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RESEARCH ARTICLE

COMPARISON AND VARIATION OF VARIOUS VERTICAL CEPHALOMETRIC PARAMETERS IN DIFFERENT SAGITTAL JAW DYSPLASIAS

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ABSTRACT

Background: Most of the malocclusions that we often encounter are in sagittal direction, however most of the malocclusions that occur in sagittal dimensions are often accompanied by discrepancies in vertical dimensions. It is rare that we will find an anteroposterior discrepancy without the vertical dimension being affected. Numerous methods are available to diagnose the malocclusion in sagittal dimensions but there are considerably fewer methods available for vertical analysis. So multiple cephalometric analysis are used to diagnose vertical skeletal facial discrepancies associated with sagittal malocclusion. **Aims and objectives:** This study was aimed to identify and compare the various vertical cephalometric parameters that perform best for the identification of vertical skeletal pattern in different sagittal dysplasias. **Materials and Methods:** A total sample of 60 subjects with 20 subjects in each Class I, Class II and Class III skeletal groups were included. The age groups 18–30 years were included with male and female subjects. The vertical cephalometric parameters were measured and variation was studied and comparison was done in each group of sagittal dysplasia, and mean values, SDs, and *P* values were calculated by applying descriptive statistics along with Analysis of variance (ANOVA) for comparison among three skeletal groups by using Statistical software SPSS (version 20.0) and Microsoft Excel. The level of significance was set at p value < 0.05. **Results:** The descriptive statistical analysis was first done to find out the means of each parameter along with the standard deviation in each group whether increased or decreased from the mean average value. After that comparison was done for each parameter among the three groups to find out any statistically significant difference by using Analysis of variance (ANOVA) for intergroup comparison. On doing the intergroup comparison statistically significant difference was found in saddle angle amongst three groups with p value less < 0.026 which was considered statistically significant. Statistically significant differences were also found between symphyseal angle and symphyseal H/A with p value < 0.012 and < 0.006 respectively which was considered statistically significant, however statistically no significant differences were found in other parameters on doing intergroup comparison. **Conclusions:** Different parameters were used in this study to identify vertical disharmony in different sagittal classes. In skeletal class II subjects the condyle is posteriorly placed in glenoid fossa and mandible is retrognathic with respect to cranial base due to large saddle angle and articular angle and mandibular plane to true horizontal plane angulation shows vertical growth direction. Symphyseal angle is obtuse in class II subjects with wide and short symphysis in both class I and Class II subjects. In class III patients lower gonial angle is increased with vertical growth direction, there is increased ramal length and lower facial height from ANS to Gn is also increased. Vertical soft tissue parameters i.e.; (vertical lip: chin ratio) are within normal range in all the three classes.

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INTRODUCTION

Malocclusion can occur in all the three dimensions i.e; sagittal, vertical and transverse dimensions. However most of the malocclusions occur in sagittal dimensions and they are often accompanied by discrepancies in vertical dimensions.

The cephalometric analysis is a diagnostic tool with which the orthodontist can assess the extent of normal and/or abnormal skeletodental relationships. Currently, as in the past, anteroposterior assays of the lateral cephalometric radiograph provide the primary criteria for making important treatment planning decisions and assessments of treatment results. Usually angular and linear dimensions constitute the analysis and describe the skeletodental relationships for the individual patient. Comparing the patient's cephalometric dimensions to the population cephalometric average for each dimension in the analysis may define the degree of abnormality or normality. The mean anteroposterior dimensions for the lateral cephalogram have the most well-developed comparative data and biologic base. However, comparative vertical dimension data for the lateral cephalograms are meager indeed (Nahoum, 1975; Nahoum, 1971; Nahoum, 1972). Only Sassouni's archial analysis, (Sassouni, 1955) Bjork's (Bjork, 1961), polygon, and Nahoum's, (Nahoum, 1975) analyses give some assessment of posterior and anterior vertical height deviations. Unfortunately neither permits the localization of skeletal disharmonies. The need for an adequate vertical analysis becomes even more critical in planning of treatment of the more difficult problems in occlusion, particularly in those patients who have a constellation of problems refractory to orthodontic therapy alone. These patient problems can be resolved by the combined, efforts of the oral surgeon and the orthodontist, but the treatment-planning process demands due consideration of the three planes of space-transverse, sagittal, and vertical, neither permits the localization of skeletal disharmonies. The sources of vertical (deep-bite and open-bite) and transverse (skeletal cross-bites) dysplasias are not easily detected and quantified. Yet the clinician often requires this information in treatment planning to pinpoint the areas of disharmony. With the addition of a vertical analysis to the diagnostic data base, the orthodontist can formulate the treatment plan necessary to correct the problem, mask it, or correct and mask it in combination.

