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Dentistry Section

Predictability and Reliability of Different Anterio-Posterior Skeletal Discrepancy Indicators in Different Age Groups - A Cephalometric Study

RANA TIWARI[1], TARULATHA R SHYAGALI[2], ABHISHEK GUPTA[3], RISHI JOSHI[4], ANIL TIWARI[5], PRIYANK SEN[6]

ABSTRACT

Introduction: The lateral cephalometric skeletal discrepancy indicators play a major role in diagnosing and preparing a case for orthognathic surgeries and the dentofacial corrections.

Aim: The study was aimed to check the reliability and the predictability of different anterio-posterior skeletal discrepancy indicators in different age groups and to derive the most reliable indicator for the orthodontic diagnosis.

Materials and Methods: A cross-sectional study was conducted on a sample of 100 subjects including 29 adolescent (15 males and 14 females) and 71 adult (41 males and 30 females) subjects with the mean age of 19.05 ± 5.78 years. All the subjects had Angle's Class I molar relationship. The lateral cephalograms of the sample were taken under the standard setting and hand tracing of the cephalometric radiographs using a sharp 4H pencil were made on acetate tracing paper. The anterio-posterior cephalometric indicators like β-angle, Wits appraisal (mm), Sella- Nasion plane to Point A and Point B distance (SN-AB mm) and Maxillo-Mandibular plane angle bisector to Point A and Point B distance (MM-AB mm) were measured. Intra-examiner reliability of tracings was evaluated using Intra Class Correlation (ICC) test. Mann Whitney U-test was applied for comparison of parameters between different malocclusion groups. Concurrent validity of various parameters was calculated using Cohen's kappa. A p-value <0.05 was considered statistically significant.

Results: The comparison of intra-examiner reliability of tracings in Angle's Class I adolescent group showed, MM-AB to have an almost perfect agreement followed by Wits. Intra-examiner reliability of tracings in Angle's Class I adult group showed moderate agreement for Wits and MM-AB showed almost perfect agreement and all the parameters showed statistically significant ICC. Comparison of parameters between adolescent and adult, Angle's Class I malocclusion group showed significant difference between adolescent and adult group for the Wits and SN-AB parameter.

Conclusion: The final outcome of the present study revealed that, the MM–AB is highly reliable in the reproducibility and also highly valid parameter for checking antero-posterior discrepancies and ANB angle was least reliable for diagnosing the antero-posterior skeletal discrepancies.

Keywords: Adult, Adolescent, Class I malocclusion, Lateral cephalograms

INTRODUCTION

The assessment of skeletal sagittal discrepancy is the key to proper diagnosis and the treatment planning. The history of orthodontic cephalometrics is full of the anterio-posterior skeletal discrepancy [1-5] and yet not one parameter is enough to suffix the exact nature of the skeletal malocclusion. Apart from this the reliability of using the parameter infinite number of times without the discrepancy will add to the creditability of the particular cephalometric indicator. The very foundation of today's diagnosis and treatment planning is based on the knowledge of cephalometrics. Most commonly used sagittal discrepancy indicator so far is ANB, but it has flaws like; ANB angle decreases with the age and nasion changes its position in three dimensions due to growth and development [6-8]. The rotation of the nasion and the jaws can also affect the reading of angle ANB [7,8]. To overcome all this Wit's appraisal was proposed. The distance between the points of intersection of the perpendicular drawn from point A and perpendicular drawn from point B (AO and BO) on the Functional Occlusal Plane (FOP) is measured to describe the maxillary/mandibular relationship [3].

Any change in angulation of the functional occlusal plane will profoundly influence the positions of point A and point B and there by the Wits appraisal reading. The cant of the occlusal plane can be easily affected by tooth eruption and dental development [9].

Further confusion occurs at the time of shedding off deciduous molars and before the eruption of the premolars, when the absence of the premolar point prevents definition of the FOP altogether. This may encourage workers to use other occlusal planes [8].

