IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 23, Issue 7 Ser. 10 (July. 2024), PP 53-54
www.iosrjournals.org

"Predicting Growth Status by Canine Calcification, Cervical Vertebrae and Hand Wrist Evaluation"

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ABSTRACT
Objectives: *Aim of this study was to assess skeletal and dental maturity and correlate with chronological age and with each other.*
Methods: *Left hand wrist radiograph, lateral cephalogram and lower left mandibular canine IOPA of 106 subjects aged 8-21 years with equal distribution of males and females were taken. MP3 stages by Hagg and Taranger on hand wrist radiograph, CVMI stages by Hassel and Farman on lateral cephalogram and Demijian's canine calcification stages on IOPA were interpreted. All the parameters were correlated with chronological age and as well as with each other.*
Results: *Significant association was observed between CVMI, MP3 and canine calcification and with chronological age.Correlation coefficient was found to be significant(P<0.001).*
Interpretation and conclusion: *The results indicated that CVMI, MP3 and canine calcification are significantly related.*
Keywords*: CVMI; MP3 ; canine calcification*

Date of Submission: 15-07-2024 Date of Acceptance: 25-07-2024

I. Introduction

Assessment of maturational status of an Orthodontic patient have a considerable influence on diagnosis, treatment goals, treatment planning, and the eventual outcome of the orthodontic treatment. Assessing maturational status and identification of period of accelerated growth is essential for clinical decisions regarding growth modulation procedures for skeletal discrepancies, extraction versus non extraction options, use of extra oral Orthopaedic forces and planning for Orthognathic surgery for skeletal malocclusions. As a result, many investigators have attempted to predict the duration, magnitude, direction and timing of the adolescent growth changes.

Aims and objectives
Present study was undertaken with the following aims and objectives:
1. To correlate status of skeletal maturation from hand wrist radiograph to the chronological age.
2. To correlate skeletal maturation from cervical vertebrae radiograph to the chronological age.
3. Also, to assess whether a positive correlation exists between dental maturity using canine calcification and skeletal maturity using hand wrist and cervical vertebrae radiograph.

II. Review of literature

Nanda (1955)[4]reported the concept, that the facial growth was in some way, related to general body growth. He stated that facial growth tended to lag slightly behind general body growth in height during the pubertal growth spurt period.
Tanner J.M. (1962)[5]found that the annual height (stature) growth increments in children reached a plateau at 16 yrs in boys and 14 yrs in girls and it was thought that these are the changes at which frontal sinus enlargement ceased.
Hunter (1966)[6]reported that the carpal bones as well as adjacent skeletal structures had proven to be the most satisfactory sites for determining skeletal maturation. Furthermore,
he stated that the maximal facial growth period was coincident with maximal growth in height. The sesamoid appeared before maximum pubertal statural growth and menarche in girls occurred after the maximum pubertal growth.

B**jork (1972)**[26]in his study reported that the pattern of facial growth is very strongly correlated with skeletal age than with chronological age, and suggested that certain types of orthodontic treatment coincided with the pubertal growth spurt.

Lamparski (1972)[7]utilized cervical vertebrae and found it to be more reliable and valid than hand wrist radiograph for assessing the skeletal age. He developed a standard for assessing the skeletal age for both male and female by using five vertebrae (second to sixth vertebrae). This method has the advantage of estimating the need for an additional radiographic exposure since the vertebrae are already recorded on lateral cephalogram.

Hagg and Taranger (1979)[22]did the study on skeletal stages of the hand and wrist indicator of the pubertal growth spurt. They did the longitudinal study on adolescent growth in height and skeletal development of the hand and wrist. The onset, peak and end of the pubertal growth spurt were defined on the unsmoothed incremental curve of height. The skeletal development was evaluated by studying the attainment of specified stages of the ulnar sesamoid of the middle and distal phalanges of the third finger and distal epiphysis of the radius.

Leonard S Fishmen (1979)[9]did the study on chronologic versus skeletal age. In his study a mixed longitudinal series of lateral cephalogram and left hand wrist radiographs was taken on sixty boys and sixty eight girls, who where randomly selected. Seven linear cephalometric measurements and standing height was compared. In his study it was found out that only a small percentage of the total sample demonstrate concurrence between skeletal and chronologic ages.