Aims and objectives: The purpose of this study is to (1) define the cephalometric measurements which can pinpoint areas of skeletal disharmony in the vertical plane of space, (2) describe the comparative data base of specific vertical cephalometric measurements in different sagittal dysplasias.

MATERIALS AND METHODS

A total of 60 lateral cephalometric radiographs of Class I, Class II and Class III subjects were selected from the department of orthodontics, Government Dental College and Hospital Srinagar, Kashmir and traced as per the inclusion criteria. The lateral head films were obtained with the model positioned in natural head position seated condyle, and with passive lips (Lundstrom, 1992). Natural head position was obtained by asking the subject to look straight ahead such that the visual axis was parallel to the floor. Lundstrom and Lundstrom noted that despite careful natural head position instructions, some patients assume an "unnatural head position.'' Accordingly, these patients need adjustment to natural "head orientation" by experienced clinicians. As noted by Lundstrom and Lundstrom, our models also assumed head positions that were obviously not a natural head position. These head films, as per Lundstrom and Lundstrom, were leveled to natural head orientations (Morrees, 1958). All the cephalograms were taken using the same x-ray machine and a standard technique. The machine used was Newtom Giana NNT. No corrections for enlargement were made in the lateral cephalograms, as all the cephalograms were taken using the same machine and the same operator. All the films were exposed with 64 KVp, 8 mA and an exposure time of 0.9 seconds.

All the cephalograms were traced on a standard acetate paper of 8 x10 inch size and 0.003 thickness by a standard technique using a soft 3H pencil using a view box. Tracings were done in a darkened room with no additional light. All the tracings were done by a single observer. Reproducibility was checked by retracing a random 10% segment of the original sample after a gap of 3 weeks with 0.5 mm linear ad 0.5 degree angular correction.

Inclusion criteria

- Patients with different types of skeletal malocclusions.
- Patients not more than 30 years of age.
- Complete eruption of the all the permanent teeth.
- Patients who are undergoing orthodontic treatment.
- The radiographs had to be of high quality and sharpness.
- All the radiographs to be taken by the same operator and in the natural head position.

Exclusion Criteria

- Patients with craniofacial anomalies and syndromes.
- Cleft lip and cleft palate patients.
- Cases with congenitally missing teeth.
- X-Ray scans showing supernumerary teeth, enlarged/cystic follicle, or any other pathology.
- History of facial trauma

Parameters defined

- **Saddle angle:** The angle formed between the nasion, sella & articulare. The mean value of this angle is 123±5º. A large angle usually signifies posteriorly placed condyle in the glenoid fossa & mandible is posteriorly positioned in relation to cranial base and small angle suggests forwardly placed mandible in relation to cranial base (Fig 1) (Rakosi, 1982).
- **Articular angle**: The articular angle is formed between sella, articulare and gonion. The mean value of this angle is 143±6º. A large articular angle is present in retrognathic mandible while as small articular angle suggests prognathic mandible (Fig 1) (Rakosi, 1982).

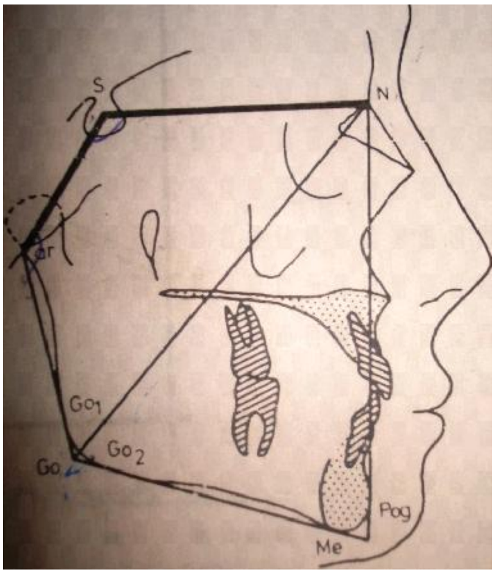

Fig (1)

