Morphometric analysis of inter-condylar width, intermandibular width and condylar inclination angle using digital orthopantomogram- An anthropometric study

Akhilanand Chaurasia[1,*], Gaurav Katheriya[2], Ranjitkumar Patil[3]

[1]Assistant Professor, [2]Junior Resident, [3]Professor & Head, Dept. of Oral Medicine & Radiology, Faculty of Dental Sciences, King George's Medical University, Lucknow

***Corresponding Author:**
Email: chaurasiaakhilanand49@gmail.com

Abstract

Objective: The present study was conducted to evaluate the correlation between age, sex and Inter-condylar width (ICW) and Intermandibular width (IMW). This study will also help in age and sex prediction (Linear regression) on the basis of Inter-condylar width (ICW) and IMW (Intermandibular width), RCI and LCI. It also evaluates the correlation between ICW (Inter-condylar width), Inter-mandibular width (IMW) and dentulous, partially dentulous and edentulous study subjects. The Right condylar inclination (RCI) and Left condylar inclination (LCI) variation in dentulous, partially dentulous and edentulous study subjects were also determined.

Material and Methods: The orthopantomograms of 200 subjects were taken from planmeca promax-dimax4 OPG machine at 66 Kvp, 8mA and exposure time 16 sec. All the measurements are done on digital orthopantomograms using planmeca Romexis 3.2.0R software.

Results: The study population consists of 119 male and 80 female in age group ranging from <18 years to >65 years of age.The Intercondylar width and Intermandibular width is statistically significant (P<.001) in all age groups however the right condylar inclination, left condylar inclination and total of RCI+LCI(TCI) was statistically insignificant (P>.005). The Unpaired t test is applied to know the association between gender and study parameters. All the study parameters (ICW, IMW, RCI, LCI and RCI+LCI) were statistically not significant (P>.05) in male and female. The one way ANOVA shows that all the study parameters (ICW, IMW, RCI, LCI and RCI+LCI) were statistically not significant (P>.05) in partially dentulous, dentulous and edentulous study subjects. Mathmatical equation derived from linear regression can be used for age prediction of an individual if any of ICW, IMW, RCI, LCI and RCI+LCI (TCI) is known.

Conclusion: The Intercondylar width, Intermandibular width has anthropometric value. It can be used in determination of age and gender of subjects in medico-legal cases.

Keywords: Panoramic Radiograph. Intercondylar Width, Intermandibular Width, Condylar Inclination Angle, Mandible.

Introduction

Skeleton remains is important in field of forensic investigation as it provides a solid base for any morphometric analysis.(1) The age estimation is mainly depend on the gender determination and its truthfulness is solely depends on how much the skeleton is remaining.(2) So in mass disaster and major tragic accidents it is very difficult to determine gender as it we could not find 100% remains of the victims. Determination of sex by morphological assessment has been one of the oldest approaches in forensic anthropology and medico-legal examinations. The method may vary and depend upon the available bones and their conditions. The identification of sex is of significance in cases of mass fatality incidents where bodies are damaged beyond recognition. In fact sometimes intact skull may not be found then mandible may provide a great asset in identification of victims and determines his/her gender.(1) The mandible is the hardest bone in our body and it is not easily destroyed or distorted in mass disasters. Mandibular ramus can differentiate between sexes, as the stages of mandibular development, growth rates, and duration are distinctly different in both sexes. In addition, masticatory forces exerted are different for males and females, which influences the shape of the mandibular ramus. Saini et al suggested that Coronoid height was the single best parameter providing an accuracy of 74.1%.(3) Steyn et al showed bigonial breadth has shown maximum percentage of dimorphism.(4) Studies done by Loth et al, on their nonmetric examination on South African sub adult samples claimed that, shape differences in the symphyseal region and anterior body of the mandible can be used to predict sex with above 80% accuracy. In a blind test of that technique, however, Scheuer showed that when applied to different population samples, sex classification accuracy declined considerably to 64%. The most accurate single indicators among cranial methods were the robustness of the mandible with accuracy of 70.93%.(5) Many variables showed significant differences which includes: bicondylar breadth, gonial angle and minimum ramus breadth according to study done by Kharoshah et al(6) in recent years, geometric morphometric methods have become increasingly common for studying human skeletal biology in both physical, and of late forensic anthropology. These methods have been used to a greater extent because they are versatile and allow detailed