Singer J (1980)[22]published a paper to help clinicians to examine certain stages of growth for rapid reliable use of hand wrist film in orthodontic practice to determine the maturational status of patients. Six stages of hand wrist development were described in the prediction of adolescent growth spurt.

Fishman L.S (1987)[14]did an extensive work to develop a system for the evaluation of skeletal maturity from hand and wrist radiographs. According to him the osseous changes seen in the hand wrist are indicator of more general skeletal changes. The system uses only four stages of bone maturation, all found at six anatomical sites located on the thumb, third finger, fifth finger and radius. Eleven discrete adolescent skeletal maturational indicators (SMI's), covering the entire period of adolescent development, are found on these six sites. The sequence of the four ossification stages progresses through epiphysial widening on selected phalanges, the ossification of the adductor sesamoid of thumb, the capping of selected epiphysis over their diaphysis and the fusion of selected epiphysis and diaphysis.

Brent Hassel and Farman AG (1995)[2]did a study on 180 subjects to determine skeletal maturity by using radiographs of hand-wrist and cervical vertebrae. They correlated stages of skeletal maturation with cervical vertebrae maturation. This was accomplished by using anatomic changes seen in cervical vertebrae bodies at various age groups.

Further they concluded that cervical vertebrae could be used for assessing skeletal maturity.

Franchi, Baccetti, McNamara (2000)[15]analyzed the validity of the six stages of Cervical Vertebrae maturation as a biologic indicator of skeletal maturity. They proposed this method as a useful tool for the appraisal of mandibular skeletal maturity and for determining appropriate timing, for treatment of mandibular deficiencies.

Divakar HS, Patil S and Jayade VP (2000)[21]compiled the work done by several researchers to develop a comprehensive analysis of stages of ossification of the carpal ,

meta carpal bones , phalanges and radius which gave the valuable information when the Orthodontic treatment could begin because the stages of physical maturity correlates well with how much jaw growth remains.

Franchi, Baccetti, McNamara (2002)[16]proposed a new Cervical Vertebrae maturation method, with five distinct Cervical Vertebrae Maturation Stages [CVMS] .They stated that the peak in mandibular growth occured between the 2nd and 3rd CVMS. This method permitted appraisal of mandibular skeletal maturity , on a single cephalogram, by analyzing only the 2nd, 3rd ,4th Cervical Vertebrae.

Tancan U, Sabri IR, Faruk AB and Zafer S (2006)[19]carried out the study in Turkish population to investigate the relationship between chronological age and maturation of cervical vertebrae and with hand wrist stages and also to determine the correlation of maturation of cervical vertebrae and hand wrist radiographs. A total of 213 males and 290 females of ages 5.3-24.1 were studied. It was found that significant correlation exists between chronological age and cervical maturation , chronological age and hand wrist stages and cervical maturation and hand wrist radiographs. Cervical vertebral stages can be used as a maturity indicator of the pubertal growth spurt with the degree of confidence similar to other indicator such as hand wrist radiographs.

Basaran G, Ozer T, and HamamciN.(2007)[25]conducted a retrospective cross sectional study for a sample of 590 Turkish subjects. He investigated relationships between the stages of calcification of teeth and the cervical vertebrae maturity stages and concluded that dental maturation stages can used as a reliable indicator of growth.

III. Materials and Methods

This study was conducted in the Department of Orthodontics and Dentofacial Orthopaedics, Dental College, Bengaluru.
The sample for the present study consisted of 106 subjects, 53 males and 53 females in the age range of 8-21 years.
The subjects were randomly selected from patients visiting Department of Orthodontics and Dentofacial Orthopaedics and Department of Pedodontics, Dr. Syamala Reddy Dental College, Bengaluru.
The sample was a mixed one consisting of patients with normal occlusion, malocclusion and those undergoing orthodontic treatment with no congenital disorders.

MATERIALS:
The study included:
1. X – rays:
• Standardized Lateral Cephalogram,
• Left Hand Wrist radiograph and
• Intra Oral Periapical radiograph of left mandibular canine of all 106 subjects selected.
A consent form was signed from the patient for the same.

