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Evaluation and Comparison of Craniofacial Morphology of Unilateral Cleft Lip Cleft Palate and Skeletal Class III Cases With Skeletal Class I Cases Using Enlows Counterpart Analysis–A Lateral Cephalometric Study

Meenakshi Tiwari*

Department of Orthodontics and Dentofacial Orthopaedics, Maulana Azad Institute of Dental Sciences, New Delhi, India .

SUMMARY

Introduction: Alignment and rotational relation of maxilla, mandible and cranial base with each other is useful for knowing the contribution of bone to skeletal and dental basis in normal as well as cases with craniofacial anomaly. The study describes and applies the procedure of craniofacial form and evaluation for individual based on counterpart analysis.

Aim: To evaluate and compare the craniofacial morphology of uni-lateral cleft lip cleft palate and skeletal class III cases with skeletal class I cases using Enlow's counterpart analysis.

Materials and methods: Lateral cephalograms of 66 subjects within age 17-25 years were divided in three groups 22 each. Angular and linear measurements were evaluated and analyzed.

Results: The aggregate length of maxilla and ramus horizontal dimension both skeletal and dental in cleft group was similar as class I whereas the cranial floor and posterior maxillary vertical alignment for the class I and cleft group was higher, a lower value in class III group indicated backward inclination of PCF suggesting mandibular protrusive effect. In cleft cases the PMV length was decreased, the ramus was aligned anteriorly, ramus width was wider than PCF horizontal length. Composite molar position analysis overall indicated that in cleft cases the maxilla was more retrusive.

Conclusion: The morphology of maxilla and mandible are related to cranial base and each other, so the applicability of counterpart analysis in clinical practice suggests that it must be an important clinical tool to evaluate structural and architectural balance or im-balance in various forms of cleft and other craniofacial anomalies.

Keywords: Duphaston; Cetrotide; Progesterone protocol; GnRH antagonist

INTRODUCTION

Growth of craniofacial component is not an isolated event but is related to other parts. No craniofacial component is developmentally self-contained and self-retained. In fact growth is a composite change of all components [1].

It has been speculated that most of the craniofacial anomalies, commonly the cleft lip and cleft palate affects the growth of craniofacial bones [2]. However, the exact impact of cleft lip and palate in the development of cranial base, maxilla and mandible collectively remains uncertain. The patients with cleft need multiple surgical corrections since infancy, this shows considerable inhibition in the anteroposterior as well as transverse development of the mid-face after completion of growth [3]. Hypoplasia and extrusion of the maxilla is a commonest finding in cleft patients [4].

To evaluate the correlation of maxilla and mandible and then with the cranial base enlow with Moyers, Hunters and McNamara proposed "Counterpart Analysis" (CPA) to explain how a particular growth pattern is produced in any individual [5].

Counterpart analysis states that the development of various craniofacial bones relays specifically with the supplementary structural and geometrical equivalents in the face and cranium [6]. This procedure provides a mean by which principle anatomic components of the craniofacial complex of an individual can be compared with one another to evaluate balance of their anatomic fit. The correlation of one bone with other bone can be assessed which is useful in planning orthographic surgeries. Multiple surgeries and fibrous tissue and inherent deficient growth potential of maxilla in UCLP tends to fall in surgical treatment option [7]. Mandible in cleft usually being normal though has a class III pattern with mandibular pragmatic appearance [8].

Therefore an understanding of differences and similarities in growth of craniofacial bones in patients with UCLP with that of normal class I cases is utmost important to understand the variations of class III that appeared in cleft. The hypoplastic maxilla in cleft seen with similar features to that of class III cases has its varied etiology, thus the treatment strategy should also vary [9]. There are numerous studies in the literature where the correlation of maxilla, mandible and cranial base, effects of surgeries on maxilla and its counter effect on mandible has been analyzed. But use of counterpart analysis in assessing individuals of unilateral CLCP is being done rarely. An observational cross sectional study was there by planned to evaluate craniofacial morphology in UCLP cases by counterpart analysis and to compare it with class I and class III cases with an hypothesis that the anterior divergence and concave profile in cleft and class III may have different etiological basis as the morphology in UCLP may vary than the skeletal class III individuals.

