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Dr. Binay Kumar Chaturvedi
M.D.S, Department of Orthodontics, Rajiv Gandhi University, Bangalore, Karnataka, India

Dr. Prashanth CS
Professor, Department of Orthodontics, Rajiv Gandhi University, Bangalore, Karnataka, India

Dr. Manjunath Hegde
Reader, Department of Orthodontics, Rajiv Gandhi University, Bangalore, Karnataka, India

Dr. Roopak M David
Reader, Department of Orthodontics, Rajiv Gandhi University, Bangalore, Karnataka, India

Dr. Pramod KM
Senior Lecturer, Department of Orthodontics, Rajiv Gandhi University, Bangalore, Karnataka, India

Correspondence
Dr. Binay Kumar Chaturvedi
M.D.S, Department of Orthodontics, Rajiv Gandhi University, Bangalore, Karnataka, India

A radiographic study for comparison of lower third molar eruption in different Anteroposterior skeletal patterns and age-related groups

Dr. Binay Kumar Chaturvedi, Dr. Prashanth CS, Dr. Manjunath Hegde, Dr. Roopak M David and Dr. Pramod KM

Abstract
The aim of this study is to evaluate the predictability of third molar eruption using parameters seen in Orthopantomograms and Lateral cephalograms. 180 lower third molars were evaluated from pre-treatment Orthopantomograms and Lateral cephalograms of 90 patients. These radiographs were grouped based on the Anteroposterior skeletal jaw base as Class I, Class II and Class III with 30 samples each; which were further classified as age-related sub-groups with 15 samples each and impaction related sub-groups. Comparison was done in these groups, using linear and angular measurements. Comparison within age and impaction-related subgroups revealed that the parameters such as RMS($P=0.008,<0.001$), SWR($P=0.002,<0.001$), α-angle($P=0.01,<0.001$), β-angle($P=0.04,<0.001$) respectively and Ar-Go($P=0.01$) in age-related groups and Ar-Gn($P=0.04$) in impaction-related groups revealed statistically significant difference. Higher prevalence of lower third molar Impactions was observed in skeletal Class II subjects. It was concluded that certain radiographic parameters can be used as predictors for estimation of mandibular third molar eruption.

Keywords: Third molar impactions, Orthopantomogram, Retromolar space, α-angle, β-angle

Introduction
Prophylactic removal of third molars is often recommended by the orthodontists and oral surgeons before roots are fully formed indicating that this would prevent the eruption of the teeth in a malposition and avoid potentially severe complications of this condition which may include incisor crowding, resorption of adjacent tooth roots, inflammatory processes (pericoronitis), and temporomandibular joint dysfunction [1, 2, 3].
It is often difficult to predict the fate of the third molars, since the second molars of an average 12-year old orthodontic patient have not yet erupted and the third molars have a limited amount of calcification at that time. Because this is usually considered the optimum age for treatment of most malocclusions, it is important to know whether and how the third molars are developing before formulating an orthodontic treatment plan [4].
From that point of view, it is of interest to investigate which parameters might be used for the early prediction of lower third molar eruption.
For a long time, insufficient development of retromolar space has been considered, to be the most important factor contributing to the high impaction rate of lower third molars. [5,6,7,30] However, several researchers have concluded that even in cases with adequate retromolar space, some lower third molars might fail to erupt indicating that there are other factors affecting this process [6, 9].
Besides retromolar space, researchers investigated the correlation between growth in length of the mandible and the risk of impaction [9, 10, 11, 12, 13]. Also, several radiographic angular measurements were proposed with a similar aim. [2] It was pointed out that excessive initial mesial angulation and minimal uprighting during follow-up might increase the likelihood of lower third molar impaction [9].
Apart from these linear and angular indicators, patient's age is an important factor, which should be considered in relation to the eruption of lower third molars. In one of the study there was no significant increase in retromolar space size after the age of 16 years, while another study confirmed that positional changes of third molars after the age of 18 years led to their eruption [3, 14, 15].

These positional changes have been explained by further skeletal growth, which might contribute to the increase of retromolar space.

Moreover, a study showed that available retromolar space could differ between Class II and Class I sides, indicating that sagittal skeletal relationships might also affect the fate of these teeth [16]. Interestingly, it was reported that differences in the impaction rate of third molars in various anteroposterior skeletal relations were more obvious after the age of 18 years [9].

In previous studies, certain radiographic predictors for the evaluation of lower third molar eruption were not thoroughly investigated regarding, different skeletal patterns and patient age [9, 13, 16].

Hence, this study was conducted to evaluate the predictability of lower third molar eruption using radiographic parameters seen in Orthopantomograms and Lateral cephalograms.

Materials and Methods

Materials

- Lateral cephalograms of 30 Class I, 30 Class II and 30 Class III patients were selected from pre-existing records from the Department of Orthodontics and Dentofacial Orthopaedics, and their corresponding Orthopantomograms were included based on the inclusion and exclusion criteria.
- Cephalometric tracing unit, 0.003" thick acetate tracing sheet, 0.3mm-micro lead pencil, eraser, scale, set squares and protractors.

