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REVIEW ARTICLE

# Forensics in Orthodontics: A Narrative Review

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## ABSTRACT

Orthodontic records including radiographs, three-dimensional digital models, and study casts serve as invaluable antemortem data for human identification due to their high detail and longitudinal nature. Research highlights the stability of anatomical landmarks like palatal rugae and the individuality of malocclusion patterns as reliable biometric markers. Furthermore, orthodontic appliances act as durable physical identifiers in forensic investigations and mass disasters. By integrating clinical documentation with emerging technologies like artificial intelligence or three-dimensional superimposition, orthodontics significantly enhances the accuracy of age estimation and victim identification, reinforcing its vital role in forensic odontology.

## KEYWORDS

• Forensic Odontology • Orthodontic Records • Identification • Palatal Rugae

## INTRODUCTION

Forensic odontology is a vital specialized branch of dental science that applies dental knowledge to legal investigations, primarily focusing on human identification when other methods are insufficient due to factors like severe trauma, decomposition, or fire.[1,2,8,13,14,15] Teeth, with their unique anatomical and physiological variations, along with any dental treatments, are remarkably resistant to environmental stressors and can retain identifiable information throughout and beyond life. This makes them invaluable for establishing identity in criminal proceedings,

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civil actions, and mass disaster victim identification.[1,8,13,15]

Orthodontics, with its inherent emphasis on detailed diagnostic procedures and long-term record-keeping, plays a significant role in forensic odontology.[1,8,12,13,15] Orthodontists routinely collect extensive ante-mortem records, including clinical photographs (intraoral and extraoral), radiographs such as orthopantomograms, lateral cephalograms, and cone beam computed tomography scans, and dental casts or digital models. These records capture a wealth of individualized information about a patient's dentition and craniofacial structures, offering crucial data for forensic comparisons when ante-mortem and post-mortem data need to be reconciled.[1,13,16]

The detailed documentation maintained by orthodontists provides various identifiers. morphological features like tooth size, shape, rotations, arch form, root characteristics, and variations in palatal rugae patterns are unique to each individual and can be reliably compared.[1,2,6,8,13,15] Therapeutic interventions, such as restorations (amalgam or composite), root canal treatments, missing teeth due to extractions, and the presence and design of orthodontic appliances (brackets, bands, wires, retainers), also serve as distinctive and durable markers for identification.[1,6,8,12,13,15] Beyond identification, orthodontic records contribute to age and sex estimation. The stages of tooth calcification, eruption patterns, root formation, and skeletal maturity indicators visible in radiographs are key for age determination, with methods like demirjian's and cameriere's proving valuable craniofacial and dental arch dimensions, exhibiting sexual dimorphism, assist in sex estimation.[2,13,15]

The advent of digital orthodontics has further enhanced the field's forensic capabilities. Three-dimensional digital models and cone beam computed tomography scans offer volumetric imaging, allowing for precise three-dimensional superimposition and morphometric analysis. Artificial intelligence and machine learning are also being integrated to automate and improve the objectivity and accuracy of these analyses.[2,3,4,15] While palatal rugae patterns have some utility, their stability, particularly regarding dimensional changes due to orthodontic treatment, can be a subject of debate, though morphological patterns often remain recognizable for visual matching.[5,7,9,10,11,14] Despite concerns about small positional changes, three-dimensional analysis systems aim to provide more robust comparisons of these unique patterns over time.[3,5]

The routine and comprehensive record-keeping inherent to orthodontic practice generates highly valuable and legally admissible evidence for forensic odontology. Orthodontists, through their meticulous documentation and understanding of dental and craniofacial biology, are indispensable collaborators in human identification efforts, particularly in challenging scenarios like mass disasters.[1,6,8,13]

## ORTHODONTIC RECORDS IN FORENSIC IDENTIFICATION

Orthodontic records constitute a critical component of forensic odontology, particularly in the identification of unknown individuals through comparison of antemortem and postmortem data. These records include photographs, study models, radiographs, and cephalometric analyses, all of which provide unique and individualized dental and craniofacial characteristics. Pre-treatment records such as facial and intraoral photographs aid in direct visual identification, while study models preserve details of dental alignment, arch form, and palatal morphology. Radiographs, including orthopantomograms and lateral cephalograms, offer valuable information regarding root morphology, missing or extracted teeth, and treatment-induced changes such as root resorption.[2,12,15]