- **Gonial angle:** The gonial angle is formed between articulare, gonion, and menton. The mean value of this angle is 128±7º. A large gonial angle suggests posterior rotation of mandible and a vertical growth pattern while as small gonial angle suggests anterior rotation of mandible with horizontal growth direction. It is divided into upper gonial angle (mean 52-55º) and lower gonial angle (mean 70-75º) by drawing a line from Nasion to gonion (Fig 1) (Rakosi, 1982).
- **Symphyseal angle:** The intersection of the point B-Menton line and the mandibular plane (union between Menton-Gonion) was used to determine the angular measurement of the symphysis. The mean value of this angle 75±5.5° (Fig 2) (Nanda, 1994)

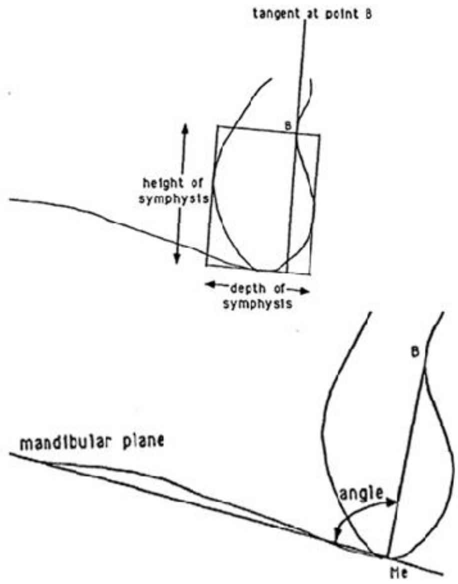

Fig (2)

To determine the morphology of the symphysis, it was essential to assess its width and height, performing a linear measurement tracing a tangent to point B and parallel and perpendicular to the said tangent (Fig.2). The width of the symphysis is defined as the distance between the most anterior and posterior points of the cortical mandibular plate. Symphyseal height in turn is defined as the distance between the most upper and lower points of the grid defined by a tangent to point B. The relationship between the width and height of the symphysis was calculated by dividing its height by the width (H/A).The mean value of symphyseal height/width (H/A) 1.5 ±0.26mm (Fig 2). (Nanda, 1994)

- **Inclination Angle:** It is the angle formed by the perpendicular line dropped from Se-N at N´and the palatal plane. A large angle expresses upward and forward inclination whereas small angle indicates down and back tipping of the anterior end of the palatal plane and maxillary base. Its mean value is 80±5°(Fig 3) (Rakosi,1982).
- **Ascending ramal length:** The length of ascending ramus is calculated by measuring the distance between the gonion and condylion. The length of ramus is more in patients having horizontal growth pattern than vertical growth pattern. Its mean value is 52.67 mm (Fig 4) (Rakosi, 1982).

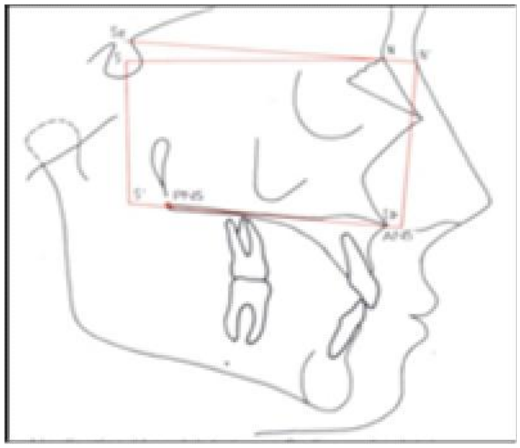

Fig (3)