Inclusion criteria

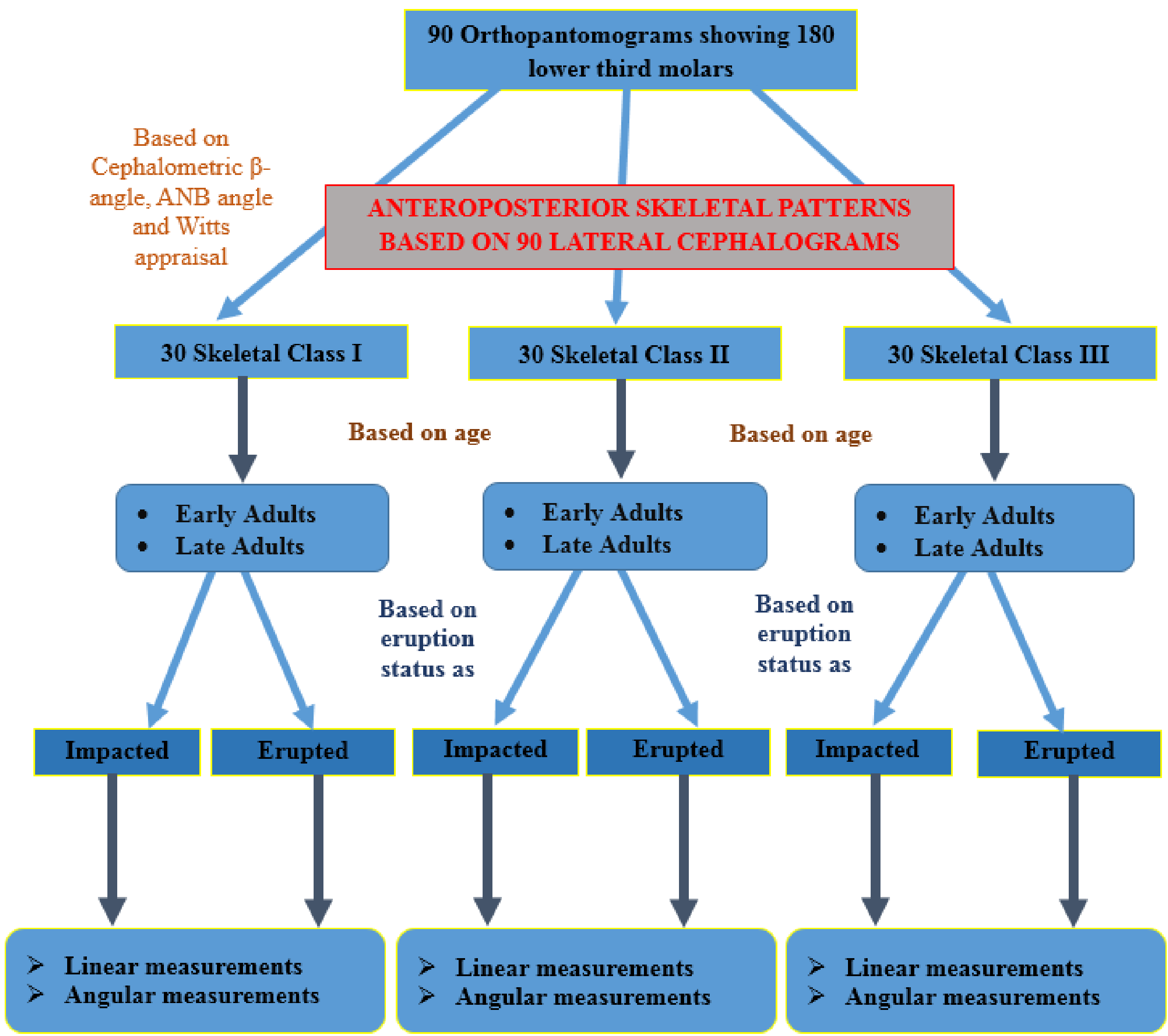
Radiographs of patients:

1. With no history of previous orthodontic or orthognathic surgical treatment,
2. With no extracted or missing permanent teeth.

Exclusion criteria

3. Radiographs of patients:
4. With developmental anomalies, dentofacial deformities, or severe facial asymmetries.

Flow chart of the methodology



Methods
The study was performed using Lateral cephalograms and Orthopantomograms available from pre-existing records of the patients.
The Lateral cephalograms and their corresponding Orthopantomograms were divided into three groups (Skeletal Class I, Class II and Class III) according to their ANB angle, Witts appraisal and cephalometric β-angle.
All the radiographic samples were further classified into two age related subgroups as:-

- 15 radiographic samples from Early adult age group (16-18 years),
- 15 radiographic samples from Late adult age group (19-28 years).

All the samples were further classified based on the eruption of lower third molar as:

- Impacted lower third molars
- Erupted lower third molars

The lower third molars were considered as erupted if they have reached the occlusal plane drawn on the Orthopantomogram; otherwise they are considered as impacted.

A single investigator traced the radiographs and following landmarks and planes were defined

1. Mandibular line (ML): tangential line of the lower border of the mandibular body.
2. Mandibular plane (MP): line that passes through gonion and menton.
3. Occlusal plane(OP): line drawn through the highest points of the crowns of the lateral incisor and first molars.
4. Tangent line(TL): drawn to the most distal points on the crown and root of the second lower molar.

Linear measurements

1. Retromolar space (RMS, in mm): length of the line drawn along the occlusal plane from the point it bisects TL to the point it bisects the anterior edge of the ramus.
2. Mesiodistal width (MDW, in mm): the greatest distance between the mesial and distal surface of the lower third molar crown.
3. Retromolar space/mesiodistal width ratio (SWR): calculated by dividing the RMS and MDW.
4. Distance between gonion and gnathion (Go-Gn, in mm): effective length of mandible.
5. Distance between articulare and gonion (Ar-Go, in mm): effective length of ramus.
6. Distance between articulare and gnathion (Ar-Gn, in mm): effective length of mandibular corpus.
7. Witts appraisal (in mm): Distance between the perpendiculars from Point A and Point B on occlusal plane.

Angular measurements

1. Alpha angle (α angle, in º): angulation of lower third molar to mandibular line.
2. Beta angle (β angle, in º): inclination between lower third and second molars.
3. Gamma angle (γ angle, in º): angulation of lower second molar to mandibular line.
4. Gonial angle (Go angle, in º): formed between tangent line to the posterior border of the mandibular ramus and the tangent line to the lower border of mandibular corpus.
5. SNA angle (in º): Angle between cranial base to subspinale (A-point).
6. SNB angle (in º): Angle between cranial base to supramentale (B-point).
7. SN/MP angle (in º): Mandibular plane to cranial base angle.
8. ANB angle (in º): Difference between SNA and SNB.
9. Cephalometric β angle (in °): Angle between a line joining Point A and Point B and perpendicular from Point A to a line joining centre of condyle and Point B.

The linear and angular measurements obtained from the tracings of 180 lower third molars were tabulated and results were computed using statistical analysis.

Statistical analysis
The following tests were used to assess the statistically significant differences:

a. Student t-test and Mann Whitney U test to compare the outcome variables between study subgroups.
b. ANOVA test followed by Bonferroni's Post hoc Analysis to compare the outcome variables among different skeletal classes.
c. Chi-square test for differences between frequencies.

Statistical interpretation:
Highly significant $p \leq 0.001$
Significant $p \geq 0.001$ and ≤ 0.05
Not significant $p \geq 0.05$

Statistical software: The Statistical software namely SPSS 11.0 and Systat 8.0 were used for the analysis of the data and Microsoft word and Excel have been used to generate graphs, tables etc.