Materials and Methods
2. X – ray machine:
• Lateral cephalogram: CRANEX EXCEL CEPH
• Hand wrist radiograph: GE GENIUS 100 MOBILE
• Intra oral periapical radiograph: VATECH
3. X – ray films:
• Lateral cephalogram: 8 x 10 KODAK (green sensitive)
• Hand wrist radiograph: 8 x 10 KODAK (green sensitive)
• Intra oral periapical radiograph: KODAK E Speed film, size 2
4. Cassette for lateral cephalogram and hand wrist radiograph: KIRAN 8 x 10 X – RAY CASSETTE with KG4 screen.
5. Lead acetate sheets(0.003 inch matte) for tracing the radiographs
6. 0.3 mm diameter lead pencil
7. Radiographic illuminator

METHODOLOGY APPLIED FOR THE STUDY
The Hand wrist radiographs taken for each patient were used to determine skeletal maturation using MP3 stages given by **Hagg and Taranger**[22]
The lateral cephalograms were used to determine skeletal maturation using CVMI stages given by **Hassel and Farman**[2]
The Intra oral periapical radiographs were used to determine dental maturity using Canine calcification stages given by **Demirjian et al**[27]

Results
The cervical vertebrae maturation indicator (CVMI) stages, MP3 stages and Canine calcification stages were obtained for a sample of 106 subjects (53 males and 53 females) and analyzed statistically by computing the descriptive statistics like mean, standard deviation, standard error of mean and 95% confidence interval for mean.
The variation in the age at different levels of CVMI, MP3, and canine calcification is assessed using one way analysis of variance for males, females and for the combined data of both sexes. Based on the F-ratio the P-value is determined and is considered statistically significant whenever $P \leq 0.05$.
To find out the relationship between age, CVMI, MP3, and canine calcification, bivariate correlation is computed. The significance of the correlation coefficient is tested using student's t-test. Based on the t-value the corresponding P-value is determined and is considered statistically significant whenever $P \leq 0.05$.

Mean and Standard Deviation
Σ Themean of the age group is the simple arithmetic average of observations.
This is calculated by dividing the total of all the observations by number of observations.
x = given variable
n = sample size

The standard deviation is the square root of the average of the squared deviation of the observations from the arithmetic mean.
i.e. S

Bivariate Correlation Coefficient
This analysis was done to find the relationship between two quantitative variables. The bivariate correlations procedure competes Pearson's correlation coefficient, Spearman's Rho, Kendall's tan with their significance levels. Here, Pearson coefficient of correlation was used: Pearson's correlation coefficient is a measure of linear association. Two variables can be perfectly related, but if the relationship is not linear, Pearson correlation is not an appropriate statistic for measuring their association.
The formula used was:
Student's 't' Test
Student 't' test was employed to test the significance of the correlation
coefficient.
Anova Analysis of Variance
Analysis of variance test was employed to compare the means obtained when the number
of groups is more than two. The analysis of variance is computed, indicating whether any of the means are significantly different from each other.

Table 1& Graph 3: Bivariate correlation between age and CVMI of both sexes
There is less variation in percentage of growth completion in early and late adolescence as compared to mid adolescence. The maximum variation is observed at age of 10-15 years.

Results
Table 2 & Graph 2: Bivariate correlation between age and MP3 of both sexes
This table computes the bivariate correlation between MP3 and age for both sexes, and shows that there is high correlation with r = 0.877, which is statistically significant at P<0.001.
There is less variation in percentage of growth completion in early and late adolescence as compared to mid adolescence. The maximum variation is observed at age of 12-15 years.
Till 10 years of age, maximum subjects are in stage F, age 10 years varies equally between stage F and stage FG. There is increased variation at age 12-13 years from stage F to H, at 13-14 years from stage F to I, from 14-15 years between stage FG and I. Stage G varies from 12 years to 14 years in maximum subjects, and stage H from 13-17 years and by 17 years all achieve stage I.

Table 3 a, b & graph 1: Descriptive statistics of age of both sexes of canine calcification
The tables analysis the difference in mean age between different stages of canine calcification, and shows that the variation between the mean age of different canine calcification stages in both sexes is statistically significant with F value of 63.37 at P<0.001.
It is observed that with increasing canine calcification stages the chronological age also increases. In both sexes stage D has been attained by 8 years, maximum pubertal growth spurt by 11.55 ± 1.18 years and apical closure occurs by 16.50 ± 2.47 years.

