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EDITORIAL

Artificial Intelligence and the Emerging Epistemology of Forensic Odontology: A Southeast Asian Perspective

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Abstract

Artificial intelligence (AI) is redefining forensic odontology through automated dental identification, radiographic comparison, biological age estimation, image segmentation, and disaster victim identification. Its application in Southeast Asia warrants particular scrutiny because population heterogeneity, variable dental records, differences in imaging infrastructure, and diverse clinical practices may compromise the external validity of algorithms developed elsewhere. Responsible implementation of AI requires population-representative datasets, multi-center validation, calibration, transparent reporting, uncertainty assessment, and preservation of evidentiary integrity. AI-derived outputs must remain auditable and subject to expert interpretation within established medico-legal frameworks. Forensic education must consequently incorporate data literacy, algorithmic bias, validation methodology, digital ethics, and cybersecurity alongside conventional competencies. Regional collaboration could enable harmonized data standards and representative repositories. Ultimately, AI should augment rather than replace forensic odontological judgment, with its evidentiary legitimacy determined by scientific validation, transparency, contextual applicability, and accountable human oversight.

Keywords: Artificial intelligence; Forensic odontology; Human identification; Southeast Asia; Algorithmic bias

Forensic odontology occupies a unique distinctive position at the intersection of dental science, human identification, jurisprudence and humanitarian investigation. Its evidentiary value derives from the durability as well as the morphological diversity of dental structures, the longitudinal nature of clinical records and the ability of trained experts to reconcile ante-mortem and post-mortem information. Today, the advances that have taken place in the utilization of artificial intelligence (AI), cutting-edge imaging and digital data infrastructures is altering this discipline. This transformation calls not merely for the adoption of new technologies, but for a key reconsideration of how forensic odontological knowledge is generated, validated, and translated into sound scientific conclusions.

AI has possible applications throughout the forensic workflow. Deep-learning systems may facilitate automated tooth detection and numbering, segmentation of maxillofacial structures, recognition of restorations and prostheses, biological age estimation, radiographic comparison, and prioritization of candidate identities. When combined with modern day imaging modalities such as panoramic radiography, cone-beam computed tomography, intraoral scanning and three-dimensional reconstruction, computational models may detect intricate morphological patterns that are difficult to quantify through visual assessment alone. In mass-fatality incidents or disasters such systems would accelerate data processing, improve case triage and support multidisciplinary teams working under considerable temporal and logistical limitations.

These possibilities are particularly relevant to the Southeast Asian region as this area encompasses substantial genetic, ethnic, cultural and socioeconomic diversity, together with considerable variation in oral disease patterns, dental treatment practices, access to care and the availability of longitudinal dental records. It is also exposed frequently to natural disasters, transportation incidents, population displacement, migration and transnational movement—circumstances in which rapid and reliable human identification may become a humanitarian and medicolegal priority.

At the same time, the Southeast Asian context presents distinctive scientific challenges. Algorithms developed using datasets from comparatively homogeneous populations or highly digitized medical systems may not generalize reliably to the mixed populations and clinical environments of this region. Variations in dental morphology, patterns of tooth loss, restorative materials, imaging quality and record-keeping systems may affect model effectiveness. Regionally underrepresented populations

may consequently experience greater classification error, producing a form of algorithmic inequity with profound forensic implications.

Computational accuracy must therefore not be confused with forensic validity as a model may perform impressively within a validated dataset yet, remain insufficiently calibrated across countries, demographic groups, imaging devices or pathological conditions. Dataset imbalance, annotation variability, spectrum bias, as well as institutional heterogeneity can generate systematic inaccuracies that are concealed by aggregate performance statistics. Southeast Asian institutions and organizations should therefore prioritize multi-center datasets, externally validated models, and reporting frameworks that subgroup performance, assess uncertainty, calibrate models, and analyze clinically relevant errors.

The evidentiary use of AI also requires transparent documentation of model provenance, training data characteristics, preprocessing procedures, decision thresholds and human oversight. Computational outputs must remain auditable within established chains of custody and compatible with the procedural mandates of individual legal jurisdictions. The forensic odontologist retains responsibility for integrating biological findings, reconciling discordant evidence and communicating uncertainty with appropriate restraint. AI should function as an instrument of augmented intelligence—not as an autonomous arbiter of identity.

Education must evolve concurrently. Future forensic odontologists require competence not only in dental anatomy, pathology, radiographic interpretation, disaster victim identification and expert testimony, but also in data literacy, algorithmic bias, model validation, digital ethics and cybersecurity. Simulation-based education using virtual cases, three-dimensional datasets and AI-assisted matching environments can provide structured exposure to complex identification scenarios. Importantly, learners must be trained to interrogate algorithmic recommendations, recognize failure modes and independently defend their conclusions.

Southeast Asia is well positioned to contribute a new intellectual and scientific perspective to global forensic odontology. Regional collaboration should facilitate interoperable dental records, harmonized data standards, multilingual forensic platforms and population-representative repositories developed under robust ethical supervision. Such initiatives should respect national sovereignty, privacy, cultural concerns and the dignity of deceased persons and their families.

The future of forensic odontology will not be determined by whether machines replace expert judgment, but by how responsibly artificial intelligence is integrated with sound biological knowledge, ethical accountability as well as contextual insight. AI can definitely expand the analytical reach of forensic science; its legitimacy in Southeast Asia and beyond will depend upon representative evidence, transparent governance, detailed validation and professionals educated to use it critically.

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