Results
The sample consisted of 180 lower third molars of 90 patients (Table 1).
One-way ANOVA test followed by Bonferroni’s post hoc analysis was done to compare the linear and angular measurements in skeletal Class I, Class II, and Class III. The test results revealed that for the linear measurement of Ar-Gn, the mean score was higher in class III subjects followed by class I and least in class II subjects (Table 2, Graph 1).
This difference in linear measurements of Ar-Gn was statistically significant (P=0.01).
Student’s t test was done to compare linear and angular measurements between the age and impaction related subgroups for the total samples of skeletal bases. Man-Witney U test was used to assess significance in β-angle (Table 3, Graph 2 and Graph 3).
The test results revealed that there was significant difference between the subgroups of impacted and erupted groups as well as age related groups in the variables of RMS, SWR, α-angle, β-angle and Ar-Go.
For the RMS, SWR and α-angle variables, the mean score for erupted group was higher than the mean score for impacted group. While for the β-angle variable, the mean score for impacted group was higher than the erupted group.
For the RMS, SWR and α-angle variables, the mean score for late adult group was higher than the mean score for early adult group. While for the β-angle variable, the mean score for early adult group was higher than the late adult group.
The prevalence of impaction was higher in Class II subjects and least in Class III subjects. In contrast, the eruption was

more in Class III subjects and least with Class II subjects (Table 4, Graph 4). Though this difference in eruption patterns in different skeletal jaw bases was not significant.

Comparison of Linear & Angular measurements in groups with different SN/MP Angles revealed that the mean value of RMS, SWR, α-angle were higher in group with SN/MP angle ≤ 32 than in the group with SN/MP angle ≥ 33. While for the β-angle variable, the mean value was lower in group with SN/MP angle ≤ 32 than in the group with SN/MP angle ≥ 33. Though this difference in mean value was not significant (Table 5, Graph 5).

Discussion

The possibility of mandibular third molar eruption depends on several factors. It has been suggested that different skeletal relationships might have an impact on this process [9, 13, 16]. The following parameters were evaluated in the study.

The mesiodistal width (MDW) was found to be smaller in impacted group than the erupted group when compared in Total sample, Skeletal Class II and Class III groups (Table 3). Even though the third molar was smaller in size in impacted group than in the erupted group, it still got impacted. This suggests that there are other factors responsible for impaction of lower third molars.

The Retromolar space and Space/Width ratio was found to be larger in the subgroup of erupted mandibular third molars (11.6±3.3mm and 0.866±0.243 respectively) than in impacted mandibular third molar subgroup (8.4±2.9mm and 0.645±0.223 respectively). This difference in Retromolar space and space/width ratio between erupted and impacted groups was found to be significant (*P*<0.001). (Table 3)

This may explain higher impaction rate of mandibular third molars in cases with reduced retromolar space and space/width ratio. In other studies also, lack of retromolar space and space/width ratio was presented as one of the most important factors that caused a high impaction rate among mandibular third molars [3, 5, 6, 8, 13, 17].

Furthermore, significantly larger sizes of retromolar space and space/width ratio were observed in the late adult subgroup (10.4±3.5mm and 0.802±0.267 respectively) rather than in the early adult subgroup (9.1±3.3mm and 0.683±0.231 respectively) of patients (P=0.008 and P=0.002 respectively). (Table 3) These results are in line with those of Chen *et al*., Zelic and Nedeljkovic, who suggested that retromolar spaces expand after the age of 16 years [18, 19].

The Effective lengths of mandibular corpus (Ar-Gn) were correlated with the impaction rate of mandibular third molars. [9,10,11,12,13,18] The significantly greatest values of these distances were observed among Class III subjects (102.4±7.1mm), and they were significantly decreased in the subgroup of Class II subjects (97.4±5.1mm), (P=0.04) (Table 1). These findings are in accordance with previously reported results [8, 9]. Furthermore, the effective lengths of mandibular corpus were significantly increased in the subgroup of patients with erupted mandibular third molars (101.2±6.6mm) and they were significantly decreased in the subgroup of patients with impacted mandibular third molars (98.5±6.5mm), (P=0.01) (Table 3).

These findings are in accordance with previously reported studies of Jakovljevic [17]. On the other hand, Kaplan *et al.* and Dierkes *et al.* did not observe differences in mandibular lengths between impacted and erupted mandibular third molars [10, 11]. Also, Abu Alhaija *et al*. did not record any significant differences between these distances in impaction related subgroups for all three skeletal classes [13]. Different landmarks and radiology methods might be the reasons for inconsistency among findings [10, 11].

The Effective lengths of mandibular ramus (Ar-Go) was found to be of significantly greater value among subgroup of late adults (46.7±5.6mm), and they were significantly decreased in the subgroup of early adults (44.0±4.5mm), (P=0.01) (Table 3). These findings are in accordance with previously reported studies of Jakovljevic *et al.* [17].

Some authors have reported that a small inclination angle in the early stages of mandibular third molar development is a sign of its impaction [9, 20, 21].

The Inclination angle of third molars to mandibular plane (α-angle) was found to be larger in the subgroups of erupted mandibular third molars (83.1±14.1˚) than in impacted mandibular third molar subgroup (57.3±19.6˚). This difference in α-angle between erupted and impacted group was found to be significant (*P*<0.001). Furthermore, the value of α-angle was found to be significantly lower in the subgroup of early adults (64.5±17.1˚), while they were significantly higher among subgroup of late adults (72.7±24.7˚), (P=0.01) (Table 3). These findings are in accordance with previously reported studies of Jakovljevic *et al*. [17] This uprighting of inclination angle of mandibular third molar in late adults subgroup might be explained by the increase in effective length of mandibular corpus and ramus in subjects of late adults subgroup.

The Angulation of lower third molar to second molar (β-angle) was found to be smaller in the subgroups of erupted mandibular third molars (8.6±12.7˚) than in impacted mandibular third molar subgroup (32.5±22.5˚). This difference in β-angle between erupted and impacted group was found to be significant (*P*<0.001). Furthermore, the value of β-angle was found to be significantly higher in the subgroup of early adults (25.2±18.5˚), while they were significantly lower among subgroup of late adults (18.8±25.1˚), (P=0.04) (Table 3). These findings are in accordance with the previously studies [17]. This uprighting of inclination angle of mandibular third molar in late adults subgroup might be explained by the increase in effective length of mandibular corpus and ramus in subjects of late adults subgroup.

