ORIGINAL ARTICLE

Age estimation of an Indian population by using the Kim's scoring system of occlusal tooth wear

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Abstract

Context: Age is one of the prime factors employed to establish the identity of an individual and the use of teeth for this purpose has been considered reliable. Tooth wear is widely accepted as a physiological consequence of aging and evaluation of tooth wear can be a simple and convenient tool to estimate age in adults. **Aims:** The present study was conducted to record the degree of tooth wear among Indian adults and to estimate their ages from the degree of tooth wear based on Kim's scoring system. **Materials and Methods:** Dental stone casts of 120 participants were used to assess the degree of occlusal tooth wear based on the criteria given by Kim *et al.* **Statistical Analysis Used:** The age of all subjects was estimated based on these scores using multiple regression analysis function. **Results:** The degree of tooth wear showed a significant positive correlation with age in each and every examined tooth of both males and females. The predicted age was within ± 5 years of actual age in 70% of males and 68.3% females, and within ± 3 years of actual age in 50% of males and 50.1% of females. **Conclusions:** Kim's scoring system has proven to be a useful tool in estimation of age using occlusal wear in an Indian population with a high level of accuracy in adults.

Key words: Age estimation, forensic odontology, Kim's scoring system, occlusal tooth wear

Introduction

Age is one of the prime factors employed to establish the identity of an individual and the use of teeth for this purpose has been considered reliable. Tooth wear is widely accepted as a physiological consequence of aging and evaluation of tooth wear has been frequently used as a tool to estimate age of adults.[1-3] There is ample evidence that the average age at which patients are becoming edentulous is rising sharply, and there is optimism that the problem of extensive caries in young people and periodontal disease may be declining. As patients keep their teeth longer and have them restored less, the problems associated with the dentition wearing out will assume greater importance.[4]

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Age estimation of living persons might be required in such cases that chronological age plays a crucial role, e.g., criminal responsibility, school attendance, social benefits, and so on.[5] Tooth wear may thus be used as a reliable marker for estimating the age of such individuals. Tooth wear may be dependent on various factors such as eating and chewing habits, hardness of the teeth, the type of food and method of mastication, existence of artificial teeth, gender, geographic location, environmental conditions and parafunctions.[5-9] Despite this, estimation of an individual's age from tooth wear is a very simple and a convenient method. This method does not need any invasive process such as tooth extraction or tissue preparation. However, a low level of accuracy is a factor to limit its usefulness. The purpose of this study was to utilize the scoring system proposed by Kim *et al*. as a method of recording the degree of tooth wear and determining the individual's age on an Indian population.

Materials and Methods

The study sample constituted 120 participants, 60 males and 60 females in the age group of 13-70 years, reporting to the Department of Oral Medicine and Radiology, J.S.S. Dental College and Hospital, Mysore, India. The participants were subdivided into six age groups in each of the male and female category with 10 individuals in each group [Table 1]. The individuals having non-carious, intact and satisfactorily aligned maxillary and mandibular permanent, posterior teeth were included in the study. Sixteen permanent posterior teeth (first and second premolars and first and second molars namely, 14, 15, 16, 17, 24, 25, 26, 27, 34, 35, 36, 37, 44, 45, 46, and 47 Fédération Dentaire Internationale system) were selected to examine the degree of tooth wear. Tooth wear of anterior teeth (from canine to canine) were disregarded because of very wide individual variations in their angles and rotations. Complete arch maxillary and mandibular impressions were made. Following the guidelines of Kim's scoring system; the degree of tooth wear for each tooth was visually evaluated from the dried casts using a magnifying lens, under good illumination.

Tooth wear score was classified into a 0-to-8 point scale based on the pattern and amount of tooth wear on the occlusal surface as proposed by Kim's scoring system [Table 2]. Tooth wear was evaluated by two different criteria. One is the area of tooth wear, which may be termed as the horizontal factor and the other is the degree of dentine exposure, which may be termed as the vertical factor. Combination of both the horizontal and vertical factors was considered to obtain an accurate score. Scoring was performed by two examiners and the intra-examiner variability was tested by blinding the results. The inter-examiner variability was assessed by asking the two examiners to score all the 120 casts individually.