Address for correspondence:

Meenakshi Tiwari, Department of Orthodontics and Dentofacial Orthopaedics, Maulana Azad Institute of Dental Sciences, New Delhi, India, Tel: 8459059628; E-mail: drmeenakshigaud@gmail.com

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MATERIALS AND METHODS

The study was done in the department of orthodontics and dentofacial Oorthopedics. The spreadsheet chart which calculates sample size for different p values, lamorte power calculations was used. For this the estimated means and standard deviations for each groups are given [10,11]. The sample size for each group was taken as 22. Non syndrome unilateral cleft lip and palate, skeletal class I, skeletal class III cases, of 17-25 years who were not treated orthopedically were selected for the study. Digital cephalograms were taken on Cephalostat machine (Planmeca Proline CC Panoramic X-ray, Planmeca OY Helsinki, Finland). (**Fig. 1** and **Fig. 2**) Kodak film size 8 x 10 inches (18 x 24 cms) and cassettes with in-built intensifying screen speed 400 was used.

Fig. 1. Landmarks.

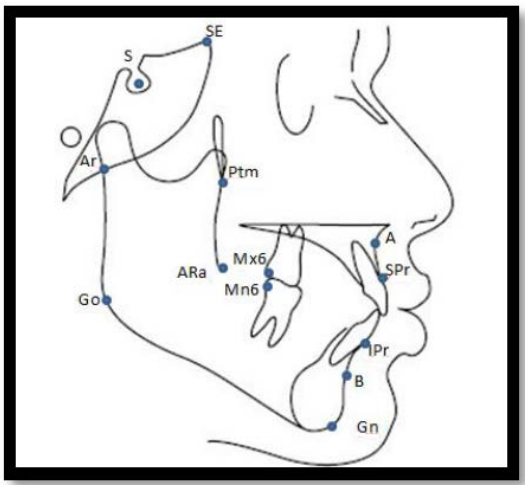
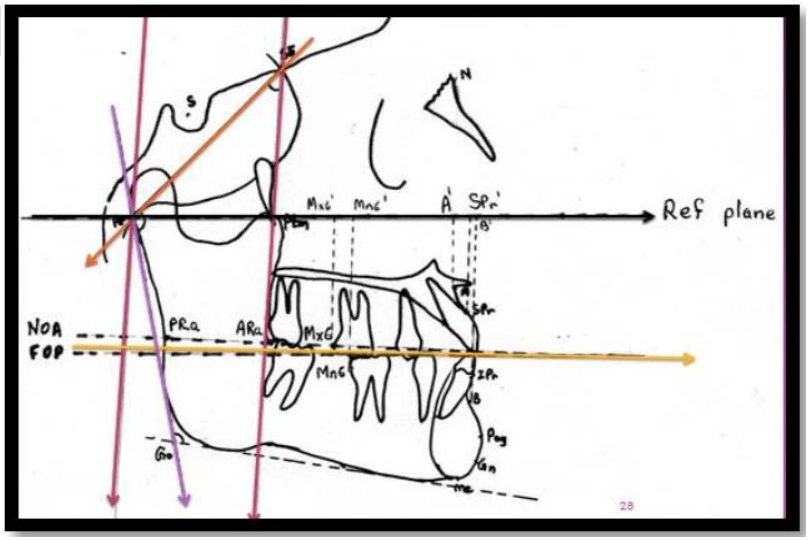


Fig. 2. Planes traced for study.