The γ-angle, Gonial angle parameters did not show any significant difference in any of the groups. Jakovljevic *et al.*, reported significant differences in these parameters [17]. These findings are in contrast to our present study which could be attributed to smaller sample size and differences in landmarks and radiology methods [10, 11].

Table 1

Distribution of demographic characteristics among study participants

Variables	Categories	N	%
Age group	Early Adult	45	50%
	Late Adult	45	50%
Sex	Males	29	32.2%
	Females	61	67.8%

Table 2

Comparison of Linear & Angular measurements in Skeletal Class I, II & III using ANOVA test followed by Bonferroni's Post hoc Analysis										
Variables	**Skeletal Class I**		**Skeletal Class II**		**Skeletal Class III**		**P-Value**	**I - II**	**I - III**	**II - III**
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**				
RMS(mm)	9.6	3.8	9.8	2.4	9.8	3.9	0.95	1.00	1.00	1.00
MDW(mm)	13.3	0.9	12.9	1.2	13.2	1.4	0.14	0.18	1.00	0.40
SWR	0.728	0.287	0.758	0.197	0.741	0.278	0.82	1.00	1.00	1.00
α-Angle	67.7	20.9	67.2	22.4	70.9	21.6	0.59	1.00	1.00	1.00
β-Angle	23.1	21.2	22.5	23.7	20.4	22.0	0.78	1.00	1.00	1.00
γ-Angle	90.7	7.2	90.2	8.1	90.6	7.5	0.93	1.00	1.00	1.00
Go Angle	122.0	6.9	121.2	5.6	123.4	8.5	0.23	1.00	0.89	0.27
Go-Gn (mm)	70.2	6.2	69.5	3.4	72.5	5.4	0.06	1.00	0.25	0.08
Ar-Go(mm)	45.9	5.8	44.4	4.0	45.8	5.7	0.45	0.81	1.00	0.86
Ar-Gn(mm)	99.2	6.8	97.4	5.1	102.4	7.1	0.01*	0.78	0.18	0.01*

* - Statistically Significant

Table 3

Comparison of Linear & Angular measurements between the age Impaction related subgroups of Skeletal Class I, II & III										
Variables	Early Adult		Late Adult		P-Value	Impacted		Erupted		P-Value
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
Total Sample										
RMS(mm)[a]	9.1	3.3	10.4	3.5	0.008*	8.4	2.9	11.6	3.3	<0.001*
MDW(mm)[a]	13.1	1.1	13.1	1.3	1.00	12.9	1.1	13.4	1.2	0.004*
SWR[a]	0.683	0.231	0.802	0.267	0.002*	0.645	0.223	0.866	0.243	<0.001*
α-Angle[a]	64.5	17.1	72.7	24.7	0.01*	57.3	19.6	83.1	14.1	<0.001*
β-Angle[b]	25.2	18.5	18.8	25.1	0.04*	32.5	22.5	8.6	12.7	<0.001*
γ-Angle[a]	89.6	7.3	91.4	7.8	0.11	89.9	8.0	91.2	7.0	0.25
Go Angle[a]	122.9	6.6	121.5	7.7	0.20	122.2	7.5	122.3	6.8	0.94
Go-Gn (mm)[a]	70.8	5.3	70.7	5.2	0.98	70.0	4.7	71.8	5.7	0.10
Ar-Go(mm)[a]	44.0	4.5	46.7	5.6	0.01*	44.7	5.3	46.2	5.0	0.18
Ar-Gn(mm)[a]	98.8	6.4	100.5	6.8	0.25	98.5	6.5	101.2	6.6	0.04*
Sk. Class I										
RMS(mm)[a]	8.7	3.0	10.6	4.3	0.04*	8.2	2.9	11.4	4.0	0.001*
MDW(mm)[a]	13.5	0.8	13.0	0.9	0.04*	13.4	0.7	13.0	1.0	0.08
SWR[a]	0.641	0.203	0.816	0.332	0.02*	0.606	0.210	0.878	0.299	<0.001*
α-Angle[a]	63.4	16.7	72.1	23.8	0.11	55.1	13.3	83.2	17.9	<0.001*
β-Angle[b]	26.1	15.5	20.1	25.6	0.27	35.8	16.7	7.6	14.9	<0.001*
γ-Angle[a]	89.6	6.2	91.7	8.1	0.25	90.9	7.2	90.4	7.3	0.79
Go Angle[a]	123.4	7.7	120.7	5.9	0.14	122.8	8.0	121.1	5.4	0.36
Go-Gn (mm)[a]	70.3	6.2	70.1	6.3	0.95	69.2	5.8	71.5	6.6	0.34
Ar-Go(mm)[a]	44.8	6.2	46.9	5.5	0.33	46.0	6.7	45.7	4.7	0.90
Ar-Gn(mm)[a]	99.1	7.7	99.3	6.1	0.94	98.8	7.5	99.8	6.1	0.71
Sk. Class II										
RMS(mm)[a]	9.4	2.2	10.3	2.6	0.15	9.3	2.6	10.8	1.8	0.02*
MDW(mm)[a]	12.7	1.2	13.0	1.1	0.33	12.6	1.1	13.4	1.1	0.009*
SWR[a]	0.722	0.183	0.794	0.208	0.16	0.729	0.214	0.807	0.158	0.14
α-Angle[a]	63.5	17.8	70.8	26.0	0.21	59.2	23.7	81.0	10.3	<0.001*
β-Angle[b]	25.8	22.6	19.1	24.6	0.27	29.1	26.9	11.0	8.7	<0.001*
γ-Angle[a]	89.0	9.3	91.4	6.7	0.26	89.5	9.7	91.4	4.3	0.39
Go Angle[a]	121.5	4.6	120.9	6.6	0.67	121.1	6.4	121.4	4.3	0.85
Go-Gn (mm)[a]	70.5	3.2	68.6	3.3	0.13	70.1	3.3	68.6	3.4	0.23
Ar-Go(mm)[a]	44.0	4.0	44.7	4.0	0.64	44.2	4.2	44.7	3.8	0.76
Ar-Gn(mm)[a]	97.8	4.4	96.9	5.8	0.65	97.7	5.4	96.8	4.7	0.66
Sk. Class III										
RMS(mm)[a]	9.2	4.3	10.5	3.4	0.22	7.4	2.8	12.2	3.4	<0.001*
MDW(mm)[a]	13.1	1.1	13.3	1.7	0.69	12.7	1.2	13.7	1.5	0.004*
SWR[a]	0.686	0.293	0.796	0.256	0.13	0.583	0.222	0.899	0.238	<0.001*
α-Angle[a]	66.6	17.1	75.2	24.9	0.12	57.2	20.0	84.6	12.9	<0.001*
β-Angle[b]	23.6	17.1	17.1	25.8	0.26	33.0	21.9	7.7	13.1	<0.001*
γ-Angle[a]	90.2	6.1	91.0	8.8	0.66	89.4	6.6	91.8	8.3	0.21
Go Angle[a]	123.8	7.0	123.0	10.0	0.72	122.9	8.3	123.9	8.9	0.63
Go-Gn (mm)[a]	71.6	6.1	73.5	4.5	0.34	70.6	5.0	74.4	5.2	0.04*
Ar-Go(mm)[a]	43.1	2.7	48.5	6.6	0.007*	43.9	4.8	47.7	5.9	0.07
Ar-Gn(mm)[a]	99.6	7.1	105.1	6.1	0.03*	99.1	6.9	105.7	5.8	0.008*

