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Age Estimation from Attrition of Permanent Molars

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ABSTRACT

Background: The average stage of attrition in permanent first and second molars is an established method of age estimation in the adult population. The study was conducted with an objective of age estimation from the average stage of attrition of permanent molars.

Methods: A total of 451 individuals of age more than 20 years were examined. Nepalese individuals with intact first and second permanent molars in the maxillary and mandibular arch on either side were included. The average stage of attrition of the maxillary first and second permanent molars on either side was calculated and subjected to regression analysis to derive equations.

Results: Among a total of 451 participants, 231 (51.22%) were females and 220 (48.78%) males, with a mean age of 44.3 ± 13.9 years. There was a strong correlation between age and average stage of attrition of molars. The correlation was stronger for upper molars compared to the lowers. Additionally, the mean of the difference between real age and estimated age was lower for maxillary compared to mandibular molars. Compared to age estimation by univariable regression, multivariable regression had greater accuracy. Similarly, estimation of age from maxillary molars was more accurate as compared to mandibular (difference in years: 3.82 ± 3.03 for maxillary molars and 5.17 ± 4.2 for mandibular molars).

Conclusions: Maxillary teeth are better for age estimation and using both maxillary first and second permanent molars gives better accuracy.

Keywords: Age estimation by teeth; age reporting; forensic anthropology; forensic dentistry; tooth attrition

INTRODUCTION

Age estimation of individuals is important for medicolegal purposes. There are gradual changes in teeth with increasing age and can be used for age estimation.[1] Age estimation from dental wear is more precise as it is based on the indicator (enamel) which does not have the capacity to remodel[2] and can also be calibrated to the defined population.[3]

Li et al.[4] developed age estimation using a method of the average stage of attrition (ASA) in permanent first and second molars. Age estimation from the attrition of teeth has also been demonstrated in other studies.[4-8] Gustafson's method[8] is a popular one but can only be used in the dead. Age estimations in Nepal are mainly based on evidence from foreign countries which may not be reliable to the Nepalese population.

The study was conducted with an objective of estimating age from ASA of permanent maxillary and mandibular first and second molars in the Nepalese population.

METHODS

This was a quantitative cross-sectional study involving 451 individuals of age more than 20 years. The study duration was from January 1, 2019, to May 31, 2019. Nepalese individuals without any hard tissue pathologies visiting the dental outpatient department of Gandaki Medical College Dental Hospital with intact first and second permanent molars in the maxillary and mandibular arch on either side were included in our

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study. Those individuals with bruxism, betel nut chewers, having artificial opposing teeth, hard tissue pathologies, and grossly carious molars on the occlusal surface and with restorations were excluded.

A total of 451 consecutive patients meeting the inclusion criteria were taken as samples. Sample size has been calculated by using the formula, $Z^2 = pq/d^2$. The value of Z is kept as 1.96, Value of P = 50%, so, d = 5% (1.96 X 1.96 X 0.5 X 0.5) / 0.05 X 0.05 = 384. Assuming non-response rate of 15%, sample = 384/0.85, = 451. Final calculated sample size was 451.

Two dental doctors were trained to assess the ASA, who were regarded as examiners. The age, sex, address, race and dietary habits of the participants were recorded by one examiner and were blinded to the other examiner who had examined the participants. The race of the participants was categorized into two primary groups; Indo-Nepalese, Tibeto-Nepalese.[9] The ASA of the maxillary and mandibular first and second permanent molars on either side was calculated based on the chart given by Li et al.[4] The stage of attrition of right and left side is not considerably different,[4] that is why molars on either side were examined. The ASA is calculated as the average stage of the attrition on all cusps of a molar when evaluating the degree of attrition from stages 0 to 7 for each cusp. Further, the eighth and ninth stages are estimated from the condition of attrition of the entire occlusal surface.[4]

The graduated standards as per the method formulated by Li et al[4] are as follows:

Stage 0: No attrition. Cusp is sharp. Gullies and ridges are clear.

Stage 1: Slight attrition on the top and ridges of the cusp.

Stage 2: Cusp appears obtuse, or a limited oblique facet appears on it.

Stage 3: The great part of the cusp is worn away. The wear facet is depressed slightly or obviously and may connect with one or more other facets.

Stage 4: Dentine appears as a spot in which the average diameter is < 1 mm.

Stage 5: Dentine appears as a spot in which the average diameter is > 1 mm, and the attrition plane is leveled or sunk deeply.