Table 4: Bivariate correlation between CVMI and MP3 of both sexes
This table computes the bivariate correlation between CVMI and MP3 for both sexes, and shows that there is high correlation with r = 0.906, which is statistically significant at P<0.001.
It is observed that stage CVMI 1 shows maximum correlation with stage F of MP3.
CVMI 2 correlates both with stage F and FG of MP3 but more with stage F. There is increased variation seen at CVMI 3 from stage F to I of MP3 but correlates maximally with stage FG and G of MP3. Maximum correlation is seen between stage CVMI 4 and H stage of MP3, CVMI 5 shows increased variation between G, H and I stage of MP3.
CVMI 6 correlates more with I stage of MP3.

Table 5: Bivariate correlation between MP3 and canine calcification of both sexes
This table computes the bivariate correlation between MP3 and canine calcification for both sexes, and shows that there is high correlation with r = 0.796, which is statistically significant at P< 0.001.
It is observed that stage F of MP3 shows maximum variation between stages E to H of canine calcification.
Stage FG of MP3 also shows increased variation between stage F to H of canine calcification, but maximally correlated to stage G of canine calcification.

Stage G and H correlate both with stage G and H of canine calcification and stage I of MP3 correlates strongly with stage H of canine calcification.

Table :6 Bivariate correlation between CVMI and canine calcification of both sexes
This table computes the bivariate correlation between CVMI and canine calcification for both sexes, and shows that there is high correlation with r = 0.797, which is statistically significant at P< 0.001.
It is observed that CVMI 1 shows increased variation between stages D to F and stage I of canine calcification, with CVMI 2 showing maximum correlation between stages E to H of canine calcification. CVMI 3 correlate more with stage G of canine calcification, CVMI 4 correlates equally with stage G and H and CVMI 5 and 6 correlate with stage H of canine calcification.

Discussion
"What we do today, right now, will have an accumulated effect on all our tomorrows"
It is of great importance to know the stage of maturity a child has reached at the treatment planning stage because then the Orthodontist will be able to estimate the growth intensity at that stage. Knowledge of the stage of maturity that a child has attained helps in evaluating the progression through expected developmental events, which is clinically important. Considerable variations in the development among children of the same chronological or calendar age have led to the concept of biologic or physiologic age.

The last physiologic measure is dental maturity, which can be determined by the stage of tooth eruption or the stage of tooth formation. The latter is proposed as more reliable for determining dental maturation87 because, its criteria consist of distinct details based on shape criteria and proportion of root length, using the relative value to crown height rather than on absolute length. Foreshortened or elongated projections of developing teeth will not affect the reliability of assessment.

Discussion
sample of 106 subjects (53 males and 53 females) aged 8-21 years were taken for the study.

Interpretation of results:
1. Correlation of cervical vertebrae maturation to chronological age:
The present study showed that between CVMI stages, significant difference existed in the mean chronological age. F value of 114.87 is found to be significant at P<0.001.
A general trend observed is that as CVMI stages increased, the corresponding chronological age also increased.
Mean age for initiation of vertebral maturation for males is 9.33 ± 1.21 years, with maximum pubertal growth spurt at 11.67 ± 2.08 years and maturation completing at 18.18 ± 1.55 years.
Mean age for initiation of vertebral maturation for females is 8.00 ± 0.00 years, with maximum pubertal growth spurt at 11.78 ± 1.09 years and maturation completing at 17.82 ± 1.98 years.
The maximum pubertal growth spurt which is occurring slightly earlier in males can be explained by the fact that, there is increased variation in age at CVMI stage 3 with only 3 samples falling under the stage and this cannot be used as an indication to conclude that maximum pubertal stage occurs earlier in males. Also, in female initiation and completion of vertebral maturation occurred earlier as compared to males. Thus, indicating that skeletal maturation is more advanced in females when compared to males. This is because of early secretion of estrogen in females, whose effect is mainly to increase bone maturation.
All the above findings are in confirmation with studies done by Lamparski(1972)[17], Baccetti et al(2002)[16], Hassel and Farman(1995)[2], Roman P.S et al(2002)[17], and Uysal T et al(2006)[19]