These scores were then subjected to statistical analysis in four steps as follows:

1. Means and standard deviation of tooth wear scores for each tooth were calculated for males and females separately and the *t*-test was used to examine gender difference.
2. Correlation analysis was done to show the correlation between the degrees of tooth wear of all the teeth.
3. Univariate regression analysis of age against tooth wear score for each tooth was done to examine the relationship between the ages and tooth wear score. The linear equation was derived, which was $Y = aX + b$, where Y = estimated age in years, X = tooth wear score, a = intercept, b = regression coefficient, r^2 = coefficient of correlation.
4. Multiple regression analysis was adopted to predict the age using the tooth wear scores of 16 teeth in each and every individual. The SPSS package was used to derive the β-coefficient. The multiple linear regression function provided a linear equation which would predict the dependent variable with the number of independent variables. In the present study the age was the dependent variable and all 16 variables (tooth wear scores) were taken as independent variables. The linear equation for estimating the age was:

$$Y = \text{Intercept } (a) + \beta_1 x_1^2 + \beta_2 x_2^2 + \beta_3 x_3^2 + \beta_4 x_4^2 + \beta_5 x_5^2 + \beta_6 x_6^2 + \beta_7 x_7^2 + \beta_8 x_8^2 + \beta_9 x_9^2 + \beta_{10} x_{10}^2 + \beta_{11} x_{11}^2 + \beta_{12} x_{12}^2 + \beta_{13} x_{13}^2 + \beta_{14} x_{14}^2 + \beta_{15} x_{15}^2 + \beta_{16} x_{16}^2$$

where Y = Estimated age, a = Intercept, β = Coefficient, and x = Tooth wear score.

Results

On comparing the values, it was observed that the wear scores of molars were consistently more than the scores of the premolars. The mean wear scores of the first premolars were found to be more than the scores of the second premolars. Similarly the mean wear scores of the first molars were found to be higher than the scores of the second molars. Also the

Table 1: Age and gender distribution of the study subjects

Gender	Age in years						
	Group I 13-20 years	Group II 21-30 years	Group III 31-40 years	Group IV 41-50 years	Group V 51-60 years	Group VI 61-70 years	Total
Male	10	10	10	10	10	10	60
Female	10	10	10	10	10	10	60
Total	20	20	20	20	20	20	120

Table 2: Kim's new scoring system

Score	Premolar	Molar
0	No visible wear	
1	1P/1L	1P/1L/2P/2L
2	2P/2L/1S/1B	3P/3L/4P/4L/1S/1B/2S/2B
3	2S/2B	3S/3B/4S/4B
4	Wear on more than 2/3 occlusal surface	
5	1Pc/1Lc	1Pc/1Lc/2Pc/2Lc
6	2Pc/2Lc/1Sc/1Bc	3Pc/3Lc/4Pc/4Pc/1Sc/1Bc/2Sc/2Bc
7	2Sc/2Bc	3Sc/3Bc/4Sc/4Bc
8	Concavity on more than 2/3 occlusal surface	

P: Point like wear facet less than approximately 1 mm in diameter, L: Linear wear facet less than approximately 1 mm in diameter, S: Surface like wear facet more than approximately 1 mm in diameter, B: Band like wear facet more than approximately 1 mm in diameter or wear facet involving more than two surfaces. 'c'(concavity) = wear of dentine. In the situation where the tooth has several different degrees of tooth wear, the highest degree should be selected as tooth wear score. *"Reprinted, with permission, from the Journal of Forensic Sciences, Vol. 45, Issue 2, copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428."*

mean wear scores of every individual tooth of the males were found to be higher than those of the females of the group, except for those in group VI. Statistically significant difference between the tooth wear scores of males and females was observed to vary from group to group [Tables 3-8].

The correlation analysis showed that the degrees of correlation were relatively strong between the tooth wear scores of all examined teeth. The coefficient of correlation (r^2) values were between 0.807 and 0.920 [Table 9].

The univariate regression analysis of age against tooth wear score were done to examine the relationship between the age and tooth wear score [Table 10]. The ranges of coefficient of correlation (r^2) were between 0.65 and 0.81 in males and 0.75 and 0.85 in females.

Table 3: Mean values and Standard deviation of tooth wear score for each tooth and levels of statistical significance between tooth wear scores of Males and Females of Group I (13-20 years)

Tooth number	Males		Females		*P* value significance
	Mean	SD	Mean	SD	
14	1.3	0.44	1.1	0.57	
15	1.0	0.04	1.0	0.43	
16	2.5	0.07	2.2	0.38	
17	1.5	0.51	1.1	0.29	
24	1.6	0.06	0.8	0.16	**
25	1.3	0.20	0.9	0.10	
26	2.6	0.23	2.3	0.05	
27	1.2	0.16	1.3	1.79	
34	1.2	0.02	0.9	0.10	
35	1.0	0.19	0.7	0.05	
36	3.3	1.25	2.9	2.04	
37	1.5	0.25	1.1	0.57	
44	1.0	0.04	0.7	0.06	
45	0.8	0.16	0.8	0.16	
46	3.0	0.77	2.8	1.12	
47	1.6	0.23	1.4	0.23	