Stage 6: One exposed dentine spot coalesces with another one and/or cusp is almost entirely worn away.

Stage 7: One exposed dentine spot coalesces with two others and/or cusp is entirely worn away.

Stage 8: Exposed dentine appears as a circle and there is a small star like island of enamel within it. The secondary dentine may also be exposed.

Stage 9: Dentine is exposed on the entire occlusal surface and the secondary dentine has been exposed.

To assess intra-observer differences, the first 30 participants were re-examined by the same examiner who had examined them previously after a period of one to two weeks. For determining inter-examiner differences, the first 30 cases were examined by two examiners separately. This analysis would be a guide to assume uniform calibration to decrease bias in further examination and calibration of scores. The data were entered in Microsoft Excel. Statistical software "STATA 15.1 and SPSS version 16.0 were used to analyze the data. SPSS version 16.0 was used for descriptive analysis. Wilcoxon signed-ranks test was performed to assess the significant difference of inter-examiner and intra-examiner variability using SPSS. P-value of <0.05 was regarded as significant. Statistical software "STATA 15.1" was used for linear regression analyses using age as dependent and the ASA as an independent variable. The linearity assumption was assessed for the continuous variables by visualization (scatter plots of age in years versus ASA of molars) and by using the likelihood ratio test. Effect modification due to sex, ethnicity, and feeding habit was also investigated. Unadjusted and adjusted mean and 95% confidence intervals for the association between the dependent variable 'chronological age' and the independent variable 'average stage of attrition' were estimated using univariable and multivariable linear regression models. Equation of linear regression is represented mathematically as; $Y = \alpha + \beta 1 \times X1 + \beta 2 \times X2$.

Sex was not the factor of the study as the literature suggests that there are no sex differences in the amount of attrition and the original study by Li et al.[4] had also not considered sex differences in the stage of attrition. The accuracy of the age from the equation was categorized as "excellent" if the error was ≤ 3 years, "acceptable" if the error was ≤ 10 years, and unsatisfactory if it was >10 years as had been done by Ajmal et al.[10]

Ethical Consideration: Written informed consent was taken from the participants. The proposal was ethically approved by the Ethical Review Board of Nepal Health Research Council (Ref. No. 1766, Reg No. 674, 2018).

RESULTS

The Wilcoxon signed-ranks test revealed no significant intra-observer and interobserver differences between the base and repeat evaluation of each tooth (P-value <0.05). The demographic variables are represented in table 1. Among a total of 451 participants, 231 (51.22%) were females and 220 (48.78%) were males. The mean age of the patients was 44.3 years with a standard deviation of 13.9. The Mean and standard deviation of the age and the ASA of all teeth studied are displayed in table 2.

Table 1. Frequency distribution of demographic variables (N=451).

Demographic variables	category	Male	Female	Number (%)
Age (years)	20-30	28 (6.21)	45 (9.31)	73 (16.18)
	30.01-40	68 (15.08)	50 (11.09)	118 (26.16)
	40.01-50	42 (9.31)	57 (12.64)	99 (21.95)
	50.01-60	44 (9.76)	49 (10.86)	93 (20.62)
	60.01-70	24 (5.32)	18 (42.86)	42 (93.12)
	70.01 and above	14 (3.10)	12 (2.66)	26 (5.76)
Race	Indo-Nepalese	201 (91.36)	152 (65.80)	353 (78.27)
	Tibeto-Nepalese	19 (8.640	79 (34.20)	98 (21.73)
Dietary habit	Vegetarian	23 (10.45)	27 (11.69)	50 (11.086)
	Non vegetarian	197 (89.55)	204 (88.31)	401 (88.91)
Sex	Female			231 (51.22)
	Male			220 (48.78)

Table 2. Distribution of variables for the data from study participants (n=451).

Variables	Mean ± SD
Age (years)	44.3 ± 13.9
ASA of Upper Molar 1	3.0 ± 1.3
ASA of Upper Molar 2	2.7 ± 1.1
ASA of Lower Molar 1	3.2 ± 1.3
ASA of Lower Molar 2	2.7 ± 0.97

ASA= Average Stage of Attrition

There was no confounding or effect modification of sex, race and feeding habit in the association between age of individual and ASA of molars of maxilla and mandible. Graphs (Figure 1a, 1b, 1c, 1d) were plotted to see the association of Age and ASA of molars of maxilla and mandible, respectively. Scatter plots show a strong positive linear association between age and ASA of molars, respectively. P-value and 95% confidence interval in Table 3 also suggest strong evidence of the association between age and attrition score of maxillary and mandibular first and second permanent molars.