2. Correlation of MP3 maturation to chronological age:
The study showed that between MP3 stages, significant difference existed in the mean chronological age. F value of 89.53 is found to be significant at P<0.001.
Mean age for attaining stage F for males is 10.36 ± 1.60 years, with maximum pubertal growth spurt (stage G) at 13.40 ± 1.14 years and completion of fusion at 18.05 ± 1.51 years.
Mean age for attaining stage F for females is 9.13 ± 1.13 years, with maximum pubertal growth spurt (stage G) at 12.50 ± 0.58 years and completion of fusion at 17.13 ± 2.15 years.
As MP3 stages increase, the corresponding chronological age also is increased. Mean age for all the stages is less for female when compared to males, thus indicating that maturation development of females was earlier than their male counterparts and this is also because of increased secretion of estrogen in females, whose effect is mainly to increase bone maturation.
These findings are in accordance with studies conducted by Hagg and Taranger(1979)[9],

3. Correlation of canine calcification to chronological age:

The present study showed that between canine calcification stages, significant difference existed in the mean chronological age. F value of 63.37 is found to be significant at P<0.001.

Mean age for attaining stage D for males is 8 ± 0.00 years, with apical closure by 16.63 ±2.40 years. In females stage D has been attained before 8 years and at age of 8.40 ± 0.55 years females are in stage E and apical closure occurs by 16.38 ± 2.57 years. Stage G, which occurs approximately 1year before PHV(peak height velocity) in males and about 5 months before PHV in females, is seen at 12 ± 1.22 years and 11.23 ± 1.09 years for males and females respectively. The obtained results are in accordance with studies conducted by Coutinho et al(1993)**.**PHV in males occurs around 14 years and in females around 12 years of age.

The occurrence of stage G long before the PHV in males reflects hormonal changes which accompany puberty. Androgen secretions in males are composed of both testicular and adrenal secretions, whereas in females, secretions are basically adrenal. Since testicular androgens have metabolic effects, they promote protein synthesis, bone growth, and govern the development of primary and secondary sex characteristics.

These findings are in accordance with the study carried out by Demirjian and Levesque(1980) which have shown advancement of girls over boys in dental development.

4. Correlation of dental and skeletal maturity:

When CVMI, MP3 and canine calcification were compared, there was significant correlation obtained. Correlation between CVMI and MP3 was highly significant with r = 0.906 at P<0.001.Correlation between CVMI and canine calcification was significant with r = 0.797 at P<0.001 and correlation between MP3 and canine calcification was significant with r = 0.796 at P<0.001.

Canine calcification stage G showed correlation with stage 3 of CVMI and stage FG and G of MP3. Also, CVMI 3 showed correlation with stage FG and G of MP3.

Maximum pubertal spurt stage of one parameter is correlating with the pubertal stage of other, thus indicating that any of the three parameters namely, cervical vertebrae, middle phalanx or mandibular canine can be used independently to assess growth status of a person.

The above findings are in confirmation with studies conducted by Hagg and Taranger(1982)[13], Hassel & Farman(1995)[2], Chertkow(1980)[12], Chertkow and Fatti(1979)[10]

Discussion

The present study also showed that among the various stages of skeletal maturation there is less variation in percentage of growth completion in early and late adolescence as compared to mid adolescence. Thus, indicating that chronological age cannot be used as a reliable indicator to accurately predict the maturational changes in a person. These results are in confirmation with studies by Bjork and Helm(1967)16, Brown(1976)8,

Fishman(1979,1982,1987)9,1,14 and Hagg and Taranger(1982)13 So, when starting with orthopedic treatment, monitoring of maturation stages either skeletal or dental is necessary. Orthopedic treatment can be accomplished when the patient is in the stages of initiation and acceleration of growth as there is good amount of adolescent growth potential still left i.e before maximum pubertal spurt stages of CVMI, MP3 and canine calcification. Around the peak pubertal stages only some amount of growth can be utilized, probably fixed functional orthopedic treatment can be accomplished. After maximum pubertal stages, appliances can bring about only minimal skeletal changes and more of dental changes. Hence, during decelerating and completion stages, it is advisable to let the growth be completed and then advise the patient to undergo orthodontic treatment alone or surgical orthodontic intervention depending on magnitude of discrepancy.