The tracing and analysis using the landmarks (**Fig. 3 and Fig. 4**) was done twice by the same observer at an interval of 1 week on a new tracing sheets and new markings to avoid the bias in the study. The data obtained was statistically analyzed by using reliability test Cronbach's method of reliability; the values more than 0.75, were considered reliable.

The values obtained were subjected to statistical analysis using descriptive and inferential statistics using, one way ANOVA, Student's unpaired t test and multiple comparison by Banferroni Test. Continuous variables were presented as mean ± SD.

Comparison was done by correlating the results of two parts 5 part 1–shows the effects of different regional dimensional and alignment variations (**Fig. 5**). Part 2-dealt with the evaluation of the individual person independent of population standards and applying the resultant information underlying the structural pattern which categories the individual as class I and class III. The various parts and counterparts were then evaluated for their actual dimensions and alignment effect of posterior cranial floor, ramus and corpus plane, to determine whether it results in neutral or protrusive effect in maxilla or mandible in comparison with the respective counterpart (**Fig. 6**).

Fig. 3. Showing regional dimension and alignment.

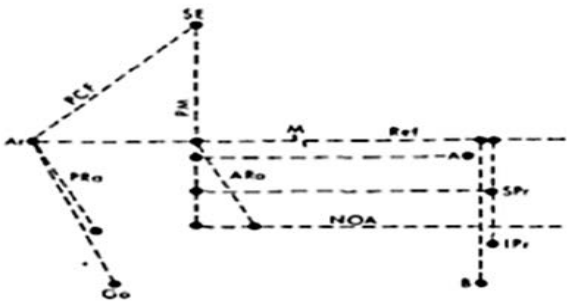


Fig. 4. Comparison of difference between the mean values of various parameters.

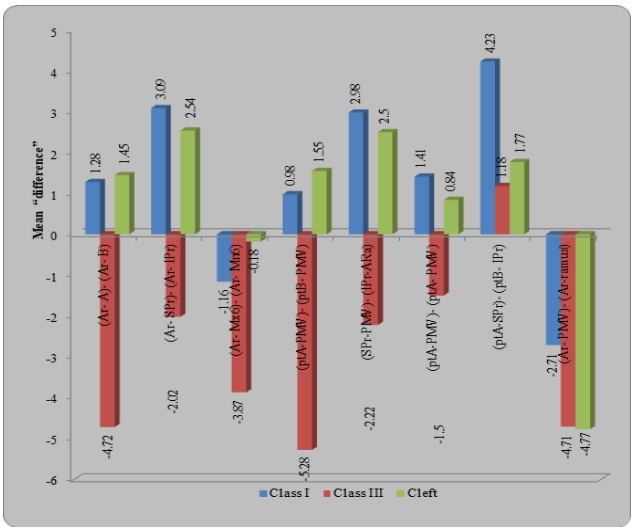


Fig. 5. PCF, Ramus alignment, PMV length: percentage of cases for class I group.

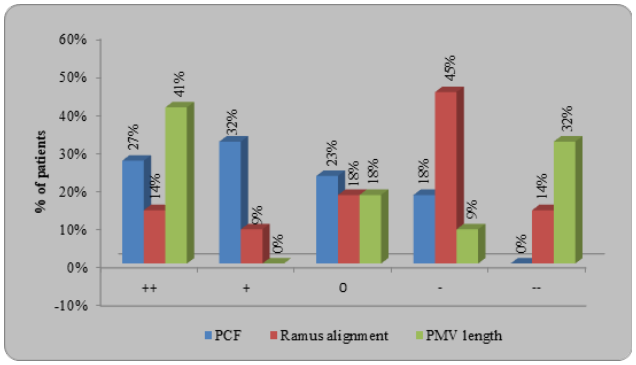
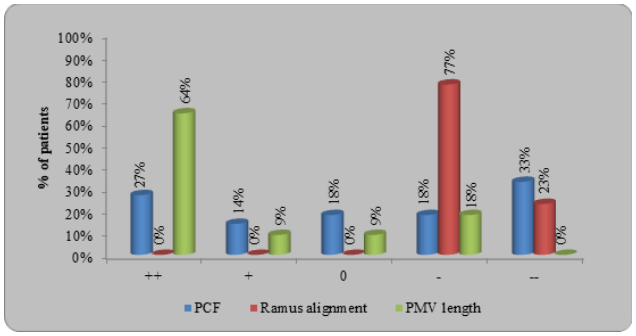