Palatal rugae patterns recorded in orthodontic casts or digital models are particularly significant due to their uniqueness and relative stability over time, even after orthodontic treatment, making them reliable markers for identification.[5] Advanced three-dimensional digital models further enhance the accuracy of rugae pattern comparison and individual matching in forensic investigations. Additionally, orthodontic treatment may leave permanent markers such as enamel decalcification, periodontal changes, and "orthodontic scars," which can serve as distinguishing forensic features.[2,3,11]

Cephalometric parameters and orthodontic profile analyses (e.g., skeletal class, Tweed, and Northwestern analyses) also contribute

to forensic identification by aiding facial reconstruction and improving the prediction of facial soft tissue thickness.[4] Overall, meticulous maintenance of orthodontic records significantly enhances the reliability of forensic identification, often providing rapid and cost-effective results when other primary methods such as fingerprints are unavailable.[2]

## CEPHALOMETRIC ANALYSIS IN FORENSIC APPLICATIONS

Cephalometric analysis plays an important role in forensic applications by providing quantitative assessment of craniofacial morphology that can assist in human identification and facial reconstruction. Lateral cephalograms and related orthodontic analyses offer standardized angular and linear measurements of the skull and dentofacial structures, which remain relatively stable and can be compared between antemortem and postmortem records. These records are particularly valuable when conventional identification methods such as fingerprints are unavailable or inconclusive.[1,2,4,11,14]

In forensic contexts, cephalometric parameters such as skeletal class, cephalic index, and angular relationships derived from analyses like tweed and northwestern contribute to understanding the individual's facial profile and growth pattern.[1,3] Recent research has demonstrated that these orthodontic profile variables can be integrated with demographic factors (age, sex, and body mass index) to improve the prediction of facial soft tissue thickness, which is essential for forensic facial approximation. Although the improvement in predictive accuracy is modest, the inclusion of cephalometric variables enhances the interpretive value of reconstruction models.[4,5,8]

Cephalometric data also aid in skull-photo superimposition and facial reconstruction by providing spatial relationships between hard and soft tissues. Since orthodontic analyses evaluate maxillomandibular relationships and incisor inclinations, they help in estimating lip posture, facial convexity, and overall profile, which are critical for recreating facial appearance. Furthermore, these measurements can reveal distinctive skeletal discrepancies or treatment-induced changes that may serve as identifying features.[4,7,11,15,16]

The integration of cephalometric records with other orthodontic data such as study models and radiographs enhances the reliability of forensic identification. When used alongside stable intraoral landmarks like palatal rugae, cephalometric analysis contributes to a comprehensive, multidisciplinary approach. Thus, cephalometry serves as a valuable adjunct in forensic odontology, bridging clinical orthodontics and medico-legal investigations.[5,8,10]

## AGE ESTIMATION USING ORTHODONTIC PARAMETERS

Age estimation using orthodontic parameters is an important adjunct in forensic odontology, particularly when conventional identifiers are unavailable. Orthodontic records provide a combination of dental, skeletal, and soft tissue indicators that can be correlated with chronological age. These include cephalometric analyses, dental development stages, and morphological features recorded in radiographs, study models, and clinical photographs.[2,6,8,9]

Cephalometric parameters contribute significantly to age estimation by assessing craniofacial growth patterns. Variables such as skeletal class, mandibular plane angle, and incisor inclination reflect developmental changes that occur with age.[2,6] Studies have shown that factors like age, sex, and body mass index influence facial soft tissue thickness, which tends to decrease with advancing age due to reduced muscle tone and

soft tissue alterations. Thus, integrating cephalometric findings with facial soft tissue analysis prediction models can improve age-related assessments in forensic cases.[7,9,13,15]

Dental structures remain one of the most reliable indicators for age estimation due to their resistance to environmental changes. Orthodontic radiographs may reveal eruption status, root development, and treatment-related changes such as extractions or root resorption, all of which can provide clues about an individual's age.[1,4,5] Additionally, palatal rugae patterns, although primarily used for identification, may show minor dimensional changes over time; however, their morphology remains relatively stable, supporting their adjunctive role in age-related assessments.[2,5,6,7]

