



Learning Analytics in Dental Anatomy

Evaluation of Drawing-Based Assessments and Perspectives for AI-Assisted Feedback – A Pilot Study

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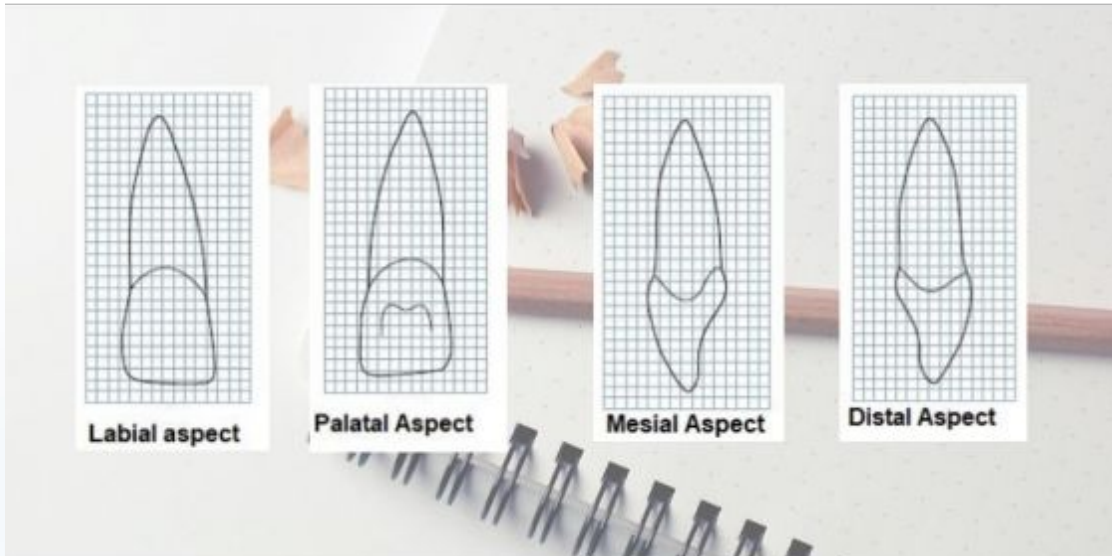
Medical University of Silesia, Poland

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Context of Dental Education

Foundations of Practice

Dental anatomy is a fundamental subject in the 1st year of dental medicine. Mastery of tooth morphology, arches, and periodontal structures is a **prerequisite** for clinical success in restorative dentistry and prosthodontics.



Manual drawing remains a key educational tool for enhancing **spatial reasoning** and hand-eye coordination.

- Experiment initiated in response to students' feedback
- Students reported difficulties with manual dental anatomy tasks
- No clearly defined assessment criteria were available
- Evaluation was mainly based on the clinician's experience
- Assessment therefore depended partly on subjective judgment

Challenges in Traditional Assessment



Manual Effort

Grading dozens of paper drawings is highly time-consuming for instructors, leading to delays in feedback.



Subjective Evaluation

Traditional assessment often lacks standardization. Variation between instructors can lead to inconsistent outcomes and a loss of valuable educational data that is rarely utilized beyond the final grade.

| Study Objectives

Goal

To analyze learning outcomes based on anonymized manual dental anatomy drawings and identify recurrent error patterns within the submitted works.

The study aims to transform traditionally subjective assessment into a more structured and data-driven evaluation process, forming the basis for AI-assisted formative feedback tools.

✓ **Systematic outcome analysis**

Evaluation of anonymized drawing samples to identify common strengths, weaknesses and learning difficulties.

✓ **Error pattern identification**

Detection of recurrent mistakes in tooth morphology, proportions, spatial orientation and anatomical details.

✓ **Misconception mapping**

Linking observed drawing errors with possible gaps in anatomical understanding.

✓ **Standardized assessment framework**

Development of more objective criteria for evaluating manual dental anatomy tasks.

✓ **AI-assisted feedback development**

Creation of a foundation for future tools supporting automated analysis and personalized formative feedback.

Study Material and Assessment Framework

Dataset: anonymized database of manual dental anatomy drawings collected within the “Introduction to Prosthodontics” course.

Topics: FDI/Universal numbering, Mühldreiter traits, histology of enamel/dentine.