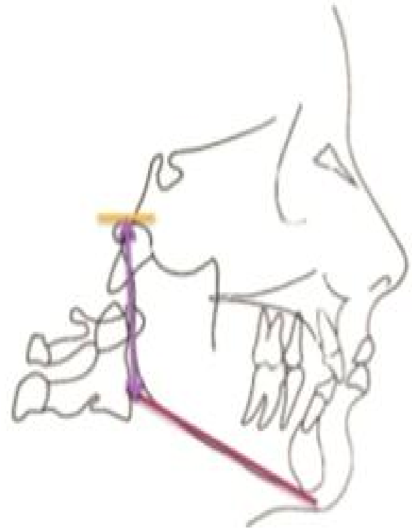

Fig (4)

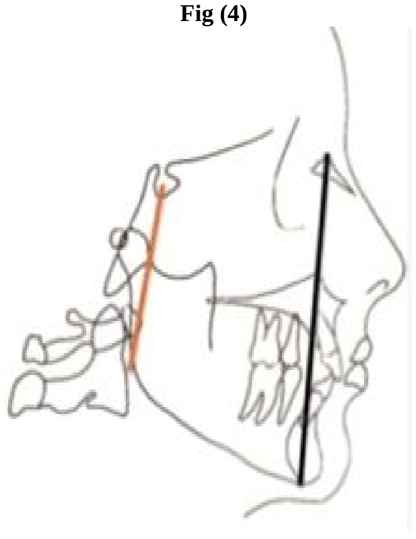

Fig (5)

Jarabak's Ratio: It is given by the formula PFH/AFH x 100i.e; S-Go/N-Me x100

- A ratio of less than 62% expresses a vertical growth pattern whereas more than 65% expresses a horizontal growth pattern (Fig 5) (Rakosi, 1982).

N-ANS perpendicular to HP: Distance between N and ANS measured perpendicular to HP gives us the middle third facial height. Its mean value is 52.7±3.2mm. Any increase or decrease in this value indicates increased or decreased middle third facial height respectively (Fig 6) (Burstone *et al.*, 1978).

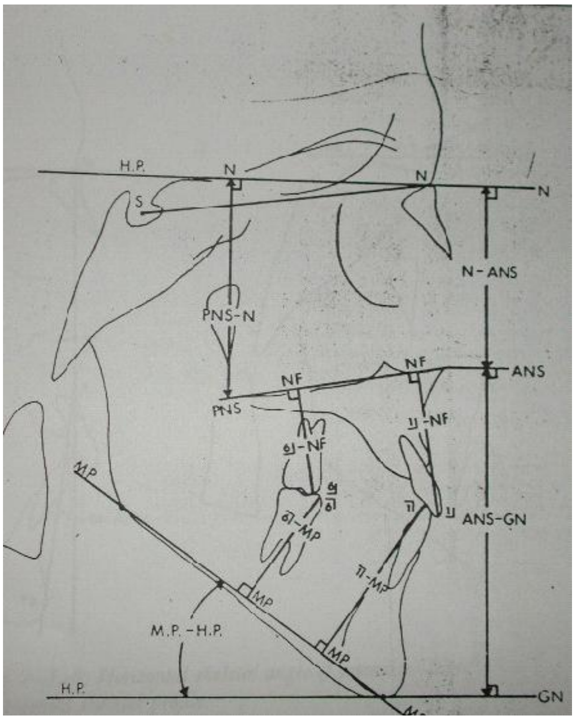

Fig (6)

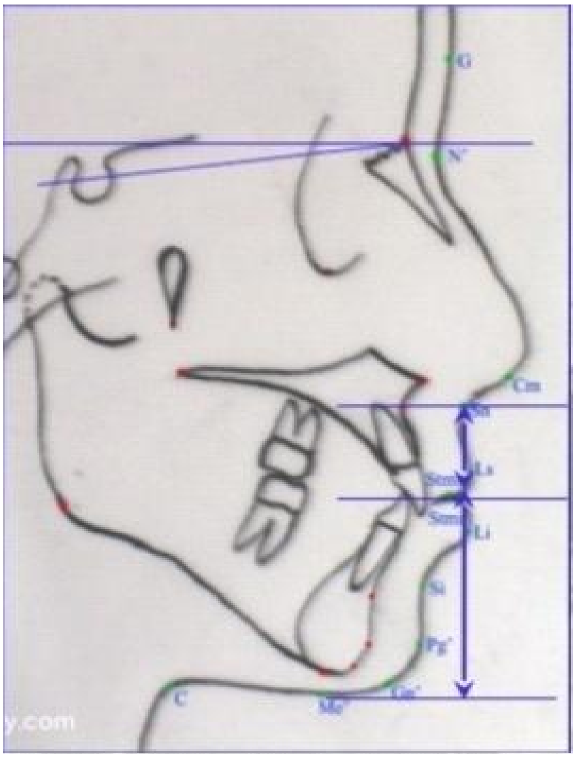

Fig (7)

