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AI-driven Implant Dentistry & Its Influence on Peri-implant Bone Levels

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Artificial intelligence (AI) is rapidly entering implant dentistry: from automated CBCT analysis and bone-quality estimation to prosthetically driven planning, dynamic navigation/robotic placement, and predictive models for peri-implant disease. Early evidence shows AI tools can accurately detect marginal bone loss on radiographs and improve planning/placement accuracy both of which are plausibly linked to better peri-implant bone preservation. However, high- quality longitudinal clinical data that directly demonstrate improved long-term bone levels because of AI workflows remain li **Where AI is being applied in implant workflows**

1. **Image analysis / diagnosis** deep learning models can detect implants and quantify peri- implant marginal bone loss on periapical and panoramic images and CBCT, with reported accuracies and sensitivities approaching those of human readers in many studies. These tools aid early detection and screening. [4]

2. **Bone quality/quantity assessment** AI models applied to CBCT can estimate bone mineral density or classify bone quality/volume, supporting selection of implant size, location, and immediate loading decisions. 3

3. **Treatment planning automation** implant planning software increasingly includes automatic implant proposals (prosthetically driven), nerve detection and collision warnings, often using large training databases and rule-based + AI assistants to speed and standardize planning.

4. **Surgical guidance: static guides → dynamic navigation → robotic systems** AI components are integrated in dynamic navigation and robotic systems that track drills/implants in real time and adapt to planned trajectories, improving placement accuracy and consistency. [5]

5. Predictive analytics machine-learning models using clinical, radiographic and patient data can predict risk of peri-implantitis and implant failure, potentially enabling individualized prevention and recall intervals. 5

How AI-driven steps can influence peri-implant bone levels (mechanisms)

- **Improved diagnostic sensitivity → earlier intervention.** AI detection of marginal bone loss can identify subtle progression earlier than routine visual review, enabling timely peri-implant therapy to halt bone loss. Evidence: systematic reviews show high accuracy of AI for peri-implant bone loss detection on radiographs. [2]

- **Better preoperative assessment of bone quality/quantity → optimized implant selection & site management.** AI-derived bone quality metrics from CBCT can guide decisions about grafting, implant diameter/length and immediate loading — factors that affect crestal bone remodeling. [3]

- **More accurate implant positioning → reduced biologic and mechanical complications.** Multiple studies and systematic reviews report that computer-assisted (static/dynamic) and robotic systems yield smaller positional deviations (depth, angular, lateral) vs freehand. Improved 3D accuracy reduces proximity to anatomic structures and avoids suboptimal angulation that can compromise bone or prosthetic contours. By reducing surgical trauma and malposition, this plausibly lowers early crestal bone loss. [5]

- **Predictive risk stratification → tailored maintenance.** ML models for peri-implantitis risk permit targeted maintenance and closer monitoring of high-risk patients, which can help preserve bone over time. [3]

Practical clinical implications (current best practice suggestions)

- Use AI-assisted image tools as **adjuncts** for screening and measurement they can improve detection sensitivity, but clinicians should corroborate AI outputs with clinical and radiographic assessment. [1]
- Incorporate AI-informed bone quality assessment into preoperative planning to inform grafting or implant selection decisions, while acknowledging device-specific validation. [3]
- For cases where ideal implant position is critical (esthetic zone, limited bone), consider computer-assisted static/dynamic guides or robotic systems to reduce placement error recognizing that improved placement accuracy is likely to reduce biologic/technical stressors on crestal bone. [5]
- Use predictive models where validated to stratify recall intervals and preventive care in high-risk patients but only after local validation of the model performance. [3]

AI has clear potential to influence peri-implant bone health through earlier diagnosis, improved bone assessment, more accurate implant placement, and individualized risk prediction. Current evidence supports the *diagnostic and technical accuracy* of AI-enabled tools and computer- assisted placement systems, but direct proof that these technologies reduce long-term marginal bone loss remains limited. High-quality prospective clinical trials and robust external validations are the next essential steps. [2,6]

References

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