From the present study, the relationship between the tooth calcification stages and skeletal maturity indicators probably allows the clinician to more easily identify the stages of the pubertal growth period from any of the radiographs i.e Cephalogram, Hand Wrist or IOPA

Summary

Radiographic interpretation of vertebral maturation stages (CVMI) and middle phalanx maturation stages (MP3)were done to assess skeletal maturity.

Radiographic interpretation of mandibular left canine calcification stages were done to assess dental maturity.

CVMI and MP3 were compared to find out correlation between them and then they were correlated with canine calcification stages.

Cross sectional study was conducted with a sample size of 106 subjects (53 males and 53 females) in the age group of 8-21 years.

The lateral cephalogram was used to determine CVMI stages (Hassel and Farman 1995).

Hand wrist radiograph was used to determine MP3 stages (Hagg and Taranger 1979).

Intra oral peri apical radiograph was used to determine mandibular canine calcification stages(Demirjian 1973).

The summary of the results is as follows:
1. Positive correlation exists between chronological age and CVMI
2. Positive correlation exists between chronological age and MP3
3. Positive correlation exists between chronological age and canine calcification
4. Chronological age cannot be used as an accurate predictor of skeletal maturity as there is wide variation in percentage of growth completion in mid adolescence among the various stages of skeletal maturation.
5. Females showed maturation at an early age compared to males
6. Highly significant correlation exists between CVMI and MP3
7. Significant correlation exists between CVMI and canine calcification
8. Significant correlation exists between MP3 and canine calcification

IV. Conclusion

Because of individual variation, physiological and anatomical maturity cannot be accurately assessed by age alone. Chronological age is not an accurate indicator of maturation level. Other parameters, such as growth velocity, secondary sex changes, dental development, and skeletal ossification, have proven of more value. Hope with this idea of accurately determining the skeletal age of patients is to coordinate this information with orthodontic treatment so as to maximize the therapeutic effect. In Orthodontics it is more useful to evaluate the individual's maturity in relation to his/her own pubertal growth spurt. This presupposes knowledge of relationships in time between maturity indicators and pubertal growth events. The cervical vertebrae maturation, middle phalanx of third finger and canine calcification are reliable skeletal maturation indicators and can be independently used to predict maturity. Orthodontists do not necessarily need to know the exact skeletal age of a patient, or how much individual facial bones may grow during treatment, or even when that growth is likely to occur. They simply need to know whether the patient will grow at all during a one- or two-year treatment period and what percentage of growth can reasonably be expected during that time. Thus, the knowledge of maturation stages gives the orthodontist needed information for the timing of various treatment procedures other than growth modification therapy and for obtaining a more objective diagnosis and treatment plan. Thus, treatment will be more optimally timed, and a better result can be expected.

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Table 1
Bivariate correlation between age and CVMI of both males and females

Age (yrs)	CVMI						Total
	1	2	3	4	5	6	
8	4	4					8
9	1	7					8
10	2	5	2				9
11	1	4	4				9
12		4	2	2			8
13		1	3	3	1		8
14			1	3	3	1	8
15					5	3	8
16					4	4	8
17					5	3	8
18					1	7	8
19						8	8
20						8	8
Total	8	25	12	8	19	34	106

r = 0.917, t = 23.54, P<0.001

Table 2
Bivariate correlation between age and MP3 of both males and females

Age (yrs)	MP3					Total
	F	FG	G	H	I	
8	5	1				6
9	5	2				7
10	4	4				8
11	4	5				9
12	3		3	2		8
13	1		4	2	1	8
14		2	1	3	2	8
15			1	2	5	8

16				4	4	8
17					8	8
18				1	7	8
19					8	8
20					8	8
Total	22	14	9	14	43	102

r = 0.877, t = 18.24, P<0.001

Table 3-a
Oneway analysis of canine calcification (Combined)

Canine calcification	No. of subjects	Minimum	Maximum	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
							Lower Bound	Upper Bound
D	1	8	8	8.00	-	-	-.	-
E	9	8	9	8.44	0.53	0.18	8.04	8.85
F	12	8	12	9.67	1.23	0.36	8.88	10.45
G	22	10	14	11.55	1.18	0.25	11.02	12.07
H	62	10	20	16.50	2.47	0.31	15.87	17.13
Total	106	8	20	13.93	3.76	0.36	13.21	14.66