ANS-Gn perpendicular to HP: Distance between ANS to Gn measured perpendicular to HP gives us the lower third facial height. Its mean value is 55±3.8mm. Any increase or decrease in this value indicates increased or decreased lower third facial height respectively (Fig 6) (Burstone *et al.*, 1978).

PNS-N perpendicular to HP: Distance between PNS to N measured perpendicular to HP gives us posterior maxillary height. Its mean value is 53.2±1.7mm. Any increase or decrease in this value indicates increased or decreased posterior maxillary height respectively (Fig 6) (Burstone *et al.*, 1978).

MP-HP angle: Mandibular plane angle in relation to the horizontal plane intersecting at Gn gives us posterior divergence of mandible. Its mean value is 27±5º. This angle relates posterior facial divergence with respect to anterior facial height. Any increase or decrease in this value indicates increased or decreased posterior facial divergence (Fig 6) (Burstone *et al.*, 1978).

Vertical lip: chin ratio: Upper vertical lip length is measured from Sn-Stms and lower lip length is measured from Stmi – Me, Vertical lip– chin ratio Sn-Stms / Stm i – Me perpendicular to HP is 0.5 or 1:2(7) (Burstone *et al.*, 1978).

STATISTICAL ANALYSIS AND RESULTS

The recorded data was compiled and entered in a spreadsheet (Microsoft Excel) and then exported to data editor of SPSS Version 20.0 (SPSS Inc., Chicago, Illinois, USA). Statistical software SPSS (version 20.0) and Microsoft Excel were used to carry out the statistical analysis of data. Data were expressed as Mean±SD. Analysis of variance (ANOVA) and were employed for inter group analysis of data. A P-value of less than 0.05 was considered statistically significant. All P-values were two tailed.

The descriptive statistical analysis was first done to find out the means of each parameter along with the standard deviation in each group whether increased or decreased from the mean average value as shown in tables (1,2,3). After that comparison was done for each parameter amongst the three groups to find out any statistically significant difference by using Analysis of variance (ANOVA) for intergroup comparison. On doing the intergroup comparison statistically significant difference was found in saddle angle amongst three groups with p value less < 0.026 which was considered statistically significant. Statistically significant differences were also found between symphyseal angle and symphyseal H/A with p value < 0.012 and < 0.006 respectively which was considered statistically significant, however statistically no significant differences were found in other parameters on doing intergroup comparison as shown in tables (1,2,3).

DISCUSSION

Cephalometric radiography is a valuable tool in orthodontic diagnosis and treatment planning. Even before Angle introduced his classification of malocclusion to the profession in the early 1900s, the anteroposterior relationship of mandible to maxilla was the most important diagnostic consideration, however malocclusions doesn’t occur only in sagittal dimensions they are also associated with discrepancies in vertical dimensions. The sources of vertical (deep-bite and open-bite) and transverse (skeletal cross-bites) dysplasias are not easily detected and quantified. Yet the clinician often requires this information in treatment planning to pinpoint the areas of disharmony.

Table 1. Descriptive statistics of vertical skeletal and soft issue cephalometric parameters in skeletal class I group

Skeletal parameters			
	Mean ±SD	Mean ±SD in class I group	P Value
Saddle Angle	123±5°	126.4±5.6	0.026
Articular Angle	143±6°	145.6±5.4	0.582
Gonial angle	128±7°	125.05±7.0	0.208
Upper gonial angle	52-55°	51.6±3.5	0.091
Lower gonial angle	70-75°	73.4±4.7	0.243
Inclination Angle	80±5°	86.5±3.8	0.975
Ascending ramal length	52.67mm	52.56	0.173
Jarabak ratio	62-65%	62.9±0.3	0.928
Symphyseal Angle	75±5.5°	83.5±5.7	0.012
Symphyseal H/A ratio	1.5±0.26	1.31±0.17	0.006
N-ANS	52.7±3.2mm	46.52±3.4	0.259
N-PNS	53.2±1.7mm	49.15±4.0	0.996
ANS-Gn	55±3.8mm	53.5±2.7	0.131
MP-HP Angle	27±5°	26.9±5.4	0.254
Soft Tissue Parameters			
Vertical lip chin ratio	0.5 or 1.2	0.4±0.09	0.732