Furthermore, orthodontic treatment itself can introduce identifiable markers, such as enamel decalcification or periodontal changes, that may indirectly indicate the timing of treatment and help narrow age ranges.[4,8,11,12]

Overall, age estimation using orthodontic parameters relies on a multidisciplinary evaluation of skeletal, dental, and soft tissue features. When combined with other forensic methods, these parameters enhance the accuracy and reliability of determining age in medico-legal investigations.[9,10,14]

## ORTHODONTIC APPLIANCES AS FORENSIC MARKERS

Orthodontic appliances serve as valuable forensic markers due to their individuality, durability, and the detailed documentation associated with their use. In forensic odontology, identification often relies on comparison between antemortem and postmortem records, and orthodontic appliances both fixed and removable can provide distinctive features that aid this process. Since these appliances are customized for each patient, they reflect unique treatment mechanics, tooth movements, and clinician preferences, making them highly specific identifiers.[2,4,5]

Fixed orthodontic appliances such as brackets, bands, archwires, transpalatal arches, and expanders may persist even after death or leave identifiable traces on teeth and supporting structures. These appliances can produce characteristic changes, including enamel decalcification (white spot lesions), enamel fractures, and root resorption visible on radiographs.[2,3] Such treatment-induced alterations, often referred to as "orthodontic scars," provide long-lasting evidence that can be correlated with dental records during forensic investigations. Additionally, extraction patterns carried out as part of orthodontic therapy, as well as the configuration of appliances used, can further narrow identification by matching specific treatment plans.[2,5,8,11]

Removable appliances and adjuncts such as retainers, headgear, and functional appliances also contribute to forensic identification. Although these may not always be present postmortem, their effects on dentition and craniofacial structures can be detected in orthodontic records. For instance, appliances used for maxillary expansion can alter inter-rugae distances and arch width, leaving measurable changes that can be traced back to treatment.[6,7] While positional changes may occur, the overall morphology of structures like palatal rugae remains relatively stable, allowing them to serve as complementary markers alongside appliance-related changes.[2,6]

Advancements in digital orthodontics have further enhanced the forensic value of appliances. Three-dimensional digital models and intraoral scans allow precise documentation of appliance placement and treatment progress. These records can be used to compare palatal landmarks and dental configurations with high accuracy, even after orthodontic treatment. Digital archives also facilitate long-term storage and easy retrieval of patient data, improving the efficiency of forensic comparisons.[5,11,12]

Cephalometric and radiographic records associated with orthodontic treatment provide additional context for appliance-based identification. Treatment mechanics often influence craniofacial relationships, which can be quantified using cephalometric analyses. These skeletal and dental changes, combined with appliance-related findings, enhance the overall reliability of forensic identification.[4,6,7]

Orthodontic appliances act as significant forensic markers by leaving unique, persistent, and well-documented evidence. Their combination with other orthodontic records, such as radiographs, study models, and cephalometric analyses, creates a comprehensive dataset that strengthens identification in medico-legal cases. Meticulous record-keeping by orthodontists is therefore essential, as it transforms routine clinical data into critical forensic evidence capable of aiding in the identification of unknown individuals.[2,4]

## DIGITAL ORTHODONTICS AND FORENSIC ADVANCEMENTS

Digital orthodontics has significantly advanced forensic odontology by improving the accuracy, reproducibility, and accessibility of dental records used for human identification. The transition from conventional plaster models to three-dimensional digital models and intraoral scans has enabled precise documentation of dental and craniofacial structures. These digital

records provide detailed information on tooth morphology, alignment, and palatal anatomy, which can be reliably compared in antemortem and postmortem analysis.[2,5,6]

One of the most important contributions of digital orthodontics in forensics is the evaluation of palatal rugae patterns using three-dimensional technology. Palatal rugae are unique and relatively stable anatomical structures that can serve as reliable markers for identification. Studies have shown that three-dimensional digital models allow accurate assessment and comparison of rugae landmarks, with minimal variation over time or after orthodontic treatment, thereby enhancing their forensic applicability. Even though minor dimensional changes may occur due to orthodontic procedures, the overall morphology remains sufficiently consistent to support identification.[5,6,13,16]