assessment of differences among specimens. Loth and Henneberg described a single morphological indicator of sexual dimorphism, namely the presence or absence of flexure on the posterior border of the mandible with a predictive accuracy of 90.6 to 99.0%.[7] In the other studies, which have criticized mandibular ramus flexure as sex indicator in adult and fossils specimens by the same method, the accuracy of sexing was found between 59.0% and 80.4% which is well below the reported 90.6 to 99.0%. In order to evaluate mandible measurements for sex determination, 18 measurements were taken on the lower jaw. This research showed that length of the mandibular body, mandibular angle and minimum ramus breadth exhibit the highest degree of sexual dimorphism. These gender specific mandibular features make the sex identification possible and reliable in cases with damaged and partially preserved lower jaws.[8] Orthopantamograph is most commonly preferred extra oral dental radiograph by dentists and it also provides a wide coverage of both the jaws and teeth.it expands the spectrum of forensic radiology for individuals case and it also plays an important role in identifying the victims in mass disasters, terrorist acts, major road traffic accidents where identifying is huge problem. So aim of our study to set new parameters for determining gender radiologically by analyzing the anatomical landmarks, inter distance between them and condylar inclination angle bilaterally.

Materials and Methods

The orthopantomograms of 200 subjects were taken from planmeca promax-dimax4 OPG machine at 66 Kvp, 8mA and exposure time 16 sec. All the measurements are done on digital orthopantomograms using planmeca Romexis 3.2.0R software.

The subject was positioned properly in the panoramic machine set up so that the jaws were within the focal trough as per the methodology described by Langland, Langlais and Morris (1982). The subject was made to stand erect with back straight. The height was adjusted by pressing the adjustable knob. The subjects were explained about the working of the machine. The operation of the panoramic machine was demonstrated to the subjects and the subjects were appraised of the need to be still during the procedure. Jacket, sweater and bulky dress materials were removed so that there could be sufficient space between the bottom of the cassette holder and patients shoulder. The subject was made to wear a lead apron and was positioned carefully in the focal through with the help of bite block covered with occlusal disposable envelope and head holder of the machine so that the lower border of mandible was equidistant on each side from the chin support and perpendicular to the Frankfurt horizontal plane. Frankfurt horizontal plane was maintained parallel to the floor of the clinic. The patient's midsagittal plane was positioned in the center of the focal trough of the x-ray unit by asking the patient to bite with his central incisors (upper and lower). The patient was asked to close the lip and place the tongue against the palate. Automatic exposure parameters were selected. After all the adjustments were made, appropriate.

66 Kvp and 8mA were selected and exposure were made at 16 sec of exposure time by depressing the control switch of the panoramic machine. The orthopantogram is displayed on console computer. The image is saved and stored in computer. Then image of orthopantogram is opened with inbuilt planmeca Romexis 3.2.0R software for measurement of study parameters. The study parameters are measured as follows in dentulous, partially dentulous and edentulous study subjects (Fig. 1, Fig. 2, Fig. 3)

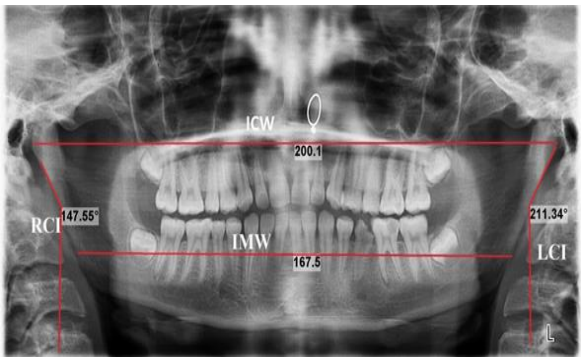


Fig. 1: Shows Dentulous subject with measurement of study parameters i.e. Intercondylar width (ICW), Inmandibular width (IMW), Right condylar inclination angle (RCI), Left condylar inclination angle (LCI)