*$P<0.05$, ** $P<0.01$, SD: Standard deviation

Table 4: Mean values and Standard deviation of tooth wear score for each tooth and levels of statistical significance between tooth wear scores of Males and Females of Group II (21-30 years)

Tooth number	Males		Females		*P* value significance
	Mean	SD	Mean	SD	
14	2.1	0.29	1.4	1.87	
15	2.4	1.87	1.7	0.81	
16	3.8	1.12	3.1	4.41	
17	2.6	0.06	2.1	0.29	*
24	1.9	0.10	1.6	0.86	
25	1.6	0.06	1.8	0.16	
26	3.8	0.38	3.0	2.40	
27	2.7	0.81	1.6	0.23	**
34	1.7	0.05	1.4	0.23	
35	1.9	0.29	1.4	0.23	
36	4.5	0.51	3.5	0.88	*
37	2.8	0.16	2.1	0.10	**
44	1.7	1.32	1.2	0.38	
45	2.1	2.70	1.7	0.44	*
46	4.4	0.86	3.6	1.32	**
47	2.9	0.10	2.1	0.10	*

*$P<0.05$, ** $P<0.01$, SD: Standard deviation

Table 5: Mean values and Standard deviation of tooth wear score for each tooth and levels of statistical significance between tooth wear scores of Males and Females of Group III (31-40 years)

Tooth number	Males		Females		*P* value significance
	Mean	SD	Mean	SD	
14	3.0	0.44	2.8	0.38	
15	3.5	0.51	2.8	2.28	
16	5.1	0.01	4.2	1.28	*
17	4.0	0.77	3.4	0.23	
24	3.2	0.38	2.7	0.44	
25	3.7	0.44	2.9	2.72	
26	5.2	0.02	4.4	1.32	*
27	4.1	0.57	3.6	0.50	
34	3.3	6.76	2.1	0.57	
35	3.3	3.43	2.6	1.87	
36	5.2	0.02	5.1	0.57	*
37	3.9	0.57	3.4	1.32	
44	2.8	2.28	2.3	0.44	
45	3.3	1.25	2.5	0.51	
46	5.1	0.10	4.7	3.16	
47	3.9	0.96	3.4	2.56	

*$P<0.05$, ** $P<0.01$, SD: Standard deviation

Table 6: Mean values and Standard deviation of tooth wear score for each tooth and levels of statistical significance between tooth wear scores of Males and Females of Group IV (41-50 years)

Tooth number	Males		Females		*P* value significance
	Mean	SD	Mean	SD	
14	4.3	0.44	3.8	0.38	
15	4.4	0.16	3.7	0.20	
16	5.5	0.25	5.0	0.19	
17	4.3	0.44	4.0	0.04	
24	4.0	0.77	3.9	0.57	
25	4.3	0.20	4.1	0.96	
26	5.6	0.23	5.3	0.05	
27	4.5	0.24	4.2	0.16	
34	3.5	0.88	4.0	0.77	
35	4.0	0.77	4.3	0.39	
36	5.9	0.10	5.7	0.39	
37	4.5	0.88	4.3	0.44	
44	3.8	1.63	3.9	1.46	
45	4.2	1.12	4.0	0.77	
46	5.8	0.16	5.6	0.23	
47	4.7	1.25	4.0	0.77	

*$P<0.05$, ** $P<0.01$, SD: Standard deviation

The multi-variant analysis was carried out to predict the age by using the 16 variables (tooth wear scores of 14, 15, 16, 17, 24, 25, 26, 27, 34, 35, 36, 37, 44, 45, 46, and 47). The intercept and β-coefficients are stated in Table 11. The values were calculated based on the tooth wear scores for each individual, separately for males and females. The multiple linear regression function provided a linear equation which would predict the dependent variable with the number of independent variables. In the present study age was the dependent variable and all 16 variables (tooth wear scores) were taken as independent variables. The coefficient of correlation (r^2) was very high for the males (r^2 = 0.959) and females (r^2 = 0.971) [Table 12].