Table 2. Descriptive statistics of vertical skeletal and soft issue cephalometric parameters in skeletal class II group

Skeletal parameters			
	Mean ±SD	Mean ±SD in class II group	P value
Saddle Angle	123±5°	126.8±5.5	0.026
Articular Angle	143±6°	147.3±7.6	0.582
Gonial angle	128±7°	124.6±7.3	0.208
Upper gonial angle	52-55°	51.6±3.5	0.091
Lower gonial angle	70-75°	73.45±4.7	0.243
Inclination Angle	80±5°	86.25±3.0	0.975
Ascending ramal length	52.67mm	52.65±4.3	0.173
Jarabak ratio	62-65%	62.45±0.03	0.928
Symphyseal Angle	75±5.5°	92±12.4	0.012
Symphyseal H/A ratio	1.5±0.26	1.21±0.15	0.006
N-ANS	52.7±3.2mm	48.4±4.0	0.259
N-PNS	53.2±1.7mm	49.15±3.3	0.996
ANS-Gn	55±3.8mm	54.4±4.82	0.131
MP-HP Angle	27±5°	30.7±7.4	0.254
Soft Tissue Parameters			
Vertical lip chin ratio	0.5 or 1.2	0.44±0.07	0.732

Table 3. Descriptive statistics of vertical skeletal and soft issue cephalometric parameters in skeletal class III group

Skeletal parameters			
	Mean ±SD	Mean ±SD in class III group	P value
Saddle Angle	123±5°	123±5	0.026
Articular Angle	143±6°	145.8±6.4	0.582
Gonial angle	128±7°	128.9±7.5	0.208
Upper gonial angle	52-55°	53.55±9.5	0.091
Lower gonial angle	70-75°	77.05±6.5	0.243
Inclination Angle	80±5°	86.35±3.7	0.975
Ascending ramal length	52.67mm	54.85±4.0	0.173
Jarabak ratio	62-65%	62.5±0.05	0.928
Symphyseal Angle	75±5.5°	86.35±3.7	0.012
Symphyseal H/A ratio	1.5±0.26	1.49±0.39	0.006
N-ANS	52.7±3.2mm	48.45±5.4	0.259
N-PNS	53.2±1.7mm	49.05±4.5	0.996
ANS-Gn	55±3.8mm	56.9±7.2	0.131
MP-HP Angle	27±5°	27.75±7.7	0.254
Soft Tissue Parameters			
Vertical lip chin ratio	0.5 or 1.2	0.4±0.08	0.732

With the addition of a vertical analysis to the diagnostic data base, the orthodontist can formulate the treatment plan necessary to correct the problem, mask it, or correct and mask it in combination. The development of a problem list derived from a diagnostic data base assures that no patient problems are overlooked or ignored.

The integration of the separate problem interactions is of utmost importance if one is to develop a unified treatment plan. Vertical dimension problems have been ignored too long. Clinicians have recognized the importance of these problems but have not been able to analyze them effectively.

Our approach to analyzing vertical problems cephalometrically in our study in different sagittal dysplasias was based on assessment that problems in sagittal dimensions are often accompanied by problems in vertical dimensions. So this study was done to evaluate and compare the various vertical cephalometric parameters in different sagittal classes and their influence on treatment planning. The identification of specific areas of dysplasia is mandatory if treatment plans and the associated therapeutic regimens are expected to incorporate the elements necessary for stability. In our study, the vertical cephalometric parameter that was used for determining the position of condyle in glenoid fossa was saddle angle, this angle was increased from the mean value of 123±5° to a mean value of 126.45±5.6° and 126.8±5.5° in class I and II subjects which suggests posteriorly placed condyle in glenoid fossa as shown in tables (1 and 2) while as saddle angle is usually decreased in class III subjects but was within the normal range in our study and a statistically significant difference was found in saddle angle when intergroup comparison was done with p value < 0.026.

