DOI: 10.21088/ijfo.0974.505X.19126.3

Indian Journal of Forensic Odontology
Volume 19 Number 1, January – June 2026

REVIEW ARTICLE

Forensic Identification Through CBCT Evaluation of Secondary Dentin, Root Canal Anatomy and Endodontic Treatment Characteristics

Neelam Mittal[1], Deepti Singh[2], Shelly Sharma[3]

HOW TO CITE THIS ARTICLE:

Neelam Mittal, Deepti Singh, Shelly Sharma. Forensic Identification Through CBCT Evaluation of Secondary Dentin, Root Canal Anatomy and Endodontic Treatment Characteristics. Ind J Forensic Odontol 2026; 19(1): 21-26.

ABSTRACT

Forensic odontology plays an important role in human identification, especially in cases involving decomposed, burned, or mutilated bodies where conventional methods such as fingerprinting are not possible. Teeth are highly durable and resist physical, chemical, and thermal damage, making them reliable forensic tools. Endodontics contributes significantly through the evaluation of secondary dentin deposition, root canal morphology, pulp chamber dimensions, and endodontic treatment characteristics, which are unique to each individual. Cone Beam Computed Tomography (CBCT) has improved forensic dental analysis by providing accurate three-dimensional imaging of dental structures. It allows detailed assessment of pulp chamber size, root canal anatomy, calcifications, restorations, obturation patterns, missed canals, and separated instruments that serve as forensic identifiers. Secondary dentin deposition is valuable for age estimation due to the reduction in pulp chamber volume with age, while variations in canal morphology and treatment patterns assist in personal identification through radiographic comparison. This review highlights the forensic importance of CBCT in evaluating secondary dentin, root canal anatomy, and endodontic treatment characteristics, emphasizing its growing role in modern forensic odontology.

KEYWORDS

• CBCT • Forensic Odontology • Human Identification • Root Canal Anatomy • Secondary Dentin

AUTHOR'S AFFILIATION:

[1] Senior Professor, Department of Conservative Dentistry and Endodontics, Faculty of Dental Sciences, Banaras Hindu University, Varanasi, India.

[2] JR-3, Department of Conservative Dentistry and Endodontics, Faculty of Dental Sciences, Banaras Hindu University, Varanasi, India.

[3] SR, Department of Conservative Dentistry and Endodontics, Faculty of Dental Sciences, Banaras Hindu University, Varanasi, India.

CORRESPONDING AUTHOR:

Deepti Singh, JR-3, Department of Conservative Dentistry and Endodontics, Faculty of Dental Sciences, Banaras Hindu University, Varanasi, India.

E-mail: deeptirocks07@gmail.com

➢ **Received:** 02-05-2026 ➢ **Accepted:** 01-06-2026

INTRODUCTION

Forensic odontology is a specialized branch of dentistry that involves the examination, preservation, interpretation, and presentation of dental evidence for legal and investigative purposes.[1] One of its most important applications is the identification of unknown individuals in criminal investigations, natural disasters, accidents, mass fatalities, and cases involving decomposed or severely burned bodies.[3] In such situations, conventional methods such as fingerprint analysis, facial recognition, and soft tissue examination may be unreliable or impossible.[3] Teeth, however, remain highly resistant to decomposition and environmental damage, making them one of the most dependable tools in forensic identification.[3,4]

The uniqueness of human dentition lies not only in the arrangement and morphology of teeth but also in restorations, pathological conditions, developmental anomalies, and previous dental treatments.[4,5] Since no two individuals have identical dental characteristics, dental evidence becomes a powerful method for establishing identity.[3] Among dental specialties, endodontics provides particularly valuable information because the internal anatomy of teeth and the modifications produced by treatment are highly individualized and relatively permanent.[1]

Secondary dentin deposition, root canal morphology, and endodontic treatment characteristics are major endodontic parameters with forensic importance.[6] Secondary dentin is continuously deposited after root formation and gradually reduces pulp chamber size, making it useful for age estimation.[6,8] Root canal morphology varies considerably among individuals and populations, offering unique anatomical patterns for comparison.[9,10] Endodontic treatment features such as obturation patterns, missed canals, fractured instruments, and posts create individualized signatures that can assist in identification.[11]

Cone Beam Computed Tomography (CBCT) has significantly advanced the field of forensic odontology by providing precise three-dimensional imaging of dental structures.[1] Unlike conventional radiographs, CBCT offers accurate visualization without superimposition or distortion, allowing detailed assessment of both anatomical and treatment-related features. This review explores the role of CBCT in forensic identification through evaluation of secondary dentin deposition, root canal anatomy, and endodontic treatment characteristics.