The predicted age values for each individual were estimated using multiple linear regression function. It was observed that the predicted age was within ±5 years of the actual age in 70% of males and 68.3% of females. It was also observed that the predicted age was within ±3 years

Table 7: Mean values and Standard deviation of tooth wear score for each tooth and levels of statistical significance between tooth wear scores of Males and Females of Group V (51-60 years)

Tooth number	Males		Females		*P* value significance
	Mean	SD	Mean	SD	
14	4.6	3.31	4.6	0.23	
15	4.7	0.20	4.6	0.23	
16	5.7	0.05	5.6	0.23	
17	4.7	0.20	4.8	0.16	
24	4.7	0.20	4.3	0.05	
25	4.6	0.50	4.6	0.06	
26	5.9	0.57	5.5	0.25	
27	4.8	1.12	4.6	0.23	
34	4.5	0.25	4.2	0.70	
35	4.8	0.38	4.7	0.39	
36	6.4	0.85	6.2	0.70	
37	5.3	0.81	5.0	0.77	
44	4.4	0.86	4.3	0.39	
45	4.9	0.96	4.5	0.07	
46	6.0	0.19	6.2	0.38	
47	4.9	0.29	4.9	0.29	

**P*<0.05, ** *P*<0.01, SD: Standard deviation

Table 8: Mean values and Standard deviation of tooth wear score for each tooth and levels of statistical significance between tooth wear scores of Males and Females of Group VI (61-70 years)

Tooth number	Males		Females		*P* value significance
	Mean	SD	Mean	SD	
14	4.9	0.10	5.0	0.43	
15	5.6	0.06	5.6	0.23	
16	6.7	0.20	7.0	0.43	
17	5.8	0.02	6.0	1.76	
24	4.7	0.20	4.9	0.10	
25	5.1	0.57	5.9	0.96	*
26	6.6	1.32	7.0	0.19	
27	5.6	0.06	6.0	1.23	
34	4.8	0.38	5.9	1.46	**
35	5.5	0.25	6.2	0.70	*
36	6.8	0.70	7.5	0.07	*
37	5.9	0.10	6.5	0.86	
44	5.3	0.39	5.9	0.96	
45	5.8	0.16	6.4	0.50	*
46	6.7	0.81	7.6	0.06	**
47	6.0	0.04	6.6	1.32	

**P*<0.05, ** *P*<0.01, SD: Standard deviation

Table 9: Correlation coefficients (r^2) observed in multiple regression function between age and tooth wear

Tooth number	Correlation coefficients	
	Males	Females
14	0.884	0.918
15	0.888	0.884
16	0.864	0.920
17	0.807	0.870
24	0.859	0.900
25	0.862	0.872
26	0.857	0.908
27	0.845	0.879
34	0.897	0.911
35	0.873	0.910
36	0.840	0.881
37	0.878	0.873
44	0.887	0.918
45	0.900	0.896
46	0.823	0.894
47	0.823	0.868

Table 10: Univariate regression analysis of age with tooth wear score for each tooth

Tooth no.	Males			Females		
	a	b	r^2	a	B	r^2
14	11.225	8.577	0.71	12.876	8.489	0.78
15	9.522	8.573	0.80	12.368	8.340	0.83
16	−5.537	9.345	0.77	3.969	7.830	0.76
17	5.951	8.947	0.76	9.439	8.832	0.83
24	7.485	9.736	0.74	11.636	9.131	0.82
25	11.021	8.470	0.74	12.995	7.823	0.81
26	−3.364	8.781	0.71	1.840	8.810	0.77
27	8.086	8.388	0.74	11.831	7.747	0.76
34	13.887	8.278	0.68	16.059	7.548	0.80
35	12.679	8.026	0.79	15.190	7.729	0.84
36	−9.503	9.272	0.68	-1.943	8.015	0.75
37	5.651	8.648	0.81	11.629	7.421	0.80
44	15.350	7.816	0.75	16.141	7.604	0.85
45	14.114	7.389	0.78	14.495	7.489	0.84
46	−6.696	9.057	0.65	−0.0.196	7.779	0.76
47	4.792	8.827	0.79	11.294	7.510	0.78

Y=aX+b, X=Tooth wear score, Y=Estimated age (years), a=Intercept, b=Regression coefficient, r^2=Correlation coefficient of the actual age in 50% of the males [Table 13] and 50.1% of the females and within ±2 years of actual age in 36.6% of males and 33.3% of females [Table 14]. For example, the actual age of case 1 of group I of males was 15 years and the estimated age (Y) was calculated using the linear regression formula as follows:

$$14.8637 = 3.489\ (+)\ -0.546x\ (2)^2 + 0.391x\ (1)^2 + 0.914x\ (2)^2\ (+)\ -3.652x\ (0)^2\ (+)\ -0.245x\ (2)^2\ (+)\ -0.565x\ (2)^2\ (+)\ 2.448x\ (3)^2\ (+)\ -2.194x\ (1)^2\ (+)\ 2.584x\ (1)^2\ (+)\ 1.741x\ (1)^2\ (+)\ 0.762x\ (5)^2\ (+)\ 2.976x\ (1)^2\ (+)\ 2.434x\ (1)^2\ (+)\ 0.919x\ (1)^2\ (+)\ -0.715x\ (5)^2\ (+)\ 2.977x\ (1)^2.$$