Hence, a new plane was proposed by Scott JH who derived geometrically based maxillo-mandibular plane angle bisector (MM bisector plane) in relation to dental base. According to the author it lies close to, but at an angle and inferior to the traditional occlusal planes and it is highly reproducible at all times, as this plane won't change the cant with the growth and if it does, will change in harmony with dental base change and so will not distort the true relationship between A and B points [10].

The measurements made on the MM° bisector are more accurate and less varied than those made to the FOP or the BOP. It can be defined at all times despite the obliteration of the teeth with stainless steel or amalgam [10]. So, the present study was taken up with the aim to check the reliability, predictability and the validity of Wit's parameter on the MM-bisector and to compare the same with the most commonly used antero-posterior skeletal discrepancy indicators in Class I malocclusion cases in adult and adolescent groups.

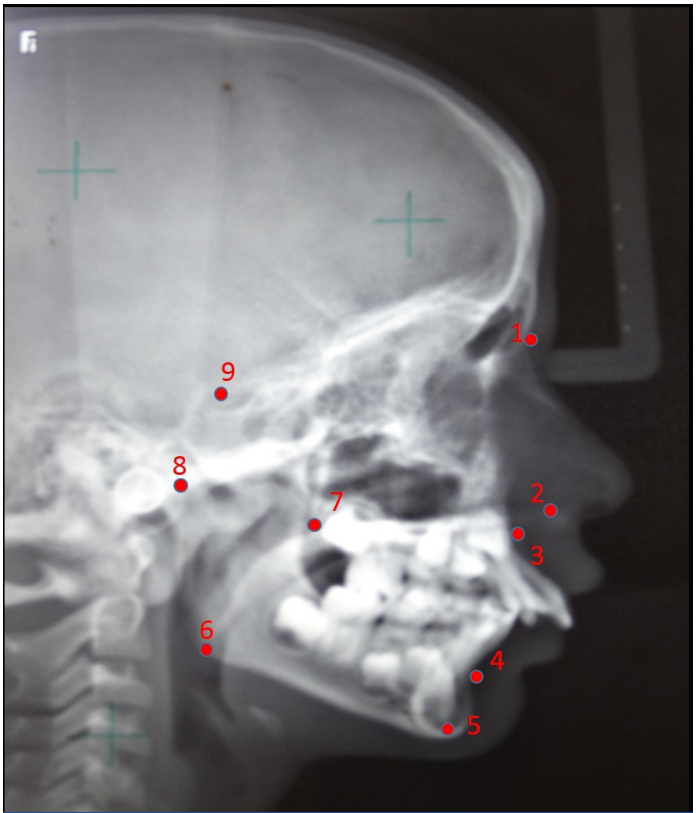
MATERIALS AND METHODS

A cross-sectional study was planned using the lateral cephalometric radiographs of patients reporting to the outpatient Department of Orthodontics and Dentofacial Orthopedics, Hitkarini Dental College and Hospital, Jabalpur, Madhya Pradesh, India.

The study design included two stage sampling, in the first stage screening of 200 subjects was performed for the segregation of sample into adult and adolescent group. After, thorough clinical examination, patients were informed about the study and written consent was obtained for their willing participation. In the second stage the lateral cephalogram was taken for each subject and tracing was done for the segregation of the sample into Angle's Class I group. Inclusion criteria for the sample selection was; presence of a full complement of teeth with fully erupted 1st molar and patients who had signed an inform consent willingly. Exclusion criteria included; Patients who had taken any orthodontic treatment, patients who had undergone any maxillo-facial surgery in the past, the patients with gross facial asymmetry and the patients with congenital anomalies.

The ethical clearance was obtained by the ethical committee of Hitkarini Dental College and Hospital. Out of 200 subjects, 100 subjects met the inclusion criteria. The final sample of 100 subjects included 29 adolescent (15 males and 14 females) and 71 adults (41 males and 30 females) subjects. The mean age of the sample was 19.05 ± 5.78 years.