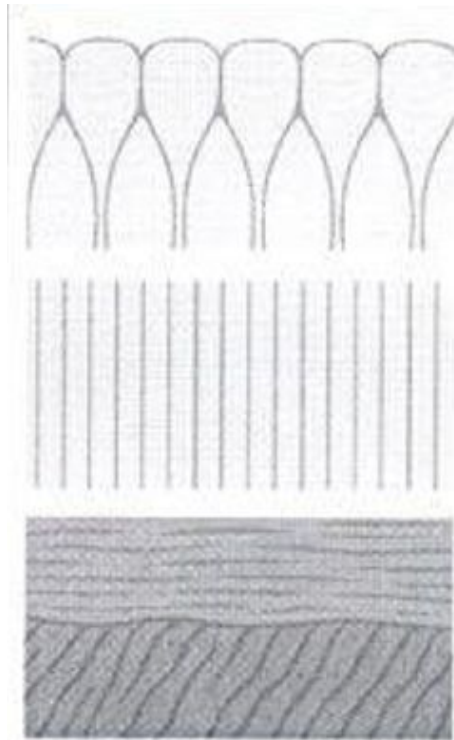
Innovation: Anonymized scans were independently reviewed using a structured rubric and pilot-tested with ChatGPT-assisted evaluation.

Criteria	Focus
Anatomical Accuracy	Shape and proportions
Functional Understanding	Periodontal relations
Graphical Clarity	Presentation and labeling

Study Material and Assessment Framework



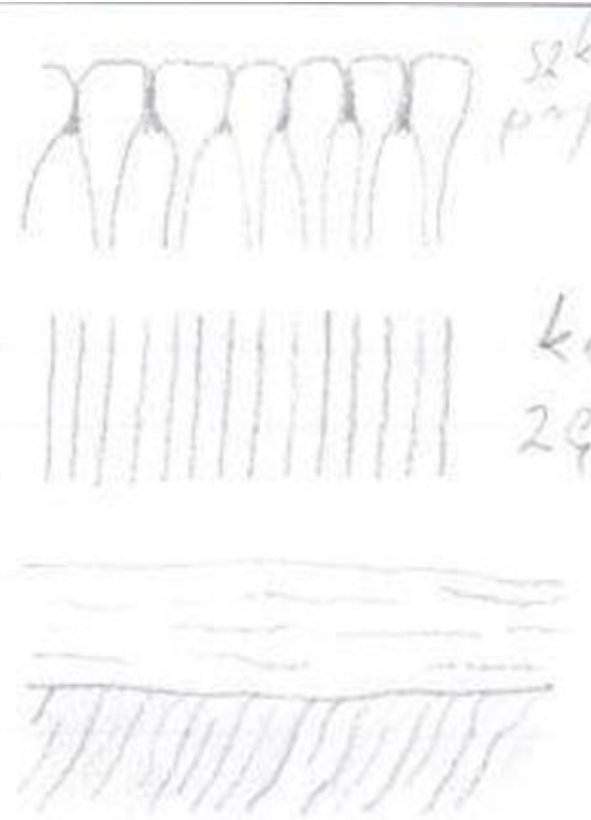
	1	2	3
FDI	3, 5	1, 1	2, 1
Zsigmondy	5	1	1
Amerykański		32	32