Table 11: The intercept and ß coefficients observed for the multiple regression analysis

	Males	Females
Constant (Intercept)	3.489	11.201
ß coefficients		
14	−0.546	0.906
15	0.391	−1.075
16	0.914	2.669
17	−3.652	1.517
24	−0.245	1.302
25	−0.565	−0.272
26	2.448	2.743
27	−2.194	−1.213
34	2.584	0.372
35	1.741	3.151
36	0.762	−0.563
37	2.976	−0.496
44	2.434	1.587
45	0.919	0.835
46	−0.715	−1.586
47	2.977	−0.937

Table 12: Correlation coefficients (r^2) observed in multiple regression function between age and tooth wear

Tooth number	Correlation coefficients	
	Males	Females
14	0.884	0.918
15	0.888	0.884
16	0.864	0.920
17	0.807	0.870
24	0.859	0.900
25	0.862	0.872
26	0.857	0.908
27	0.845	0.879
34	0.897	0.911
35	0.873	0.910
36	0.840	0.881
37	0.878	0.873
44	0.887	0.918
45	0.900	0.896
46	0.823	0.894
47	0.823	0.868

When the total of 120 subjects was divided into two groups, the accuracy of estimation of age increased. In the group less than or equal to the age of 40 years, the age could be estimated within ±5 years in 23 male subjects (76.6%) and 22 females (73.3%). In the group above 40 years, the estimated age was within ±5 years of actual age in 19 males (66.3%) and 23 females (76.6%). It was further noted that in the group ≤40 years, the age could be estimated within ±3 years in 17 male (566%) and 17 female subjects (56.6%) and within ±2 years in 11 males (36.6%) and 9 females (30%). Whereas, in the group above 40 years, the age could be estimated within ±3 years in 13 males (43.3%) and 14 females (46.6%) and within ±2 years in 11 males (36.6%) and 11 females (36.6%) [Table 15 and Graph 1].

Discussion

Occlusal tooth wear is one of the degenerative changes related to age, and increased levels of tooth wear with age have been consistently reported in the literature.[3,5,6,10-17] The process of occlusal tooth wear may be dependent on various factors such as eating and chewing habits, hardness of the teeth, the type of food and the degree of pressure transmitted by the jaws to the teeth during mastication, presence or absence of teeth in the opposing arch, existence of artificial teeth, gender, geographic location, environmental conditions, parafunctions like bruxism and malocclusion. Hence, it has been suggested by various studies that age estimation based on occlusal tooth wear alone may not be accurate.[5,7-9] However, in cases where age estimation has to be carried out inevitably with limited information, especially in living persons over the age of 20-30 years, occlusal tooth wear scoring may be used as an effected tool. This has been demonstrated to be accurate and reliable by the use of Kim's scoring system.[3,5] Our study also focuses on the scoring system itself in the manner of selecting limited number of sound teeth to prove its validity in an Indian population.

It was observed that the degree of tooth wear score increased with the age in each and every tooth in both males and females. This fact agrees with the results of Kim *et al*.[3] and Ekfeldt *et al*.[13] In group I of the present study the first premolars showed greater wear compared to the second premolars, which agrees with the findings of Kim *et al*. In their study the first premolars of all four quadrants consistently showed increased wear compared with that of the second premolars.[3] However, in the rest of the groups of the present study (groups II, III, VI, V, and VI), the second premolars showed more wear than the first premolars, contradictory to the findings of Kim *et al*. There are a number of factors which could contribute to this finding. Firstly, it is well understood that the occlusal forces increase from the anterior to posterior teeth as we move distally.[18,19] The second premolar is placed distal to the first premolar in the

Table 13: Actual age and predicted ages of males derived through multiple regression analysis