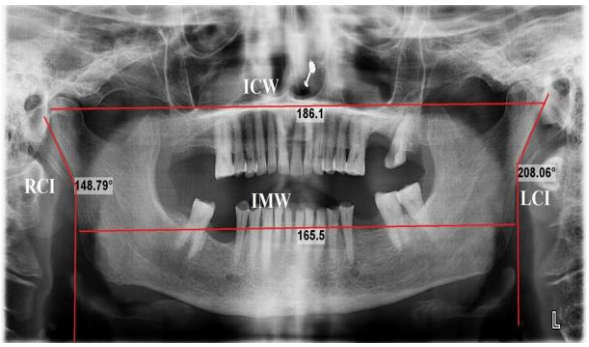


Fig. 2: Shows Partially Dentulous subject with measurement of study parameters i.e. Intercondylar width (ICW), Inmandibular width (IMW), Right condylar inclination angle (RCI), Left condylar inclination angle (LCI)

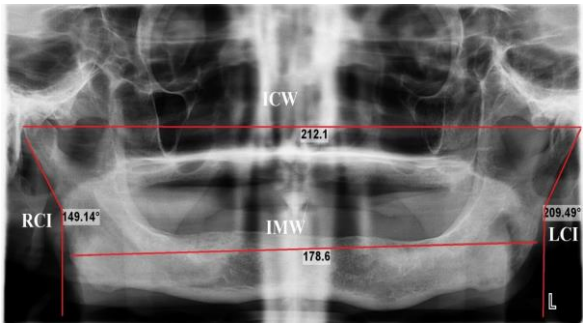


Fig. 3: Shows edentulous subject with measurement of study parameters i.e. Intercondylar width (ICW), Inmandibular width (IMW), Right condylar inclination angle (RCI), Left condylar inclination angle (LCI)

1. Intercondylar width (ICW)- is measured as width between the farthest distal condyle head points.
2. Inmandibular width (IMW)- is measured as width between the farthest distal mandibular angle points.
3. Right condylar inclination angle (RCI)- It is an angle between a parallel line with the distal right condyle neck and a vertical line.
4. Left condylar inclination angle (LCI)- It is an angle between a linear line with the distal left condyle neck and a vertical line.

Statistical Analysis: Categorical variables is presented in number and percentage (%) and continuous variables will be presented as mean and SD. Quantitative variables is compared using Unpaired t-test between two groups and ANOVA test between three groups. Pearson correlation coefficient is used to determine the relationship between two scale parameters while correlation was defined as a measure of the strength of a linear relationship between two variables. A p value of <0.05 is considered statistically significant. The data will be entered in MS Excel spreadsheet and analysis is done using Statistical Package for Social Sciences (SPSS) version 21.0.

Results

The study population consists of 199 subjects. The study population consists of 119 male and 80 female i.e. that male proportion was higher than female i.e. 59.8 % and 40.2% respectively (Table 1). The study population is divided on the basis dentition status into partial dentulous, dentulous and edentulous. The dentulous subjects were higher (58.3%) in number than partial dentulous and edentulous (Table 2). The study population consists of study subjects in age group ranging from <18 years to >65 years of age.The majority of study subjects(40.2%) were in 30 to 55 years of age group(Table 3). The distribution of males and females in age groups, in age group 18-35 years the males(40%) and females(40%) highest in number(Table 4). The majority of the partially dentulous subjects were between 30 to 55 years (50.0%), dentulous subjects between 18 to 30 years (41%) and in edentulous subjects between 30 to 55 years (67.0%) There was no significant association between age groups and dental status of study subjects. (p>0.05)(Table 5). The Pearson correlation coefficient is used to know the association between age and ICW, IMW, RCI, LCI and RCI+LCI and it was found that there was no obvious significant correlation(p>.05)between age of study subjects with ICW, IMW, RCI, LCI and RCI+LCI (Table 6). The Pearson correlation coefficient is used to know the association between gender and ICW, IMW, RCI, LCI and RCI+LCI and it was found that there was no obvious significant correlation(p>.05)between gender of subjects and there was no significant correlation between male subjects with female subjects of ICW, IMW, RCI, LCI and RCI+LCI. (p>.05) (Table 7). The study parameters are studied in age groups by one way ANOVA. It was found that the Intercondylar width and Intermandibular width is statistically significant (P<.001) in all age groups however the right condylar inclination, left condylar inclination and total of RCI+LCI was statistically insignificant (P>.005) (Table 8). The Unpaired t test is applied to know the association between gender and study parameters. All the study parameters were statistically not significant (P>.05) in male and female (Table 9). The one way ANOVA is applied to know the association of study parameters with dental status. The study parameters were statistically non-significant (P>.05) in partially dentulous, dentulous and edentulous study subjects (Table 10). The Pearson Correlation between study parameters and age shows no significant correlation between age of study subjects with ICW, IMW and TCI. (P>.001) (Table 11).