The size of articular angle depends on the position of the mandible, it can be increased or decreased with opening or closing of bite respectively. In our study this angle was within normal range in class I and class III subjects but was increased in class II subjects with a mean value of 147.3±7.6° which suggests posteriorly placed mandible in class II subjects and no statistically significant difference was found in this angle when intergroup comparison was made. The growth pattern in vertical direction was studied by using gonial angle, its value was decreased from the mean value of 128±7° to a value of 125.5±7° and 124.5±7° in class I and II subjects, its value was within the normal range in class III subjects but with increased lower gonial angle in class III cases with a value of 77.5±6.5° from the mean value of 70-75°, and no statistically significant difference was found in the gonial angle when intergroup comparison was made. An assessment of symphyseal morphology is useful determining the growth pattern, in our study, the symphyseal angle was within the normal range in class I and class III subjects but was increased in class II subjects from the mean value of 75±5° to a value of 92±12.4° which suggests backward growth of symphysis in class II subjects andthe symphyseal H/A ratio was decreased from a mean value of 1.5±0.26mm to 1.31±0.17mm and 1.21±0.15mm in class I and II subjects respectively which suggests short and wide symphysis in class I and class II cases, while its value was within the normal range in class III subjects, a statistically significant difference was found in symphyseal angle and symphyseal H/A ratio when intergroup comparison was done with p value < 0.012 and 0.006 respectively.

While as ramal length, jarabak's ratio and angle of inclination was within the normal range in class I and class II groups and statistically no significant difference was found in these parameters when intergroup comparison was done, but the ramal length was increased in class III subjects with a value of 54.85±4mm from the mean value of 52.67mm. On doing the measurements of facial heights, the upper anterior and posterior facial heights were within the normal range in all the three groups but the lower anterior facial height was increased in class III patients from a mean value of 55±3.8mmto 56.9±7.2mm and no statistically significant difference was found in the facial heights when intergroup comparison was made. MP-HP angle was used to study the growth direction of mandible, its value was within the normal range in class I and class III subjects but its value was increased from the mean value of 27±5° to 30.7±7.4° in class II subjects, while as no statistically significant difference was found when intergroup comparison was done. Soft tissue vertical parameters (vertical lip: chin ratio) were also within the normal range in all the three classes and as no statistically significant difference was found when intergroup comparison was done for soft tissue parameters.

Conclusion

Saggital malocclusions are often associated with problems in vertical dimensions, so the sources of vertical (deep-bite and open-bite) and transverse (skeletal cross-bites) dysplasias are not easily detected and quantified. Yet the clinician often requires this information in treatment planning to pinpoint these areas of disharmony in order to develop an integrated treatment plan so as to address the saggital malocclusions along with associated vertical discrepancy. The following conclusions can be drawn:

- In skeletal class II subjects the condyle is posteriorly placed in glenoid fossa and mandible is retrognathic with respect to cranial base due to large saddle angle and articular angle and mandibular plane to true horizontal plane angulation shows vertical growth direction. So during class II correction a large saddle angle along with the large articular angle has poor prognosis for skeletal correction and saggital correction should be achieved without increasing vertical dimensions in class II cases.
- Symphyseal angle is obtuse in class II subjects with wide and short symphysis in both class I and class II subjects, which is also present in brachyfacial patterns while as narrow symphysis is associated with vertical growth direction.
- In class III patients lower gonial angle is increased with vertical growth direction, there is increased ramal length and lower facial height from ANS to Gn is also increased in these subjects and class iii patients with increased lower facial height are difficult to be treated with camouflage alone.
- Vertical soft tissue parameters i.e.; (vertical lip: chin ratio) are within normal range in all the three classes.

Abbreviations

Ar articulare
B point B
Cd condylion
Gn gnathion
Go gonion
HP horizontal plane
ANS anterior nasal spine
PNS posterior nasal spine
MP mandibular plane
Me menton
N nasion
N´ soft tissue nasion
S sella
Se sella entrance
Sti stomion inferius
Sts stomion superius
Sn subnasale

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