Category	Case number	Std. Residual	Actual age	Predicted age	Residual
GrI M	1	0.025	15.00	14.8637	0.1363
GrI M	2	0.189	19.00	17.9847	1.0153
GrI M	3	0.233	20.00	18.7473	1.2527
GrI M	4	−0.899	20.00	24.8243	−4.8243
GrI M	5	0.595	20.00	16.8055	3.1945
GrI M	6	0.461	18.00	15.5244	2.4756
GrI M	7	0.595	20.00	16.8055	3.1945
GrI M	8	−0.143	18.00	18.7700	−0.7700
GrI M	9	0.405	19.00	16.8282	2.1718
GrI M	10	0.346	13.00	11.1451	1.8549
GrII M	11	−0.020	26.00	26.1054	−0.1054
GrII M	12	−0.999	30.00	35.3598	−5.3598
GrII M	13	−0.432	23.00	25.3201	−2.3201
GrII M	14	0.248	25.00	23.6678	1.3322
GrII M	15	−0.940	23.00	28.0472	−5.0472
GrII M	16	0.073	26.00	25.6096	0.3904
GrII M	17	−2.181	22.00	33.7075	−11.7075
GrII M	18	0.219	26.00	24.8243	1.1757
GrII M	19	−0.114	25.00	25.6096	−0.6096
GrII M	20	0.420	21.00	18.7473	2.2527
GrIII M	21	−0.895	32.00	36.8058	−4.8058
GrIII M	22	−0.509	31.00	33.7303	−2.7303
GrIII M	23	−1.274	34.00	40.8367	−6.8367
GrIII M	24	−2.287	31.00	43.2742	−12.2742
GrIII M	25	1.482	36.00	28.0472	7.9528
GrIII M	26	−0.132	33.00	33.7075	−0.7075
GrIII M	27	−0.672	35.00	38.6054	−3.6054
GrIII M	28	−2.808	38.00	53.0699	−15.0699
GrIII M	29	−0.702	40.00	43.7700	−3.7700
GrIII M	30	−0.475	38.00	40.5471	−2.5471
GrIV M	31	0.282	49.00	47.4886	1.5114
GrIV M	32	−2.007	45.00	55.7742	−10.7742
GrIV M	33	−0.225	45.00	46.2075	−1.2075
GrIV M	34	−0.374	41.00	43.0074	−2.0074
GrIV M	35	0.103	46.00	45.4450	0.5550
GrIV M	36	−0.260	50.00	51.3949	−1.3949
GrIV M	37	1.183	42.00	35.6493	6.3507
GrIV M	38	0.244	50.00	48.6905	1.3095
GrIV M	39	0.250	41.00	39.6575	1.3425
GrIV M	40	−0.258	46.00	47.3867	−1.3867
GrV M	41	0.929	60.00	55.0117	4.9883
GrV M	42	1.452	54.00	46.2075	7.7925
GrV M	43	0.485	54.00	51.3949	2.6051
GrV M	44	1.588	58.00	49.4758	8.5242
GrV M	45	0.020	52.00	51.8907	0.1093
GrV M	46	0.073	51.00	50.6096	0.3904
GrV M	47	−0.136	58.00	58.7303	−0.7303
GrV M	48	−0.594	58.00	61.1905	−3.1905
GrV M	49	−1.582	51.00	59.4928	−8.4928
GrV M	50	1.347	51.00	43.7700	7.2300
GrVI M	51	1.306	62.00	54.9889	7.0111

Cont....

Table 13: Contd...

Category	Case number	Std. Residual	Actual age	Predicted age	Residual
GrVI M	52	0.806	65.00	60.6720	4.3280
GrVI M	53	1.023	61.00	55.5074	5.4926
GrVI M	54	1.156	62.00	55.7970	6.2030
GrVI M	55	−0.822	60.00	64.4134	−4.4134
GrVI M	56	0.061	61.00	60.6720	0.3280
GrVI M	57	0.806	65.00	60.6720	4.3280
GrVI M	58	1.493	63.00	54.9889	8.0111
GrVI M	59	1.221	64.00	57.4492	6.5508
GrVI M	60	0.620	64.00	60.6720	3.3280

Table 14: Actual age and predicted ages of females derived through multiple regression analysis