Lateral cephalometric radiograph for each participant was taken in centric occlusion with lips in rest position and the Frankfort Plane oriented horizontally according to Natural Head Position (NHP). To obtain a NHP, a wall mirror 4 x 2 feet in size was fixed on the wall about 3 feet from floor level. The subject was asked to determine the self-balanced position of the head by tilting the head backward and forward with decreasing amplitude to find the most neutral position [11] and he/she was asked to establish the eye contact in the mirror and then the cephalograms were taken in this position. All the cephalograms were taken by single operator.



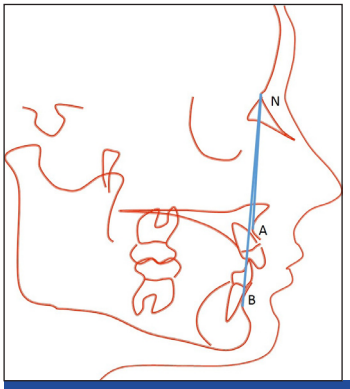
[Table/Fig-1]: Cephalometric anatomical landmarks.

S. No.	Anatomical Landmarks		Description
1.	A-Point	:	The deepest point in the midline between the anterior nasal spine and alveolar crest between the two central incisors
2.	ANS (Anterior Nasal Spine)	:	The most anterior point on the maxilla at the level of the palate
3.	B-Point	:	The deepest point in the midline between the alveolar crest of mandible and the mantal process
4.	Point C	:	Center of the condyle
5.	Go (Gonion)	:	The lowest most point at the angle of the mandible
6.	Me (Menton)	:	Lowest point on the symphyseal outline of the chin
7.	N (nasion)	:	The most anterior point midway between the frontal and nasal bones on the fronto-nasal suture
8.	PNS (Posterior Nasal Spine)	:	The most posterior point on the sagittal plane. usually the meeting point of the inferior and superior surfaces of hard palate
9.	S (sella)	:	Centre of sella turcica

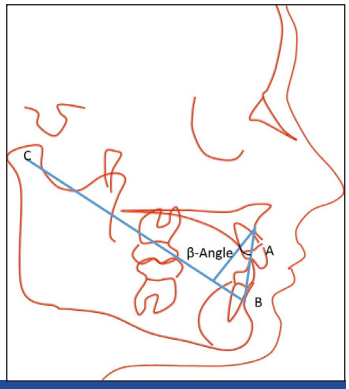
Hand tracing of the cephalometric radiographs using a sharp 4H pencil was made on acetate tracing paper in a dark room using X-ray viewer by a single examiner. For the measurement of the linear distance scale was used to the nearest of 0.5 millimetre (mm) and angles were measured to the nearest of 0.5 degrees. Different required landmarks and the anterio-posterior jaw relation indicators were drawn [Table/Fig-1-6] and measured. After one week same parameters were redrawn and measured in other tracing paper to check the intra-examiner variability.

STATISTICAL ANALYSIS

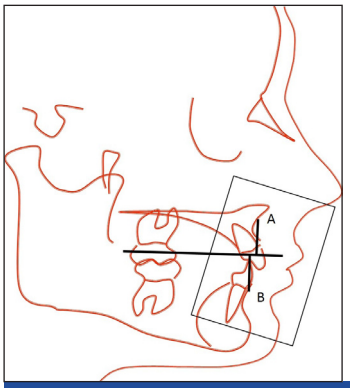
The collected data was tabulated and the frequencies, percentage, mean±standard deviation (SD), median, minimum and maximum values of various parameters were calculated. Intra-examiner reliability of tracings was evaluated using Intra Class Correlation



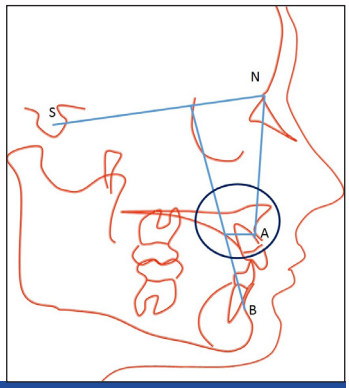
[Table/Fig-2]: ANB angle.



