changes in the upper and lower incisor protrusion and inclination.

GROUP I

The mean values of upper incisor protrusion and inclination was $(2.9233 \pm .96304 \text{ mm}; 17.240 \pm .5026 \text{ degrees})$ in Group I respectively. The lower incisor had mean values of protrusion and inclination Group I as $(2.4960 \pm .56343 \text{ mm}; 14.233 \pm .6532 \text{ degrees})$.

GROUP II

The mean values of upper incisor protrusion and inclination was $(6.2567 \pm .56343 \text{ mm}; 30.860 \pm 1.3426 \text{ degrees})$ in Group II respectively. The lower incisor had mean values of protrusion and inclination Group II as $(3.3447 \pm .86574 \text{ mm}; 17.467 \pm .6241 \text{ degrees})$ respectively.

TABLE 2-Descriptive statistics of Skeletal and Dental (Linear and Angular) parameters in **CORONAL PLANE** (Group I & Group II).

S.NO.	PARAMETERS		Group I Mean $\pm$ Standard Deviation (N=15)	Group II Mean $\pm$ Standard Deviation (N=15)
	<u>SKELETAL</u>			
	(LINEAR MEASUREMENTS)	ABBREVIATIONS	(in mm)	(in mm)
1.	Interorbital width	LoR-LoL	91.247 $\pm$ 2.8046	92.420 $\pm$ 1.357
2.	Facial width	ZyR-ZyL	122.27 $\pm$ 3.150	123.13 $\pm$ 3.270
3.	Nasal width	NcR-NcL	31.560 $\pm$ 1.2993	28.413 $\pm$.8774
4.	Maxillary width	JR-JL	60.153 $\pm$ 2.2532	64.207 $\pm$ 1.5224
5.	Antegonial width	AgR-AgL	83.0333 $\pm$ 1.39061	82.9853 $\pm$ 1.93976
	(ANGULAR MEASUREMENTS)		(in degrees)	(in degrees)
6.	Postural Symmetric Right	ZyR-AgR-LoR	15.887 $\pm$ 1.1141	16.460 $\pm$.8218
7.	Postural Symmetric Left	ZyL-AgL-LoL	15.887 $\pm$.9635	16.287 $\pm$.7577
	<u>DENTAL</u>		(in mm)	(in mm)
8.	Maxillary molar width	Max6R-Max6L	53.500 $\pm$ 1.2490	56.840 $\pm$ 1.3357
9.	Mandibular molar width	Mand6R-Mand6L	55.333 $\pm$ 1.1127	54.807 $\pm$ 1.1480

Table 2 depicts the descriptive statistics of Skeletal and Dental (Linear and Angular) parameters in Coronal plane (Group I & Group II).

SKELETAL PARAMETERS

For **linear measurements**,

GROUP I

The mean value for interorbital width was $(91.247 \pm 2.8046 \text{ mm})$ in Group I and facial width was $(122.27 \pm 3.150 \text{ mm})$ in Group I. The nasal width was observed in Group I as $(31.560 \pm 1.2993 \text{ mm})$. The mean value of maxillary width was $(60.153 \pm 2.2532 \text{ mm})$ in Group I. The mean value of antegonial width in the mandible was $(83.0333 \pm 1.39061 \text{ mm})$ in Group I.

GROUP II

The mean value for interorbital width was $(92.420 \pm 1.3571 \text{ mm})$ and facial width was $(123.13 \pm 3.270 \text{ mm})$ in Group II. The nasal width was observed in Group II as $(28.413 \pm 0.8774 \text{ mm})$. The mean value of maxillary width was $(64.207 \pm 1.5224 \text{ mm})$ in Group II. The mean value of antegonial width in the mandible was $(82.9853 \pm 1.93976 \text{ mm})$ in Group II.

For **angular measurements**,

GROUP I

The postural symmetry in Group I on the right side was $(15.887 \pm 1.1141 \text{ degrees})$ and left side was $(16.460 \pm 0.8218 \text{ degrees})$.

GROUP II

The postural symmetry in Group II on the right side was $(15.887 \pm 0.9635 \text{ degrees})$ and left side was $(16.287 \pm 0.7577 \text{ degrees})$.

DENTAL PARAMETERS

For **dental measurements**,

GROUP I

The mean value for maxillary molar width was (53.500 $\pm$ 1.2490mm) and the mandibular molar width was (55.333 $\pm$ 1.1127mm) in Group I.

GROUP II

The mean value for maxillary molar width was (56.840 $\pm$ 1.3357mm) and the mandibular molar width was (54.807 $\pm$ 1.1480mm) in Group II.

TABLE 3-Descriptive statistics of Skeletal and Dental (Linear) parameters in AXIAL PLANE (Group I & Group II).

S.NO.	PARAMETERS		Group I Mean $\pm$ Standard Deviation (N=15)	Group II Mean $\pm$ Standard Deviation (N=15)
	<u>SKELETAL</u>			
	(LINEAR MEASUREMENTS)	ABBREVIATIONS	(in mm)	(in mm)
1.	Facial width	ZyR-ZyL	121.33 $\pm$ 3.352	122.53 $\pm$ 3.248
2.	Maxillary width	JR-JL	59.693 $\pm$ 2.5081	63.860 $\pm$ 1.5431
	<u>DENTAL</u>		(in mm)	(in mm)
3.	Maxillary molar width	Max6R-Max6L	51.8470 $\pm$ 1.2112	55.333 $\pm$ 1.3927

Table 3 depicts the descriptive and comparative statistics of Skeletal and Dental (Linear) parameters in Axial plane (Group I & Group II).

SKELETAL PARAMETERS

GROUP I

The mean value of facial width was (121.33 $\pm$ 3.352mm) and the mean value of maxillary width was (59.693 $\pm$ 2.5081mm) in Group I.

GROUP II

The mean value of facial width was (122.53 $\pm$ 3.248mm) and the mean value of maxillary width was (63.860 $\pm$ 1.5431mm) in Group II.

DENTAL PARAMETERS

GROUP I

For dental measurements, the mean value for maxillary molar width was (51.8470 $\pm$ 1.2112mm) in Group I.

GROUP II

For dental measurements, the mean value for maxillary molar width was (55.333 $\pm$ 1.3927mm). in Group II.

Table 4: Inter-Group comparison of Skeletal and Dental (Linear and Angular) parameters in **SAGITTAL PLANE** using Student t test (Group I vs Group II).

S.NO.	PARAMETERS		Group I Mean $\pm$ Standard Deviation (N=15)	Group II Mean $\pm$ Standard Deviation (N=15)	P Value
	<u>SKELETAL</u>				
	(LINEAR MEASUREMENTS)	ABBREVIATIONS	(in mm)	(in mm)	

1.	Anterior Cranial Base Length	N-Se	66.627 $\pm$ 1.9612	69.507 $\pm$ 1.0687	0.001
2.	Posterior Cranial Base length	S-Ba	33.440 $\pm$.8356	35.187 $\pm$.2408	0.001
3.	Maxillary Length	PNS-ANS	44.047 $\pm$ 1.1463	48.513 $\pm$ 1.6894	0.001
4.	Ramus Length	Co-Go	57.427 $\pm$ 1.2623	62.340 $\pm$ 1.3282	0.001
5.	Corpus length	Go-Gn	71.560 $\pm$ 1.2252	73.360 $\pm$ 3.4694	0.069
6.	Mandibular Length	Co-Gn	114.47 $\pm$ 1.356	117.93 $\pm$ 1.335	0.001
7.	Total Anterior Face Height	N-Me	122.73 $\pm$.961	120.60 $\pm$ 1.404	0.001
8.	Total Posterior Face Height	S-Go	75.207 $\pm$ 1.5083	78.880 $\pm$.6450	0.001
9.	Lower Anterior Facial Height	ANS-Me	71.300 $\pm$.1.0268	67.780 $\pm$.9667	0.001
10.	Jaraback Ratio	S-Go/N-Me x 100	61.227 $\pm$ 1.1380	65.467 $\pm$.9116	0.001
	(ANGULAR MEASUREMENTS)		(in degrees)	(in degrees)	
11.	Cranial Base Angle	N-S-Ba	130.60 $\pm$ 1.454	128.07 $\pm$ 1.033	0.001
12.	Maxillary Prognathism	SNA	77.113 $\pm$ 1.2524	83.060 $\pm$ 1.1044	0.001
13.	Mandibular Prognathism	SNB	76.580 $\pm$.9719	80.833 $\pm$ 1.119	0.001
14.	Skeletal Discrepancy	ANB	.6600 $\pm$.88574	2.2227 $\pm$.65317	0.001
15.	Angle of Convexity	N-A-Pog	-3.4173 $\pm$.53940	4.4753 $\pm$.55420	0.001
16.	Saddle Angle	N-S-Ar	122.07 $\pm$ 1.163	122.40 $\pm$ 1.404	0.485
17.	Articular Angle	S-Ar-Go	145.07 $\pm$ 2.052	145.87 $\pm$ 1.506	0.234
18.	Gonial Angle	Ar-Go-Me	126.60 $\pm$ 1.993	127.07 $\pm$ 1.033	0.427

19.	Bjork Sum		393.60 $\pm$ 1.549	394.73 $\pm$ 1.387	0.044
	<u>DENTAL</u>				
	(LINEAR MEASUREMEN TS)		(in mm)	(in mm)	
20.	Maxillary Incisor protrusion	U1 to A-Pog	2.9233 $\pm$.96304	6.2567 $\pm$.56343	0.001
21.	Mandibular Incisor protrusion	L1 to A-Pog	2.4960 $\pm$.56343	3.3447 $\pm$.86574	0.001
	(ANGULAR MEASUREMEN TS)		(in degrees)	(in degrees)	
22.	Maxillary Incisor Inclination	U1 to A-Pog	17.240 $\pm$.5026	30.860 $\pm$ 1.3426	0.001
23.	Mandibular Incisor Inclination	L1 to A-Pog	14.233 $\pm$.6532	17.467 $\pm$.6241	0.001

Table 4 depicts the **Inter-Group comparison** of Skeletal and Dental (Linear and Angular) parameters in Sagittal plane (Group I vs Group II).