Fig. 6. PCF, Ramus alignment, PMV length: percentage of cases for class III group



RESULTS

The significant difference in skeletal and dental relationships and characteristics was noted in three different groups. The statistical significance thus obtained was tabulated (**Tab. 1**) and following deduction was made. The aggregate length of maxilla and ramus horizontal dimension both skeletal and dental in cleft and class I group was significantly different smaller compared to class III group. The cranial floor and posterior maxillary vertical alignment for the class I and cleft group was significantly higher than class III group. In cleft group the PMV length was decreased, the ramus was aligned anteriorly; ramus width was wider than PCF horizontal length. Composite molar position analysis with maxillary/mandibular arches dental dimension-A point compared with B point and SPr point compared with IPr point in cleft cases had significantly reduced values compared to class I and class III group suggesting retrusive maxilla.

Tab. 1. Comparison of the parameters in all the three groups.

Table no	Parameters	Groups	Mean	SD	Lower bound	Upper bound	F-Test	Multiple comparison : Bonferroni test		
								I: III	I : Cleft	III : Cleft
1.a	Ar-A	class I	92.04	7.15	88.87	95.21	12.76 p=0.0001,S	0.0001,S	0.0001,S	1.00,NS
		class III	84.7	5.18	82.4	87				
		Cleft	82.72	3.64	81.11	84.34				

1.b	Ar-B	class I	84.22	6.81	81.2	87.24	12.26 p=0.0001,S	0.0001,S	0.0001,S	1.00,NS
		class III	83.9	4.54	81.89	85.92				
		Cleft	77.18	4.25	75.29	79.06				
1.c	Ar-SPr	class I	92.04	7.15	88.87	95.21	17.41 p=0.0001,S	0.0001,S	0.0001,S	0.717,NS
		class III	84.7	5.18	82.4	87				
		Cleft	82.72	3.64	81.11	84.34				
1.d	Ar-IPr	class I	88.95	6.83	85.92	91.98	14.96 p=0.0001,S	0.559,NS	0.0001,S	0.001,S
		class III	86.72	5.36	84.34	89.1				
		Cleft	80.18	4.02	78.39	81.96				
1.e	PMV	class I	71.95	7.71	67.53	74.37	0.39 p=0.67,NS	0.005,S	1.00,NS	1.00,S
		class III	68.36	5.9	66.3	80.41				
		Cleft	70.84	5.29	68.49	73.18				
1.f	PCF/PM	class I	38.27	4.13	36.44	40.1	7.26 p=0.001,S	0.002,S	1.00,NS	0.013,S
		class III	34.54	3.92	32.8	36.28				
		Cleft	37.63	1.91	36.78	38.48				
1.g	Ar-Go/ Ar-Nra (mm)	class I	1.15	1.6	0.44	1.86	2.93 p=0.001,S	0.001,S	0.042,S	0.034,S
		class III	-0.44	0.6	-0.71	-0.17				
		Cleft	-0.92	0.12	-0.97	-0.86				
1.h	Ar-ramus (mm)	class I	37.27	3.11	35.88	38.65	0.46 p=0.36,NS	1.00,NS	1.00,NS	1.00,NS
		class III	36.77	3.16	35.36	38.17				
		Cleft	37.63	2.66	36.45	38.81				
1.i	Ar-PMV (mm)	class I	34.56	3.35	33.08	36.05	2.45 p=0.038,S	0.038,S	0.246,NS	1.00,NS
		class III	32.09	3.42	30.57	33.6				
		Cleft	32.86	2.78	31.62	34.09				
1.j	Ar-Mx6 (mm)	class I	53.65	5.63	51.16	56.15	7.84 p=0.001,S	0.15,NS	0.001,S	0.15,NS
		class III	50.72	5.03	48.49	52.95				
		Cleft	47.79	3.89	46.06	49.52				
1.k	Ar-Mx6 (mm)	class I	54.81	5.31	51.16	56.15	7.84 p=0.001,S	0.15,NS	0.001,S	0.15,NS
		class III	54.59	6.64	48.49	52.95				
		Cleft	47.97	3.39	46.06	49.52				