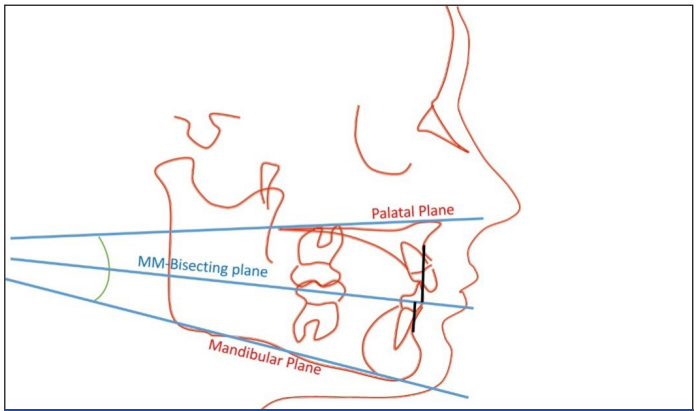
[Table/Fig-3]: Beta angle.



[Table/Fig-4]: Wits appraisal



[Table/Fig-5]: SN-AB distance.



[Table/Fig-6]: MM-AB distance.

(ICC) test. Shapiro-Wilk test showed that data did not follow a normal distribution hence, non-parametric test, namely Mann Whitney U-test was applied for comparison of parameters between different malocclusion groups. Concurrent validity of various parameters was calculated using Cohen's kappa. A p-value <0.05 was considered statistically significant. Data analysis was done using Statistical Package for Social Sciences (SPSS) v.21 for windows.

RESULTS

Characteristics of the study population are depicted in the [Table/Fig-7]. Of the total 67% of the sample fell in Angle's Class I group and the remaining 33% was in Class II Division group.

The intra–examiner reliability of tracings in Angle's Class I adolescent group showed, MM-AB to have an almost perfect agreement followed by Wits. There was statistically significant ICC for all the parameters except for β-angle where ICC was not significant. The same is shown in [Table/Fig-8].

Intra-examiner reliability of tracings in Angle's Class I adult group is shown in [Table/Fig-9], ICC statistics show moderate agreement for Wits and MM-AB has the highest ICC=0.972 which shows almost perfect agreement in the tracing 1 and tracing 2, all the parameters showed statically significant ICC.

Comparison of parameters between adolescent and adult Angle's Class I malocclusion group showed significant difference between adolescent and adult group for the Wits and SN-AB parameter. No significant difference was seen for MM-AB followed by ANB and β-angle which means the parameter of these measurements were same in both adolescent and adult groups as proved by Mann-Whitney U-test statistics. The results for same are represented in [Table/Fig-10].

Concurrent validity of various parameters with respect to Angle's Class I in adult group is shown in [Table/Fig-11]. For the predictability of these measurements tracing 1 is taken in our study and we found that MM-AB has moderate agreement with CkC=0.598 which is highest than other measurements followed by β-angle and SN-AB shows slight agreement and Wits shows fair agreement with CkC=0.318 that is least in the table.

Concurrent validity of various parameters with respect to Angle's Class I in adolescent group is represented in [Table/Fig-12]. MM-AB and SN-AB showed moderate agreement. This again is the

Characteristics	
Adults {n (%)}	71 (71%)
Adolescents {n (%)}	29 (29%)
Age	
Mean ± SD	19.05 ± 5.78 years
Min-Max	09-40 years
Gender	
Male {n (%)}	57 (57%)
Female {n (%)}	43 (43 %)
Angle class	
Class I	67 (67%)
Class II div I	33 (33%)

[Table/Fig-7]: Characteristics of study population.

