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Assessment of Dental Wear for Age Estimation in a Modern Indian Population: A Cross-Sectional Study

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Abstract

Introduction: Teeth, which are known for their durability, even under extreme conditions, have long been a key tool in forensic investigations. Among the various indicators, dental wear is frequently used for age estimation when other biological markers are unavailable. In this study, we aimed to assess the effectiveness of dental wear for age estimation in the modern Indian population by applying Brothwell's method. The total wear score was translated into an estimated age range based on the established correlation between dental wear and age as defined by the Brothwell chart.

Materials and Methods: This cross-sectional observational study was conducted on a sample of 104 participants whose chronological ages were known, allowing for a comparison between their actual age and that estimated from dental wear. The participants were selected according to specific inclusion criteria. Archived occlusal surface photographs of the maxillary and mandibular molars were examined. Dental wear assessment was conducted using Brothwell's 1981 chart as a standard reference. Statistical analysis was performed to determine the correlation between the estimated age from dental wear and the participants' chronological age as well as the accuracy of this method.

Results: The mean chronological age of male participants was 35.11 years (±10.64), while for female participants, it was 34.96 years (±10.81). Males had a mean Brothwell score of 4.19 (±2.07), which was slightly lower than that of females with a mean score of 4.32 (±2.23). A strong association was found between the estimated Brothwell age group and chronological age group, as demonstrated by a statistically significant chi-square value (0.001*) and Cohen's kappa of 0.64. Spearman's correlation analysis revealed a strong relationship between chronological age and Brothwell score, with a value of 0.97. The Mann-Whitney U test comparing dental wear scores between vegetarian and non-vegetarian participants revealed no significant differences.

Conclusion: This study confirms the usefulness of Brothwell's dental-wear method in forensic age estimation, although it underscores the need for modifications when applied to modern populations. The moderate agreement between estimated and actual ages suggests that dental wear remains a valuable indicator, but factors such as modern dietary habits and dental care practices should be considered.

Keywords: Forensic odontology, Brothwell Score, Dental wear, Chronological age, Diet.

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INTRODUCTION

Forensic odontology plays a pivotal role in the identification of individuals, especially in cases where traditional methods such as fingerprinting or facial recognition are impractical due to advanced decomposition, burning, or other damage to the body.1 Dental identification has long been used in forensic investigations because of the durability of teeth, even under extreme conditions. One of the most significant aspects of forensic odontology is age estimation, which provides crucial information about an individual's identity when other biological characteristics are unavailable.[2]

Age estimation techniques in forensic odontology rely heavily on developmental and degenerative changes in teeth. Dental wear, one of the most commonly used indicators in age assessment, is the progressive loss of tooth structure due to physiological factors such as mastication and pathophysiological conditions such as bruxism.[3] Teeth wear gradually throughout an individual's life, and the extent of this wear can provide insights into their approximate age.[4] In modern forensic practice, the study of dental wear has evolved as a reliable method for age estimation, especially in adults, where developmental markers such as tooth eruption and calcification have already been completed.[5]

Various methods have been developed for age estimation based on dental wear, with one of the most notable being Brothwell's method.[6] This technique categorizes dental wear patterns into a systematic framework that correlates the degree of wear with age range, offering a reproducible approach for forensic experts. Brothwell's method involves detailed observation of wear on the occlusal surfaces of teeth and assigning stages of wear to different age groups. This method has been particularly useful in archaeological contexts, but is now being applied to modern populations, including the Indian demographic.[7,8]

The dental wear patterns of individuals in modern Indian populations may differ from those in earlier generations due to significant changes in dietary habits.[9] In traditional societies, a coarse diet rich in unrefined grains and raw vegetables often resulted in accelerated dental wear.[10] However, with the advent of processed foods and softer diets in modern times, dental wear patterns have altered. Despite this shift, dental wear remains a valuable tool for forensic age estimation, albeit one that must be interpreted in the context of contemporary eating habits and lifestyle changes.[11]

This study aimed to evaluate the applicability of dental wear for age estimation in the modern Indian population using Brothwell's method as a framework for analysis. By correlating dental wear with age, we hope to refine the accuracy of this method in contemporary forensic cases.

MATERIAL AND METHODS

This cross-sectional observational study was conducted on 104 participants at the Department of Oral Pathology, JMF ACPM Dental College, from February 2024 to July 2024. As the study was conducted on photographic material from archival data, ethical clearance was not recommended. Participants were selected from the archives of the Orthodontic Department, where photographs of the maxillary and mandibular occlusal surfaces were recorded. The chronological ages of the participants were known, allowing for a comparison between the ages estimated from dental wear and the actual chronological age.