1.l	ptA-PMV (mm)	class I	51.02	4.01	49.24	52.8	12.59 p=0.0001,S	0.001,S	0.0001,S	1.00,NS
		class III	46.9	2.54	45.77	48.03				
		Cleft	45.86	4.04	44.07	47.65				
1.m	ptB-PMV (mm)	class I	50.04	4.93	47.85	52.23	18.10 p=0.0001,S	0.35,NS	0.0001,S	0.0001,S
		class III	52.18	3.8	50.49	53.86				
		Cleft	44.31	4.63	42.26	46.37				
1.n	SPr-PMV (mm)	class I	57.18	4.46	55.2	59.16	16.47 p=0.0001,S	0.010,S	0.0001,S	0.027,S
		class III	53.5	2.77	52.27	54.72				
		Cleft	50.22	4.56	48.2	52.25				
1.o	Ipr-PMV (mm)	class I	54.2	4.7	52.11	56.29	21.73 p=0.0001,S	0.72,NS	0.0001,S	0.0001,S
		class III	55.72	3.06	54.36	57.08				
		Cleft	47.72	4.82	45.58	49.86				
1.p	ptA-Mx6	class I	31.06	2.37	30.01	32.11	4.59 p=0.0001,S	0.0001,S	0.0001,S	0.001,S
		class III	28.56	3.18	27.15	29.97				
		Cleft	29.95	2.6	28.79	31.11				
1.q	ptB-Mn6	class I	29.65	3.24	28.22	31.09	0.62 p=0.53,NS	1.00,NS	1.00,NS	0.80,NS
		class III	30.06	3.07	28.7	31.43				
		0.804	0.804	0.804	0.804	0.804				
1.r	SPr-Mx6 (mm)	class I	38.04	2.68	36.85	39.23	9.10 p=0.0001, S	0.019,S	0.0001,S	0.549,NS
		class III	35.31	3.77	33.64	36.99				
		Cleft	34.02	3.01	32.68	35.36				
1.s	Ipr-Mn6 (mm)	class I	33.81	3.3	32.35	35.28	2.50 p=0.09, NS	1.00,NS	0.26,NS	0.12,NS
		class III	34.13	3.65	32.51	35.75				
		Cleft	32.25	1.6	31.53	32.96				

DISCUSSION

The quest to understand growth to its fullest is still not fulfilled. An aesthetic facial profile includes harmony, form and function. These are governed by genetic, epigenetic and environmental factors [12]. Any disturbances in this, contributes to the development of craniofacial deformity.

Orthodontist has been trying to use various methods to intercept dentofacial deformity and redirect abnormal development. Herman et al found that major deviations in the cleft group as decreased posterior length and height of the maxilla, retrognathia of the basal part of the maxilla with relative protrusion of the premaxilla, the width of the maxilla and nasal cavity was markedly increased and the mandible was short and retrognathic [13]. Clefts is associated with localized defects, Wardill concluded, cleft may be associated with 'wide spread structural changes in other parts of the skull and, perhaps, even further afield'. Corbo demonstrated that, the asymmetries of the facial skeleton in unilateral clefts were limited to the maxilla, with the zygomatic bones unaffected [14].