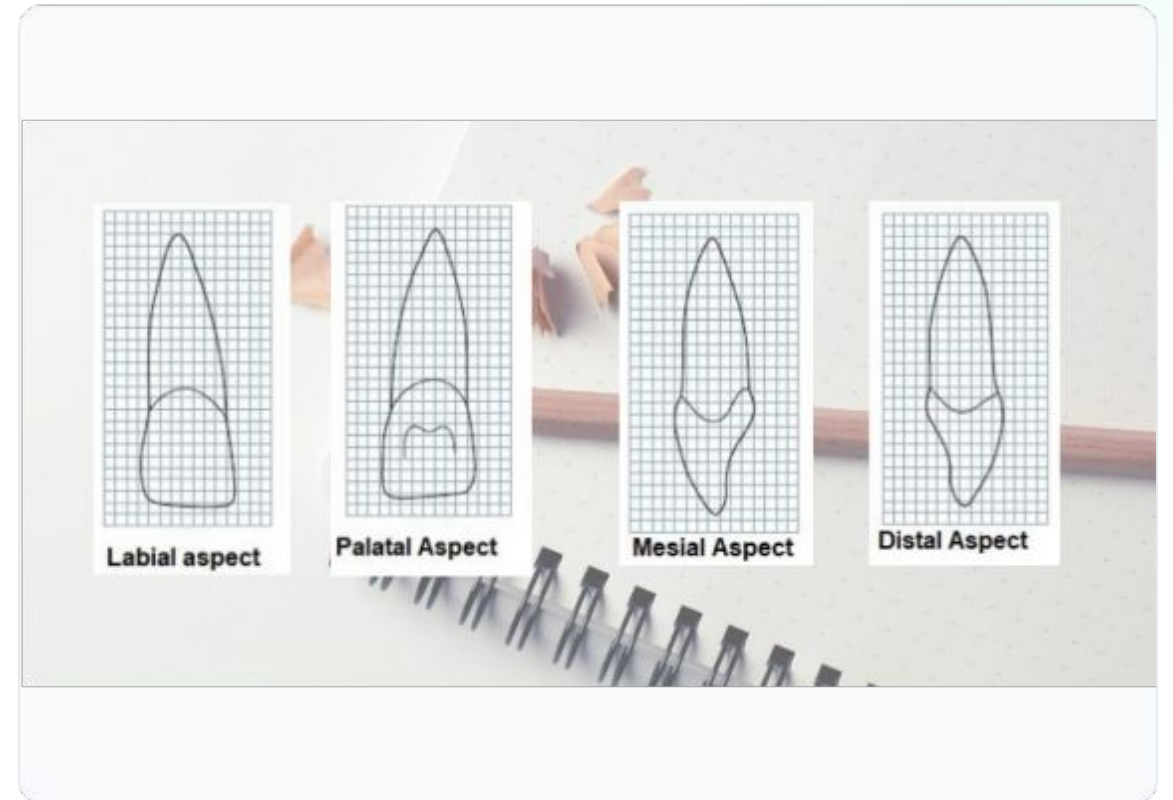
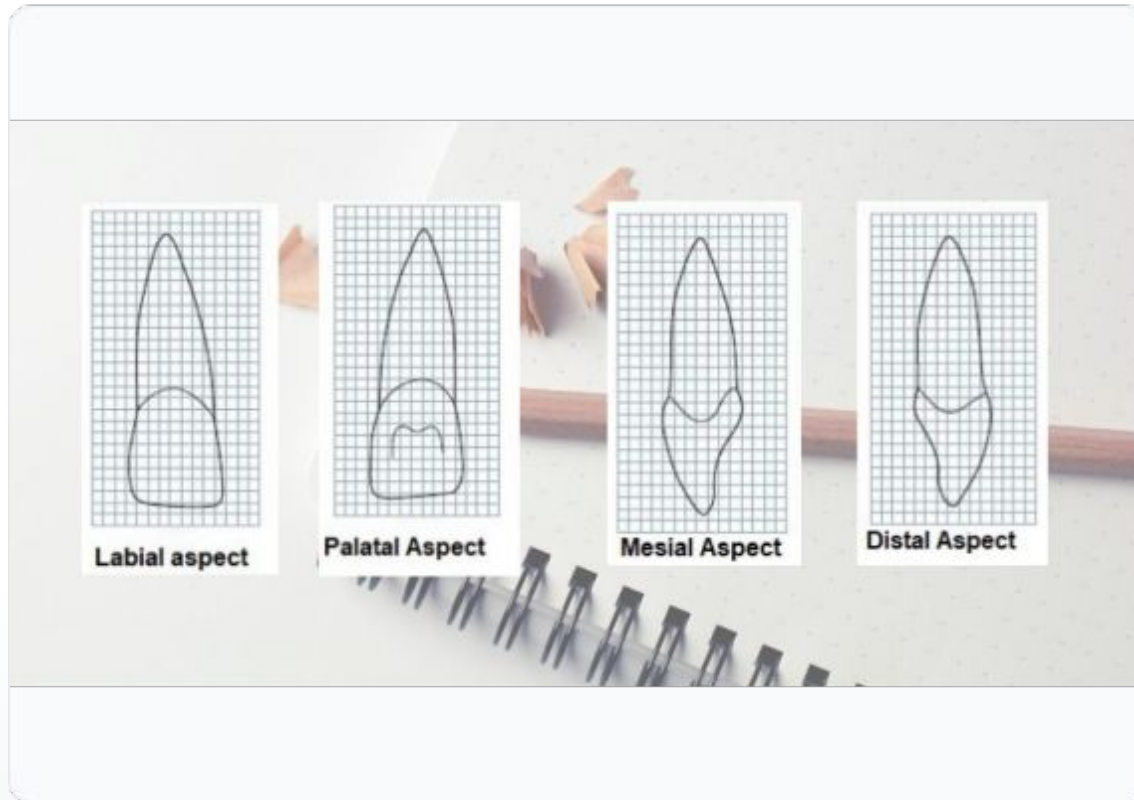
Prismatic
enamel