* - Statistically Significant

a. Student's t test

b. Mann Whitney U test

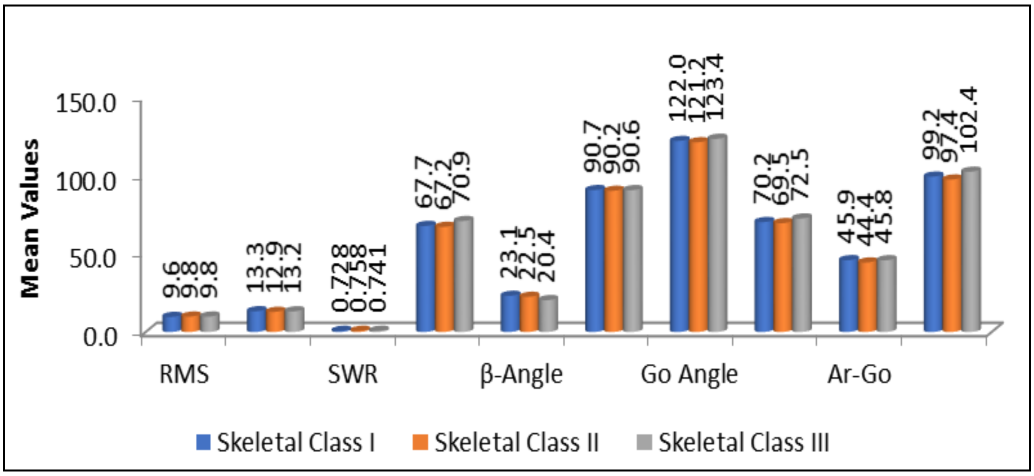
Table 4

Evaluation of Mandibular third molar eruption in adult group with different skeletal classes using Chi Square test								
Skeletal Class	Mand. third Molar Eruption				Total		c^2 Value	P-Value
	Impacted		Erupted					
	n	%	N	%	n	%		
Class I	33	55.0%	27	45.0%	60	100%	2.211	0.33
Class II	38	63.3%	22	36.7%	60	100%		
Class III	30	50.0%	30	50.0%	60	100%		

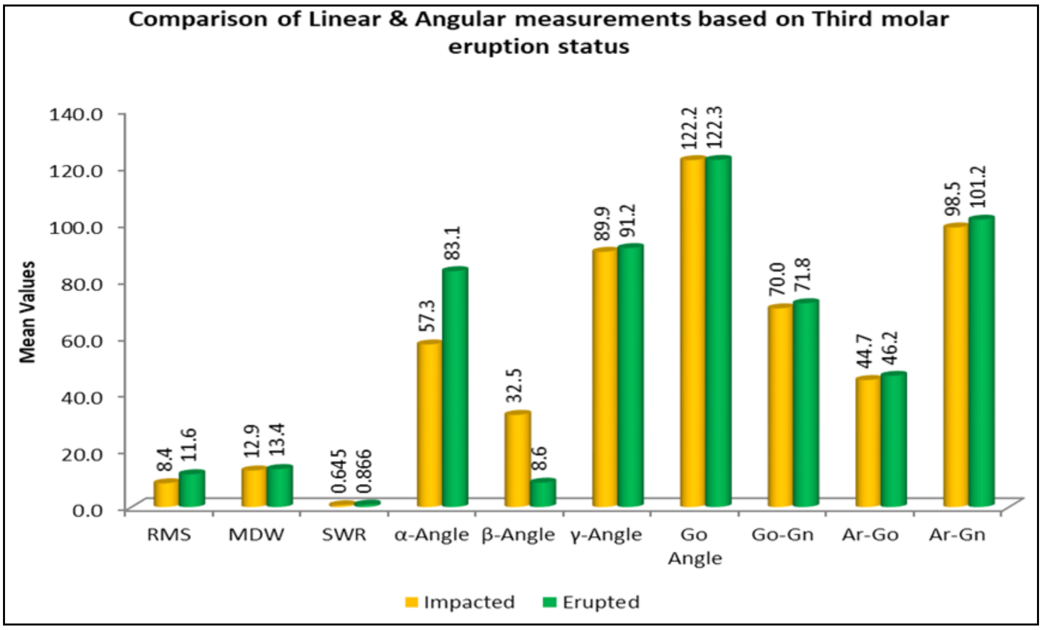
Table 5

Comparison of Linear & Angular measurements in groups with different SN/MP Angles					
Variables	SN/MP [≤ 32]		SN/MP [≥ 33]		P-Value
	Mean	SD	Mean	SD	
RMS(mm)[a]	10.1	3.0	9.8	3.8	0.72
SWR[a]	0.758	0.239	0.749	0.269	0.86
α-Angle[a]	68.4	19.9	67.6	24.6	0.86
β-Angle[b]	21.0	20.4	26.5	25.7	0.27

