ISSN 0973-2063 (online) 0973-8894 (print)

Bioinformation 22(8): 5257-5260 (2026)

BIOINFORMATION
Discovery at the interface of physical and biological sciences

BIOMEDICAL INFORMATICS

www.bioinformation.net

Volume 22(8)

Research Article

Received August 1, 2026; Revised August 31, 2026; Accepted August 31, 2026, Published August 31, 2026

DOI: 10.6026/973206300225257

SJIF 2026 (Scientific Journal Impact Factor for 2026) = 8.478
2022 Impact Factor (2023 Clarivate Inc. release) is 1.9

Edited by Hiroj Bagde
E-mail: hirojbagde8@gmail.com
Phone: +91 9766105900
Citation: Sarode *et al.* Bioinformation 22(8): 5257-5260 (2026)

Development and comparative validation of a Pune-specific regression formula for forensic age estimation using root dentin translucency

Manish Bhagwan Sarode[1,*], Pratibha Sultane[2], Jagdishchandra Vathar[2], Vivek Nandkishor Padghan[3], Ashish Diwakar Meshram[4], Siddharth Uttam Chaudhari[5] & Nisha C. Salvi[6]

[1]Department of Oral and Maxillofacial Pathology, Government Dental College and Hospital, Jalgaon, Maharashtra, India; [2]Department of Public Health Dentistry, Government Dental College and Hospital, Jalgaon, Maharashtra, India; [3]Department of Oral and Maxillofacial Surgery, Government Dental College and Hospital, Jalgaon, Maharashtra, India; [4]Department of Prosthodontics, Government Dental College and Hospital, Jalgaon, Maharashtra, India; [5]Department of Oral Diagnosis, Medicine & Radiology, Government Dental College and Hospital, Jalgaon, Maharashtra, India; [6]Department of Periodontology, Government Dental College and Hospital, Jalgaon, Maharashtra, India; *Corresponding author

ISSN 0973-2063 (online) 0973-8894 (print)
Bioinformation 22(8): 5257-5260 (2026)

Affiliation URL:
https://www.gdchjalgaon.ac.in/

Author contact:
Manish Bhagwan Sarode - E-mail: drmanishsarode@gmail.com
Pratibha Sultane - E-mail: 090pratibha@gmail.com
Jagdishchandra Vathar - E-mail: drjagdish.v@rediffmail.com
Vivek Nandkishor Padghan - E-mail: vivek.padghan2989@gmail.com
Ashish Diwakar Meshram - E-mail: ashishmeshram837@gmail.com
Siddharth Uttam Chaudhari - E-mail: drsiddharth619@gmail.com
Nisha C. Salvi - E-mail: nishasalvi291@gmail.com

Abstract:
Root dentin translucency is a measurable age-related change that may require population-specific calibration for forensic use. Therefore, it is of interest to evaluate 100 extracted permanent mandibular second premolars from individuals in the second to eighth decades of life; 250-µm buccolingual sections were digitally scanned and translucency length was measured using the Bang and Ramm approach. Chronological age showed a strong positive correlation with translucency length ($r = 0.890$, $p = 0.001$), yielding the Pune-specific equation: Age = 22.29 + 4.670 × translucency length. Mean age estimated by the Pune formula (47.76 years) closely matched actual age (47.87 years; $p = 0.877$), whereas the Acharya formula estimated 48.73 years and differed significantly from actual age ($p = 0.029$), with higher absolute error across age groups. A locally calibrated root-dentin-translucency equation therefore provided better age-estimation accuracy in this sample and supports regional validation before forensic application.

Keywords: Forensic odontology, age estimation, root dentin translucency, regression formula, mandibular second premolar

Background:
In adults, forensic age estimation frequently relies on regressive alterations in dental tissues, as developmental indicators are constrained after the development of permanent dentition. Root dentin translucency has become one of the most reliable indicators among the various methods that can be used since it is not affected by post-mortem changes, measurable and closely related to age-related dentinal sclerosis **[1, 2]**. One of the key challenges in forensic age estimation is the applicability of regression formulae across populations. Even though dentin sclerosis is a biological process that is universal, its speed and degree can differ among geographic and ethnic groups. As a result, a formula created in one group can be systematically overestimated or underestimated when used in another. This issue is especially critical in medico-legal situations, where even a small discrepancy may have important implications for personal identification and legal decision-making **[3-6]**. The standard model of age estimation based on root dentin translucency was first developed by Bang and Ramm **[2]**. Subsequent researchers improved the technique by using computerized densitometric analysis, digital methods of measurement and comparative analysis of various types of teeth **[7]**. Nevertheless, a number of studies have showed that formulae based on translucency differ in their performance across populations, highlighting the need to validate them in a population-specific manner **[8]**. Acharya and Vimi tested the relevance of the formulae of Bang and Ramm in an Indian population and came up with a modified equation that exhibited higher predictive value than the original formulae **[6]**. However, India is a country with high levels of biological and regional diversity. The rate of dentin sclerosis may vary due to factors like ancestry, diet, oral health patterns, environmental influences and local habits. Thus, what works well with one Indian population might not be the best with another. In this regard, the current research was aimed at creating a regression equation that is particular to the Pune population based on root dentin translucency and comparing its accuracy with the Indian formula that was published earlier by Acharya and Vimi **[6]**. The objective was to find out whether a locally calibrated equation would give a better fit to chronological age and thus enhance the forensic utility of this technique. Recent studies using digital image analysis and forensic reference databases further support population-aware validation of root dentin translucency for adult age estimation **[12, 13].** Therefore, it is of interest to develop a Pune-specific regression equation based on root dentin translucency and compare its age-estimation accuracy with the previously published Indian equation.