Dentinal
tubules

Sharpey's
fibers



Visual Assessment Examples



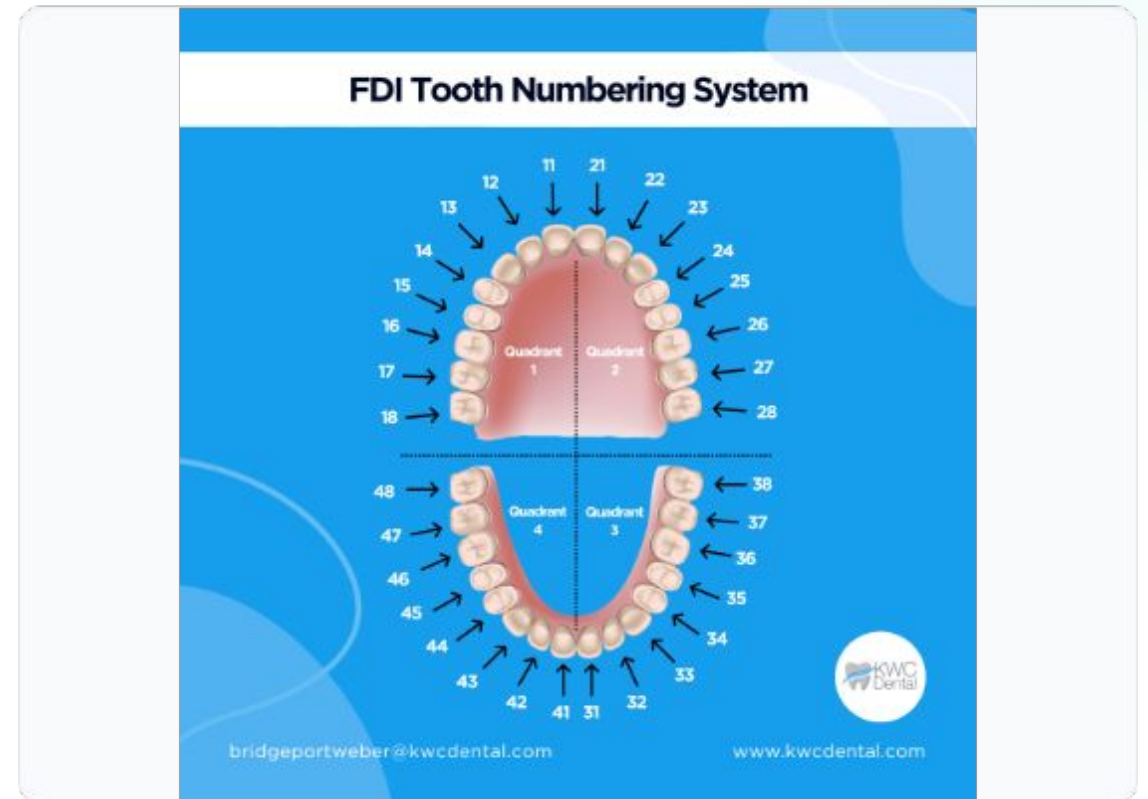
Anonymized assignments showing tooth morphology and numbering exercises.