Sample size estimation

The sample size was estimated using G power software version 3.6.9. The study power was set at 95%, and at an alpha error of 0.5%, the recommended sample size was 104participants with a population variability of 0.81.

Inclusion and exclusion criteria

The participants were included in the study based on specific criteria. Only those with complete dental records, including clear photographs of both maxillary and mandibular occlusal surfaces, were considered. Additionally, participants needed to have a full set of teeth, excluding the third molars, to ensure a consistent analysis of dental wear across the sample. Individuals with no significant dental anomalies, such as extensive restorations or missing teeth that could interfere with the accurate assessment of wear patterns were also included.

Exclusion criteria were applied to eliminate factors that could distort the studied natural wear patterns. Participants with severe periodontal disease or dental trauma that could alter the typical progression of dental wear were excluded. Similarly, individuals with prosthetic dental work such as crowns or implants on molars and premolars were not included in the study. Finally, patients with systemic conditions known to affect

dental health, such as osteoporosis or severe bruxism, were excluded to prevent these conditions from confounding the analysis of dental wear and its relationship with age estimation.

Intra and Inter-observer reliability

To assess intra-observer reliability, ten photographs of the maxillary or mandibular occlusal surfaces of teeth showing varying wear patterns, not included in the main study, were selected by an independent analyst. The identification marks of the photographs were concealed, and only the occlusal surfaces were visible. The wear patterns on the mandibular first and second molars were recorded using randomized tables. This process was repeated after three weeks, and the scores were compared until a high agreement was achieved. Inter-observer reliability was similarly tested by comparing the scores between two independent observers across different sequences.

Fig. 1: Maxillary and mandibular first and second molar teeth for Brothwell scoring

Data Collection

The occlusal surface photographs of the maxillary and mandibular molar teeth of 104 participants were retrieved from the archives. These photographs were taken using standardized protocols for intraoral imaging, ensuring consistent angles and exposure for the analysis of dental-wear

Dental Wear Assessment

Dental wear was assessed using Brothwell's 1981 dental wear chart as the standard reference (Figure 2). This method classifies dental wear into specific categories based on the observable wear patterns on the occlusal surfaces of the first and second molars. The Brothwell system ranks the extent of wear into stages corresponding to age ranges (in years) as follows:

- 17-25: Score 1-2
- 26-35: Score 3-4
- 36-45: Score 5-6
- 46-55: Score 7-8
- 56 and above- Score 9+

Each tooth was scored independently and the cumulative dental wear score was calculated for each participant based on the wear observed in the photographs.

Wear Stage	Pictorial Diagram	Description
0		Tooth is at occlusal level but no wear is visible.
1		Enamel faceting. Attrition is visible as tiny planes or facets that reflect light.
2		Enamel rounding. The cusps of the molars are slightly rounded and have lost their peaks and angular faceting.
3		Enamel flattening. The molar cusps are flattened but there is no dentine exposure.
4		Dentine exposed on one cusp only.
5		Dentine exposed on two cusps.
6		Dentine exposed on three cusps.
7		Dentine exposed on four cusps, but the dentinal areas are discrete. These dentine areas consist of small points of exposure.
8		Dentine exposed on four cusps, but the dentinal areas are discrete. These dentine areas consist of differing amounts of exposure. Typically, two cusps have large areas of dentine exposure and two cusps have small areas of dentine exposure.
9		Dentine exposed on four cusps. These dentine areas consist of large points of exposure, are all approximately equal in size, and are approaching coalescence but remain as discrete areas.
10		Two dentinal areas coalesced.
11		Three dentinal areas coalesced.
12		Four dentinal areas coalesced, connected by small bridges of exposed dentine.
13		Four dentinal areas coalesced, leaving a small island of enamel
14		The total occlusal surface of the tooth has dentine exposed, with an enamel rim remaining.
15		The total occlusal surface of the tooth has dentine exposed, with an enamel rim remaining. This enamel rim is low is height and close to reaching the cemento-enamel junction (CEJ). Secondary dentine is visible.
16		The total occlusal surface of the tooth has dentine exposed. The crown height has decreased to the cemento-enamel junction (CEJ) or slightly below in places and secondary dentine is visible. An enamel rim is visible although it is broken.
17		Wear has reached the tooth neck. There is no enamel of the crown remaining.
18		Wear has extended past the root furcation. The individual roots are now separate from each other.

Fig. 2: Brothwell chart for dental wear scoring[8]

Age Estimation

The total wear score was converted to an estimated age range based on the correlation between dental wear and age, as outlined in the Brothwell chart. The estimated age of each participant was calculated by averaging the wear scores for their teeth and assigning an age range according to the chart. The estimated age derived from the dental-wear scores was then compared to the known chronological age of each participant. This comparison was conducted to assess the accuracy of dental wear as a tool for age estimation in a modern Indian population.