Category	Case number	Std. Residual	Actual age	Predicted age	Residual
GrI F	1	−0.577	13.00	15.5468	−2.5468
GrI F	2	−0.717	13.00	16.1686	−3.1686
GrI F	3	−0.178	18.00	18.7846	−0.7846
GrI F	4	0.275	20.00	18.7846	1.2154
GrI F	5	0.587	18.00	15.4094	2.5906
GrI F	6	0.587	18.00	15.4094	2.5906
GrI F	7	−0.038	16.00	16.1686	−0.1686
GrI F	8	0.047	13.00	12.7934	0.2066
GrI F	9	−0.544	19.00	21.4006	−2.4006
GrI F	10	−1.644	18.00	25.2602	−7.2602
GrII F	11	−1.362	22.00	28.0136	−6.0136
GrII F	12	−0.597	26.00	28.6354	−2.6354
GrII F	13	−1.416	25.00	31.2514	−6.2514
GrII F	14	−1.244	25.00	30.4922	−5.4922
GrII F	15	−0.629	22.00	24.7758	−2.7758
GrII F	16	0.361	21.00	19.4064	1.5936
GrII F	17	−0.060	21.00	21.2632	−0.2632
GrII F	18	−0.597	22.00	24.6384	−2.6384
GrII F	19	0.761	28.00	24.6384	3.3616
GrII F	20	1.858	21.00	12.7934	8.2066
GrIII F	21	−1.241	35.00	40.4804	−5.4804
GrIII F	22	0.170	32.00	31.2514	0.7486
GrIII F	23	0.428	35.00	33.1082	1.8918
GrIII F	24	−0.790	31.00	34.4892	−3.4892
GrIII F	25	0.655	40.00	37.1052	2.8948
GrIII F	26	−0.337	33.00	34.4892	−1.4892
GrIII F	27	1.075	36.00	31.2514	4.7486
GrIII F	28	1.129	33.00	28.0136	4.9864
GrIII F	29	−1.692	39.00	46.4716	−7.4716
GrIII F	30	−1.414	31.00	37.2426	−6.2426
GrIV F	31	0.228	45.00	43.9931	1.0069
GrIV F	32	0.969	44.00	39.7212	4.2788
GrIV F	33	−0.389	42.00	43.7182	−1.7182
GrIV F	34	0.035	50.00	49.8468	0.1532
GrIV F	35	−0.161	45.00	45.7124	−0.7124
GrIV F	36	−1.011	48.00	52.4628	−4.4628
GrIV F	37	0.118	41.00	40.4804	0.5196
GrIV F	38	0.033	44.00	43.8556	0.1444

Cont....

Table 14: contd...

Category	Case number	Std. Residual	Actual age	Predicted age	Residual
GrIV F	39	0.346	48.00	46.4716	1.5284
GrIV F	40	−1.237	47.00	52.4628	−5.4628
GrV F	41	0.887	57.00	53.0847	3.9153
GrV F	42	1.566	60.00	53.0847	6.9153
GrV F	43	1.057	51.00	46.3342	4.6658
GrV F	44	−0.665	56.00	58.9384	−2.9384
GrV F	45	−1.064	51.00	55.7006	−4.7006
GrV F	46	1.025	51.00	46.4716	4.5284
GrV F	47	1.198	55.00	49.7094	5.2906
GrV F	48	0.659	52.00	49.0876	2.9124
GrVF	49	1.025	51.00	46.4716	4.5284
GrV F	50	0.745	53.00	49.7094	3.2906
GrVI F	51	2.698	65.00	53.0847	11.9153
GrVI F	52	−2.130	62.00	71.4053	−9.4053
GrVI F	53	−0.360	61.00	62.5885	−1.5885
GrVI F	54	−1.031	61.00	65.5515	−4.5515
GrVI F	55	−0.266	61.00	62.1763	−1.1763
GrVI F	56	1.200	61.00	55.7006	5.2994
GrVI F	57	−0.156	65.00	65.6889	−0.6889
GrVI F	58	0.155	63.00	62.3137	0.6863
GrVI F	59	1.146	64.00	58.9384	5.0616
GrVI F	60	0.521	62.00	59.6977	2.3023

arch and may thus show more amount of wear. Secondly, the second premolar is positioned adjacent to the first molar, on which the maximum occlusal forces are exerted during grinding of food. This position of the second premolar may cause it to take more active part in the grinding of food than does the first premolar. In addition, the maxillary second premolars occlude partly with the mandibular first molars which exert more forces during the grinding of food.[18] This