Key Error Patterns Observed

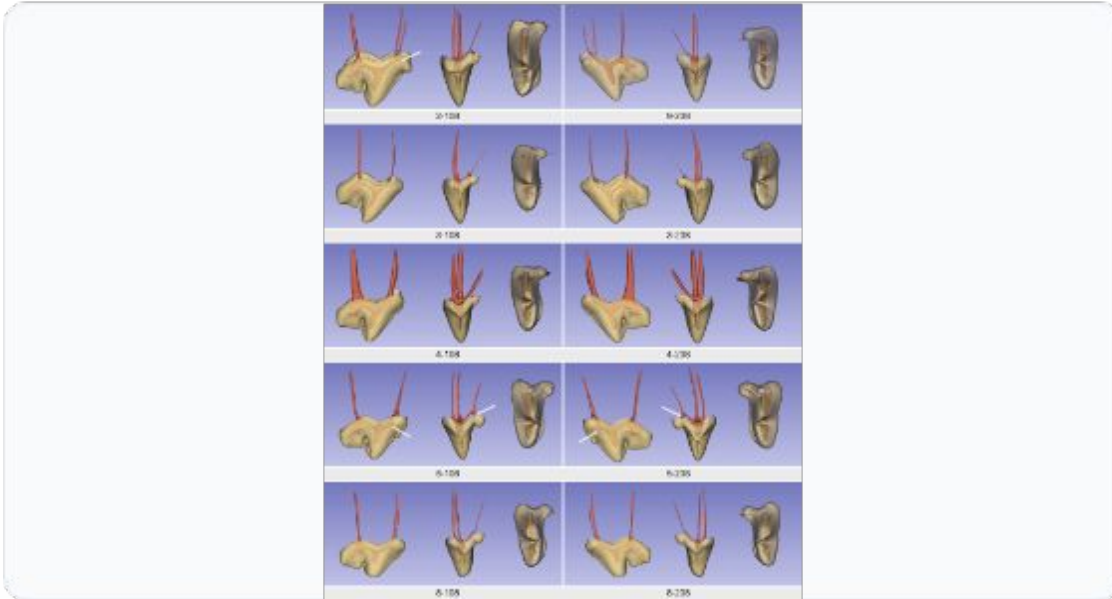


Numbering Confusion

Frequent mixing of **FDI**, **Zsigmondy**, and **Universal** notation systems was observed within the same assignment. Difficulties were particularly evident when the same tooth had to be labeled across multiple systems.



Morphological Misunderstandings



Recurrent Challenges

- **Mühlreiter Traits:** Difficulty differentiating mesial vs. distal features in premolars.
- **Functional Stability:** Poor understanding of periodontal ligament relations.
- **Pattern Recognition:** High success in isolated naming, but low accuracy in integrated visual tasks.

AI Feedback Potential



Computer Vision

Automated extraction of anatomical landmarks from anonymized dental anatomy drawings to detect deviations from a reference model.