SKELETAL PARAMETERS

The mean value of anterior cranial base length was found to be lesser in Group I(66.627 $\pm$ 1.9612mm) as compared to Group II(69.50 $\pm$ 1.0687mm).The mean value of posterior cranial base length also showed lesser mean value in Group I(33.440 $\pm$.8356mm) as compared to Group II(35.187 $\pm$.2408mm) and differential mean was statistically significant for both the parameters (p value =0.001). For maxilla statistically significant change(p value =0.001) was obtained between the two groups, mean value of maxillary length was lesser in Group I(44.047 $\pm$ 1.1463mm) as compared to Group II(48.513 $\pm$ 1.6894mm).The linear measurements in the mandible with respect to the mean values of ramal

length($57.427 \pm 1.2623\text{mm}$) and mandibular length ($114.47 \pm 1.356\text{mm}$) showed lesser values among Group I as compared to Group II where ramal length($62.340 \pm 1.3282\text{mm}$) and mandibular length ($117.93 \pm 1.335\text{mm}$) showed greater values with a statistically significant differential mean (p value =0.001). However, no statistically significant difference (p value =0.069) was seen in the mean value of corpus length which showed slightly lesser value in Group I($71.560 \pm 1.2252\text{mm}$) as compared to Group II($73.360 \pm 3.4694\text{mm}$). Changes in the maxilla along with its effect on facial measurements was also anticipated. A greater mean value for total anterior face height($122.73 \pm .961\text{mm}$) and lower anterior face height($71.300 \pm .10268\text{mm}$) was seen in Group I as compared to Group II, total anterior face height($120.60 \pm 1.404\text{mm}$) and lower anterior face height($67.780 \pm .9667\text{mm}$) and differential mean was statistically significant (p value =0.001) for the two parameters. On the contrary mean value of total posterior face height was lesser in Group I($75.207 \pm 1.5083\text{mm}$) as compared to Group II($78.880 \pm .6450\text{mm}$). The mean value of Jaraback ratio was also lesser in Group I(61.227 ± 1.1380) than in Group II ($65.467 \pm .9116$). Both of these parameters showed a statistically significant differential mean (p value =0.001).

The **angular measurements** also followed a similar trend showing highly significant changes in the antero-posterior positioning of jaw bases. The mean value of cranial base angle was more obtuse in Group I($130.60 \pm 1.454\text{degrees}$) as compared to Group II($128.07 \pm 1.033\text{degrees}$) and differential mean was statistically significant (p value =0.001). Depicting the maxillo-mandibular relationship with the cranial base, lesser mean values in the SNA($77.113 \pm 1.2524\text{degrees}$), SNB($76.580 \pm .9719\text{degrees}$), ANB($.6600 \pm .88574\text{degrees}$) was seen in Group I as compared to Group II SNA($83.060 \pm 1.1044\text{degrees}$), SNB($80.833 \pm 1.1191\text{degrees}$), and ANB($2.2227 \pm .65317\text{degrees}$). The mean value of angle of convexity was lesser in Group I($-3.4173 \pm .53940\text{degrees}$) indicative of retrusive maxilla as compared to the Group II($4.4753 \pm .55420\text{degrees}$). All of the above stated parameters

showed that the differential mean was statistically significant (p value =0.001). No statistically significant difference in mean values was observed in the Saddle angle(p value=0.485);(Group I 122.07 ± 1.163 degrees; Group II 122.40 ± 1.404 degrees),Articular angle(p value=0.234);(Group I 145.07 ± 2.052 degrees; Group II 145.87 ± 1.506 degrees) and Gonial angle(p value=0.427);(Group I 126.60 ± 1.993 degrees; Group II 127.07 ± 1.033 degrees) in both the groups.Bjork sum showed slightly lesser mean value in Group I(393.60 ± 1.549) as compared to Group II(394.73 ± 1.387) but differential mean was statistically significant (p value =0.044).

DENTAL PARAMETERS

The **dental parameters** showed linear and angular changes in the upper and lower incisor protrusion and inclination.The mean values of upper incisor protrusion and inclination was lesser in Group I($2.9233 \pm .96304$ mm; $17.240 \pm .5026$ degrees) as compared to Group II($6.2567 \pm .56343$ mm; 30.860 ± 1.3426 degrees) respectively.The lower incisor also had lesser mean values of protrusion and inclination among the two groups,GroupI($2.4960 \pm .56343$ mm; $14.233 \pm .6532$ degrees) and GroupII ($3.3447 \pm .86574$ mm; $17.467 \pm .6241$ degrees) respectively.All the above stated dental parameters showed a differential mean that was statistically significant (p value =0.001).

Table 5: Inter-Group comparison of Skeletal and Dental (Linear and Angular) parameters in CORONAL PLANE using Student t test (Group I vs Group II).

Table 5 depicts the **Inter- group comparision** of Skeletal and Dental (Linear and Angular) parameters in Coronal plane (Group I vs Group II).

S.NO.	PARAMESTERS		Group I Mean $\pm$ Standard Deviation (N=15)	Group II Mean $\pm$ Standard Deviation (N=15)	P Value
	<u>SKELETAL</u>				
	(LINEAR MEASUREMEN TS)	ABBREVIATIO NS	(in mm)	(in mm)	
1.	Interorbital width	LoR-LoL	91.247 $\pm$ 2.8046	92.420 $\pm$ 1.357	0.37
2.	Facial width	ZyR-ZyL	122.27 $\pm$ 3.150	123.13 $\pm$ 3.270	0.466
3.	Nasal width	NcR-NcL	31.560 $\pm$ 1.2993	28.413 $\pm$.8774	0.001
4.	Maxillary width	JR-JL	60.153 $\pm$ 2.2532	64.207 $\pm$ 1.5224	0.001
5.	Antegonial width	AgR-AgL	83.0333 $\pm$ 1.39061	82.9853 $\pm$ 1.93976	0.938
	(ANGULAR MEASUREMEN TS)		(in degrees)	(in degrees)	
6.	Postural Symmetric Right	ZyR-AgR-LoR	15.887 $\pm$ 1.1141	16.460 $\pm$.8218	0.120
7.	Postural Symmetric Left	ZyL-AgL-LoL	15.887 $\pm$.9635	16.287 $\pm$.7577	0.217
	<u>DENTAL</u>		(in mm)	(in mm)	
8.	Maxillary molar width	Max6R-Max6L	53.500 $\pm$ 1.2490	56.840 $\pm$ 1.3357	0.001
9.	Mandibular molar width	Mand6R- Mand6L	55.333 $\pm$ 1.1127	54.807 $\pm$ 1.1480	0.212

SKELETAL PARAMETERS

For **linear measurements**, the mean value for interorbital width was lesser in Group I($91.247 \pm 2.8046\text{mm}$) as compared to Group II($92.420 \pm 1.3571\text{mm}$) and the differential mean was statistically significant (p value =0.37).The facial width showed no statistically significant difference in mean value(p value =0.466) but was less in Group I($122.27 \pm 3.150\text{mm}$) than in Group II($123.13 \pm 3.270\text{mm}$).The nasal width was observed as greater in Group

I($31.560 \pm 1.2993\text{mm}$) as compared to the mean value in Group II($28.413 \pm .8774\text{mm}$) and the differential mean was statistically significant (p value =0.001)..The mean value of maxillary width was lesser in Group I($60.153 \pm 2.2532\text{mm}$) than in Group II($64.207 \pm 1.5224\text{mm}$) and the differential mean was statistically significant (p value =0.001).The mean value of antegonial width in the mandible showed no statistically significant difference(p value=0.938) but was greater in Group I($83.0333 \pm 1.39061\text{mm}$) and in Group II($82.9853 \pm 1.93976\text{mm}$).