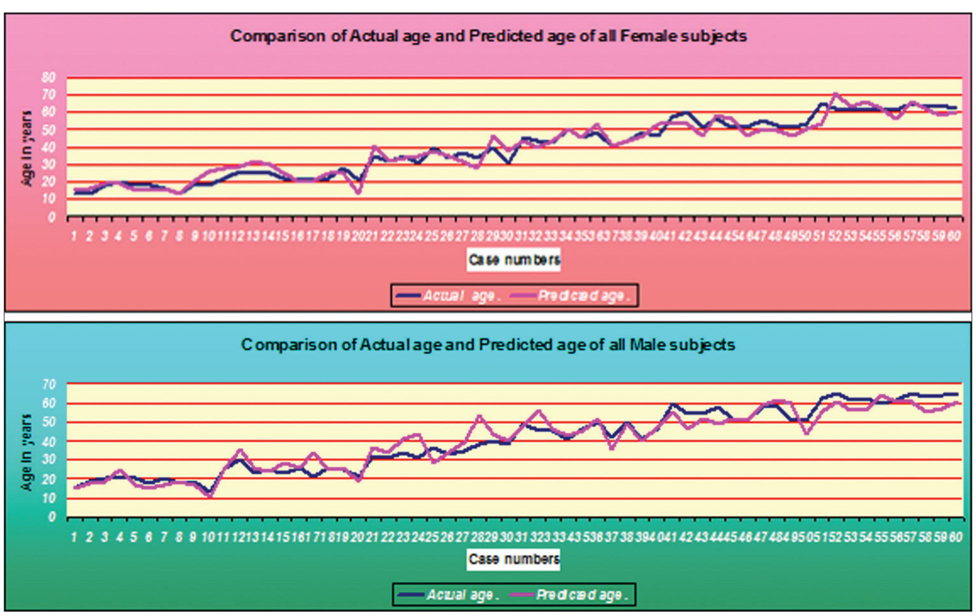
Table 15: Accuracy of age estimation

Age	Gender	Range of error (years) (%)		
		Within +/-2 years	Within +/-3 years	Within +/-5 years
Total	Males	36.6	50.0	70.0
	Females	33.33	50.1	68.3
Less than or equal to 40 years	Males	36.6	56.6	76.6
	Females	30.0	56.6	73.3
More than 40 years	Males	36.6	43.3	66.3
	Females	36.6	46.6	76.6

could be another reason for amount of occlusal force being exerted on this tooth, attributing to more wear. However, further studies are warranted to observe this pattern of wear and confirm this finding.

It was observed in the present study that the molars in general showed more wear when compared with the premolars in all the groups. The first molars of all the groups showed more degrees of wear when compared with the second molars which can be attributed to the eruption pattern of permanent teeth. Teeth that erupt early are exposed to more physiological wear with age. This finding was consistent with the study findings of Kim *et al*.[3] The molars are more bulky, have larger occlusal tables and greater anchorage and receive greater occlusal forces when compared with the premolars.[18,19] Thus irrespective of the pattern of eruption the molars tend to show more wear than the premolars.

In the present study when all the males and females irrespective of their age groups were considered together, it was found that the males had greater degree of tooth wear



Graph 1: Comparision of actual age and predicted age of all subjects

than the females. This is in accordance with Kim *et al*.,[3] Seligman *et al*.,[11] and Donachie and Walls[12] who observed that males show better development of masticatory muscles, muscle fiber mass and stronger ligaments than females and thus males could exert a stronger biting force than females. A general observation (in five of the six groups) was that, males had higher tooth wear scores than the females of the same group in the present study, but this difference was statistically significant with respect to only few teeth. In case of group VI (61-70 years) although the females of showed more wear compared with the males of the group, only a few teeth (6 out of 16) showed statistically significant difference.

In groups IV, V, and VI, it was seen that the tooth wear scores of females were very close to the scores of the males. Keeping the above observations in mind, it could possibly be inferred that as the age advances the wear scores of males and females parallel each other.

The tooth wear scoring system implemented in the present study was similar to the method used by Kim *et al*. The regression analysis for the whole data was carried out and multiple regression function provided a linear equation which was used to predict the ages of all the subjects. The age could be calculated by adding the intercept to the sum of the β-coefficients multiplied by the individual tooth wear scores. In the present study, in 70% of males and 68.3% of females, the age could be estimated within ±5 years of the actual age and in 50% of the males and 50.1% of the females the predicted age was within ±3 years of the actual age. On further observation in 36.6% of males and 33.3% of females, the age could be estimated within ±2 years of actual age. It was further observed that in 31.3% males and 41.6% females, the age could be estimated within ±2 years of actual age.

It was also noted that the accuracy of estimation of age increased when the total of 120 subjects was divided into two groups. In the group less than or equal to 40 years of age, in 23 male subjects (76.6%) and 22 females (73.3%), the age could be estimated within ±5 years of actual age. In the group above 40 years, in 19 males (66.3%) and 23 females (76.6%) the estimated age was within ±5 years of actual age. It was further noted that in the group less than or equal to 40 years, in 17 male (56.6%) and 17 female subjects (56.6%) the age could be estimated within ±3 years and in 11 males (36.6%) and 9 females (30%) it could be estimated within ±2 years. Whereas, in the group above 40 years, the age could be estimated within ±3 years in 13 males (43.3%) and 14 females (46.6%) it was within ±2 years in 11 males (36.6%) and 11 females (36.6%).

Conclusion

Several scoring systems for the evaluation of degree of tooth wear have been presented in literature. However, there is no universally applicable tooth wear scoring system and moreover a low level of accuracy limits their usefulness. Kim's scoring system has proven to be a useful tool in estimation of age using occlusal wear in an Indian population with a high level of accuracy adults. It has been observed that once the individual is classified into the young or old age group, age can be estimated with a higher level of accuracy. We recommend that further studies using larger samples may be needed to observe the trend in various populations.

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