Table 1

Gender	N	%
Male	119	59.8
Female	80	40.2
Total	199	100.0

Table 2

Partial dentulous/ Edentulous/ Dentulous	N	%
Partial Dentulous	80	40.2
Dentulous	116	58.3
Edentulous	3	1.5
Total	199	100.0

Table 3

Age intervals	N	%
< 18 years	30	15.1
18 – 30 years	61	30.7
30 – 55 years	80	40.2
55 -65 years	21	10.6
>65 years	7	3.5
Total	199	100.0

Table 4

Age intervals	Male (N=119)		Female (N=80)	
	N	%	N	%
< 18 years	18	15	12	15
18 – 30 years	34	29	27	34
30 – 55 years	48	40	32	40
55 -65 years	14	12	7	9
>65 years	5	4	2	3

Applied Chi-square test

Table 5

Age intervals	Partially Dentulous (N=80)		Dentulous (N=116)		Edentulous (N=3)	
	N	%	N	%	N	%
< 18 years	3	4	27	23	0	0
18 – 30 years	14	18	47	41	0	0
30 – 55 years	40	50	38	33	2	67
55 -65 years	17	21	4	3	0	0
>65 years	6	8	0	0	1	33

Applied Chi-square test

Table 6

Parameters	Pearson correlation coefficient (r)	P value
ICW	0.138	0.052
IMW	0.129	0.069
RCI	-0.016	0.820
LCI	-0.014	0.847
TCI	-0.045	0.529

Table 7

Parameters	Pearson correlation coefficient (r)	P value
ICW	0.009	0.939
IMW	0.054	0.636
RCI	0.191	0.090
LCI	0.020	0.861
TCI	0.159	0.158

Table 8: Applied one way ANOVA for significance. *Significant

		N	Mean	Std. Deviation	P value
ICW	< 18 years	30	178.63	14.40	0.011*
	18 – 30 years	61	187.30	11.68	
	30 – 55 years	80	187.64	11.35	
	55 -65 years	21	185.71	16.84	
	>65 years	7	190.86	7.71	
IMW	< 18 years	30	161.03	17.04	0.003*
	18 – 30 years	61	172.70	12.92	
	30 – 55 years	80	171.15	12.91	
	55 -65 years	21	170.76	13.97	
	>65 years	7	172.86	10.16	
RCI	< 18 years	30	162.03	13.82	0.888
	18 – 30 years	61	161.46	7.09	
	30 – 55 years	80	161.86	10.51	
	55 -65 years	21	162.19	7.46	
	>65 years	7	158.00	7.07	
LCI	< 18 years	30	199.13	15.79	0.950
	18 – 30 years	61	198.20	6.87	
	30 – 55 years	80	198.90	9.97	
	55 -65 years	21	197.19	9.08	
	>65 years	7	199.43	5.16	
TCI	< 18 years	30	361.17	7.240	0.530
	18 – 30 years	61	359.66	5.275	
	30 – 55 years	80	360.76	7.666	
	55 -65 years	21	359.38	5.417	
	>65 years	7	357.43	3.409	

Table 9

	Male (N=119)		Female (N=80)		P value
	Mean	**Std. Deviation**	**Mean**	**Std. Deviation**	
ICW	187.88	12.16	183.41	13.37	0.015
IMW	172.50	14.43	166.58	12.78	0.003
RCI	162.39	9.24	160.58	10.42	0.197
LCI	197.97	9.94	199.44	10.08	0.310
TCI	360.36	7.594	360.01	4.796	0.716