Table -3 b
One way ANOVA(combined)

Age (yrs)	Sum of Squares	Df	Mean Square	F-value	P-value
Between Groups	1058.6943	4.00	264.67	63.37	<0.001
Within Groups	421.843434	101.00	4.18		
Total	1480.53774	105.00			

Table 4
Bivariate correlation between age and CVMI and MP3 of males and females

CVMI	MP3					Total
	F	FG	G	H	I	
1	4					4
2	16	8		1		25
3	2	5	4		1	12
4			2	5	1	8
5		1	3	6	9	19
6				2	32	34
Total	22	14	9	14	43	102

r = 0.906, t = 21.35, P<0.001

Table 5
Bivariate correlation between MP3 and Canine calcification of males and females

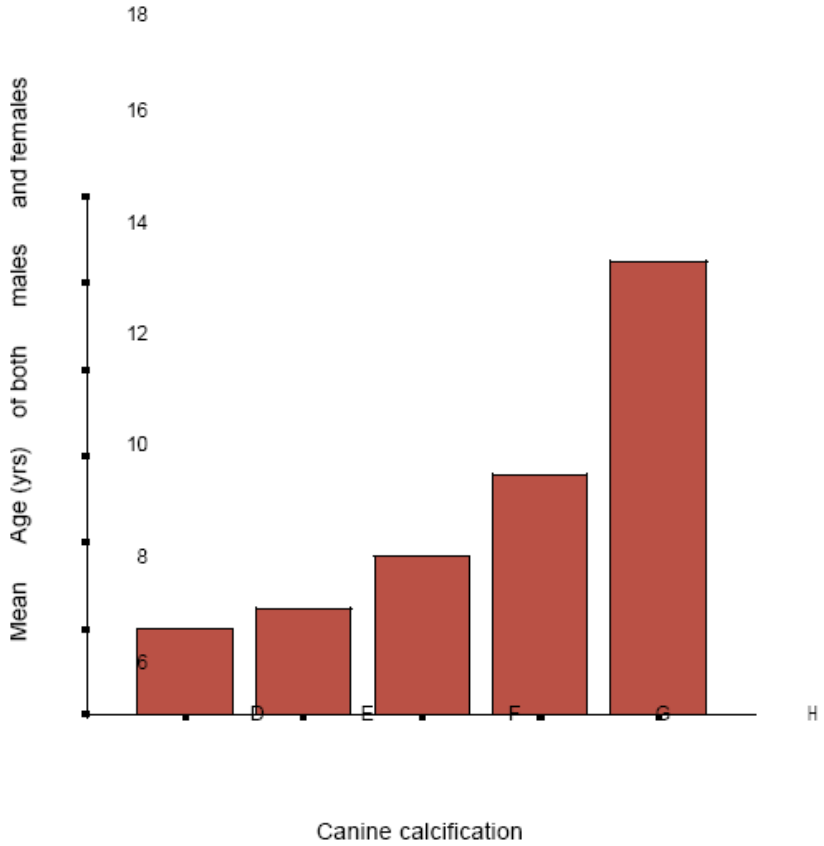
MP3	Canine calcification				Total
	E	F	G	H	
F	8	6	7	1	22
FG		4	8	2	14
G			3	6	9
H			4	10	14
I				43	43
Total	8	10	22	62	102