Materials and Methods:
This analytical paper was done on 100 extracted permanent mandibular second premolars of people aged between the second and eighth decades of life. The teeth were sampled in the Department of Oral and Maxillofacial Surgery at M.A. Rangoonwala College of Dental Sciences and Hospital, Pune and in the private dental clinics of the city of Pune. Only healthy, erupted mandibular second premolars removed due to valid therapeutic reasons, including periodontal disease, orthodontic treatment, malocclusion, or prosthodontics were included. Teeth with apparent attrition, abrasion, erosion, or caries were not included to prevent skewing of the translucency boundary. Demographic information such as age, sex and tooth number was noted after extraction. The teeth were washed and fixed in

10% neutral formalin. The specimens were then oriented along a longitudinal axis and cast in acrylic resin to be sectioned. A hard-tissue microtome was used to prepare buccolingual sections of about 250 µm thickness. The sections were scanned at 600 dpi and kept in digital format. The length of translucency was determined as the distance between the apex of the root and the crown until the junction of transparent and opaque dentin as per the procedure outlined by Bang and Ramm **[2]**. The actual age, estimated age and the error of estimation were tabulated in Microsoft Excel. The statistical analysis was done by means of SPSS version 10.0. The correlation between the chronological age and the length of translucency was evaluated by Pearson correlation analysis. The Pune-specific formula was derived through simple linear regression where the chronological age was the dependent variable and the length of translucency was the independent variable. The t-tests were paired to compare the actual age with the age predicted by the Pune formula and the Acharya formula **[6]**. Comparative evaluation involved the mean predicted age, statistical significance of the difference between the actual age and the predicted age and the absolute estimation error of the various age groups.

Results:

The correlation between chronological age and translucency length was strong and statistically significant ($r = 0.890$, $p = 0.001$). Linear regression analysis yielded the Pune-specific regression equation: Age = 22.29 + 4.670 × translucency length. The coefficient of determination was 79.21%, indicating that translucency length explained a substantial proportion of variation in chronological age. As shown in **Table 1**, the mean estimated age using the Pune-specific formula (47.76 years) was very close to the mean actual age (47.87 years) and the difference was not statistically significant ($p = 0.877$). In contrast, the Acharya formula produced a mean estimated age of 48.73 years, which showed a statistically significant difference from actual age ($p = 0.029$), suggesting reduced accuracy in the present population. **Table 2** shows that the Pune formula followed the trend of actual age more closely than the Acharya equation across all age groups. The difference was especially noticeable in the younger age groups, where the Acharya formula markedly overestimated age. In the older group of 61–70 years, the Acharya formula underestimated age, whereas the Pune formula remained closer to the actual age. **Table 3** shows that the Pune-specific formula had lower absolute estimation error than the Acharya formula in every age group studied. The weighted mean absolute error was approximately 3.4 years for the Pune model and 6.8 years for the Acharya model. The improved performance of the local formula was particularly evident after 30 years of age, when translucency becomes more consistently expressed and the slope of the regression line is better suited to the regional sample.

Table 1: Overall agreement between actual age and predicted age by the two formulae

Measure	Value
Mean actual age	47.87 years
Mean estimated age by Pune formula	47.76 years
Mean estimated age by Acharya formula	48.73 years
SD of actual age	13.12
SD of Pune estimate	13.40
SD of Acharya estimate	13.16
Paired t test p value: actual vs Pune	0.877
Paired t test p value: actual vs Acharya	0.029

Table 2: Decade-wise comparison of actual age and predicted ages by the Pune and Acharya formulae

Age group (years)	n	Mean translucency (mm)	Actual age (years)	Predicted age, Pune formula	Predicted age, Acharya formula
11–20	8	0.3	15.4	23.5	34.2
21–30	8	0.8	26.4	25.9	35.6
31–40	17	4.7	38.5	44.3	46.6
41–50	20	5.3	47.2	46.9	48.3
51–60	25	6.3	57.7	51.7	51.1
61–70	22	8.8	64.3	63.6	58.1

Table 3: Absolute estimation error by decade for the two formulae

Age group (years)	Absolute error, Pune formula (years)	Absolute error, Acharya formula (years)	Better-performing model
11–20	8.1	18.8	Pune
21–30	0.5	9.2	Pune
31–40	5.8	8.1	Pune
41–50	0.3	1.1	Pune
51–60	6.0	6.6	Pune
61–70	0.7	6.2	Pune