Digital imaging also enhances cephalometric analysis and craniofacial reconstruction. Advanced imaging techniques such as computed tomography and digital cephalograms allow integration of orthodontic parameters like skeletal class, cephalic index, and angular measurements into predictive models for facial soft tissue thickness. These models contribute to more accurate facial approximations in forensic investigations.[5,6]

Furthermore, digital orthodontic records facilitate efficient storage, retrieval, and sharing of patient data, which is crucial in mass disaster scenarios and medico-legal cases compared to traditional methods. Digital systems reduce errors, allow superimposition techniques, and enable automated matching processes, thereby increasing the speed and reliability of identification.[5,6,13]

Digital orthodontics has transformed forensic odontology by providing highly accurate, stable, and easily accessible data. The integration of three-dimensional models, digital imaging, and advanced analytical tools has strengthened the role of orthodontic records in forensic identification, making them indispensable in modern medico-legal practice.[2,4,5,7]

## LIMITATIONS OF FORENSIC ORTHODONTICS

Despite its valuable contributions, forensic orthodontics has several limitations that may affect the accuracy and reliability of identification. One major constraint is its secondary role in forensic science, as it is generally considered less definitive compared to primary identification methods such as analysis and fingerprinting. Orthodontic identification relies heavily on the availability and quality of antemortem records; incomplete, outdated, or poorly maintained records can lead to inconclusive or erroneous results.[1,2,11,13]

Another limitation involves biological variability and treatment-induced changes. Orthodontic procedures can alter dental alignment, extraction patterns, and craniofacial relationships, which may complicate comparisons between pre and post-treatment records. Although structures like palatal rugae are relatively stable, studies indicate that positional changes can occur due to orthodontic interventions such as maxillary expansion, potentially affecting their reliability.[6,7,11]

Cephalometric and soft tissue analyses also present challenges, as their predictive value may be limited. For instance, the inclusion of orthodontic profile variables provides only modest improvements in predicting facial soft tissue thickness, indicating restricted accuracy in forensic facial reconstruction.[4,14]

Additionally, environmental factors such as trauma, decomposition, or thermal damage can distort dental and craniofacial structures, reducing the usability of orthodontic evidence. Therefore, while forensic orthodontics is a valuable adjunct, it must be used in conjunction with other forensic methods for reliable identification.

## FUTURE PERSPECTIVES

Future perspectives in forensic orthodontics emphasize the integration of advanced technologies, improved record standardization, and multidisciplinary collaboration to enhance identification accuracy. The growing use of digital orthodontics, including three-dimensional imaging, intraoral scanning, and computerized record storage, is expected to revolutionize forensic investigations by enabling precise, reproducible, and easily retrievable data for comparison. The development of automated matching algorithms and artificial intelligence-based systems may further improve the speed and objectivity of identifying individuals using orthodontic records.[5,15]

Advancements in craniofacial analysis, particularly the incorporation of cephalometric parameters with demographic variables, hold promise for improving facial reconstruction techniques. Although current models show only modest improvements in predicting facial soft tissue thickness, future research with larger datasets and refined methodologies may significantly enhance predictive accuracy.[4,7,11]

Additionally, further exploration of stable intraoral landmarks such as palatal rugae, especially through three-dimensional analysis, may strengthen their reliability as forensic identifiers despite minor treatment-related changes. Standardisation of orthodontic record-keeping practices and increased awareness among clinicians regarding their medico-legal importance are also crucial.[1,3,6]

Overall, the future of forensic orthodontics lies in combining digital innovation, robust databases, and interdisciplinary research to transform routine orthodontic records into powerful tools for human identification in forensic science.

## CONCLUSION

In conclusion, forensic orthodontics represents a valuable adjunct within forensic odontology, contributing significantly to human identification through the analysis of dental and craniofacial records. Orthodontic records including photographs, radiographs, study models, and cephalometric analyses provide individualized and often permanent features that can be compared between antemortem and postmortem data. Although not as definitive as primary methods like fingerprint analysis, these records are cost-effective, readily available, and capable of yielding rapid results in many medico-legal situations.