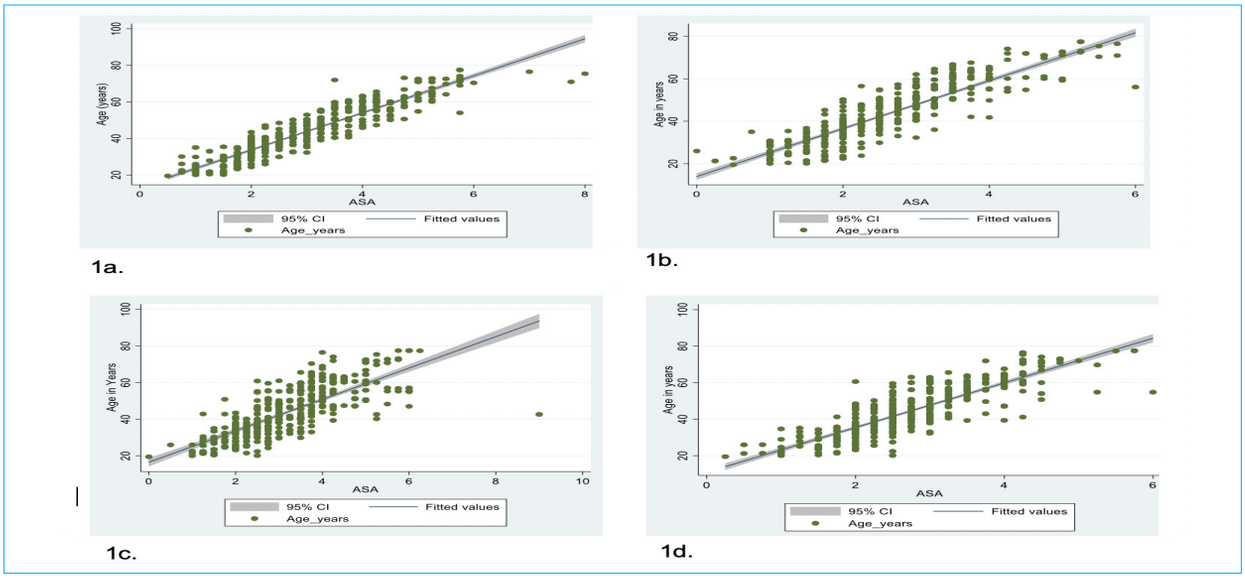

Figure 1. Scatter plot of age in years and ASA. 1a: Upper first molar (UM1), 1b: Upper second molar (UM2), 1c: Lower first molar (LM1), 1d: Lower second molar (LM2).

Table 3. Univariate and multivariate linear regression of age in years against average stage of attrition (n=451).

Variables	Coeff.	Std. error	95% CI	p-value
Univariable regression[□]				
Upper Molar 1	10.14	0.19	9.75, 10.53	0.001
Upper Molar 2	11.29	0.27	10.75, 11.82	0.001
Lower Molar 1	8.6	0.33	7.91, 9.22	0.001
Lower Molar 2	12.2	0.3	11.56. 12.90	0.001
Multivariable regression[†]				
Upper Molar 1	6.86	0.4	6.08, 7.64	0.001
Upper Molar 2	4.26	0.45	3.36, 5.16	0.001
Multivariable regression [‡]				
Lower Molar 1	2.96	0.4	2.18, 3.74	0.001
Lower Molar 2	9.3	0.5	8.29, 10.3	0.001

Note: Regression used to the association are summarized using; [□]univariable regression, [†]multivariable regression for upper molars, [‡]multivaraible regression for lower molars.

Table 4. Linear regression for outcome 'Age (years)' and exposure 'average stage of attrition' (n=451).

Average stage of attrition	Regression Equations ($y = \alpha + \beta_1 X_1 + \beta_2 X_2$)	r	Mean of the difference of chronological and estimated age.	SD of the difference of chronological and estimated age.
UM1[▫]	Age = 13.41 + 10.14 x ASA of UM1	0.92	4.21	3.27
UM2[†]	Age = 13.97 + 11.29 x ASA of UM2	0.89	4.86	4.01
UM1[▫] + UM2[†]	Age = 11.95 + 6.86 x ASA of UM1 + 4.26 x ASA of UM2	0.88	3.82	3.03
LM1[‡]	Age = 16.55 + 8.57 x ASA of LM1	0.77	6.76	5.63
LM2[§]	Age = 10.94 + 12.23 x ASA of LM2	0.86	5.47	4.47
LM1[‡] & LM2[§]	Age = 9.36 +2.96 x ASA of LM1 + 9.3 x ASA of LM2	0.77	5.17	4.2

[▫]UM1= Upper first permanent molar, [†]UM2= Upper second permanent molar, [‡]LM1=Lower first mandibular molar, [§]LM2=Lower second permanent molar.