Discussion:

The most significant conclusion of the current research is that a regression equation that was obtained specifically on a population of Pune was better than the Indian formula that had been published earlier when it was applied to the same local population. This finding has significant forensic implications in that it shows that even country-specific equations cannot always be accurate enough to all regional populations. The high association between chronological age and root dentin translucency in the current research is consistent with the existing literature. Translucency was introduced by Bang and Ramm as a useful dental age indicator **[2]**. Later studies by Drusini *et al.* and Solheim established its usefulness as a single parameter or as a combination with other regressive dental changes **[3, 4]**. The overall findings of these studies are that dentin translucency is a biological phenomenon that is age-related. Nevertheless, the current research indicates that correlation is not sufficient. A regression model can indicate a good correlation with age yet still give biased estimates unless the slope and intercept are adjusted to the target population.

This problem was revealed when the Acharya formula, despite being based on an Indian sample and being a much better methodological advancement **[6]**, showed a statistically significant difference with actual age in the Pune population. Conversely, the Pune-specific formula did not exhibit any significant difference with actual age and lower absolute error between all age groups. The potential causes of this better performance are the differences in biology and the environment among populations. Local diet, oral health, masticatory stress, general health and other regional factors may affect the rate of dentin sclerosis. The close relationship between translucency and age has been also confirmed by previous Indian research by Singhal *et al.* and Gupta *et al.*, although the methodology variability and differences in interpretation due to population have been highlighted **[8, 10]**. The current results also support the necessity of regional recalibration even within the country. Earlier forensic dental age-estimation methods based on age-related dental changes likewise demonstrate that methodological approach and population context can influence predictive accuracy **[5, 9].** The results could also have been due to methodological consistency. Sectioned teeth, high-resolution digital scanning and software-assisted measurement probably reduced observer bias and enhanced reproducibility. Digital techniques have already been suggested as an improvement to traditional manual measurement techniques **[10, 11].** The current research validates the usefulness of this method in generating a strong local regression equation. The other notable finding was that the error in estimation was still more in younger age groups despite the use of Pune formula. This is probably the biological constraint of translucency as a marker prior to the third decade of life when sclerotic change is either non-existent or slight **[12, 13].** Therefore, despite the fact that local calibration enhances the predictive performance, the age-related constraints of the marker still exist. More confidence can be placed on translucency-based estimates in adults over 30 years in real-world forensic practice. The study has certain limitations. The sample size, though sufficient to conduct a preliminary analytical study, is rather limited in terms of developing a conclusive forensic standard. Only second premolars of the mandible were taken and teeth with significant wear or pathology were left out. This can restrict its applicability to field cases of damaged or diseased teeth. Moreover, the formula would have to be adopted by external validation in an independent Pune or western Indian sample before it can be used routinely in medico-legal. In spite of these shortcomings, the comparative outcomes are a strong indication of the usefulness of local calibration. The absence of a large difference between actual age and Pune-estimated age, combined with the statistically significant error of the Acharya formula, suggests that region-specific regression equations will probably yield more accurate forensic age estimation than nationalized formulae.

Conclusion:

Pune-specific root dentin translucency equation agreed more closely with chronological age than the previously published Indian equation. Thus, root dentin translucency was a practical age indicator, particularly in adults older than 30 years. Hence, regional calibration and external validation are recommended before routine forensic use.

References:

[1] Gustafson G. *J Am Dent Assoc*. 1950 **41**:45. [PMID: 15428197]
[2] Bang G & Ramm E. *Acta Odontol Scand*. 1970 **28**:3. [PMID: 5265990]
[3] Drusini AG *et al. Am J Phys Anthropol*. 1991 **85**:25. [PMID: 1853940]
[4] Solheim T. *Scand J Dent Res*. 1989 **97**:189. [PMID: 2740830]
[5] Kvaal SI & Solheim T. *J Forensic Odontostomatol*. 1994 **12**:6. [PMID: 9227083]
[6] Acharya AB & Vimi S. *Int J Legal Med*. 2009 **123**:483. [PMID: 19370359]
[7] Acharya AB. *Am J Forensic Med Pathol*. 2010 **31**:133. [PMID: 20081523]
[8] Singhal A *et al. J Forensic Dent Sci*. 2010 **2**:18. [PMID: 21189985]
[9] Singh A *et al. J Indian Acad Forensic Med*. 2004 **26**:94. [DOI: 10.1177/0971097320040303]
[10] Gupta S *et al. J Forensic Dent Sci*. 2017 **9:**42. [PMID: 28584476]
[11] Singh S *et al. J Forensic Dent Sci*. 2013 **5**:47. [PMID: 23960415]
[12] Durand AM *et al. Anat Cell Biol*. 2024 **57**:271. [PMID: 38551025]
[13] Parra RC *et al. Forensic Sci Int*. 2025 **369**:112433.[PMID: 40043496]