Parameters		Mean ± SD	Intra-class Correlation Coefficient	p-value
ANB angle (°)	Tracing 1	3.39 ± 0.58	0.386 Fair agreement	p=0.048 (<0.05) Significant
	Tracing 2	3.25 ± 0.52		
β- angle (°)	Tracing 1	28.56± 1.29	0.357 Fair agreement	p=0.063 (>0.05) Not Significant
	Tracing 2	29.33± 0.91		
Wits (mm)	Tracing 1	3.06± 0.95	0.734 Strong agreement	p=0.000 (<0.001) Significant
	Tracing 2	3.19± 0.84		
SN-AB (mm)	Tracing 1	12.94 ± 0.84	0.655 Strong agreement	p=0.001 (<0.01) Significant
	Tracing 2	13.31 ± 0.81		
MM-AB (mm)	Tracing 1	1.33± 1.24	0.963 Almost Perfect agreement	p=0.000 (<0.001) Significant
	Tracing 2	1.33 ± 1.21		

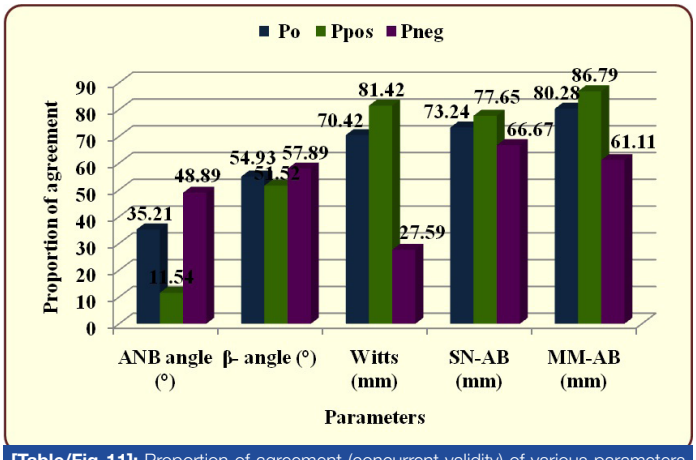
[Table/Fig-8]: Intra–examiner reliability of tracings in Angle's Class I adolescent group.

Parameters		Mean ± SD	Intra-class Correlation Coefficient	p-value
ANB angle (°)	Tracing 1	3.37 ± 0.79	0.768 Strong agreement	p=0.000 (<0.001) Significant
	Tracing 2	3.49 ± 0.72		
β- angle (°)	Tracing 1	29.11 ± 1.42	0.907 Almost Perfect agreement	p=0.000 (<0.001) Significant
	Tracing 2	29.21 ± 1.50		
Wits (mm)	Tracing 1	3.67 ± 0.54	0.547 Moderate agreement	p=0.000 (<0.001) Significant
	Tracing 2	3.61 ± 0.48		
SN-AB (mm)	Tracing 1	12.20 ± 0.79	0.742 Strong agreement	p=0.000 (<0.001) Significant
	Tracing 2	12.11 ± 0.71		
MM-AB (mm)	Tracing 1	1.32± 1.48	0.972 Almost perfect agreement	p=0.000 (<0.001) Significant
	Tracing 2	1.33 ± 1.53		

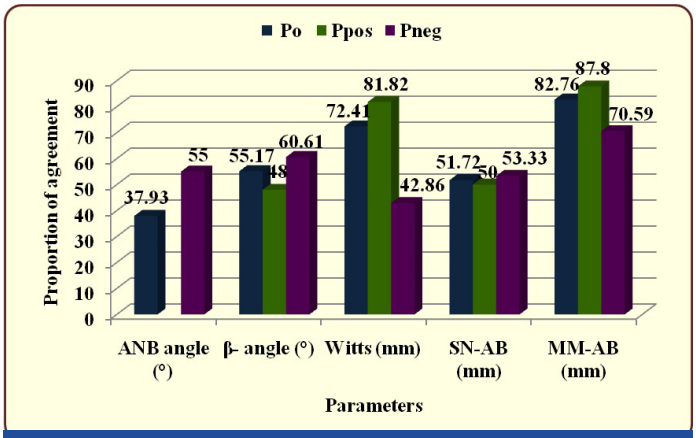
[Table/Fig-9]: Intra-examiner reliability of tracings in Angle's Class I adult group.