Unadjusted coefficients from univariable regression in table 3 show that one unit increase in the first molar leads to a greater increase in mean age compared to one unit change in the second molar in both maxilla and mandible. To be more specific, the estimated mean increase in age (years) for one unit increase in ASA of the maxillary first molar was 10.14 years. Whereas, after adjusting for the maxillary second molar, the estimated mean increase in age for one unit increase in ASA of the first molar was 6.86 years. Likewise, for one unit increase in ASA of the maxillary second molar, there was a mean increase of 11.29 years in age without adjustment and 4.26 years in age after adjustment of the first molar. In the same line, the unadjusted estimated mean increase in individual age for one unit increase in score of mandibular first and second molar was 8.6 years and 12.2 years respectively. However, coefficients from multivariable regression suggest that mean change in estimated age was higher for a one-unit change in ASA of maxillary first molar compared to the second molar, but the result was reversed for mandibular molars.

Table 4 delineates that there was a strong correlation between the age of individuals and ASA of molars. However, the correlation was stronger for the upper molar compared to the lower molar. Additionally, the mean of the difference between real age and estimated age was lower for maxillary molar compared to mandibular molar. Compared to mean age estimation by univariable regression, mean age estimated by multivariable regression had greater accuracy for both upper and lower jaw. Similarly, estimation of age by regression equations from maxillary molars was more accurate as compared to mandibular molars (difference of age in years: 3.82 ± 3.03 of maxilla < 5.17 ± 4.2 of mandible).

Table 5. Accuracy of age estimation from ASA.	
Accuracy	Number (%)
Excellent	210 (46.56)
Acceptable	227 (50.34)
Unsatisfactory	14 (3.10)
Total	451 (100)

The accuracy of age estimation was studied as a difference of the real age and calculated age using the ASA of maxillary first and second molars both as it had given the best results among all. A total of 210 (46.56%) of the estimates were excellent, 227 (50.34%) were acceptable, and only 14 (3.10%) were unsatisfactory (Table 5).

DISCUSSION

There are several methods of age estimation from physiological changes of teeth. Most of the methods based on dental wear were developed utilizing prehistoric archaeological samples.[11,12] The true age at death of those remains was unknown leading to unreliability in the application of those methods.[12] Those studies mainly calibrated the amount of dental wear to other teeth as by Miles[13] and to other skeletal indicators, like the pubic symphyseal age.[3] In a study from Northeast China, Li et al[4] developed a new method of age estimation; the method of the average stage of attrition (ASA) in permanent first and second molars from the archaeological samples. The application of this method in living cases has been successfully done by Ajmal et al[9] in an Indian study. The methods of age estimation by Gustafson,[8] Kashyap et al[14] and its variations need microscopic examination and thus extraction of teeth. So, they can only be used in dead individuals. Whereas ASA is a clinical method and it uses just clinical examination, is noninvasive and more accurate in comparison with other methods.[10] This method might also better as it uses the average stage of attrition by measuring the degree of attrition in different cusps, not just on the entire occlusal surface. When the dental age estimation is challenging as the age progresses,[15] application of ASA in the adult population can be useful for forensic age estimation of the living and the dead. Age estimation from the attrition was done with reliability among Indigenous Amazon Populations by Vieira et al.[7]

In our study, ASA in maxillary first molar (UM1) was better for age estimation (r= 0.92 and SD of the difference between the estimated and real age was 3.27 years). It was slightly better in comparison to that given by Li et al[4] (r=0.96 and SD 3.97 years) and Ajmal et al[10] (SD=3.9). Although the addition of the second molar in the maxillary arch decreased the SD of the difference between the estimated and real age to 3.03 years, the value of r decreased to 0.88. The SD of difference between real age and estimated age using both the maxillary molar was more than given by Ajmal et al[10] in a study from the Indian population (SD=2.98). The estimate was better using maxillary molars than mandibular molars, which contrasted with that presented by Li et al[4] and Ajmal et al[9] in an Indian population. The SD of difference was 2.76 years using both mandibular molars as presented by Ajmal et al[10] and 3.56 years by Li et al[4] and 5.17 years in our study. The accuracy of the results of estimates was inferior in our study than in the study presented by Ajmal et al.[10]

The age from the ASA was not significantly different with sex, dietary habits; vegetarian or non-vegetarian and also in different ethnic groups in our study population, which could be attributed to the age-dependent attrition to the food habits rather than the other factors.