For **angular measurements**, the postural symmetry on the right side(p value=0.120) and left side (p value=0.217) showed no statistically significant difference in mean values of Group I($15.887 \pm 1.1141\text{degrees}$; $15.887 \pm .9635\text{degrees}$) and Group II($16.460 \pm .8218\text{degrees}$; $16.287 \pm .7577\text{degrees}$) respectively.

DENTAL PARAMETERS

For **dental measurements**, the mean value for maxillary molar width was lesser in Group I($53.500 \pm 1.2490\text{mm}$) as compared to Group II($56.840 \pm 1.3357\text{mm}$) and the differential mean was statistically significant (p value =0.001).The mandibular molar width was greater in Group

I(55.333 ± 1.1127 mm) as compared to Group II(54.807 ± 1.1480 mm) but showed no statistically significant difference (p value=0.212).

Table 6: Inter-Group comparison of of Skeletal and Dental (Linear) parameters in AXIAL PLANE using Student t test (Group I vs Group II).

S.NO.	PARAMETERS		Group I Mean $\pm$ Standard Deviation (N=15)	Group II Mean $\pm$ Standard Deviation (N=15)	P Value
	<u>SKELETAL</u>				
	(LINEAR MEASUREMENTS)	ABBREVIATIONS	(in mm)	(in mm)	
1.	Facial width	ZyR-ZyL	121.33 ± 3.352	122.53 ± 3.248	0.328
2.	Maxillary width	JR-JL	59.693 ± 2.5081	63.860 ± 1.5431	0.001
	<u>DENTAL</u>		(in mm)	(in mm)	
3.	Maxillary molar width	Max6R-Max6L	51.8470 ± 1.2112	55.333 ± 1.3927	0.001

Table 6 depicts the **Inter-Group comparison** of of Skeletal and Dental (Linear) parameters in Axial plane (Group I vs Group II).

SKELETAL PARAMETERS

The facial width no showed no significant difference (p value=0.328) in mean value but was less in Group I(121.33 ± 3.352 mm) than in Group II(122.53 ± 3.248 mm). The mean value of maxillary width was lesser in Group I(59.693 ± 2.5081 mm) than in Group II(63.860 ± 1.5431 mm) and the differential mean was statistically significant (p value =0.001).

.DENTAL PARAMETERS

For **dental measurements**, the mean value for maxillary molar width was lesser in Group I($51.8470 \pm 1.2112\text{mm}$) as compared to Group II($55.333 \pm 1.3927\text{mm}$) and the differential mean was statistically significant (p value =0.001).

Orthodontics have long been concerned about skeletal and dental deformities seen in repaired cleft lip and palate which form a significant number of patients coming to the orthodontist. These developing dental and skeletal problems cause both aesthetic and functional implications for patients in their social interactions, particularly on their ability to communicate effectively and on their facial appearance with or without involvement of lip. The treatment of such patients starts as early as 3-4 months from surgical repair of the lip and palate to orthodontic treatment late in life to compensate for the morbidity.⁷

Williams et al² examined repaired cleft lip and palate patients at 5 and 12 years of age and observed 40% of the patients at 5 years of age had poor dental arch form and 70% at 12 years of age had mid-face retrusion. The abnormal facial morphology in surgically treated cleft lip and palate patients has been attributed to two factors- intrinsic development or iatrogenic factors induced by treatment. Inhibition of the growth and development of the naso-maxillary complex in surgically treated cleft lip and palate patients was also documented by **Graber**⁴ in his landmark study. The clinical presentation of craniofacial region of surgically repaired CLP patients significantly affects all three planes, i.e. Sagittal, Vertical and Transverse plane.⁴

Growth completes in transverse plane firstly, followed by antero-posterior dimension and vertical dimension attain growth completion lastly.⁴ Hence, early assessment of these discrepancies is of paramount importance in proper diagnosis and treatment planning. Considering the consequences of CLP, not only the sagittal but transverse craniofacial morphology should be evaluated. There is a paucity of studies which have focused on measuring both the transverse and sagittal parameters of patients affected with repaired CLP.

Apparent maxillofacial asymmetry has been assessed by **Abuhijleh et al**¹⁶, **Athanasίου et al**¹⁷ and **Alexandra I. Holst et al**¹⁸ using radiographic techniques like lateral cephalograms and frontal proportional cephalometric

analysis. Magnification, distortion and superimposition of craniofacial morphology are a few drawbacks of these conventional radiographs. CBCT provides unobstructed views of bilateral landmarks and 3D reconstruction along with more accurate skeletal, dental and volumetric measurements (Suri et al 2008²⁰, Suleyman Kutalmis et al 2017¹, Anuraj S Kochar¹⁹ 2020). As suggested by Molsted et al³⁵ a three dimensional approach is needed in order to obtain a more coherent understanding of the role of the development of craniofacial structures in cleft anomalies.

To overcome these limitations, this study was conducted in the Department of Orthodontics and Dentofacial Orthopaedics, BBDCODS, Lucknow to evaluate the craniofacial morphology of surgically repaired CLP patients in sagittal and transverse plane using CBCT and to evaluate the iatrogenic effects of surgical procedures on the morbid anatomy.

30 CBCT scans were collected from the Department of Plastic Surgery, KGMU based on the inclusion and exclusion criteria and were grouped as: GROUP I (n=15) included subjects with surgically repaired cleft lip and palate who came to the Department of Plastic Surgery, KGMU through Smile Train for orthodontic treatment; GROUP II (n=15) included non-cleft subjects from the Department of Plastic Surgery, KGMU. These scans were uploaded on laptop and converted into the appropriate format using DICOM file. 35 parameters (22 linear and 13 angular) were measured in sagittal, coronal and axial views using CS 9300 imaging software. The measured data was tabulated and subjected to appropriate statistical analysis.

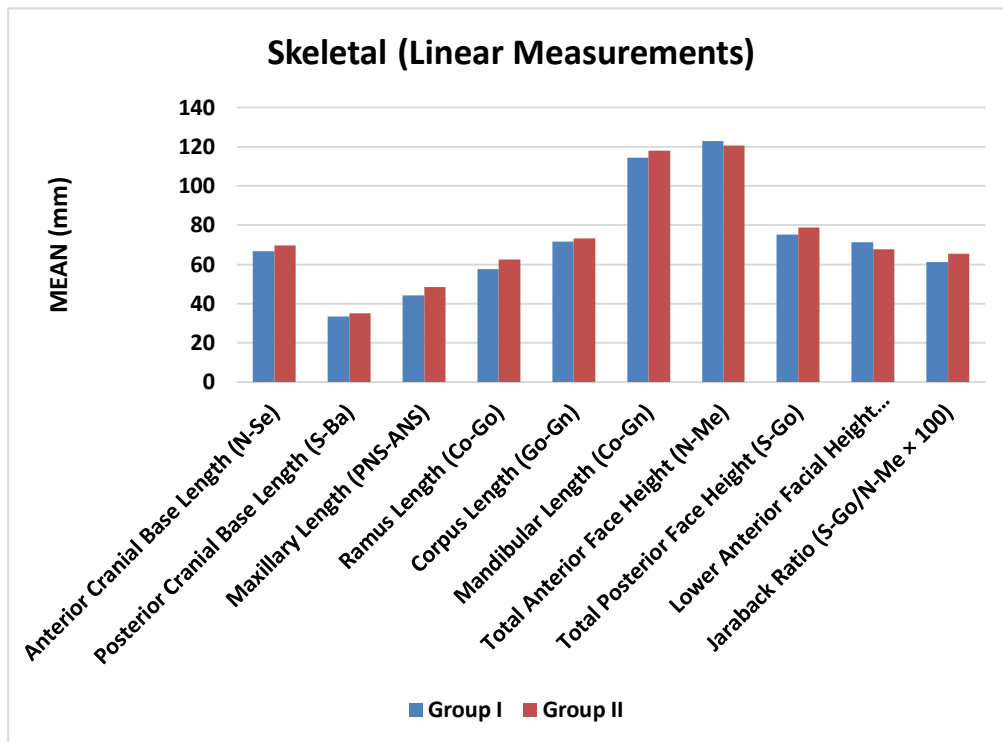
The result of the present study suggested that craniofacial morphology differed between the surgically repaired cleft lip and palate patients and the non-cleft patients in all three planes i.e. Sagittal, Coronal and Axial planes. The presence of significant difference in growing subjects as suggested by linear and angular parameters related to cranial base between the surgically repaired cleft and non-cleft subjects indicated deviation of cleft subjects from normal growth because of both morphogenetic and

environmental factors.