Statistical analysis

Statistical analysis for this study was conducted to evaluate the correlation and accuracy of age estimation using dental wear compared to the participants' known chronological age. Descriptive statistics, including mean and standard deviation, were calculated for both estimated and chronological ages to provide an overview of the data distribution. Spearman's correlation coefficient was used to assess the strength and direction of the relationship between the dental wear scores and chronological age, providing insight into the relationship between these two variables. Additionally, a Bland-Altman plot was generated to visually assess the agreement between the estimated and actual ages, offering a clear representation of any bias or limits of agreement between these measurements. Statistical significance was set at a p-value of less than 0.05, and all analyses were performed using SPSS version 23.

RESULTS

The descriptive analysis of the participants shows that the mean chronological age for males was 35.11 years (±10.64), and for females, it was 34.96 years (±10.81), with an overall average of 35.04 years (±10.67). The mean Brothwell score for males was 4.19 (±2.07), while females had a slightly higher mean score of 4.32 (±2.23), resulting in an overall average score of 4.02 (±2.14) (Table 1).

Table 1: Descriptive analysis of participants

	Male (54)	Female (50)	Average
Chronological age (Mean ± SD)	35.11 ± 10.64	34.96 ± 10.81	35.04 ± 10.67
Brothwell score (Mean ± SD)	4.19 ± 2.07	4.32 ± 2.23	4.02 ± 2.14

The gender-wise distribution of Brothwell scores revealed that among the 104 participants, males comprised 51.92% (54 individuals), while females made up 48.08% (50 individuals). The most common Brothwell score was 3, which was observed in 12 males (11.54%) and 8 females (7.69%), totaling 19.23% of the sample. Scores of 5 were also frequent, with 10 males (9.62%) and 8 females (7.69%). Scores of 7 were obtained for 10 males (9.62%) and 4 females (3.85%). Lower scores of 1 and 2 were less common, with 9.62% of the total sample scoring 1 and 15.38% scoring 2, respectively (Table 2).

Table 2: Genderwise distribution of the Brothwell score

Brothwell score	Gender				Total	
	Male		Female			
	n	%	n	%	n	%
1	6	5.77%	4	3.85%	10	9.62%
2	6	5.77%	10	9.62%	16	15.38%
3	12	11.54%	8	7.69%	20	19.23%
4	6	5.77%	4	3.85%	10	9.62%
5	10	9.62%	8	7.69%	18	17.31%
6	2	1.92%	6	5.77%	8	7.69%
7	10	9.62%	4	3.85%	14	13.46%
8	2	1.92%	6	5.77%	8	7.69%
Total	54	51.92%	50	48.08%	104	100%

The reliability between chronological age group and Brothwell age group estimation showed a strong association, with a statistically significant chi-square value (0.001*) and a Cohen's kappa of 0.64, indicating moderate agreement. The majority of participants (22) in the 17-25 chronological age group were correctly estimated using Brothwell's method, while higher agreement was also noted in other age ranges (Table 3). The correlation analysis between chronological age and Brothwell score using Spearman's test yielded a value of 0.97, which shows a strong positive correlation (Fig. 1).

Table 3: Reliability between chronological age and Brothwell age group estimation

Brothwell age group	Chronological age group					Chi square	Cohen kappa
	17-25	26-35	36-45	46-55	Total		
17-25	22	4	0	0	26	0.001*	0.64
26-35	6	20	4	0	30		
36-45	0	4	18	4	26		
46-55	0	0	6	16	22		
Total	28	28	28	20	104		