This present study was aimed to estimate the age from the attrition of maxillary and mandibular first and second permanent molars using an established method. This can be useful for forensic age estimation of individuals beyond the age of two decades. The dietary habits and thus the degree of attrition of teeth with age may differ in different populations, and therefore data from the different populations has to be generated. This study has given equations to estimate age from the average stage of attrition of permanent molars which can be used in the Nepalese population.

The age estimation from the people in their age of more than two decades can be estimated by using the equations derived in our population. This serves as an evidence to estimate age for both in the living persons and as well in the human remains.

The study included the cases which were attending the outpatient department of a teaching hospital. It could not have represented the overall population of the nation.

CONCLUSIONS

The average stage of attrition of first and second maxillary and mandibular permanent molars has strong evidence of association with age. The maxillary teeth are better for age estimation compared to mandibular teeth. Furthermore, using both permanent molars for age calculation gave better age estimation.

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CONFLICT OF INTEREST: None.

REFERENCES

1. Cameriere R, Ferrante L, Belcastro MG, Bonfiglioli B, Rastelli E, Cingolani M. Age estimation by pulp/tooth ratio in canines by peri-apical X-rays. J Forensic Sci. 2007;52(1):166-70. [Article][PubMed]
2. Boldsen JL. Analysis of dental attrition and mortality in the medieval village of Tirup, Denmark. Am J Phys Anthropol. 2005;126(2):169-6. [Article][PubMed]
3. Lovejoy CO. Dental wear in the Libben population: Its functional pattern and role in the determination of adult skeletal age at death. Am J Phys Anthropol. 1985;68(1):47-56. [Article][PubMed]
4. Li C, Ji G. Age estimation from the permanent molar in northeast China by the method of average stage of attrition. Forensic Sci Int. 1995;75(2–3):189-96. [Article][PubMed]
5. Kim YK, Kho HS, Lee KH. Age estimation by occlusal tooth wear. J Forensic Sci. 2000;45(2):303-9. [Article] [PubMed]
6. Faillace KE, Bethard JD, Marks MK. The applicability of dental wear in age estimation for a modern American population. Am J Phys Anthropol. 2017;164(4):776-87. [Article] [PubMed]
7. Vieira EP, Barbosa MS, Quintão CCA, Normando D. Relationship of tooth wear to chronological age among indigenous Amazon populations. PLoS ONE. 2015;10(1):6-10. [Article][PubMed]
8. Gustafson G. Age determination on teeth. J Am Dent Assoc. 1950;41(1):45-54. [DOI][PubMed]
9. People of Nepal Race and Ethnicity. [Internet]. 2017 [Cited: March 8, 2021]. https://responsibleadventures.com/blog/people-of-nepal-race-and-ethnicity/
10. Ajmal M, Mody B, Kumar G. Age estimation using three established methods. A study on Indian population. Forensic Sci Int. 2001;122(2–3):150-4. [Article][PubMed]
11. Papageorgopoulou C, Xirotiris NI, Iten PX, Baumgartner MR, Schmid M, Rühli F. Indications of embalming in Roman Greece by physical, chemical and histological analysis. J Archaeol Sci. 2009;36(1):35-42. [Article]
12. Prince DA, Kimmerle EH, Konigsberg LW. A Bayesian approach to estimate skeletal age-at-death utilizing dental wear. J Forensic Sci. 2008;53(3):588-93. [Article] [PubMed]
13. Miles AEW. The miles method of assessing age from tooth wear revisited. J Archaeol Sci. 2001;28(9):973–82. [Article]
14. Kashyap VK, Koteswara Rao NR. A modified Gustafson method of age estimation from teeth. Forensic Sci Int. 1990;47(3):237–47.[Article][PubMed]
15. Verma M, Verma N, Sharma R, Sharma A. Dental age estimation methods in adult dentitions: An overview. J Forensic Dent Sci. 2019;11(2):57. [Article][PubMed]