a. Student's t test, b. Mann Whitney U test



Graph 1



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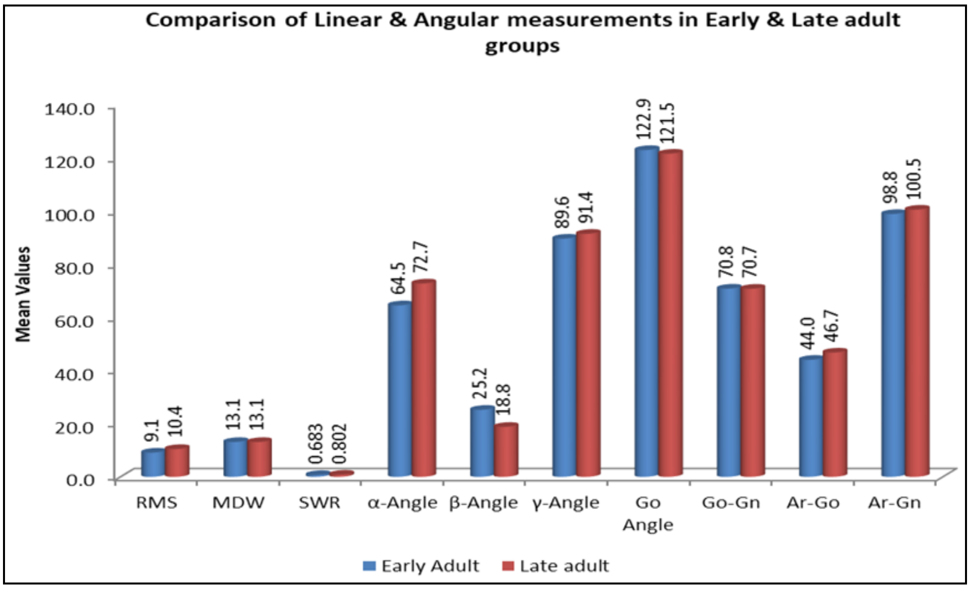

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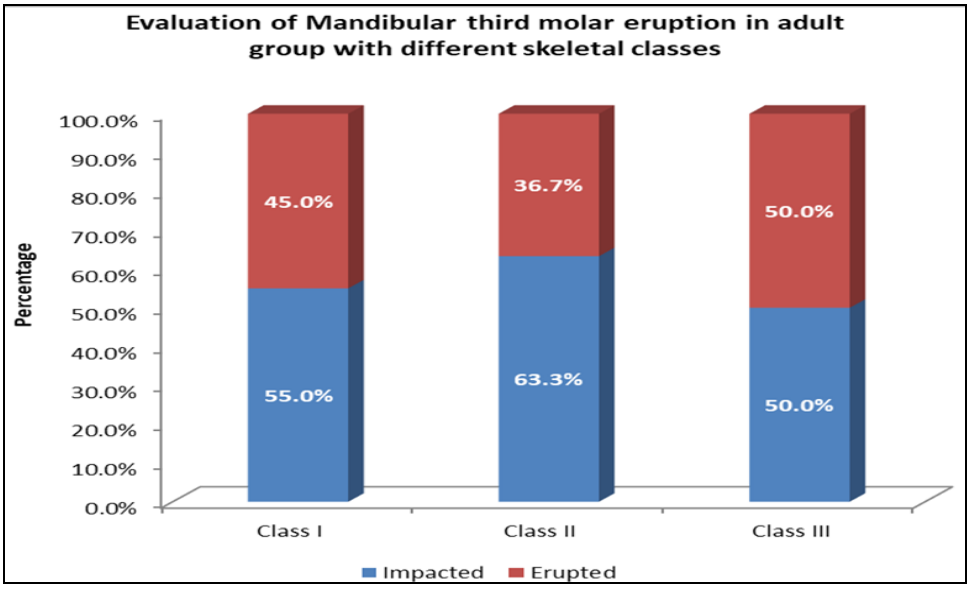
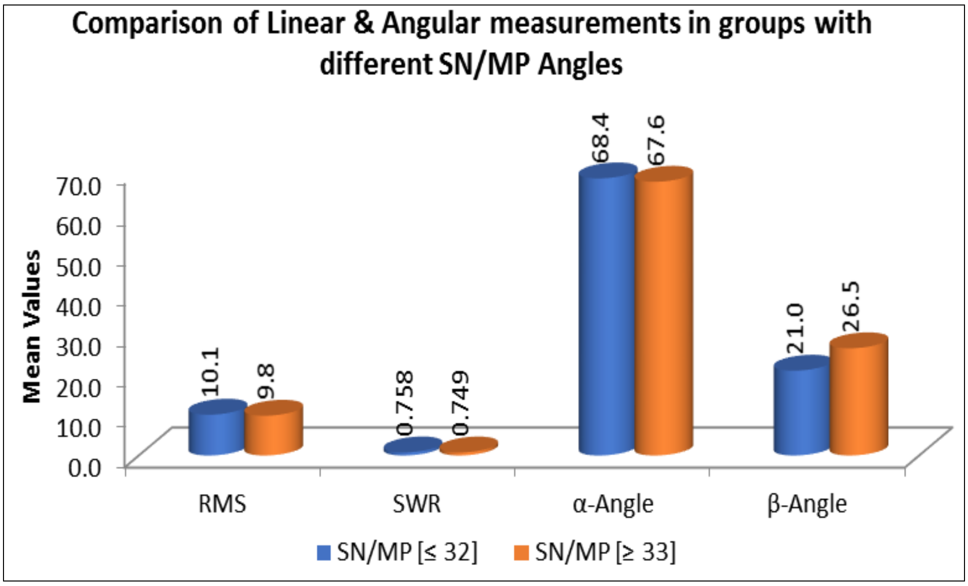
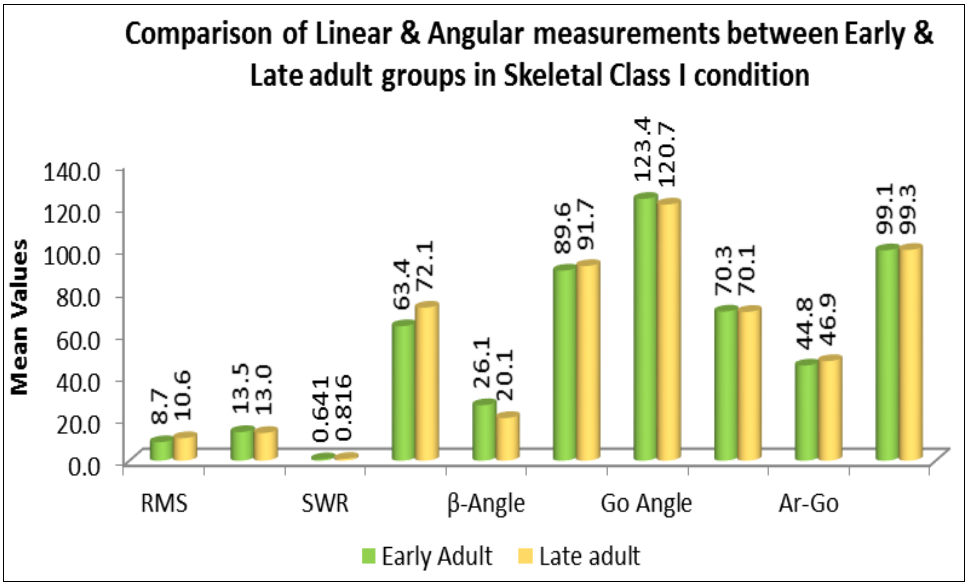