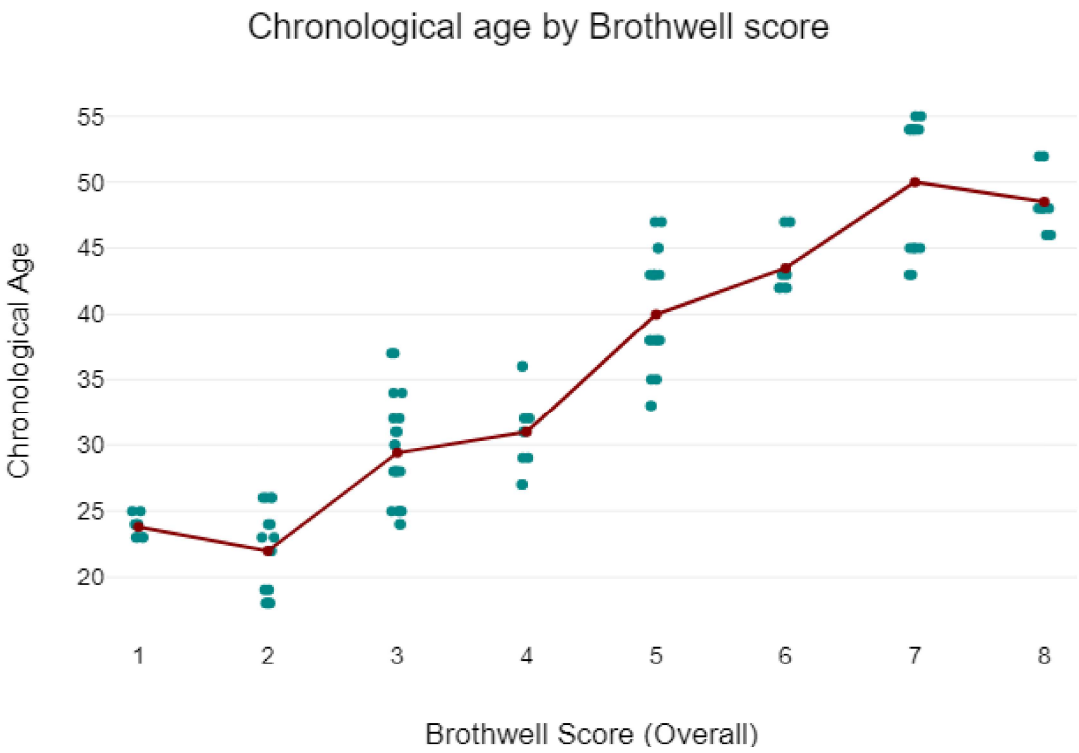

Fig. 1: Correlation of Brothwell score and chronological age analysed by spearman's test

The Mann-Whitney U test was conducted to compare dental wear scores between individuals with vegetarian and non-vegetarian dietary habits, as summarized in Table 4. The mean rank for the vegetarian group was 50.38, whereas the non-vegetarian group had a higher mean rank of 54.32. Despite this difference in mean ranks, the test yielded a p-value of 0.593, indicating that the difference in dental-wear scores between the two dietary groups was not statistically significant. The effect size for this comparison was 0.07, suggesting a very small effect of dietary habits on the dental wear score.

Table 4. Mann-Whitney U test to compare the dental wear score in dietary habits

Dietary habit	n	Mean Rank	Sum of Ranks	P value	Effect size
Veg	48	50.38	2418	0.593	0.07
Non-veg	56	54.32	3042		

DISCUSSION

The findings of our study, which investigated the applicability of Brothwell's dental wear method for age estimation in the modern Indian population, provide important insights into the reliability and challenges of using dental wear as a forensic tool. The moderate agreement observed between the estimated ages from dental wear and the chronological ages of the participants, reflected in a Cohen's kappa value of 0.64 and a statistically significant chi-square value ($p = 0.001$), supports the continued relevance of dental wear in age estimation. However, variations in dental wear patterns due to modern lifestyle factors require careful consideration when applying this method to contemporary populations.[6,8]

In comparison to earlier studies, the results align with previous studies that explored the relationship between dental wear and age estimation. For example, Ball J (2002) demonstrated that dental wear is a reliable age indicator when other skeletal markers are unavailable.[12] However, it is also acknowledged that factors such as modern diets, dental treatments, and overall healthcare can influence the rate of wear.[3,4] This is particularly relevant in our study, where the distribution of Brothwell scores showed some discrepancies, especially in older age groups, where vegetarian

diets may have mitigated natural wear progression.

Moreover, the study by Richard and Turner on dental anthropology emphasizes the consistency of dental wear patterns in relation to age, especially in traditional societies where coarse diets result in accelerated wear.[9] However, as our study involved participants from a modern Indian population, the variance in wear across gender and age groups observed in our results likely reflects the impact of contemporary dietary practices.[10] Abdullah A 'swork supports our findings that while dental wear correlates with age, adjustments may be needed when applying Brothwell's method in populations exposed to softer diets or with access to advanced dental care.[10,11]

Moreover, studies such as Franklin emphasize the importance of using multiple dental and skeletal markers in forensic age estimation.[13]While dental wear alone provides valuable data, and combining it with other biological markers can enhance the precision of age estimates. This corroborates our observation that although Brothwell's method offers a reasonable estimate, integrating it with other forensic techniques could improve reliability, particularly in older age ranges where dental wear patterns alone may not fully capture biological age.

CONCLUSION

Our study reaffirms the utility of Brothwell's dental wear method for forensic age estimation but highlights the need for adaptations when applied to modern populations. The moderate agreement between estimated and chronological ages indicates that while dental wear remains a useful marker, contemporary lifestyle factors, such as dietary changes and dental care, must be considered. Future studies should explore the integration of dental wear with other forensic markers to enhance the accuracy of age estimations in diverse populations.

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