www.sada.co.za / SADJ Vol. 81 No.4

AI in the Dental Surgery: From Diagnostic Aid to Practice Partner – A Strategic & Ethical Framework

SADJ MAY 2026, Vol. 81 No.4 P230-P242

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Beyond the Hype: The Practical Arrival of AI in Dentistry
Artificial Intelligence has transcended buzzword status and entered the tangible reality of dental practice. No longer a speculative future technology, it is an active clinical tool, offering capabilities that are simultaneously revolutionary and deeply practical. However, its integration demands more than a software purchase; it requires a profound understanding of its applications, limitations, and the complex ethical terrain it creates. For the South African dentist, the challenge is not *if* to adopt AI, but *how* to adopt it responsibly, professionally, and with a clear-eyed view of the legal and moral landscape.

CONCRETE APPLICATIONS: THE AI TOOLBOX IN MODERN PRACTICE

The true power of AI lies not in replacing the clinician, but in augmenting human perception and analysis. Here is what it does today:

1. Enhanced Diagnostic Precision on 2D Radiographs

- Caries Detection: AI algorithms, trained on millions of annotated images, can identify demineralisation and proximal caries with sensitivity often surpassing the human eye, especially in early stages or in dense, overlapping anatomical areas. They serve as a powerful «second look,» reducing false negatives.
- Periodontal Bone Loss Analysis: AI can automate the measurement of bone levels around each tooth across full-mouth series, creating consistent, quantitative baseline data and tracking subtle changes over time that might be overlooked in a visual assessment.
- Pathology Screening: Algorithms are increasingly adept at flagging anomalies – from periapical lesions and root fractures to incidental findings like calcifications in soft tissue – prioritising them for the dentist›s review.

2. Three-Dimensional Intelligence in CBCT & Digital Impressions:

- Automated Anatomy Mapping: In CBCT scans, AI can instantly segment and identify critical structures: the mandibular canal, mental foramen, maxillary sinuses, and tooth roots. This drastically reduces preoperative planning time for implants and surgical extractions and enhances safety.
- Virtual Implant Planning: AI can suggest optimal implant size, positioning, and angulation based on bone density, anatomy, and prosthetic goals, creating a data-driven starting point for the clinician›s plan.
- Orthodontic & Restorative Analysis: On 3D intraoral scans, AI can perform automated tooth segmentation, occlusal analysis, and even predict tooth movement or propose restorative tooth preparations, standardising aspects of the digital workflow.

3. Administrative & Predictive Practice Intelligence:

- Treatment Plan Support: By analysing historical practice data, AI can suggest common treatment sequences or flag potentially missed diagnoses based on patterns in charting and radiographs.
- Patient Communication & Scheduling: AI-powered chatbots can handle initial FAQs and appointment requests, while predictive algorithms can forecast cancellations to optimise the appointment book.

THE CRITICAL QUESTIONS: NAVIGATING LIABILITY, DATA, AND ETHICS

Adopting AI without addressing these core issues is professionally perilous. The HPCSA and South African law provide the overarching principles, but the specifics are evolving.

1. The Liability Labyrinth: Who is Responsible for an AI Error?

The foundational principle is *inalienable clinician responsibility*. AI is a diagnostic aid, not a diagnostician. The HPCSA's ethical rules make the treating dentist ultimately liable for all clinical decisions.

- Scenario: An AI fails to flag a subtle osteolytic lesion on a panoramic radiograph, and the dentist, relying on the AI›s «clear» assessment, also misses it. Who is liable?
- Answer: The dentist. The standard of care requires a dentist to personally review and interpret all diagnostic images. The AI›s output is one piece of information in the clinician›s decision-making process. The clinician must be able to understand the AI›s limitations and override its suggestions. **Your indemnity insurer must be informed of your AI use, and your clinical notes should reflect your independent review (e.g., "AI-assisted caries detection software indicated potential caries on tooth 36; this was confirmed on visual and radiographic review").**

2. The Data Dilemma: How is Patient Data Used to Train Algorithms?

This is a paramount privacy and ethical concern. Most AI companies use de-identified patient data to train their models.

- Key Questions for Vendors: Before purchasing any AI software, practices must ask: Was the training data used to develop this algorithm sourced with explicit patient consent? Is it **de-identified** (all personal and metadata removed) to POPIA and international standards? Where are the servers hosting this data located (data sovereignty)? Does your licence agreement grant the company rights to use your practice›s data to further train their models?

- **The Local Imperative:** Algorithms trained predominantly on Northern European or North American populations may not perform optimally on the diverse skeletal, dental, and pathological presentations common in South Africa. This creates a clinical risk and an opportunity for locally developed, representative AI.

PROPOSING A SOUTH AFRICAN FRAMEWORK FOR ETHICAL AI ADOPTION

To guide safe integration, we propose a five-pillar framework for dentists and the broader profession:

Pillar 1: Validation & Context-Specificity

- **Action:** Before implementation, demand peer-reviewed, independent validation studies for any AI tool. Specifically, ask if it has been validated on a South African or similar demographic dataset. The onus is on the vendor to provide this evidence.

Pillar 2: Continuous Education & "AI Literacy"

- **Action:** Dentists must pursue CPD that explains not just how to *use* AI, but how it *works*—its strengths, failure modes (e.g., over-reliance on training data patterns), and biases. Understanding concepts like sensitivity, specificity, and confidence intervals for AI outputs is now part of clinical competence.

Pillar 3: The "Human-in-the-Loop" Protocol

- **Action:** Establish an in-practice protocol mandating that all *AI outputs must be verified and signed off by a qualified dentist*. AI should be a "co-pilot," not an autopilot. This must be documented in clinical records.

Pillar 4: Transparent Patient Communication

- **Action:** Update informed consent processes. Patients should be told when AI is used as part of their diagnostic workflow, its role as an assistive tool, and that ultimate responsibility remains with the dentist. This builds trust and manages expectations.

Pillar 5: Professional Body Leadership (The SADA Mandate)

- **Action:** SADA must proactively:

1. Engage the HPCSA to develop clear, anticipatory guidelines on AI use in dentistry.
2. Create a vendor assessment checklist for members, covering liability, data privacy, and validation.
3. Foster research partnerships to develop and validate AI tools on African data.
4. Establish a forum for members to share experiences, report anomalies, and build collective wisdom.

Conclusion: The Augmented Dentist

The future belongs not to AI, but to the **augmented dentist** – the professional who wields these powerful tools with skill, scepticism, and unwavering ethical commitment. AI will not make the dentist obsolete; it will make the unskilled or uncritical dentist obsolete.

The goal is a synergistic partnership: AI handles pattern recognition at scale and superhuman consistency, freeing the clinician to focus on complex judgment, treatment planning, surgical skill, and the irreplaceable human elements of empathy, communication, and trust.

For the South African practice, thoughtful AI adoption is a strategic imperative. It elevates diagnostic standards, enhances patient safety, and streamlines practice economics. However, it must be built on a foundation of rigorous professional ethics, robust data stewardship under POPIA, and an unshakeable commitment to the dentist's role as the final, accountable clinical authority.

Embrace the tool. Uphold the principle. Lead the evolution. The most intelligent system in the surgery must always remain the informed, ethical mind of the dentist.