The cranial base is of particular interest because its growth pattern is a cranial structure, being situated in close proximity to facial structures [15]. The full extent of the malformation recognized as cleft lip and palate has not yet been determined. For this it becomes necessary to understand what affects the normal growth pattern. Many methods are used to evaluate the craniofacial growth pattern of which lateral cephalogram are commonly used till date. This study identifies and evaluates facial and cranial patterns that relate to the composite anatomical relationships by analyzing the following

Aggregate length of maxilla and corpus horizontal dimension at point A and B points: Point A was ahead of point B in class I and cleft group thus indicating that the maxillary and mandibular length in cleft was similar as class I (Tab. 1). In cleft group both points A and B were retrognathic having 0% protrusive effect

compared to class I and class III group. But when comparison was done within the cleft group, a point was protrusive in 45% where as 55% had protrusive B point, thus suggesting increase in mandibular length even in cleft cases.

Aggregate length of maxilla and corpus horizontal dimension at point SPr and IPr points: SPr was ahead of pt IPr *i.e,* there was maxillary dental protrusion and mandibular dental retrusion effect in class I and cleft group. In class III group point IPr was ahead of point SPr, suggesting maxillary retrusion effect.

Length of PMV: The PMV length in cleft cases was also reduced compared to class I group which affected the maxilla thus leading to more counter clockwise rotation of mandible thus producing the mandibular protrusive effect. These results were similar to the results obtained when Ar-A and Ar-B difference was evaluated for cleft cases.

The cranial floor and posterior maxillary vertical alignment (PCF/PM angle): Class I and cleft group with the higher values suggest anterior (forward) inclination of posterior cranial floor (PCF). Whereas, a lower value in class III group indicated posterior (backward) inclination of PCF. The values for class I and cleft group suggested that forward and downward alignment of PCF carries SPr anteriorly. Among class III group, a backward aligned cranial floor most often occurs in conjunction with an inferiorly rotated corpus, both of which has mandibular protrusive effect. This produces the characteristic downward slope of corpus which is present in 61% cases in class III group.

Ramus alignment (Ar-Go)-(Ar-NRa): The factor of inclination is important because an upward, downward, forward or backward tilt directly alters the expression of a given part's actual vertical and horizontal dimensions and change in the nature of composite fit relative to other bones or parts.

The findings of this study suggested that in class III group the ramus was anteriorly aligned in relation to class I and cleft group indicating that the mandibular protrusive effect occurred and skeletal basis for class III type of molar relationship is produced. Findings of the following study were similar to that of Enlow's study which stated that in causacians class III 60% of cases showed forward and upward (-) ramus orientation [16]. In the cleft group, the PM length was small compared to class I group but PCF was anteriorly aligned leading to some compensation that masked the protrusive effect of mandible.

Ramus width (Ar-ARa)-compared with PCF horizontal dimension (Ar-PMV)–skeletal: The ratio of 1:1.14, suggested that the ramus width was wider than the PCF horizontal length. This explains the retrusive effect on maxilla and a protrusive effect on mandible. The narrow ramus width in certain cases of cleft contributes to some compensation for mandibular protrusion caused by the other anatomical factors.

Ramus/PCF horizontal dimension (Ar-M x 6)-compared with PCF horizontal dimension (Ar-Mn 6)-(dental): The PCF horizontal dimension and ramus width also has a counterpart effect on the dental arches. The neutral position M is determined by adding or subtracting the distance between the position of the posterior edges of the maxillary and mandibular first molars from the point Ar.

Enlow and Kurado stated that the (-) position is considered normal because mandibular molars are anteriorly offset relative to maxillary molars. In the following study class I and class III group were consistent with the study reported by Enlow. A more negative value for class III could be due to increase in the ramus width which could explain for the protrusive relation of mandible and therefore more protrusive mandibular dental arch.