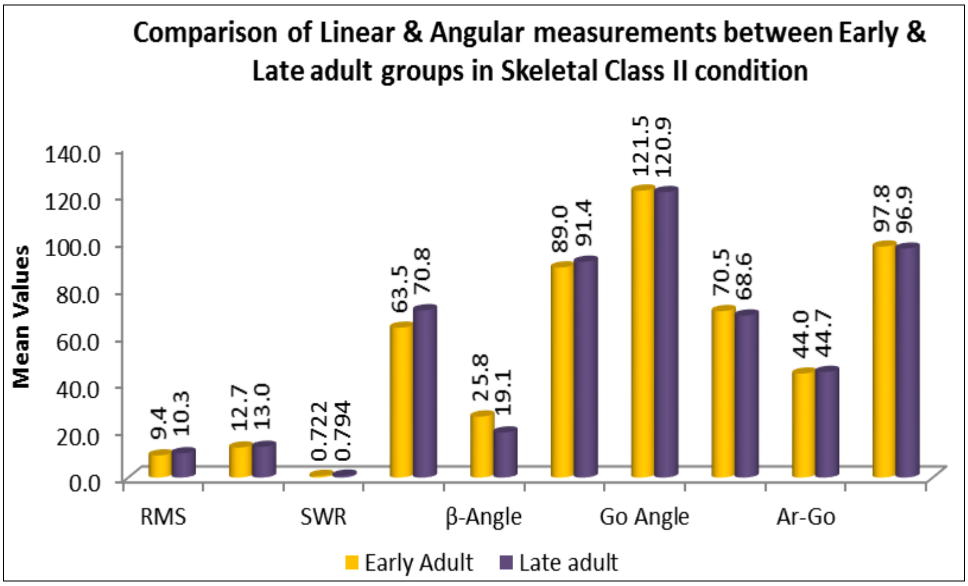
Graph 4



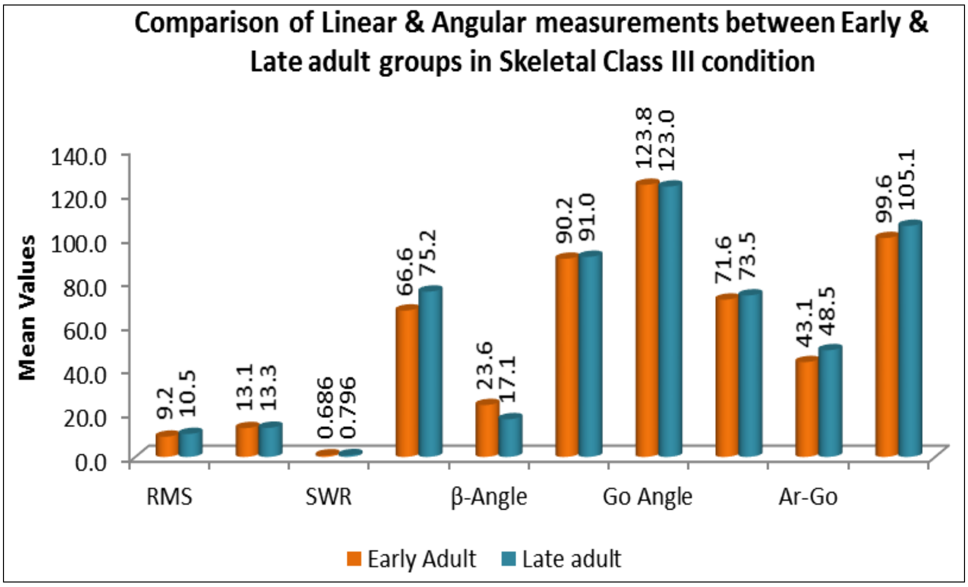
Graph 5



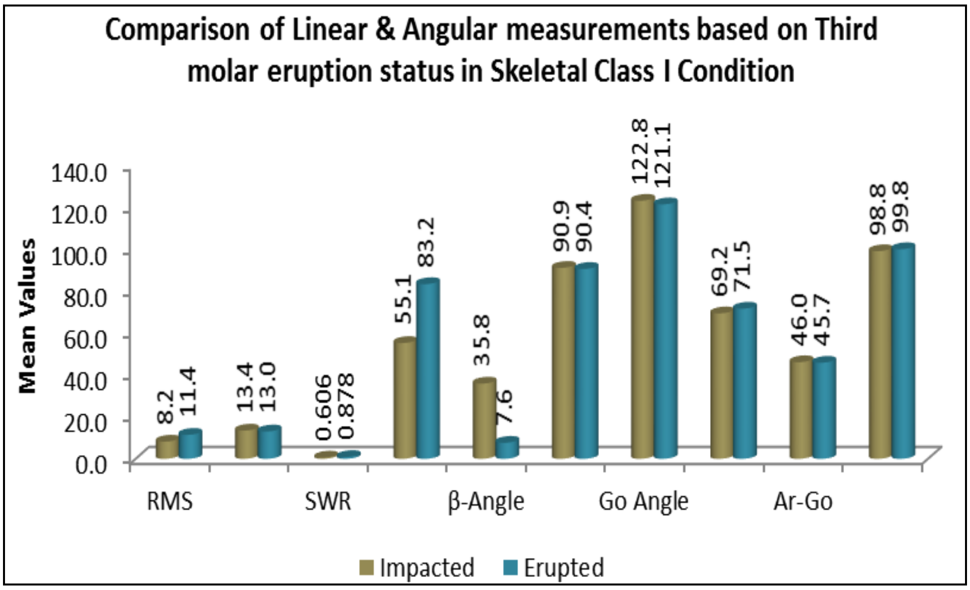
Graph 6



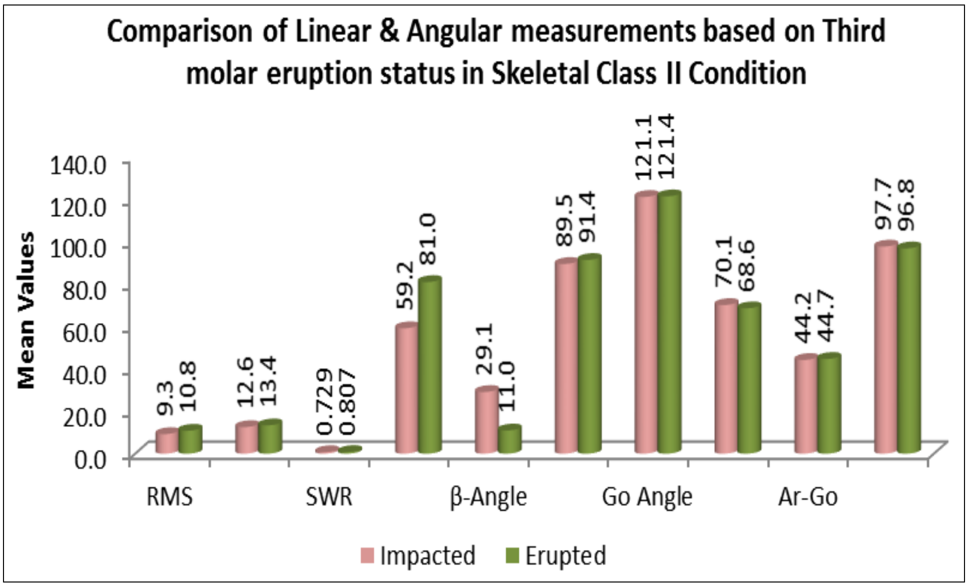
Graph 7



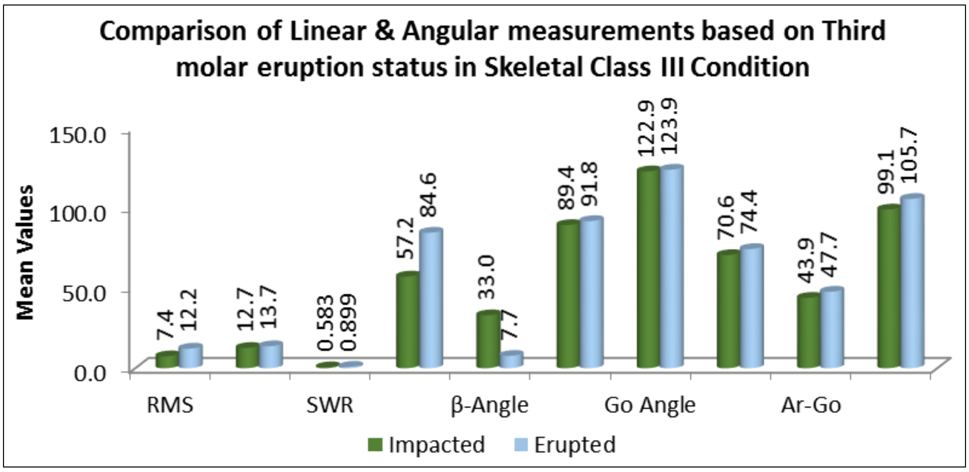
Graph 8



Graph 9



Graph 10



Graph 11

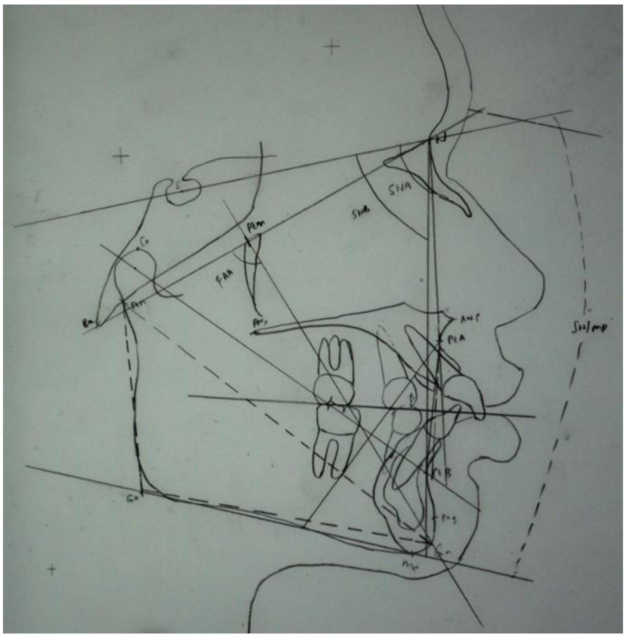


Fig 1: Linear and angular measurements used for lateral cephalogram analysis.; ANB, ANB angle; SNA, SNA angle; SNB, SNB angle; SN/MP, SN/MP angle; MP, Mandibular plane; β, Cephalometric Beta angle.

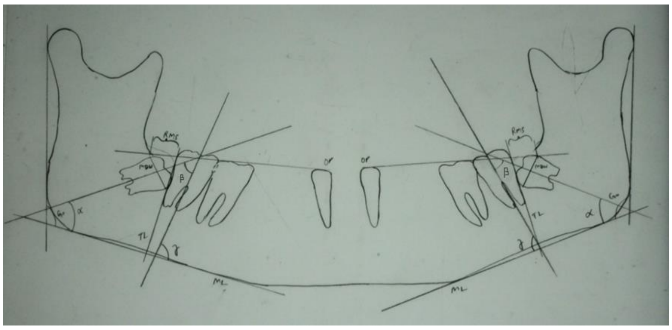


Fig 2: Linear and angular measurements used for OPG analysis. MDW, mesiodistal width of the lower third molar crown; RMS, retromolar space; α, angle α; β, angle β; γ, angle γ;Go, Gonial angle; ML, mandibular line;OP, occlusal plane; TL, tangent line.

Conclusion

The conclusions drawn from this study are:-

1. The parameter values with decreased Retromolar space, decreased Space/width ratio, increased β-angle, decreased α-angle and reduced Ar-Gn distance can be used as radiographic predictors for estimation of mandibular third molar impaction.
2. Highest number of lower third molar eruptions were present in Skeletal Class III group whereas impactions of lower third molars were more prevalent in Skeletal Class II group. This could be attributed to the increased length of mandibular corpus in Skeletal Class III group compared to Skeletal Class II group.

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