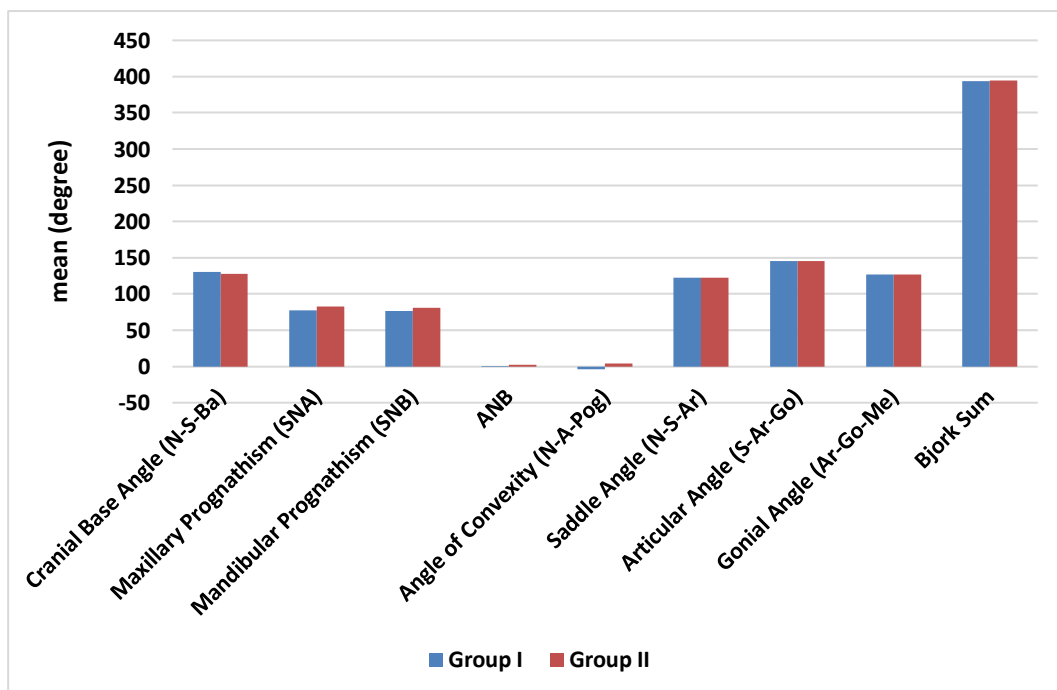
Horizontal asymmetry was evident by various parameters evaluated in Sagittal, Coronal and Axial plane whereas vertical asymmetry was evident by various parameters in Sagittal plane. There was noticeable horizontal asymmetry for the maxilla in surgically repaired cleft subjects, with significant overall vertical asymmetry in sagittal plane. Also transverse dimensions of maxilla was significantly restricted with no significant change in mandible between surgically repaired cleft and non cleft subjects in Coronal and Axial planes.

SAGITTAL PLANE

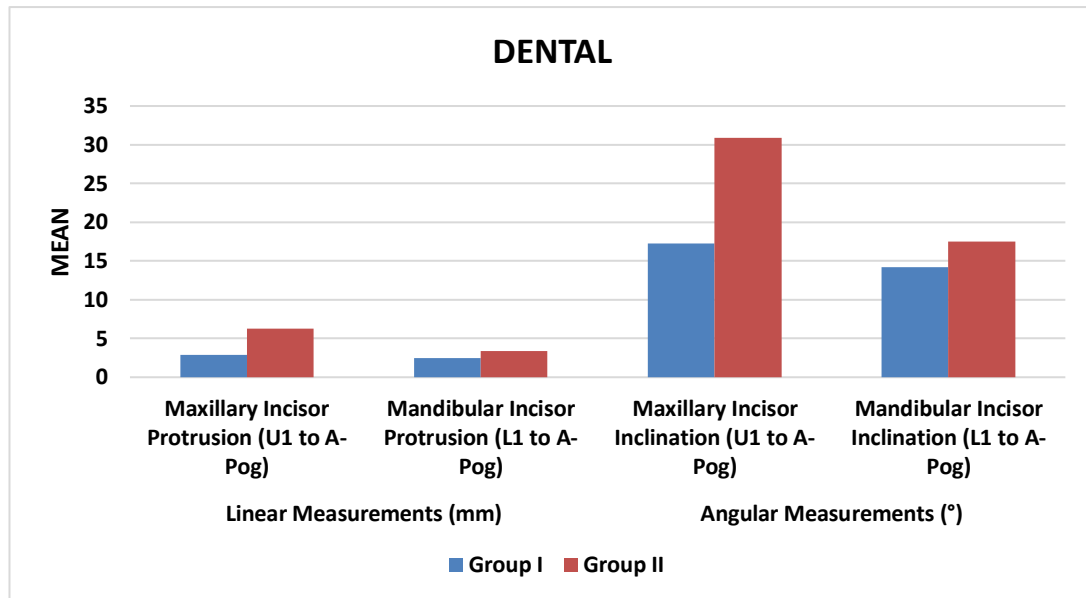
In the present study, **Inter-Group comparison** of Skeletal and Dental (Linear and Angular) parameters in **SAGITTAL PLANE** (Group I vs Group II) as seen in Graph 1 showed statistically significant differences for most of the **linear parameters**-Anterior Cranial Base Length(**N-Se**), Posterior Cranial Base length(**S-Ba**), Maxillary Length(**PNS-ANS**), Ramus Length(**Co-Go**), Mandibular Length(**Co-Gn**), Total Anterior Face Height(**N-Me**), Total Posterior Face Height(**S-Go**), Lower Anterior Facial Height(**ANS-Me**), Jaraback Ratio(**S-Go/N-Mex 100**), Maxillary Incisor protrusion(**U1 to A-Pog**), Mandibular Incisor protrusion(**L1 to A-Pog**) and **angular parameters**-Cranial Base Angle(**N-S-Ba**), Maxillary Prognathism(**SNA**), Mandibular Prognathism(**SNB**), Skeletal Discrepancy(**ANB**), Angle of Convexity(**N-A-Pog**), Bjork Sum, Maxillary Incisor inclination(**U1 to A-Pog**), Mandibular Incisor inclination(**L1 to A-Pog**) between the two groups. Exceptions were observed in the study which showed no statistical significant mean difference in **mandibular linear parameter**-Corpus length(**Go-Gn**) and **angular parameters**-Saddle Angle(**N-S-Ar**), Articular angle(**S-Ar-Go**) and Gonial Angle(**Ar-Go-Me**).



Bar Graph 1a-Inter-Group comparison of Skeletal Linear parameters in **SAGITTAL PLANE** (Group I vs Group II)



Bar Graph 1b-Inter-Group comparison of Skeletal (Angular) parameters in **SAGITTAL PLANE** (Group I vs Group II)



Bar Graph 1c-Inter-Group comparison of Dental (Linear and Angular) parameters in **SAGITTAL PLANE** (Group I vs Group II)

For linear measurements, the mean value of anterior cranial base length was found to be significantly lesser, Group I ($66.627 \pm 1.9612 \text{ mm}$) < Group II ($69.50 \pm 1.0687 \text{ mm}$). The mean value of posterior cranial base length also showed significantly lesser mean value, Group I ($33.440 \pm .8356 \text{ mm}$) < Group II ($35.187 \pm .2408 \text{ mm}$) and mean difference was statistically significant for both the parameters (p value = 0.001).

Cranial base length has been discussed and debated in the literature more than flexure abnormalities. **Mazaheri et al**²⁷ believed that the cranial base displayed a regional difference of growth potential in cleft types, with variability in dimension. This concept was expanded by **Krogman et al**²⁸ when they observed that cranial base shape was influenced by clefting. **Ross**²⁹ and **Bishara and Iversen**¹⁰ have observed a generally smaller cranial base in orofacial clefting, but this was not significant in their studies. **Dahl et al**³⁰ compared infants with isolated cleft palate and those with cleft lip only and found a smaller ACB in those infants with palatal clefts. They theorized that clefting of the palate may be associated with an intrinsic defect in the embryonic basicranial structures.

Horswell et al³¹ also had shorter anterior cranial base length for the cleft group of ages 7-18 years, similar to the present study. **Smahel³²** also observed a shorter PCB in his cleft subjects, particularly in those with BCLP. Similar findings as in the present study were also reported by **Shetye PR, Evans CA⁸ and Abuhijleh et al¹⁶**. On the contrary, **Sandham A et al³³ and Goyenc YB et al³⁴** found no abnormal growth in the cranial base structures. Much of the contradiction and controversy lies in the use of limited and indirect instruments for measuring growth, ie, cephalometric radiographs. The association between the abnormal cranial base morpholog and cleft palate can be explained both anatomically and functionally. Anatomically, the cranial base can be considered as a border structure between the neurocranium and the facial skeleton. Thus, development and growth of the cranial base may interact with both neurocranial and facial skeletal development (**Molsted et al.³⁵**). Also, as the sphenooccipital synchondrosis represents remnants of the early chondrocranium, it is possible that an inborn alteration, an aberrant growth, or delayed maturation of the cartilage tissue may affect the cranial base (**Muller and O'Rahilly³⁶**). Functionally, factors such as extended head posture caused by reduced size of the airway, may also affect the postnatal growth pattern of the cranial base in subjects with CLP (**Hermann et al.³⁷**).