SECONDARY DENTIN DEPOSITION AND AGE ESTIMATION

Age estimation is one of the most common and important applications of forensic odontology. It helps in narrowing the search for unidentified individuals and contributes significantly to medico-legal investigations.[3] Teeth are ideal for age estimation because they undergo predictable physiological changes throughout life and are less affected by environmental factors than skeletal tissues.[8] One of the most reliable dental indicators of age is secondary dentin deposition. Secondary dentin is formed after the completion of root development and continues to be deposited slowly throughout life along the walls of the pulp chamber and root canals.[6] This deposition causes gradual narrowing of the pulp space, which can be measured radiographically and correlated with chronological age.[6,7]

Traditional age estimation methods relied on periapical and panoramic radiographs. Although useful, these methods are limited by magnification errors, image distortion, and superimposition of surrounding structures. These limitations reduce measurement accuracy and reproducibility.[8] CBCT overcomes these problems by providing three-dimensional images that allow precise volumetric analysis of the pulp chamber and root canals.[6]

CBCT-based age estimation commonly involves measuring the pulp-to-tooth ratio or total pulp chamber volume.[6] Teeth such as maxillary canines, mandibular premolars, and incisors are frequently selected because of their simple anatomy and relatively lower incidence of restorations or pathological changes.[7] Specialized software allows accurate segmentation of pulp and tooth structures, improving the precision of measurements.[6]

Several studies have demonstrated a strong inverse relationship between pulp volume and age. As age increases, pulp chamber volume decreases due to continuous dentin deposition.[6] This method is particularly useful in adult age estimation where skeletal indicators become less reliable.[8] It is also advantageous

because it is non-destructive and preserves the tooth structure. In forensic cases involving skeletonized remains or burned victims, age estimation using CBCT can provide valuable information when other biological indicators are unavailable.[3,6] It is also useful in legal cases involving age disputes. However, factors such as attrition, restorations, trauma, and systemic diseases may influence secondary dentin deposition and should be considered during interpretation.[8]

Despite these limitations, CBCT-based evaluation of secondary dentin remains one of the most accurate and clinically applicable methods for dental age estimation and continues to play an essential role in forensic identification.[6]

ROOT CANAL ANATOMY AS AN INDIVIDUAL IDENTIFIER

Root canal morphology is highly variable and represents one of the most individualized aspects of dental anatomy. Variations in the number of roots, number of canals, canal curvature, canal configuration, accessory canals, apical deltas, bifurcations, and unusual anatomical patterns provide unique characteristics that can aid in forensic identification.[10,12]

The complexity of root canal anatomy differs among tooth types and populations. For example, mandibular first molars may have an additional distal canal, maxillary first premolars may present with three canals, and mandibular second molars may exhibit C-shaped canals.[10] Some individuals may show rare variations such as radix entomolaris or dens invaginatus. These anatomical findings can serve as distinctive forensic markers. Conventional radiographs often fail to detect such complex variations because they provide only two-dimensional images.[12] Overlapping structures and angulation errors can lead to inaccurate interpretation. CBCT has greatly improved the evaluation of root canal morphology by allowing three-dimensional assessment in axial, coronal, and sagittal planes.[12] This enables clinicians and forensic experts to visualize intricate anatomical details with greater accuracy.

In forensic investigations, comparison of antemortem and postmortem radiographs is a standard method of identification.[4] When CBCT records are available, root canal morphology can be matched with high precision. Since internal anatomy is highly stable over time and less likely to be altered by environmental damage, it serves as a reliable parameter for identification.

Population-based studies have shown significant ethnic and regional differences in canal morphology. These findings may also help in biological profiling by providing clues regarding ancestry and population origin. For example, C-shaped canals are more common in Asian populations, while certain root variations may be more prevalent in specific ethnic groups.[10]

Root canal anatomy also remains useful in cases where restorations are absent and external tooth morphology is damaged. In burned or fragmented remains, internal canal patterns often remain preserved and detectable through CBCT.[13] This increases the value of root canal anatomy in difficult forensic scenarios. Thus, CBCT assessment of root canal morphology offers both individual identification and supplementary population-based information, making it an important tool in modern forensic odontology.[12]