Parameters		Mean ± SD	Intra-class Correlation Coefficient	p-value
ANB angle (°)	Mean ± SD	3.39± 0.58	3.37 ± 0.79	MW= 424.000 p = 0.803 (>0.05) Not Sig.
	Median	3.50	3.50	
	Min-Max	2.50-4.00	0.00-4.50	
β- angle (°)	Mean ± SD	28.56± 1.29	29.11 ± 1.42	MW= 357.000 p = 0.224 (>0.05) Not Sig.
	Median	29.00	29.00	
	Min-Max	27.00-30.00	27.00-33.00	
Wits (mm)	Mean ± SD	3.06 ± 0.95	3.67 ± 0.54	MW= 243.500 p = 0.003 (<0.01) Sig. Difference
	Median	3.00	4.00	
	Min-Max	0.00-4.00	2.00-4.50	
SN-AB (mm)	Mean ± SD	12.94 ± 0.84	12.20 ± 0.79	MW= 238.500 p = 0.003 (<0.01) Sig. Difference
	Median	13.00	12.00	
	Min-Max	11.50-14.00	11.00-14.00	
MM-AB (mm)	Mean ± SD	1.33 ± 1.24	1.32 ± 1.48	MW= 413.500 p = 0.695 (>0.05) Not Sig.
	Median	1.50	1.50	
	Min-Max	-1.00-3.00	-2.00-5.00	

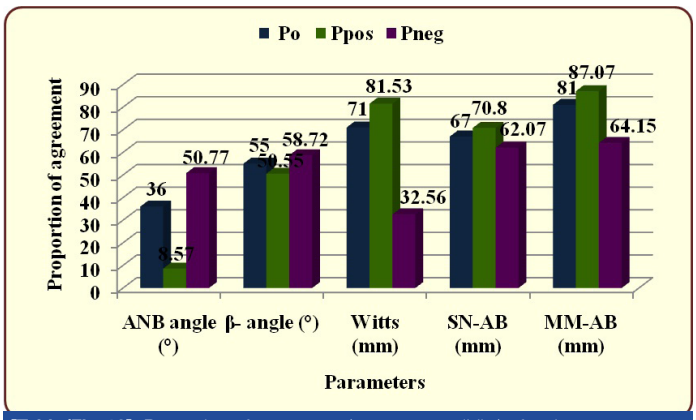
[Table/Fig-10]: Comparison of parameters between adolescent and adult Angle's Class I group.



[Table/Fig-11]: Proportion of agreement (concurrent validity) of various parameters with respect to Angle's Class I in adult group.
Po: proportion of observed agreement
Ppos: proportion of agreement on positive rating
Pneg: proportion of agreement on negative rating



[Table/Fig-12]: Proportion of agreement (concurrent validity) of various parameters with respect to Angle's Class I in adolescent group.
Po: proportion of observed agreement
Ppos: proportion of agreement on positive rating
Pneg: proportion of agreement on negative rating



[Table/Fig-13]: Proportion of agreement (concurrent validity) of various parameters with respect to Angle's Class I (adolescent + adults) group.
Po: proportion of observed agreement
Ppos: proportion of agreement on positive rating
Pneg: proportion of agreement on negative rating

most predictable measurement. Beta angle shows fair agreement indicating lowest validity in Class I adult group.

Over all predictably of various parameter for Angle's Class I malocclusion by pooling the data together of the adult and adolescent group is depicted in [Table/Fig-13]. MM-AB showed moderate agreement. This depicts that predictability of MM-AB is much higher than other parameters in any age group followed by SN-AB and β-angle, which showed fair agreement with CkC = 0.357 and 0.235 respectively. ANB and wits showed slight agreement but ANB has least validity in this table with CkC=0.030.

DISCUSSION

Since the inception of the cephalometrics into the orthodontic diagnosis and the treatment planning, a valid and due importance has been attached to its utility [12]. Multitudinal use of this diagnostic aid is not limited to orthodontic itself, orthognathic surgeries without the proper cephalometric aid can be disaster.