In maxilla statistically significant change (p value = 0.001) was obtained between the two groups in the present study, mean value of maxillary length was significantly lesser, Group I (44.047 ± 1.1463 mm) < Group II (48.513 ± 1.6894 mm).

Studies by **Hayashi et al³⁸, Ozturk et al³⁹, Treutlein C et al⁴⁰, Schneiderman et al⁴¹, Pradeep et al⁸ and Antonarakis et al⁴²** showed similar results for the maxillary length. **Smahel et al³²** found that the shortening of the maxilla was not present in UCLP patients prior to palate surgery. **Bardach J⁴³, Ozturk et al³⁹ and Capellozza Filho et al⁴⁴** stated that this deficiency in maxillary growth might be due to palatoplasty and scar tissue on the lips. The other reason could also be improper development of the cranial base.

The linear measurements in the mandible as observed in the present study, with respect to the mean values of ramal length($57.427 \pm 1.2623\text{mm}$) and mandibular length ($114.47 \pm 1.356\text{mm}$) showed significantly lesser values among Group I as compared to Group II where ramal length($62.340 \pm 1.3282\text{mm}$) and mandibular length ($117.93 \pm 1.335\text{mm}$) showed significantly greater values, and a statistically significant mean difference(p value $=0.001$) was seen. However, no statistically significant mean difference (p value $=0.069$) was seen in the mean value of corpus length which showed slightly lesser value, Group I($71.560 \pm 1.2252\text{mm}$) < Group II($73.360 \pm 3.4694\text{mm}$).

Studies by **Bishara et al⁴⁵**, **Mars and Houston¹¹**, **Abuhijleh et al¹⁶** and **Shetye PR and Evans CA⁸** was in line with the results in our study. **Capellozza Filho et al** and **Silvia OG et al⁴⁴** reported contrary findings and showed no significant difference in the ramal length, mandibular length and corpus length and stated that surgery for cleft lip and palate has no influence on mandibular growth. Although mandible may not be directly affected by cleft, it may have altered growth pattern because of affected maxilla and functional factors.

In the present study, effect of clefts on facial measurements was also anticipated. A significantly greater mean value for total anterior face height($122.73 \pm .961\text{mm}$) and lower anterior face height($71.300 \pm .1.0268\text{mm}$) was seen in Group I as compared to Group II, total anterior face height($120.60 \pm 1.404\text{mm}$) and lower anterior face height($67.780 \pm .9667\text{mm}$) and mean difference was statistically significant (p value $=0.001$) for the two parameters. On the contrary mean value of total posterior face height was significantly lesser, Group I($75.207 \pm 1.5083\text{mm}$) < Group II($78.880 \pm .6450\text{mm}$). The mean value of Jaraback ratio was also significantly lesser, Group I(61.227 ± 1.1380) < Group II ($65.467 \pm .9116$). Both of these parameters showed a statistically significant mean difference (p value $=0.001$).

Similar findings were seen in studies by **Ortiz-Monasterio et al⁹**, **Bishara et al⁴⁵** and **Shetye PR and Evans CA⁸**. Although similar mean values were noted by **Abuhijleh et al¹⁶** in his study but no significant difference was reported. **Swennen G et al⁴⁶**

stated that the decreased posterior facial height was due to more posterior inclination of the palatal plane. A reduced Jaraback ratio in cleft group was suggestive of vertical growth direction proposed by **Ortiz-Monasterio et al⁹**, **Bishara et al⁴⁵** and **Alexandra I. Holst et al¹⁸**.

For angular measurements, the mean value of cranial base angle was more obtuse in Group I (130.60 ± 1.454 degrees) as compared to Group II (128.07 ± 1.033 degrees) and mean difference was statistically significant (p value = 0.001).

Contrary to our findings **Capelozza Filho et al⁴⁴**, **Mars and Houston¹¹** and **Yu Xi⁴⁷** noted no difference in the cranial base angle. **Molsted K and Dahl E³⁵** and **Ross²⁹**, **Hayashi et al³⁸**, **Ozturk Y³⁹** and **Shetye PR and Evans CA⁸** observed a larger cranial base angle in cleft group as compared to the non cleft group. The effect of cranial base angle on the pharyngeal space and position of the mandible is of importance because this may directly affect the breathing pattern.

Depicting the maxillo-mandibular relationship with the cranial base, significantly lesser mean values in the SNA (77.113 ± 1.2524 degrees), SNB ($76.580 \pm .9719$ degrees), ANB ($.6600 \pm .88574$ degrees) was seen, Group I < Group II SNA (83.060 ± 1.1044 degrees), SNB (80.833 ± 1.1191 degrees), and ANB ($2.2227 \pm .65317$ degrees). The mean value of angle of convexity was significantly lesser in Group I ($-3.4173 \pm .53940$ degrees) indicative of retrusive maxilla as compared to the Group II ($4.4753 \pm .55420$ degrees). All of the above stated parameters showed that the mean difference was statistically significant (p value = 0.001).

Similar findings were seen in the studies by **Alexandra I. Holst et al¹⁸** and **Wolfgang Zemmann et al⁴⁷** indicating distal jaw bases relationship for cleft subjects. **Alexandra I. Holst et al¹⁸** suggested that maxillary retrognathism became more remarkable with increasing age; whereas, the retrognathic position of the mandible became less pronounced in cleft patients as compared with non cleft patients. **Liao and Mars⁴⁸** suggested that surgical lip and palatal repair inhibits the

forward development of the maxilla and antero posterior development of the dentoalveolar dentition. Contrary findings from our study was seen in observations made by **Capellozza Filho et al⁴⁴** and **Mars and Houston¹¹** which showed an increase in SNA and maxillary prognathism in unoperated CLP patients. **Peltomaki et al⁴⁹** did not find a significant difference in the SNA, SNB, and ANB between UCLP patients and individuals with no cleft.

In the present study, no statistically significant difference in mean values was observed in the Saddle angle (p value=0.485); (Group I 122.07 ± 1.163 degrees < Group II 122.40 ± 1.404 degrees), Articular angle (p value=0.234); (Group I 145.07 ± 2.052 degrees < Group II 145.87 ± 1.506 degrees) and Gonial angle (p value=0.427); (Group I 126.60 ± 1.993 degrees < Group II 127.07 ± 1.033 degrees) in both the groups. Bjork sum showed slightly lesser mean value, Group I (393.60 ± 1.549) < Group II (394.73 ± 1.387) but mean difference was statistically significant (p value =0.044).

Ozturk Y and Vinas et al⁵⁰ showed no significant findings for Saddle angle and Articular angle as reported in the present study but the Gonial angle was decreased in both the studies as contrary to our present study.

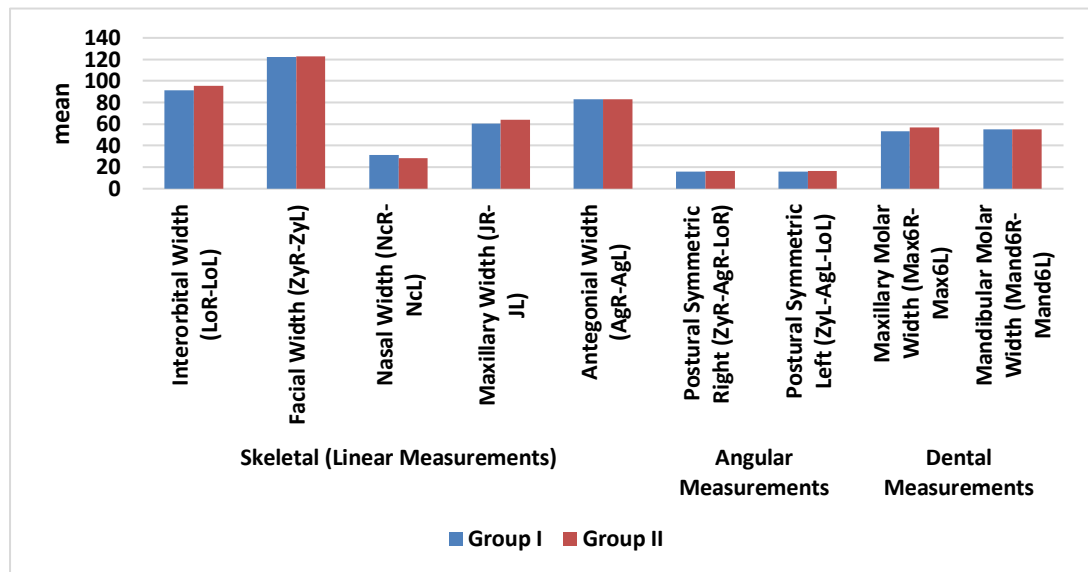
The **dental parameters** showed significant linear and angular changes in the upper and lower incisor protrusion and inclination as observed in our study. The mean values of upper incisor protrusion and inclination was significantly lesser, Group I ($2.9233 \pm .96304$ mm; $17.240 \pm .5026$ degrees) < Group II ($6.2567 \pm .56343$ mm; 30.860 ± 1.3426 degrees). The lower incisor also had significantly lesser mean values of protrusion and inclination among the two groups, Group I ($2.4960 \pm .56343$ mm; $14.233 \pm .6532$ degrees) < Group II ($3.3447 \pm .86574$ mm; $17.467 \pm .6241$ degrees) respectively. All the above stated dental parameters showed a mean difference that was statistically significant (p value =0.001).