r = 0.796, t = 13.16, P<0.001

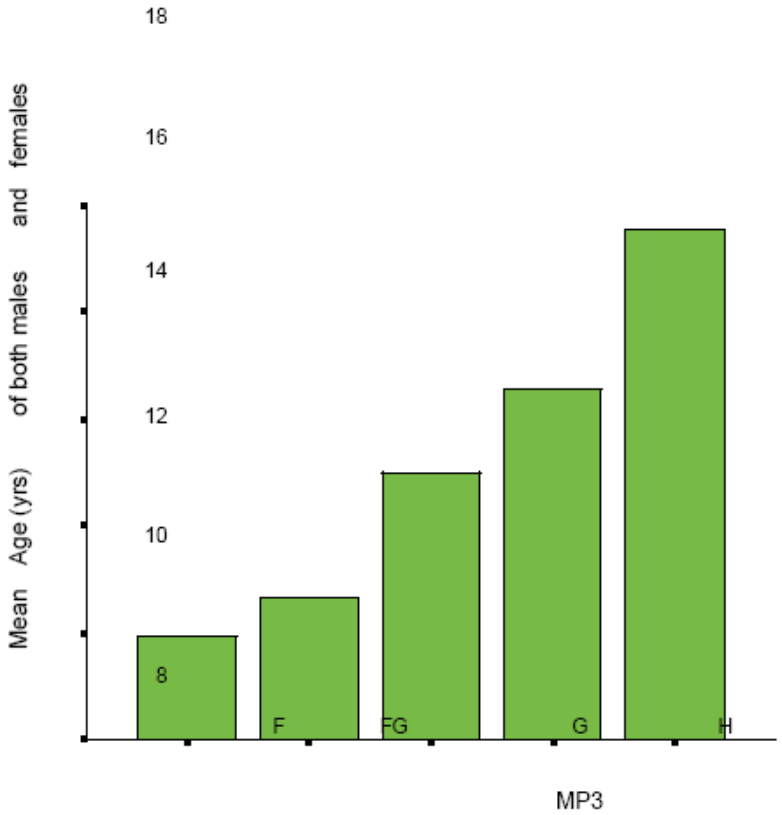
Table 6
Bivariate correlation between CVMI and Canine calcification of males and females

CVMI	Canine calcification					Total
	D	E	F	G	H	
1	1	3	3		1	8
2		6	9	9	1	25
3				8	4	12
4				4	4	8
5				1	18	19
6					34	34
Total	1	9	12	22	62	106

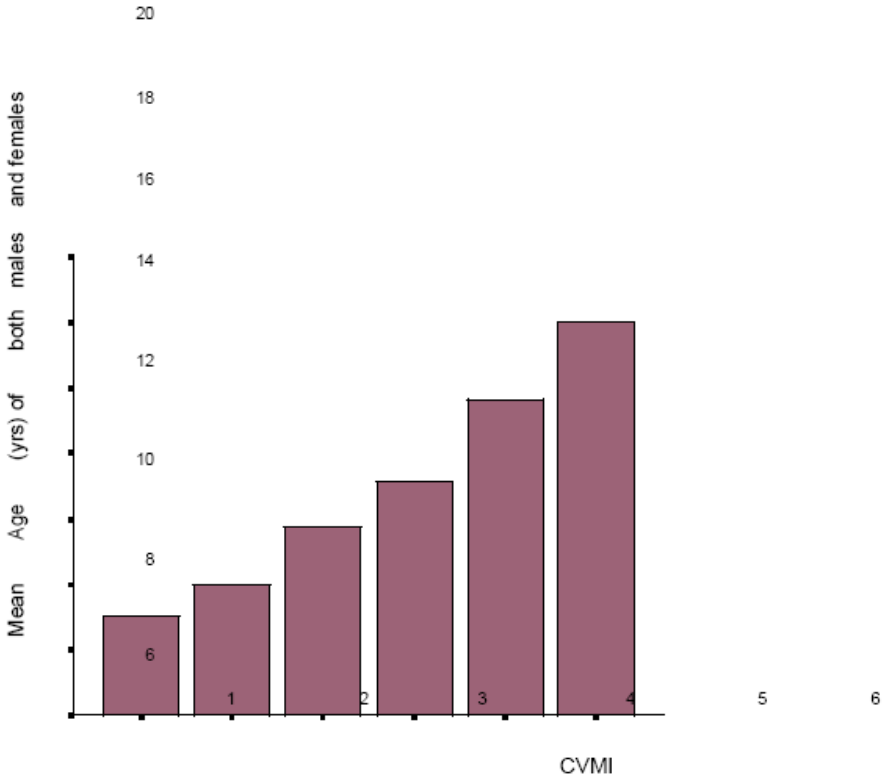
r = 0.797, t = 13.48, P<0.001



Graph 1: Bar graph representing mean age of canine calcification (combined)



Graph 2: Bar graph representing mean age of MP3 (combined)



Graph 3: Bar graph representing mean age of CVMI (combined)