Structures such as palatal rugae demonstrate uniqueness and relative stability, reinforcing their role as reliable forensic markers, especially when analyzed using modern three-dimensional digital techniques. At the same time, orthodontic treatments leave identifiable changes such as extraction patterns, root resorption, and enamel alterations that further enhance the evidentiary value of these records. Cephalometric analyses and orthodontic profile assessments also contribute to facial reconstruction and identification, although their predictive accuracy remains moderate.

Despite certain limitations, including treatment-induced changes and dependence on record availability, the integration of digital technologies and standardized documentation is strengthening the role of orthodontics in forensic science.

## REFERENCES


1. Hanafi MGS, Utsuno H, Namiki S, Aoki N, Saitoh H, Minegishi S, et al. Assessing the contribution of orthodontic profiles in predicting facial soft tissue thickness for forensic facial approximation. Int J Legal Med. 2025;139:2951–2964.
2. Reddy G, Reddy VP, Sharma M, Aggarwal M. Role of orthodontics in forensic odontology—A social responsibility. J Clin Diagn Res. 2016;10(4):ZE01–ZE03.
3. Taneva ED, Johnson A, Viana G, Evans CA. 3D evaluation of palatal rugae for human identification using digital study models. J Forensic Dent Sci. 2015;7(3):244–252.
4. Gupta AA, Kheur S, Alshehri A, Awadh W, Ahmed ZH, Feroz SMA, et al. Is palatal rugae pattern a reliable tool for personal identification following orthodontic treatment? A systematic review and meta-analysis. Diagnostics (Basel). 2022;12(2):418.
5. Shailaja AM, Romana IRU, Narayanappa G, Smitha T, Gowda NC, Vedavathi HK. Assessment of palatal rugae pattern and its significance in orthodontics and forensic odontology. J Oral Maxillofac Pathol. 2018;22(3):430–435.
6. Goutham N, Shishira RJ, Shailaja AM, Vedavathi HK, Sowmya KS, Neeharika S. Malocclusion: An adjunctive aid in individual identification. J Forensic Dent Sci. 2014;6(1):36-41.
7. Choi SH, Koh K, Lee KJ, Hwang CJ, Cha JY. Analysis of the Morphological Characteristics of the Palatal Rugae for Three-Dimensional Superimposition of Digital Models in Korean Subjects. BioMed Res Int. 2018:3936918.
8. Papageorgiou SN, Giannakopoulou T, Eliades T, Vandevska-Radunovic V. Occlusal outcome of orthodontic treatment: a systematic review with meta-analyses of randomized trials. Eur J Orthod. 2024;46(6):cjae060.
9. Pires CD, da Silva DT, Paranhos LR, Franco A. Forensic value of orthodontic records for human identification: a systematic review. Acta Sci Health Sci. 2024;46(1):e64703.
10. Lambrou P, Kaklamanos EG, Christodoulou N, Giannakopoulos K. Orthodontics in Forensic Science: A Review of Its Contribution to Human

Identification. Forensic Sci. 2026;4(1):598-603.

**11.** Rath SK, Panda SM. Orthodontic Forensic Science: The Unseen Part of our Profession. J Forensic Res. 2017;8(3):1000378.

**12.** Harshitha S, Chezian NG, Sukanya R, Saranya P, Poovalingam J. Role of Orthodontics in Forensic Dentistry: A Review. Int J Creativ Res Thoughts. 2024;12(5):d403-d408.

**13.** Almeida MA, Phillips C, Kula K, Tulloch C. Stability of the palatal rugae as landmarks for analysis of dental casts. Angle Orthod. 1995;65(1):43-48.

**14.** Emam ANM. Role of Forensic Odontology in Identification of Persons: A Review Article. Cureus. 2024;16(3):e56570.

**15.** Vidal-Parra M, Fonseca GM. Orthodontic records for forensic identification: A scoping review. Rev Esp Med Legal. 2022;48(2):78-83.

**16.** Goutham N, Shishira RJ, Shailaja AM, Vedavathi HK, Sowmya KS, Neeharika S. Malocclusion: An adjunctive aid in individual identification. J Forensic Dent Sci. 2014;6(1): 36-41.