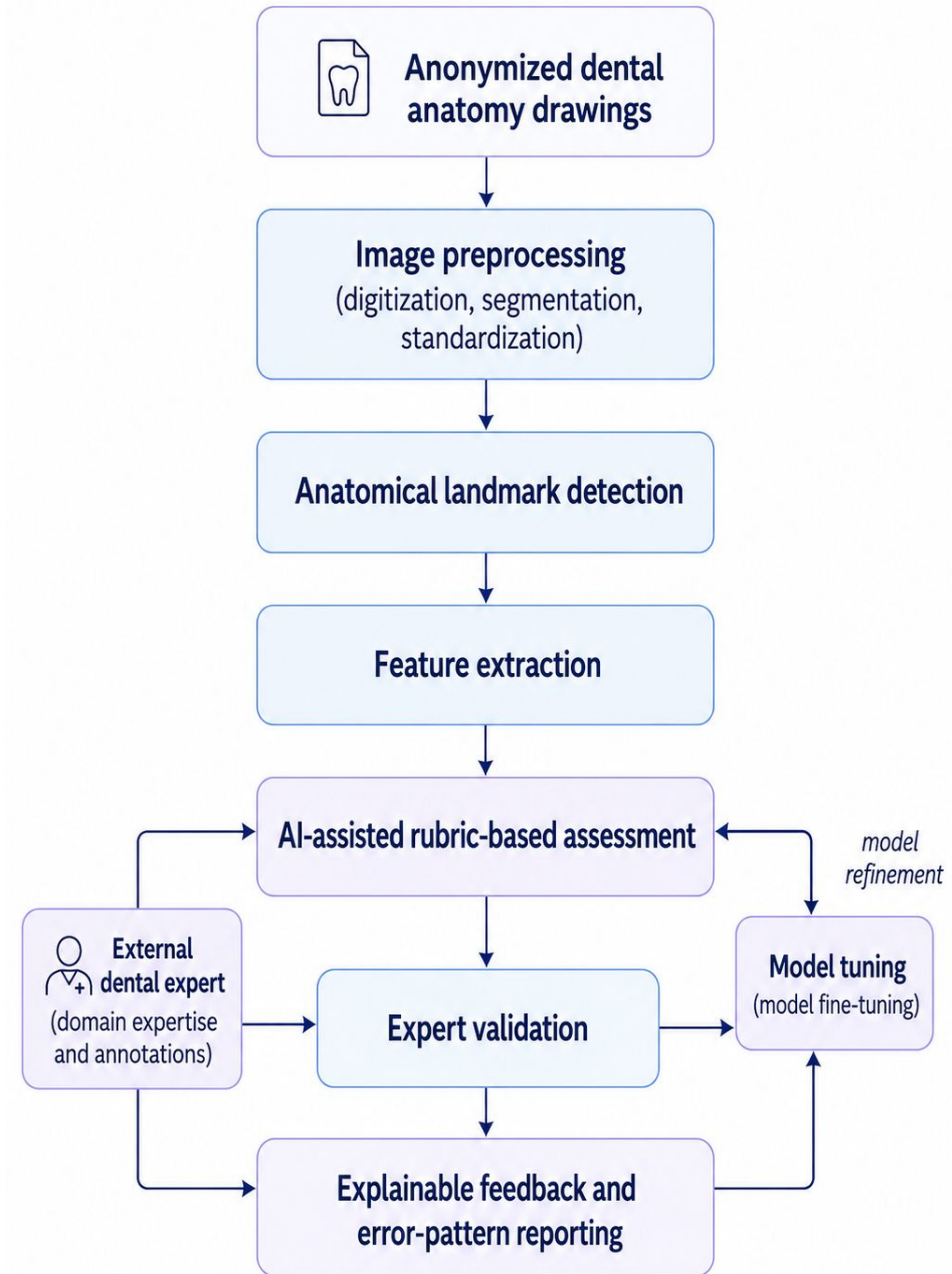
Explainable AI (XAI)

Not only a score, but narrative feedback explaining why a drawing may be anatomically inaccurate and indicating areas for correction.

Proposed AI Framework for Dental Anatomy Assessment

A proposed framework for structured analysis of anonymized dental anatomy drawings and AI-assisted formative assessment.

- **Input:** Anonymized dental anatomy drawings
Preprocessing: Digitization, segmentation and image standardization
- **Analysis:** Computer vision and anatomical feature extraction
- **Evaluation:** Comparison with reference models and structured assessment criteria
- **Output:** Explainable formative feedback and error-pattern reporting



Final Conclusions

Drawing-based assessments are a goldmine of educational data.

Systematic analysis of anonymized dental anatomy drawings allows the identification of specific “danger zones” within the curriculum, particularly in areas such as Mühlreiter traits and the use of multiple dental numbering systems. These recurrent error patterns indicate where learners may require more targeted explanation, additional practice, or improved visual guidance.

The integration of artificial intelligence and learning analytics may support a transition from subjective, experience-based assessment toward a more structured, objective, and data-driven evaluation process. Such an approach can reduce faculty workload, improve consistency between evaluators, and provide a foundation for personalized formative feedback in dental education.

Future Work



Dataset Expansion

Expansion of the anonymized drawing database



Structured drawing templates

Use of graph paper to improve spatial reference and proportional accuracy.



Model Fine-Tuning

Improving computer vision accuracy



Expert-guided AI agent

Rule-based evaluation of anatomical drawings using expert-defined criteria.



Publication

Full study results planned for 2026



Research dissemination

Preparation of a full manuscript and conference follow-up.



Integration

Pilot implementation of an AI-assisted tutoring system



Educational deployment

Testing the system in a controlled teaching environment.

Thank you for your attention!

Department of Materials Science and Artificial Intelligence in Dentistry, Medical University of Silesia

We invite researchers, clinicians and industry partners to collaborate in AI-driven medicine through joint research, AI-based solution development, grant applications and interdisciplinary partnerships.

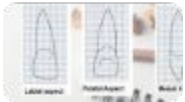
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