ENDODONTIC TREATMENT CHARACTERISTICS IN FORENSIC IDENTIFICATION

Previous dental treatment often provides some of the strongest evidence for personal identification because treatment outcomes are highly individualized.[11] Endodontically treated teeth possess numerous distinctive features that can serve as forensic markers. These include access cavity design, canal preparation patterns, obturation length and density, type of sealer used, posts and cores, retreatment changes, missed canals, perforations, separated instruments, and evidence of apical surgery.[13]

No two endodontic treatments are exactly identical because results depend on the operator's skill, anatomical complexity, clinical decisions, and patient-specific factors.[13] For example, an overextended gutta-percha point beyond the apex, a broken endodontic file lodged in the canal, or a missed mesiobuccal second canal in a maxillary molar may create highly distinctive features that are unlikely to be duplicated in another individual.[13]

CBCT provides excellent visualization of these treatment characteristics. It allows accurate assessment of obturation quality, canal filling extent, perforations, internal and external resorption, root fractures, and periapical lesions.[1] Metallic posts and fractured instruments can be precisely localized, and retreatment procedures can be identified more clearly than with conventional radiographs.[12] Even failed endodontic treatments can have strong forensic significance. Missed canals, ledges, transportation, perforations, and separated instruments often produce irregular and highly specific patterns that become useful identifiers.[13] In some cases, these unique findings may provide stronger evidence than ideal root canal treatments because of their unusual presentation.

Comparison of antemortem and postmortem radiographs of endodontically treated teeth is considered strong forensic evidence. A properly documented root canal treatment can confirm identity with high confidence, especially when multiple matching features are present.[13] This highlights the importance of maintaining detailed clinical records, including preoperative, working length, master cone, and postoperative radiographs.

With the increasing use of bioceramic sealers, fiber posts, and advanced endodontic materials, new radiographic patterns are being introduced into forensic practice.[14] These materials may create distinctive signatures that improve identification accuracy. Therefore, endodontic treatment characteristics represent a highly valuable component of forensic identification, and CBCT significantly enhances their diagnostic and comparative value.[13]

ROLE OF CBCT IN MODERN FORENSIC ODONTOLOGY

Cone Beam Computed Tomography has become one of the most important technological advancements in forensic dentistry.[1] It provides high-resolution three-dimensional imaging of the maxillofacial region with relatively low radiation exposure compared to conventional medical CT.[15] Its ability to produce isotropic voxels and multiplanar reconstructions makes it especially suitable for dentomaxillofacial analysis.[16]

In forensic odontology, CBCT is used for age estimation, dental identification, assessment of trauma, craniofacial reconstruction, bite mark analysis, and evaluation of skeletal remains. It allows detailed examination of teeth, alveolar bone, maxillary sinuses, temporomandibular joints, and jaw relationships, all of which may contribute to personal identification.[15]

One of the major advantages of CBCT is the elimination of image superimposition. Conventional radiographs may hide critical structures because of overlapping anatomy, whereas CBCT provides separate views from multiple planes.[1] This is particularly important in evaluating root canal anatomy and post-treatment changes. CBCT is also useful in identifying developmental anomalies such as impacted teeth, supernumerary teeth, taurodontism, and enamel pearls. These uncommon findings can serve as individual identifiers. Craniofacial characteristics visible on CBCT may provide additional support for establishing identity when dental evidence alone is insufficient.[3]

In mass disasters and severely burned bodies, CBCT allows non-invasive examination without damaging remains.[4] Digital records can be stored, shared, and compared rapidly, improving the efficiency of forensic investigations. As more dental clinics adopt CBCT in routine practice, the availability of antemortem scans for forensic comparison is expected to increase significantly.[11]

However, certain limitations remain. CBCT equipment is expensive and may not be available in all forensic centers.[2] Standardized protocols for forensic applications are still developing, and interpretation requires trained professionals. Ethical concerns regarding patient consent, privacy, and long-term storage of dental records must also be addressed.[5] Despite these challenges, CBCT continues to transform forensic odontology by improving accuracy, reliability, and reproducibility in human identification.

FUTURE PERSPECTIVES

The future of forensic identification in endodontics is closely linked with digital dentistry, artificial intelligence, and advanced imaging technologies.[16] Automated software for pulp volume analysis, canal morphology recognition, and treatment pattern detection can reduce operator bias and improve reproducibility.

Artificial intelligence and machine learning models may provide highly accurate age prediction by combining multiple variables such as pulp chamber volume, dentin thickness, root morphology, and treatment history.[6] These systems may become valuable tools in mass disaster victim identification where rapid screening is required. Digital dental record systems integrated with forensic databases could significantly improve access to antemortem information.[5] Standardization of CBCT protocols for forensic purposes may further enhance reliability and legal acceptance.