Applied Unpaired t test for significance. *Significant

Table 10

	Partially Dentulous (N=80)		Dentulous (N=116)		Edentulous (N=3)		P value
	Mean	**Std. Deviation**	**Mean**	**Std. Deviation**	**Mean**	**Std. Deviation**	
ICW	186.06	13.64	185.78	12.19	198.67	10.69	0.229
IMW	169.39	14.68	170.48	13.70	175.67	13.65	0.686
RCI	162.15	10.58	161.66	9.01	148.67	7.23	0.062
LCI	198.51	10.13	198.34	9.91	208.33	6.81	0.232

Applied one way ANOVA for significance. *Significant

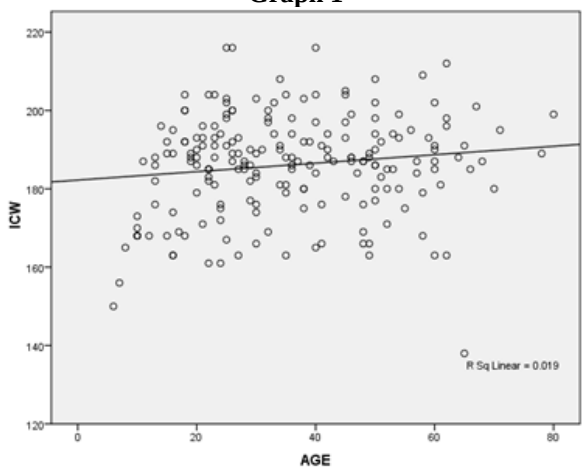
Table 11

		AGE	ICW	IMW	TCI
AGE	Pearson Correlation	1	.138	.129	-.045
	Sig.(2-tailed)		.052	.069	.529
	N	199	199	199	199
**. Correlation is significant at the 0.01 level (2-tailed).					

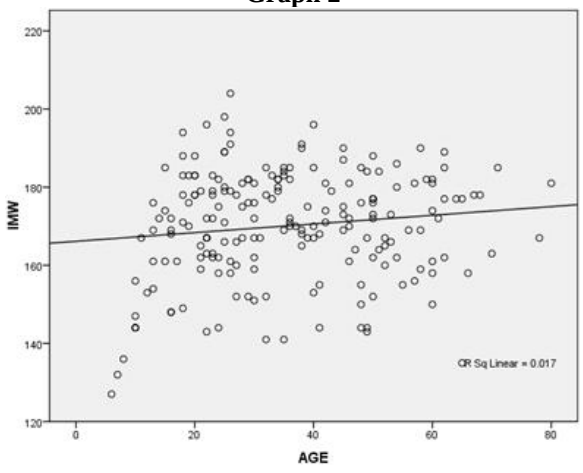
The Linear regression analysis have been derived the mathematical equations to predict the age of study subjects-

- If the intercondylar width is known- Y=182.23+0.108*X(Graph 1)
- If intermandibular width is known- Y=166.15+0.111*X (Graph 2)
- If total condylar inclination(RCI+LCI) is known- Y=360.87+(-0.018)*X(Graph 3)

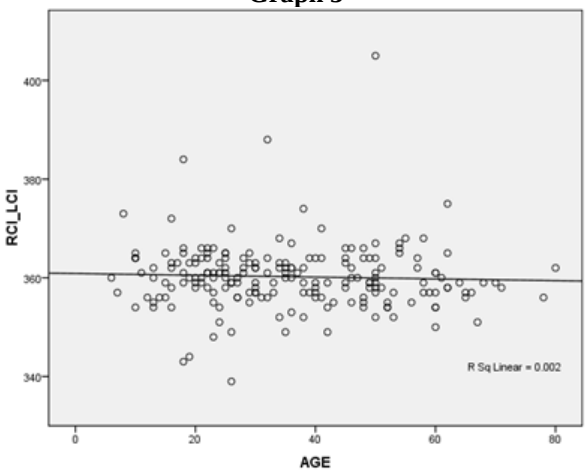
Graph 1



Graph 2



Graph 3



In male subjects of study population, the study parameters are co-related with age of male subjects by Pearson Correlation and it was found that Intercondylar width (ICW) and inter mandibular width (IMW) is directly associated with age of male subjects and demonstrates a significant positive relation (r=0.231, p=0.011) in Intercondylar width (ICW) and significant positive relation (r=-0.242, p=0.008) in inter mandibular width (IMW). However no significant co-relation noted between total condylar inclination angle (RCI+LCI) and age (Table 12).