Retrusion of the maxillary and mandibular centrals was more pronounced in the cleft

patients than in non cleft patients as studied by **Alexandra I. Holst et al¹⁸** and **S Rawat et al⁵¹** which was in line with the findings in our study. Anterior crossbite is a common feature in patients with repaired clefts. As suggested by **Filho⁵²** the probable explanation to these similar findings compared to our present study could be forward growth of the mandible at symphysis and restrictive effect on the maxilla of the perioral musculature pull in the surgically repaired cleft lip and palate patients. On the contrary, **Shetye PR and Evans CA⁸** stated maxillary incisor protrusion was similar to that in the control group when compared to the unoperated cleft lip and palate patients. A tight lip repair may retrocline the maxillary incisors as evaluated by **Mars and Houston¹¹**.

CORONAL PLANE

In the present study, **Inter-Group comparison** of Skeletal and Dental (Linear and Angular) parameters in **CORONAL PLANE** (Group I vs Group II) as shown in Graph 2 depicts statistically significant differences in the **linear parameters**- Nasal width (**NcR-NcL**), Maxillary width (**JR-JL**), Maxillary molar width (**Max6R-Max6L**). No statistically significant difference was seen in the **linear parameters**- Interorbital width (**LoR-LoL**), Facial width (**ZyR-ZyL**), Antegonial width (**AgR-AgL**), Mandibular molar width (**Mand6R-Mand6L**) and **angular measurements**- Postural Symmetric Right (**ZyR-AgR-LoR**), Postural Symmetric Left (**ZyL-AgL-LoL**) in the surgically treated cleft and non cleft groups.



Bar Graph 2-Inter-Group comparison of Skeletal and Dental (Linear and Angular) parameters in **CORONAL PLANE** (Group I vs Group II)

For linear measurements, the mean value for interorbital width was lesser Group I ($91.247 \pm 2.8046 \text{ mm}$) < Group II ($92.420 \pm 1.3571 \text{ mm}$) but the mean difference was not statistically significant (p value = 0.37). Similarly facial width also showed no statistically significant difference in mean value (p value = 0.466) but was less in Group I ($122.27 \pm 3.150 \text{ mm}$) < Group II ($123.13 \pm 3.270 \text{ mm}$).

These findings were seen in accordance with other studies by **Gorucu- Coskuner et al⁶**, **Duffy et al⁵³**, **Hood et al⁵⁴** and **Suri et al²⁰**. **Molested and Dahl³⁵** in a landmark study found insignificant changes in the lateral orbital margins but feebly significant changes on the medial orbital margin. On the contrary **Buyuk et al¹** concluded a significantly reduced interorbital width in cleft patients. Moreover, **Harikrishnan et al⁵⁵** also divulged that the asymmetry in UCLP patients is not limited to the maxilla, instead emanating to the orbital and zygomatic regions.

The transverse nasal cavity dimensions is one of the interests of the clinicians due to potential interaction between the nasal cavity and breathing pattern. The nasal width was observed in this study as significantly greater, Group I ($31.560 \pm 1.2993 \text{ mm}$) > Group II ($28.413 \pm 0.8774 \text{ mm}$) and the mean difference was statistically significant (p

value =0.001).

Nose widening could be an expected result in the CLP patients because of the potential drift in the nasal base. Previous reports by **Athansiou et al¹⁷**, **Mulliken and La Brie⁵⁶** and **Abuhijleh et al¹⁶** had findings similar to our study with greater nasal width in the cleft patients. However, contrary to our study **Buyuk et al¹** showed no significant changes in the nasal width because the width was obtained parallel to the horizontal plane whereas in the present study, increase in reference to the non cleft group was obtained because of the vertical drift of most of the lateral points on both sides of the nasal cavity. **Gorucu- Coskuner et al⁶** suggested a decrease in nasal width in the UCLP group contrary to the present study which implies that the involvement affected unilateral or bilateral areas in cleft may have varied differences in nasal width when evaluated.

Silvia et al⁴⁴ suggested that the primary surgeries of the lip and palate usually results in the reduction in the transverse dimensions of the upper arch. In the present study, mean value of maxillary width was lesser, Group I ($60.153 \pm 2.2532\text{mm}$) < Group II ($64.207 \pm 1.5224\text{mm}$) and the mean difference was statistically significant (p value =0.001).

These findings were in accordance with studies by **Buyuk et al¹**, **Di Biase et al⁵⁷**, **Jiang et al⁵⁸**, **Wahaj and Ahmed⁵⁹**, **Subtelny et al⁶⁰**, **Gorucu- Coskuner et al⁶** and **Nakamura et al⁶¹**. Contrary results were seen in a study by **Athansiou et al¹⁷** who studied the transverse dimension of maxilla in unoperated cleft patients. The smaller dimensions of maxillary width could be as a result of scar tissue in surgically repaired cleft lip and palate patients (**Ross and Jhonston et al⁶²**). Reduced maxillary width should be taken into account during early orthodontic treatment. Well timed maxillary expansion is suggested to compensate for less favorable transverse jaw growth (**Loomans et al⁶³**).

In the present study the mean value of antegonial width in the mandible showed no statistically significant mean difference (p value=0.938) but was greater, Group

I($83.0333 \pm 1.39061\text{mm}$) > Group II($82.9853 \pm 1.93976\text{mm}$).

For **angular measurements**, the postural symmetry on the right side(p value=0.120) and left side (p value=0.217) showed no statistically significant difference in mean values of Group I ($15.887 \pm 1.1141\text{degrees}$; $15.887 \pm .9635\text{degrees}$) and Group II ($16.460 \pm .8218\text{degrees}$; $16.287 \pm .7577\text{ degrees}$). Likewise previous studies by **Nakamura et al.⁶⁰** and **Krogman et al.²⁸**, **Abuhijleh et al.¹⁶**, **Gorucu- Coskuner et al.⁶** and **Buyuk et al.¹** also obtained similar results. However when evaluating different growth periods significant results were obtained according to **Abuhijleh et al.¹⁶** According to **Veli et al.⁶⁴** patients have symmetric mandibles when comparing the two groups which was in accordance with our study, where we found non significant differences in the postural symmetry of the mandible.

For **dental measurements**, the mean value for maxillary molar width was significantly lesser, Group I($53.500 \pm 1.2490\text{mm}$) < Group II($56.840 \pm 1.3357\text{mm}$) and the mean difference was statistically significant (p value =0.001).

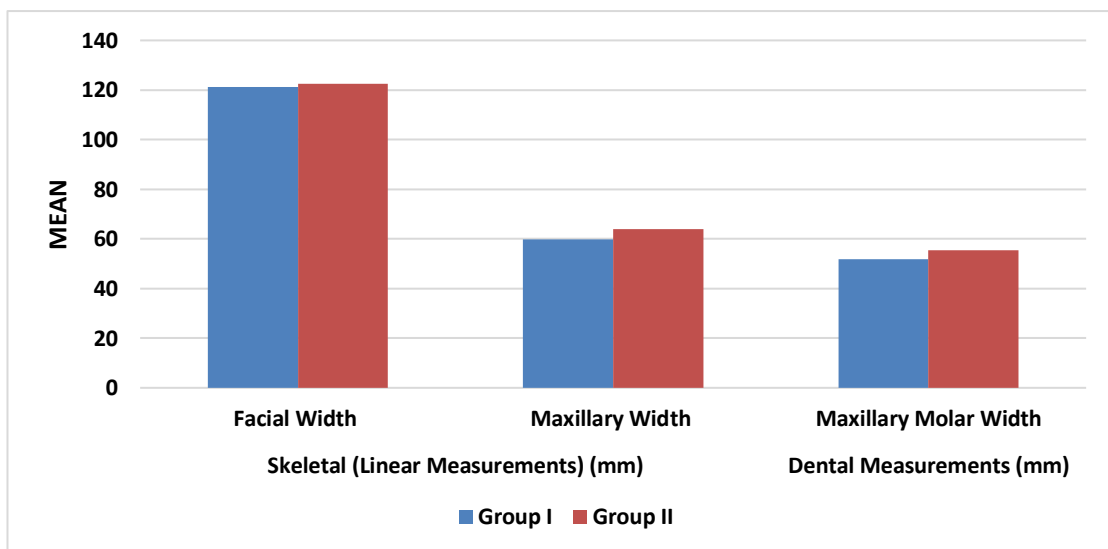
Previous studies by **Buyuk et al.¹**, **Di Biase et al.⁵⁷**, **Jiang et al.⁵⁸**, **Wahaj and Ahmed⁵⁹**, **Subtelny et al.⁶⁰**, **Gorucu- Coskuner et al.⁶**, **Celikoglu et al.¹** and **Nakamura et al.⁶⁰**. Reported similar results. Expansion of the maxillary molar along with the maxillary arch is an essential step in appropriate orthodontic treatment.