Regenerative endodontics may also introduce new forensic considerations. Newly formed tissues following regenerative procedures may alter conventional age estimation methods and create new radiographic patterns requiring interpretation. Similarly, advanced biomaterials and bioactive sealers may produce unique radiographic appearances useful in identification.[14]

Interdisciplinary collaboration among endodontists, oral radiologists, forensic odontologists, and legal authorities will be essential for maximizing the benefits of these technologies in future forensic practice.[3,4]

CONCLUSION

Forensic identification through dental evidence remains one of the most reliable methods of human identification, especially when conventional methods are not possible. Teeth provide durable and individualized evidence that can withstand extreme physical and environmental conditions. In endodontics, secondary dentin deposition, root canal morphology, and endodontic treatment characteristics serve as important forensic markers for age estimation and personal identification. CBCT has significantly enhanced this field by enabling accurate three-dimensional evaluation of internal tooth structures and treatment-related changes. Secondary dentin aids in age estimation, root canal anatomy supports individual identification, and endodontic treatment patterns provide unique radiographic markers. With the increasing use of CBCT and digital dental records, the role of endodontics in forensic odontology continues to grow, improving the accuracy and reliability of medico-legal investigations.

REFERENCES

1. Patel S, Durack C, Abella F, Shemesh H, Roig M, Lemberg K. Cone beam computed tomography in Endodontics – a review. Int Endod J. 2015;48(1):3-15.
2. Khanna AB. Applications of cone beam computed tomography in endodontics. Evid Based Endod. 2020;5(1):1.
3. Krishan K, Kanchan T, Garg AK. Dental evidence in forensic identification – an overview, methodology and present status. Open Dent J. 2015;9:250-256.
4. Shah P, Velani PR, Lakade L, Dukle S. Teeth in forensics: A review. Indian J Dent Res. 2019;30(2):291-299.
5. Bansode SC, Kulkarni MM. Importance of dental records in forensic identification. J Forensic Dent Sci. 2009;1(2):75-77.
6. Pinchi V, Pradella F, Buti J, Baldinotti C, Focardi M, Norelli GA. A new age estimation procedure based on the 3D CBCT study of the pulp cavity and hard tissues of the teeth for forensic purposes. Sci Rep. 2015;5:14298.
7. Jagannathan N, Neelakantan P, Thiruvengadam C, Ramani P, Premkumar P, Natesan A, et al. Age estimation in an Indian population using pulp/tooth volume ratio of mandibular canines obtained from cone beam computed tomography. J Forensic Odontostomatol. 2011;29(1):1-6.
8. Verma M, Verma N, Sharma R, Sharma A. Dental age estimation methods in adult dentitions: An overview. J Forensic Dent Sci. 2019;11(2):57-63.
9. Nanci A. Ten Cate's Oral Histology: Development, Structure, and Function. 9th ed. St. Louis: Elsevier; 2017.
10. de Pablo OV, Estevez R, Peix Sánchez M, Heilborn C, Cohenca N. Root anatomy and canal configuration of the permanent mandibular first molar: A systematic review. J Endod. 2010;36(12):1919-1931.
11. Forrest AS, Wu HY. Endodontic imaging as an aid to forensic personal identification. Aust Endod J. 2010 Aug;36(2):87-94. doi: 10.1111/j.1747-4477.2010.00242.x.
12. Matherne RP, Angelopoulos C, Kulild JC, Tira D. Use of cone-beam computed tomography to identify root canal systems in vitro. J Endod. 2008;34(1): 87-89.
13. Jayasenthil A, Sathish ES, Divyambika CV, Karthik K, Maheswaran T, Nivethitha S.

Forensic identification of endodontically treated teeth after heat-induced alterations: An in vitro study. J Forensic Dent Sci. 2021; 13(1):1-7.

14. Schwartz RS, Robbins JW. Post placement and restoration of endodontically treated teeth: A literature review. J Endod. 2004;30(5): 289-301.

15. Scarfe WC, Levin MD, Gane D, Farman AG. Use of cone beam computed tomography in endodontics. Int J Dent. 2009;2009:634567.

16. Venskutonis T, Plotino G, Juodzbalys G, Mickevičienė L. The importance of cone-beam computed tomography in the management of endodontic problems: A review of the literature. J Endod. 2014;40(12):1895-1901.