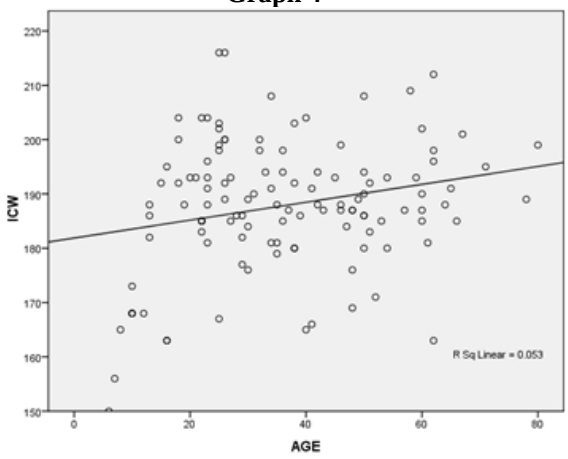
Table 12

		AGE	ICW	IMW	RCI_LCI
AGE	Pearson Correlation	1	.231*	.242**	-.038
	Sig.(2-tailed)		.011	.008	.680
	N	119	119	119	119
*.Correlation is significant at the 0.05 level (2-tailed).					
**Correlation is significant at the 0.01 level (2-tailed).					

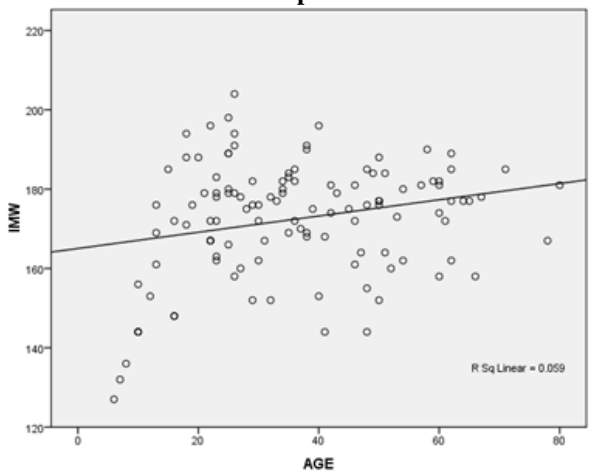
The Linear regression analysis have been derived the mathematical equations to predict the age of male subjects-

- If the Intercondylar width is known- Y=181.882+(0.165)*X(Graph 4).
- If Intermandibular width is known Y=165.043+0.205*X(Graph 5).
- If total condylar inclination(RCI+LCI) is known- Y=360.98+(-0.017)*X(Graph 6).

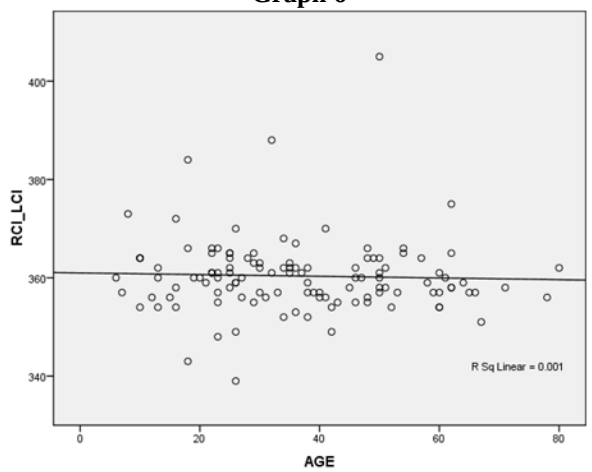
Graph 4



Graph 5



Graph 6



In female subjects of study population, the study parameters are co-related with age of female subjects by Pearson Correlation. However no significant co-relation noted between Intercondylar width (ICW), intermandibular width (IMW), total condylar inclination angle (RCI+LCI) and age.(Table 13)