The mandibular molar width was greater in Group I as compared to Group II but showed no statistically significant mean difference. **Shrestha et al.⁶⁵** and **Gorucu- Coskuner et al.⁶** observed results similar to our study and stated that in the mandible, unceasing remodeling and remineralization of the cortical bone are seen when subjected to heavy loads such as mastication forces irrespective of the alveolar or palatal clefts.

AXIAL PLANE

In the present study, **Inter-Group comparison** of Skeletal and Dental (Linear) parameters in **AXIAL PLANE** (Group I vs Group II) as shown in Graph 3 depicts

statistically significant differences in the **linear parameters**- Maxillary width(JR-JL) and Maxillary molar width(Max6R-Max6L).No statistically significant difference was seen in the **linear parameter**-Facial width(ZyR-ZyL) in the surgically treated cleft and non cleft groups.



Bar Graph 3-Inter-Group comparison of Skeletal and Dental (Linear and Angular) parameters in **AXIAL PLANE** (Group I vs Group II)

In the present study the facial width showed no significant difference (p value=0.328) in mean value but was slightly lesser Group I(121.33±3.352mm) < Group II(122.53±3.248mm). The mean value of maxillary width was significantly lesser, Group I(59.693±2.5081mm) < Group II(63.860±1.5431mm) and the mean difference was statistically significant (p value =0.001)

In axial view, the cleft and non cleft sides were juxtaposed and similar findings were seen in previous studies by **Anuraj S Kocchar et al¹⁹**, **Harikrishnan et al⁵⁵** and **Patel⁶⁶** whereas **Suri et al²⁰** reported contrasting results. These authors also stated that more accurate results are obtained in axial views of CBCT because, regional anatomy is shown in a series of cross-sectional axial images unobstructed by other anatomic features.

The main limitations of the study are that the surgically repaired cleft subjects were not segregated on the basis of the type of cleft, that is unilateral or bilateral and also unoperated cleft subjects were not included in the sample population. Within these limitations of the present study, it can be concluded that the effect of surgical management on dentofacial morphology as well as compensatory changes to horizontal and vertical asymmetries due to growth were the main reason for observed variations in most of the parameters in all three planes between surgically repaired cleft and non cleft subjects. The amount of scar tissue due to surgical repair of unilateral and bilateral cleft was thought to be the main reason for the restraining effect on growth in maxillary region, which explains the altered functional matrices that play a significant role in determining the growth of craniofacial structures. Besides this in subjects with respect to unilateral clefts, the cleft side contributed to the lesser segment with lesser amount of muscular attachments hence, was vulnerable to abnormal muscle pull created post surgically as compared to the non cleft group.

The findings of the present study suggested that negative effects of surgery do occur but these iatrogenic effects should be weighed upon the benefits of surgery that restores the speech, esthetics and improves the personality of these cleft patients. The surgical act should have minimal tissue manipulation and mobilization to reduce the formation of fibrous scar tissue and thereby minimizing iatrogenicity. Appropriate timing of these surgical protocols for the lip and palate repair should also be considered to minimize the untoward effects on growth of the craniofacial region.

The clinical implications of results of present study would be helpful in managing maxillary constriction in cleft subjects. Maxillary arch constriction as evident in all planes should be managed early and alveolar grafting must be refined and individualized before planning other orthodontic treatments. **Al Gunaid**⁶⁷ stated that the maxillary arch form play an important role in the stabilization of the dental arch width following orthodontic interventions and diminish the tendency of relapse in the

cleft patients. Reshaping the constriction at definite areas with appropriate modalities of expansion required according to the age of the patient helps to gain the adequate amount of expansion and decreases the post treatment relapse. Also management of maxillary retrusion with orthopaedic appliances would be helpful in restraining mandible from becoming prognathic.

The accuracy of measurement on CBCT can be explained for a smaller sample size to be acceptable for the present study. Future scope of the study included validating results on larger samples size and divisions on the basis of type of cleft, that is unilateral or bilateral. Though it is unethical to withhold patient from surgical management at an early stage however if sample is available for unoperated cleft subjects for comparison, the role of surgical management could be understood in a better way.

The following conclusions are drawn from the present study conducted to assess the craniofacial morphology between surgically repaired cleft subjects and non cleft subjects measured in sagittal, coronal and axial planes using CBCT were as follows:

Significantly shorter anterior and posterior cranial base length with significantly increased cranial base angle was seen in surgically repaired cleft subjects in comparison to normal subjects suggestive of deviation from normal growth in surgically repaired cleft subjects.

1. Shorter maxillary length and the posterior positioning of the maxilla in surgically repaired cleft subjects with respect to non cleft subjects showed restricted maxillary growth in sagittal plane. On the contrary mandible was placed normally in sagittal plane.

2. Surgically repaired cleft subjects demonstrated increased vertical dimensions with tendency towards clockwise rotation in comparison to non cleft subjects.

3. A tendency towards concave profile and skeletal Class III pattern was seen in surgically repaired cleft subjects in comparison to non cleft subjects.

4. The restricted maxillary growth was also reflected in retruded and upright maxillary incisors in surgically repaired cleft subjects.

5. Mandibular incisors tried to compensate for the skeletal Class III tendency by being significantly retroclined in surgically repaired cleft subjects in comparison to non cleft subjects.

6. Maxilla was constricted in transverse plane with significantly decreased maxillary width and maxillary molar width in surgically repaired cleft subjects as compared to non cleft subjects in coronal and axial planes.

The overall conclusion demonstrated noticeable horizontal asymmetry for the maxilla in all three planes (sagittal, coronal and axial) with significant overall vertical asymmetry in sagittal plane in surgically repaired cleft subjects. This must be considered while planning treatment for subjects with cleft lip and palate.

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Children With Operated Unilateral Complete Cleft Lip and Palate. Cleft Palate
Craniofac J. 2015 Nov;52(6):e196-200.

Orthodontics have long been concerned about skeletal and dental deformities seen in repaired cleft lip and palate which form a significant number of patients coming to the orthodontist. These developing dental and skeletal problems cause both aesthetic and functional implications for patients in their social interactions, particularly on their ability to communicate effectively and on their facial appearance with or without involvement of lip. The treatment of such patients starts as early as 3-4 months from surgical repair of the lip and palate to orthodontic treatment late in life to compensate for the morbidity. Early assessment of craniofacial discrepancies in cleft subjects is of paramount importance in proper diagnosis and treatment planning.

The present study was conducted in the Department of Orthodontics and Dentofacial Orthopaedics, BBDCODS, Lucknow to evaluate and compare the cranio-facial dimensions in sagittal and transverse plane in surgically repaired cleft lip and palate patients and non cleft patients using CBCT images.

30 CBCT scans were collected from the Department of Plastic Surgery, KGMU based on the inclusion and exclusion criteria and were grouped as: GROUP I (n=15) included subjects with surgically repaired cleft lip and palate who came to the Department of Plastic Surgery, KGMU through Smile Train for orthodontic treatment; GROUP II (n=15) included non-cleft subjects from the Department of Plastic Surgery, KGMU. CBCT scans of surgically repaired cleft lip and palate patients and control group patients were taken using Carestream CS 9300 CBCT machine. The scans were taken in natural head position with the Frankfort plane parallel to the floor and lips relaxed. These scans were uploaded on laptop and converted into the appropriate format using DICOM file. The image enhancement feature of the CS 9300 imaging software like brightness, contrast adjustment and magnification were used to identify individual landmarks as precisely as possible. The landmarks were marked with the help of cursor. 35 parameters (22 linear and 13 angular) were measured in sagittal, coronal and axial views using CS 9300 imaging software. To maintain the uniformity in locating the landmarks, identification of all landmarks were carried out

by the same operator. The data obtained was tabulated and subjected to statistical analysis using SPSS software.