There are various studies in the literature to compare various methods of evaluation of sagittal jaw relationship [13] but very few studies compared all the angular and linear parameters to check the variability of all the sagittal parameters in adults and adolescent population. Therefore, to check the variability and reliability of sagittal parameters of jaw base relationship in different age groups, a comparative study is required and the current study was done on this base line. The reason behind choosing these different parameters for the study is the most frequent utilization of these anterio-posterior skeletal discrepancy indicators for judging the skeletal malocclusion in day to day clinical practice.

ANB angle is bound to give faulty inference regarding the judgement of malocclusion due to influence of growth and development. Furthermore, changes of Wits, β angle and SN-AB measurement may also reflect change in functional occlusion plane, rather than pure sagittal changes of the relationship of the jaws [14]. Therefore, an accurate AP measurement of jaw relationship is critically important in orthodontic treatment planning and to overcome this Wits value on the MM bisector as a new parameter was included in this study.

The comparison of intra-examiner reliability for the different parameter in the Class I adolescent group showed strong agreement between tracing 1 and tracing 2 for parameter like Wits and SN-AB. The remaining parameters like ANB angle, β-angle showed a fair agreement. However, MM-AB parameter showed perfect agreement indicating its validity as a best possible parameter to overcome the intra-examiner tracing error. It is also noted that all the parameters showed significant ICC except for β-angle, which showed that β-angle exhibits least amount of intra-examiner reliability.

Two of the parameters, SN-AB and ANB angle showed strong agreement in adult Class I group. However, almost perfect agreement was appreciated for β angle and MM-AB and the rest of other parameters showed moderate agreement.

In the comparison of parameters between adolescent and adult Angle's Class I patients there is a significant difference in Wits and SN-AB value. This difference for Wits might be due to the rotational tendency of the occlusal plane during the growth period from adolescent to adult [15]. This is true even with SN plane and point A and point B as these parameters too have influence of growth on them [16]. Even the literature is explicit with the fact that there will be random rotation of functional occlusal plane in growing patient [14]. Adding to this, Wits Appraisal completely depended on functional occlusal plane and the description of same is vague [17]. This is backed by the Ganiger RC et al., who quoted that in adolescent's Wits technique should be reproduced on a plane which rotates with the jaw [18].

ANB angle showed varied reading for Class I malocclusion both in adult as well as in adolescent group. In most of the tracing for Class I, ANB angle measured more than 20° which happens to be the mean score of ANB. It so happens with the interpretation of ANB, that more than 20 indicate Class II malocclusion and less than 20 shows Class III malocclusion. So, in the current study during checking the validity of different parameters, it was decided to omit the ANB angle due to wide range of variation.

When we checked the validity of various parameters with respect to Angle's Class I in adolescent group, it is found that MM-AB showed moderate agreement followed by Wits which shows a fair agreement. Whereas, β-angle and SN-AB showed slight agreement. The results indicates that MM-AB shows highest predictability than the rest of parameters. Similar reports were reported in earlier studies [10,18] where, they concluded that MM-AB is more valid than the usual parameters used for judging the antero-posterior discrepancies. The review of literature pertaining to β-angle research shows that β-angle is prone to be a valid and predictable angle for measuring the sagittal jaw relationship [18-20]. However, the result of current study are contradictory suggesting β angle showed slight agreement pertaining to kappa statistics and it is inferior in comparison to MM-AB which showed moderate agreement.

The highest validity was noted for MM-AB and SN-AB for Class I in adult patients. The β-angle showed fair agreement in both adult and adolescent group, ANB and Wits show slight agreement. The validity of MM-AB was confirmed in earlier studies too [10,14] Taylor CM in his study reported prediction in SN-AB which is in agreement with result with the present study [21]. ANB angle which is bound to change with age showed slight agreement in our study. It is concurrent with the finding of Bishara et al., nevertheless Ishikawa et al., [22] reported contradictory finding in relation to the ANB angle stating that ANB is more valid than Wits [23].