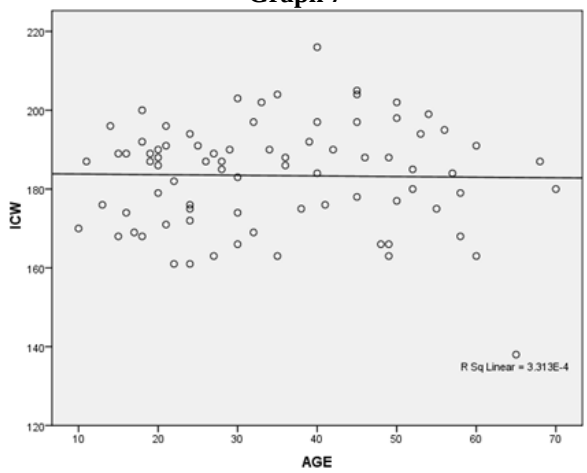
Table 13

		AGE	ICW	IMW	TCI
AGE	Pearson Correlation	1	-.018	-.105	-.070
	Sig. (2-tailed)		.873	.356	.539
	N	80	80	80	80
**Correlation is significant at the 0.01 level (2-tailed).					

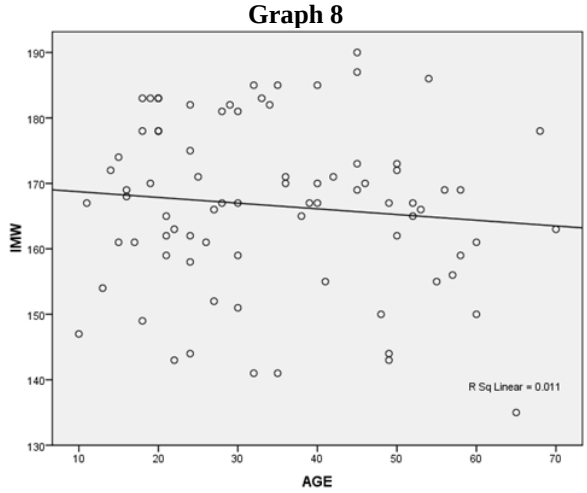
The Linear regression analysis have been derived the mathematical equations to predict the age of female subjects-

- If the Intercondylar width is known- Y=182.229+(0.108)*X(Graph 7).
- If Intermandibular width is known-
- Y=169.601+(-0.087)*X(Graph 8).
- If total condylar inclination (RCI+LCI) is known- Y=360.768+(-0.022)*X(Graph 9).

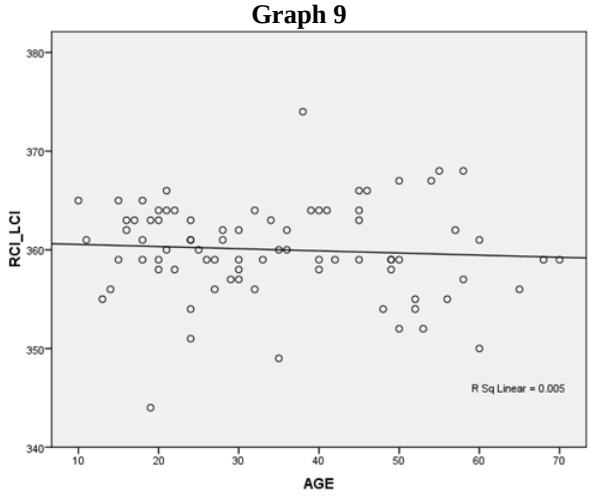
Graph 7



Graph 8



Graph 9



Discussion

Panoramic radiographs have been advocated routinely as a one of the appropriate screening tool for diagnosis of oral diseases. The principal advantages of panoramic image is its broad coverage, low patient radiation dose, short time required for image acquisition and has been a very good source for retrospective studies.[9] Kieser JA et al[10] stated that 'Sexual dimorphism' refers to those differences in size, stature and appearance between male and female that can be applied to dental identification because no two mouths are alike. The mandible is the largest and hardest facial bone and retains its shape better than other bones in the forensic and physical anthropologic field. The mandible can be used to distinguish among ethnic groups and between sexes. Mandibular ramus can differentiate between sexes, as the stages of mandibular development, growth rates, and duration are distinctly different in both sexes. In addition, masticatory forces exerted are different for males and females, which influences the shape of the mandibular ramus.

Saini et al[11] stated that Coronoid height was the single best parameter providing an accuracy of 74.1%. Steyn et al[12] showed bigonial breadth was the most dimorphic of the measurements taken. Ayoub F et al[13] observed no significant difference in mandibular angle in sex determination in the young Lebanese population (83 young individuals - 40 males and 43 females) aged between 17 and 26 years. Larheim et al[14] have found that the gonial angle assessed from a panoramic

radiograph was almost identical to that measured on the dried mandible.