The results of the present study indicated, significantly shorter anterior cranial base length was found in Group I ($66.627 \pm 1.9612\text{mm}$) < Group II ($69.50 \pm 1.0687\text{mm}$) with significantly increased cranial base angle in Group I ($130.60 \pm 1.454\text{degrees}$) > Group II ($128.07 \pm 1.033\text{degrees}$). Maxilla was restricted in all three planes with significantly shorter maxillary length Group I ($44.047 \pm 1.1463\text{mm}$) < Group II ($48.513 \pm 1.6894\text{mm}$), SNA Group I ($77.113 \pm 1.2524\text{degrees}$) < Group II ($83.060 \pm 1.1044\text{degrees}$), significantly decreased maxillary width Group I ($60.153 \pm 2.2532\text{mm}$) < Group II ($64.207 \pm 1.5224\text{mm}$) as well as maxillary molar width Group I ($53.500 \pm 1.2490\text{mm}$) < Group II ($56.840 \pm 1.3357\text{mm}$). Mandible was placed normally. Group I demonstrated increased anterior face height in Group I ($122.73 \pm .961\text{mm}$) < Group II ($120.60 \pm 1.404\text{mm}$). A tendency towards concave profile and skeletal Class III pattern was seen in Group I. The restricted maxillary growth was also reflected in retruded and upright maxillary incisors in Group I ($2.9233 \pm .96304\text{mm}$; $17.240 \pm .5026\text{degrees}$) < Group II ($6.2567 \pm .56343\text{mm}$; $30.860 \pm 1.3426\text{degrees}$).

The following conclusions are drawn from the present study conducted to assess the craniofacial morphology between surgically repaired cleft subjects and non cleft subjects measured in sagittal, coronal and axial planes using CBCT were as follows:

1. Significantly shorter anterior and posterior cranial base length with significantly increased cranial base angle was seen in surgically repaired cleft subjects in comparison to normal subjects suggestive of deviation from normal growth in surgically repaired cleft subjects.
2. Shorter maxillary length and the posterior positioning of the maxilla in surgically

repaired cleft subjects with respect to non cleft subjects showed restricted maxillary growth in sagittal plane. On the contrary mandible was placed normally in sagittal plane.

3. Surgically repaired cleft subjects demonstrated increased vertical dimensions with tendency towards clockwise rotation in comparison to non cleft subjects.

4. A tendency towards concave profile and skeletal Class III pattern was seen in surgically repaired cleft subjects in comparison to non cleft subjects.

5. The restricted maxillary growth was also reflected in retruded and upright maxillary incisors in surgically repaired cleft subjects.

6. Mandibular incisors tried to compensate for the skeletal Class III tendency by being significantly retroclined in surgically repaired cleft subjects in comparison to non cleft subjects.

7. Maxilla was constricted in transverse plane with significantly decreased maxillary width and maxillary molar width in surgically repaired cleft subjects as compared to non cleft subjects in coronal and axial planes.

The overall conclusion demonstrated noticeable horizontal asymmetry for the maxilla in all three planes (sagittal, coronal and axial) with significant overall vertical asymmetry in sagittal plane in surgically repaired cleft subjects. This must be considered while planning treatment for subjects with cleft lip and palate.



Dr. Lakshmi Bala

Professor and Head, Deptt of Biochemistry and

Member-Secretary, Institutional Ethics Committee (IEC) of BBD University, Lucknow

Communication of the Decision of the VIIIth Institutional Ethics Committee Meeting

IEC Code: 29

BBDU/MDS/29/2024

Date: 07/03/2024

Title of the Project: Evaluation Of Craniofacial Dimensions In Sagittal And Transverse Plane In Subjects With Surgically Repaired Cleft Lip And Palate-A CBCT Study.

Principal Investigator: Dr. SINEEN KHAN

Department: Department of Orthodontics and
Dentofacial Orthopaedics

Name and Address of the Institution: BBD University, Lucknow

Type of Submission: NEW, MDS Dissertation proposal

Dear Dr. Sineen Khan

The meeting of the Institutional Ethics Committee (IEC) was held on 06-02-2024 in Conference room, First Floor, BBDCODS, BBD University, Lucknow. Following members were present:

1	Dr. Chandishwar Nath Rtd. Chief Scientist, CDRI, Lucknow.	Chairman
2	Dr. JS Srivastava, Rtd. Chief Scientist, CDRI, Lucknow.	Member
3	Dr. Manodeep Sen, Professor, Department of Microbiology, RMLIMS, Lucknow	Member
4	Dr. Shaleen Chandra, Professor & Dean, Dental Sciences, Atal Bihari Vajpai Medical University (ABVM University), Lucknow	Member
5	Dr. Manuka Khanna, Professor, Deptt. of Political Science, Lucknow University, Lucknow	Member
6	Mr Abhishek Chaudhary, Advocate, Lucknow	Member
7	Dr. Puneet Ahuja, Professor of Oral Pathology and Principal, BBD College of Dental Sciences, BBD University, Lucknow	Member
8	Dr. Lakshmi Bala, Professor & Head, Department of Biochemistry, BBD College of Dental Sciences, BBD University, Lucknow	Member-Secretary

The committee reviewed and discussed your submitted documents of the research proposal in the meeting. Following comments were suggested and communicated.

Comments:

1. To obtain 'voluntary consent' from patients while undergoing routine radiological examination required for treatment purposes that "your data may be used for research and future studies".

Thereafter, the proposal was revised by Principal Investigator and duly approved by the Supervisor and Head of the Department.

Decisions: The committee provided waiver to obtain consent for the above proposal.

Lakshmi Bala
07/03/24

(Dr. Lakshmi Bala)

Member-Secretary IEC

BBD University

Ethics Cell (Vth Floor, BBDCODS)

ethics@bbdu.ac.in

Dr. LAKSHMI BALA
Member-Secretary
Institutional Ethics Committee
BBD University, Lucknow-28

Babu Banarasi Das College of Dental Sciences
(Babu Banarasi Das University)
BBD City, Faizabad Road, Lucknow – 227105 (INDIA)

1. Title of the project: **Evaluation of craniofacial dimensions in sagittal and transverse plane in subjects with surgically repaired cleft lip and palate-A CBCT study.**

2. Name of the department/ address of the investigator: **Department of orthodontics and dentofacial orthopaedics.**

3. Name of Faculty (Guide/Co-Guide) with designation and department: **GUIDE - Prof. Dr. Rohit Khanna, HOD, Co-Guide -Dr. Sneh Lata Verma (Reader), - Department of Orthodontics and Dentofacial Orthopaedics, Prof. Dr. Vasu Siddhartha Saxena**

4. Date of approval by Institutional Research Committee (IRC) (PI enclose approval letter along with finally approved research proposal):

5. Sources of funding: **Nil**

6. Study related information:

(i) Place of Study:

(a) **BBDU-BBDCODS**

(b) Other Institution* - **Smile Train Centres of Lucknow**

Kindly attached Consent letter from the concerned faculty/clinician of other Institution.

(ii) *In-vitro studies on human subjects:* Please specify if it is body fluid blood/tissues/ teeth.

(a) Bile, Saliva etc. []

(b) Teeth, please specify type []

(c) Tissue, please specify type []

(d) Use of stored or left over specimens []

(e) Any other- Old radiographic records [☒]

(iii) *In-vivo study on human subjects:*

(a) Intervention []

(b) Drugs []

(c) Implants []

(d) Any other e.g. X-rays/ultrasound/etc []

(vi) Vulnerable subjects.

(a) Pregnant Woman []

(b) Elderly []

(c) Terminally ill []

(d) Physically/ mentally challenged []

(e) Children under 18 []

(f) Students []

(g) Orphans []

(vii) Survey of human subject:

(a) Verbal questionnaire []

(b) Non- invasive examination []

(c) Invasive procedures []

(viii) SEA (Severe Adverse Events) reporting:

(a) Is there a plan for reporting of adverse events []

If yes it will be done to Institution (s) [N A]] All []

IEC

(for guidance please consult ICMR guidelines 2006)-**Less than Minimal risk**

8. Do you need exemption from obtaining Informed Consent from study subject – if so give justifications -YES

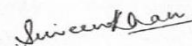
In following cases exemption can be requested:

- Audits of educational practices.
- Research on microbes cultured in the laboratory.
- Research on immortalized cell lines.
- Computer Simulation and Dental Materials
- Analysis of data freely available in public domain.
- Any other. Old radiographic records

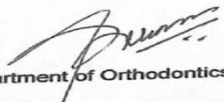
9. Whether Consent forms and Participant Information Document in English and in Hindi are enclosed? **NO**

10. Conflict of interest for any other investigator(s) (if yes, please explain in brief)-**NO**

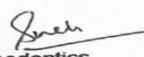
11. We the undersigned, have read and understood this protocol and hereby agree to conduct the study in accordance with this protocol and to comply with all requirements of the ICMR guidelines (2006)

Signature of the Investigator: **Dr Sineen Khan** 

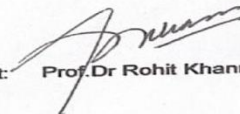
Date: **29/12/23**

Signature of the Guide:
Dr. Rohit Khanna
Prof. & Head, Department of Orthodontics
BBDCODS, BBDU 

Date: **29.12.23**

Co- Guide : **Dr. Sneh Lata Verma**
Reader, Department of Orthodontics
BBDCODS, BBDU 

Date: **29/12/23**

Signature of the Head of the Department: **Prof. Dr Rohit Khanna** 

Date: **29.12.23**

(Note: The investigator must provide information to the subjects in a simple language, and it should address the subjects, in a dialogue format)

Sineen Khan
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