It is important to check the validity of parameter in combination of adult and adolescent group to obtain more valid parameter for antero-posterior discrepancy. When we check Angle's Class I group with adult and adolescent together we found highest validity for MM-AB with kappa statistics 0.523. This is in agreement with Ganiger RC et al., [18] and with findings of Scott JH [10]. But in other aspect we found a slight agreement for ANB angle and Wits. Whereas, β-angle and SN-AB showed fair agreement for Angle's Class I malocclusion. This was in agreement with reports of previous literature [22] and was in contradiction to the study by Doshi et al., [19].

The final outcome of the present study revealed that, the MM–AB is highly reliable in the reproducibility and it is a highly valid parameter for checking antero-posterior discrepancies in comparison to ANB angle, β-angle and SN–AB. ANB angle shows least validity in all age groups and it is least valid for judging Angle's Class I discrepancies . MM–AB is more reliable because the MM bisector is highest stable plane with the relation of cranial base. The β-angle shows intra-examiner variability as it is dependent on the centre of condyle. Fair agreement of Wits is due to variation in the functional occlusion plane in adolescent group.

According to Lagravere OM the CBCT provides the three dimensional data to the clinician for the descriptive diagnosis purpose in comparison to the traditional cephalometric radiographs [24]. Further, there exists a scope to study the intra examiner reliability and validity of the current study parameters using the present day investigations tools like CBCT and this future implication can help the orthodontist to judge the skeletal malocclusion in a better way.

The highlight of the present study is the checking of intra examiner reliability of the different parameters in various age groups at different periods of time. Though the literature is explicit with data on cephalometric parameter inventions, none of the research explored the intra examiner reliability. Finally, it is recommend that the orthodontist can use MM-AB parameter for judging the anterio-posterior skeletal discrepancy with better accuracy and validity than its contemporary parameters.

LIMITATION

The limitation of this particular study is the usage of traditional two dimensional image for the three dimensional object. This can be overcome by using the latest technological investigations like CBCT. There were other limitations in the form discrepancy in the sample size and the age groups selected and the study lacked to examine the inter examiner reliability. These need to be considered in the future studies of this nature. The current study didn't include different skeletal malocclusion groups to compare the reliability of different parameters. Thus, the study further carries the scope to compare the reliability of these parameters in judging different skeletal malocclusions.

CONCLUSION

The final outcome of the present study revealed that, the MM–AB is highly reliable in the reproducibility and also highly valid parameter for checking antero-posterior discrepancies in comparison to ANB angle, β-angle and SN–AB. ANB angle shows least validity for comparison in any age group and also least valid in angle's Class I discrepancies.

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PARTICULARS OF CONTRIBUTORS:

1. Postgraduate Student, Department of Orthodontics and Dentofacial Orthopedics, Hitkarini Dental College and Hospital, Jabalpur, Madhya Pradesh, India.
2. Professor and Head, Department of Orthodontics and Dentofacial Orthopedics, Hitkarini Dental College and Hospital, Jabalpur, Madhya Pradesh, India.
3. Reader, Department of Orthodontics and Dentofacial Orthopedics, Hitkarini Dental College and Hospital, Jabalpur, Madhya Pradesh, India.
4. Professor, Department of Orthodontics and Dentofacial Orthopedics, Hitkarini Dental College and Hospital, Jabalpur, Madhya Pradesh, India.
5. Postgraduate Student, Department of Orthodontics and Dentofacial Orthopedics, Hitkarini Dental College and Hospital, Jabalpur, Madhya Pradesh, India.
6. Postgraduate Student, Department of Orthodontics and Dentofacial Orthopedics, Hitkarini Dental College and Hospital, Jabalpur, Madhya Pradesh, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Tarulatha R Shyagali,
Professor and Head, Department of Orthodontics and Dentofacial Orthopedics,
Hitkarini Dental College and Hospital, Jabalpur-482001, Madhya Pradesh, India.
E-mail: drtarulatha@gmail.com

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