Maxillary/mandibular arches skeletal dimension-A point compared with B point: The distance from A to the individual's own PM line (not the neutral PM) parallel with the functional occlusal plane was compared with the distance from B to the ramus/corpus junction (intersection of ARa and ref). Suggested that the mandible in class III is protrusive compared to class I and cleft group.

Also the mean values for maxilla in all three groups suggested that in cleft cases the maxilla was retrusive compared to the mandibular corpus by 5.16 mm considering the neutral value.

Maxillary/mandibular arches skeletal dimension-SPr point compared with IPr point: The distance from SPr to the individual's own PM line (not the neutral PM) parallel with the functional occlusal plane is compared with the distance from IPr to the ramus/corpus junction (intersection of ARa and ref).

This suggested that the mandible in class III was protrusive compared to class I and cleft group. The finding for class I and class III group were consistent with the study reported by Enlow.

Thus in class III also the mean values for maxilla in all three groups suggested that in cleft cases the maxilla was retrusive compared to the mandibular corpus by 6.96 mm considering the neutral value.

Composite molar position evaluation: This parameter determines the position of maxillary and mandibular molars including the effects of cranial floor and ramus alignment. The results merely indicate the conventional 'molar relation' as customarily determined. Any distance between respective posterior edges of molar is measured without the skeletal rotation corrections to neutral position.

According to Enlow and Kurado it should be noted that the (-) position is considered normal because mandibular molars are anteriorly offset relative to maxillary molars.

Maxillary/mandibular arches dental dimension-A point compared with B point: This is the difference between the distances from A to the distal surface of maxillary molar and from point B to the mandibular molar. The mean difference suggested that the mandibular arch in class III was protrusive compared to class I and cleft group.

Also the mean values for maxilla suggested that in cleft cases the maxillary arch was retusive compared to the mandibular arch by 1.11 mm considering the neutral value.

Maxillary/mandibular arches dental dimension-SPr point compared with IPr point: This parameter signifies the difference between the distances from SPr to the distal surface of maxillary molar and from point IPr to the mandibular molar. The mean difference suggested that the mandibular arch in class III was protrusive compared to class I and cleft group.

Also the mean values for maxilla in all three groups suggested that in cleft cases the maxillary arch was retrusive compared to the mandibular arch by 4.02 mm considering the neutral value.

This composite analysis for the molar position overall indicated that in cleft cases the maxilla is more retrusive (skeletal factor is significantly more for all the parameters compared to the maxillary arch *i.e.* dental factor). Whereas in class III cases the mandible as well as the mandibular arch both are significantly protrusive.

Conclusion

Conclusive points of the study

- The aggregate length of maxilla and ramus horizontal dimension (skeletal) in cleft group was similar as class I, whereas class III suggested mandibular protrusive effect.
- The aggregate length of maxilla and ramus horizontal dimension (dental) in cleft group was similar with class I, whereas class III suggested maxillary extrusion effect.
- The PMV length in cleft and class III cases was reduced compared to class I group which affected the maxilla thus leading to more counter clockwise rotation of mandible thus producing the mandibular protrusive effect.
- The cranial floor and posterior maxillary vertical alignment for the class I and cleft group was higher and had anterior (forward) inclination of Posterior Cranial Floor (PCF). Whereas, a lower value in class III group indicated posterior (backward) inclination of PCF suggesting mandibular protrusive effect.
- The Ramus alignment as a factor of inclination in cleft and class III group suggested that it was aligned anteriorly compared to class me indicating the mandibular protrusive effect.
- The ramus width and PCF horizontal dimension comparison in cleft group, wherein ramus width was seen to be wider than PCF horizontal length, suggested the retrusive effect on maxilla and protrusive effect on mandible.
- The composite molar position analysis overall indicated that in cleft cases the maxilla was more retrusive (skeletal factor is significantly more for all the parameters compared to the maxillary arch *i.e.* dental factor). Whereas in class III cases the mandible as well as the mandibular arch both are significantly protrusive.

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