Jambunath U et al[15] stated that the condylar, coronoid and projection height of ramus was higher in males than the females, thus emphasizing that sex differences are more pronounced in mandibular ramus than in body. He also stated that the gonial angle was larger in females and bigonial width was not significantly different in males and females.

Casey et al[16] found no statistical significant difference in gonial angle in the edentulous and dentulous sides. Their results suggested slight widening of the mandibular angle in the edentulous patients. Similar results were found by Ohm and Silness[17] who showed that the edentulous participants had the largest mean angle, as compared to the participants in possession of all teeth.

Xie et al[18] found difference in size of the gonial angle between dentate men and women (in the young and in the older dentate group) but not between elderly edentulous men and women. The elderly edentulous subjects had significantly larger gonial angles (128.4 degrees±6.6) than did the young (122.4 degrees±6.6,) and older dentate subjects (122.8 degrees ± 6.6,). Raustia et al[19] measured the gonial angles of the mandible and condylar and ramus heights of 30 complete denture wearers (18 women, 12 men, mean age 61 years, range 42–74 years) coming for renewal of their dentures, using panoramic radiographs. No statistically significant difference was observed between the sexes in the sizes of gonial angles and condylar and ramus heights. Huumonen et al[20] found significantly larger gonial angle in females as compared to males. However, in their study in edentulous subjects, the gonial angle was significantly larger, while the ramus and condylar heights were significantly smaller on both sides compared with dentate subjects. Ceylan et al[21] found no significant differences between the mandibular angles when comparing partially edentulous and totally edentulous subject.

Fish F et al[22] proposed that the gonial angle may show enlargement or reduction, as may be expected of any bony angular relationship, and that ageing and loss of teeth are not, and should not be expected to be, the sole determinants of such change.

Shahabi et al[23] showed that the mean value of the gonial angle in the panoramic radiograph was 124.17° with a standard deviation of 5.87°. The gonial angle in males was 123.68° and that in females was 124.39° with no statistically significant difference between the two genders. The mean value of the right gonial angle was 123.94° with a standard deviation of 6.20° and the mean value of the left gonial angle was 124.40° with a standard deviation of 5.88°. However, there was no statistically significant difference between the right and left gonial angles.

Mattila et al[24] demonstrated that the size of the gonial angle can be determined from the orthopantomogram with the same degree of accuracy as from the generally used lateral cephalogram. It also showed that the right and left gonial angles can be quite easily determined individually from orthopantomogram, thus avoiding the disturbing influence of the superimposed images found on lateral cephalograms.

Gungor et al[25] evaluated gonial angle in Anatolian populations and showed that there were no significant differences between the right and left gonial angles of the individuals, but there was a significant difference at the left gonial angle between sexes.

On the other hand in our study we stated that there was no significant association between age groups and dental status of study subjects. The Pearson correlation coefficient is used to know the association between gender and ICW, IMW, RCI, LCI and RCI+LCI and it was found that there was no obvious significant correlation ($p>.05$) between gender of subjects and there was no significant correlation between male subjects with female subjects of ICW, IMW, RCI, LCI and RCI+LCI. We had derived the mathematical equations to predict the age of study subjects with the help of linear regression analysis-

- If the Intercondylar width is known- $Y=182.23+0.108*X$
- If intermandibular width is known $Y=166.15+0.111*X$
- If total condylar inclination(RCI+LCI) is known- $Y=360.87+(-0.018)*X$

It was found that in male subjects of study population Intercondylar width (ICW) and intermandibular width (IMW) was directly associated with age of male subjects and demonstrates a significant positive relation ($r=0.231$, $p=0.011$) in Intercondylar width (ICW) and significant positive relation ($r=-0.242$, $p=0.008$) in intermandibular width (IMW). However no significant co-relation noted between total condylar inclination angle (RCI+LCI) and age.

However in female subjects of study population, the study parameters were co-related with age of female subjects by Pearson Correlation. However no significant co-relation noted between Intercondylar width (ICW), intermandibular width (IMW), total condylar inclination angle (RCI+LCI) and age

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