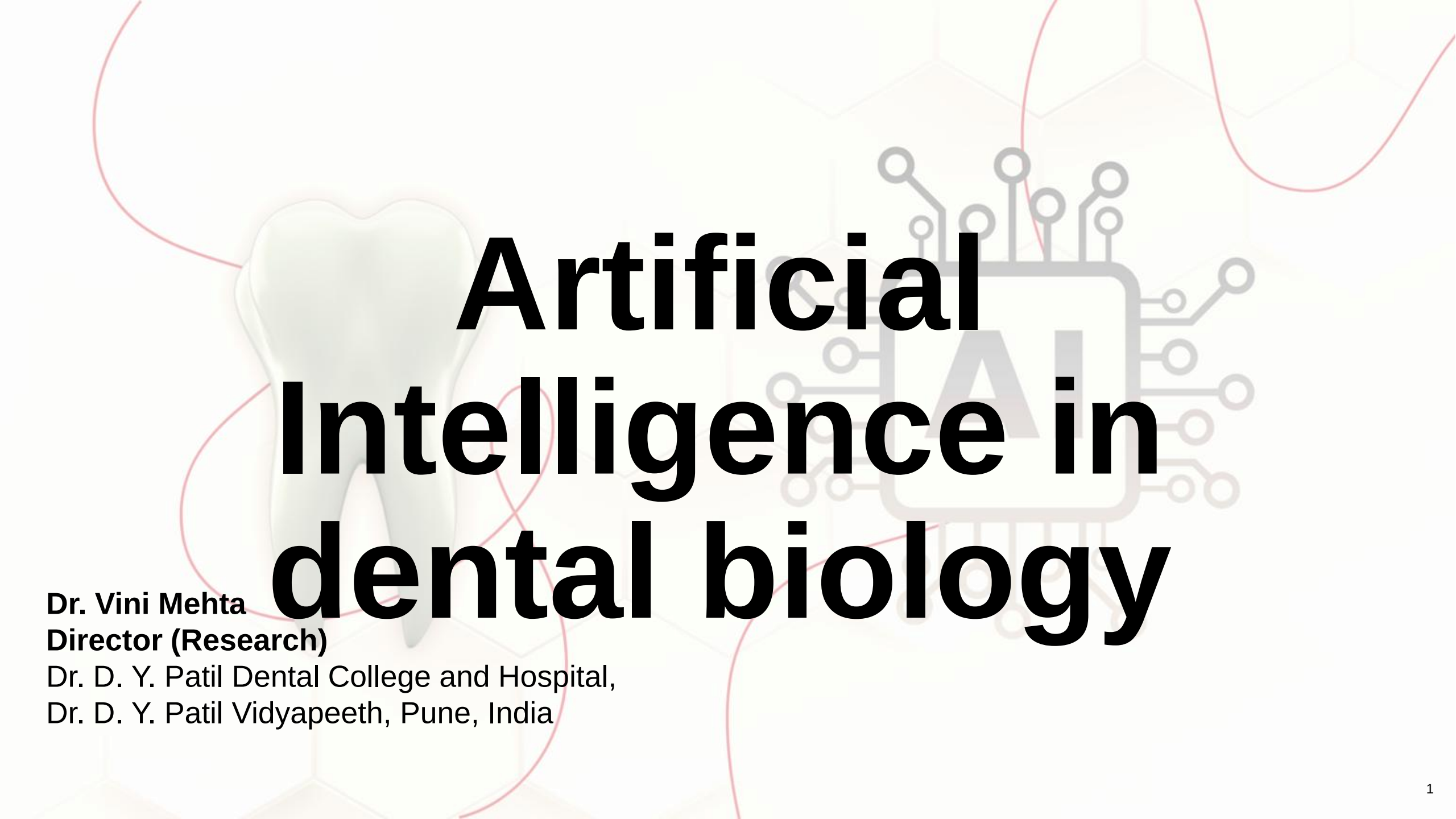




Artificial Intelligence in dental biology

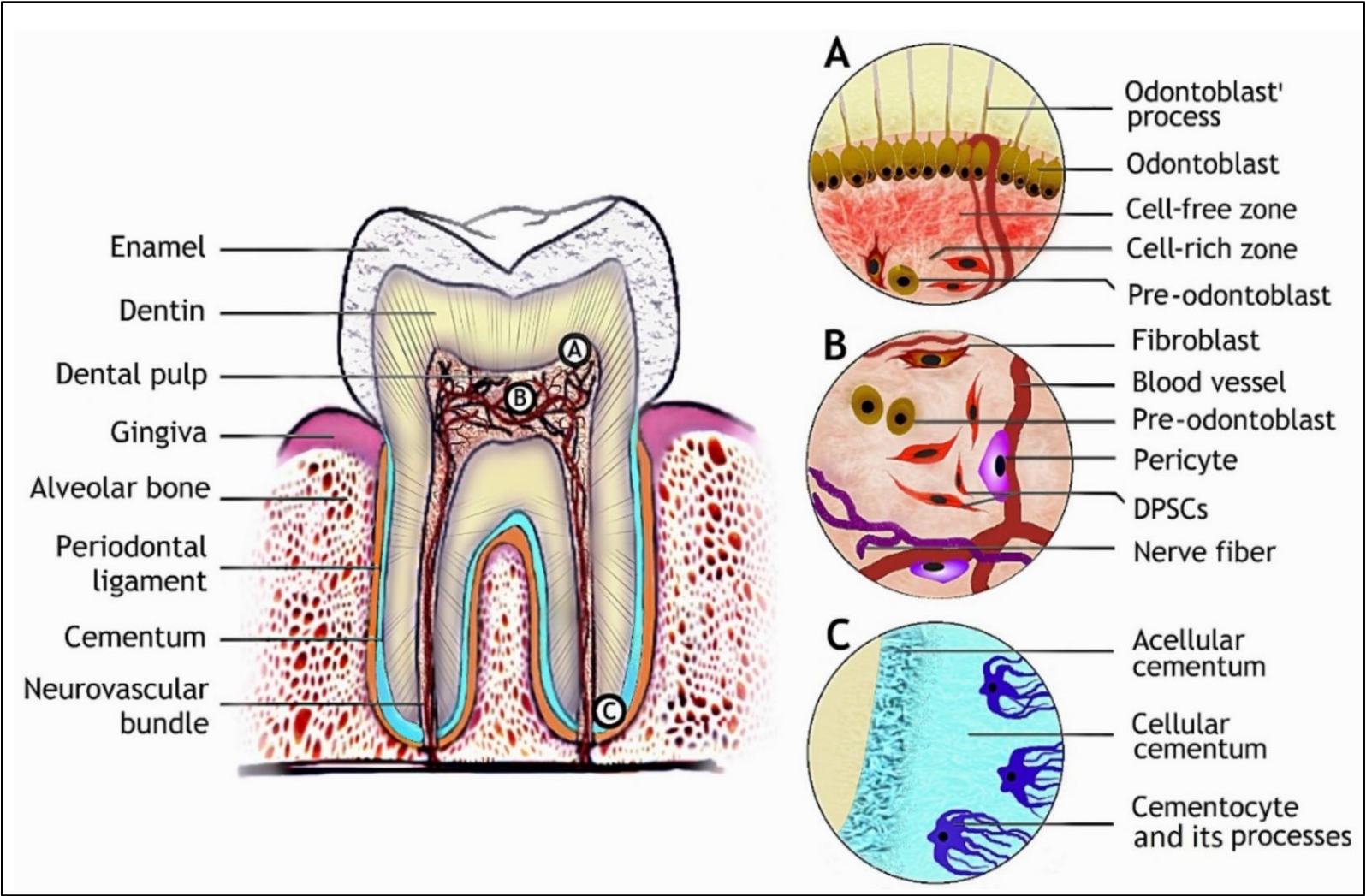
Dr. Vini Mehta

Director (Research)

Dr. D. Y. Patil Dental College and Hospital,

Dr. D. Y. Patil Vidyapeeth, Pune, India

Introduction to dental biology



- Dental biology encompasses the study of the structure, development, function of tooth and its supporting structures along with associated pathologies.
- It comprises of hard dental tissues, soft dental tissues and supporting structures.

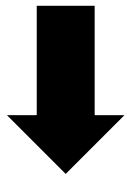
Hard dental tissues	Soft dental tissues	Supporting structures
Enamel	Dental pulp	Cementum
Dentin	Odontoblasts	Periodontal ligament
Cementum	Fibroblasts	Alveolar bone
		Gingiva

Global burden of oral diseases

Oral disease burden

3.5 billion

people globally are affected by oral diseases in 2019

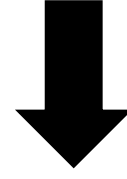


- Untreated dental caries affects 2.5 billion people
- Severe periodontal disease affects 1 billion people
- Complete tooth loss affects 350 million people
- Oral cancer affects 380,000 people

Oral health inequality

3 out of 4

people affected living in middle-income countries in 2019

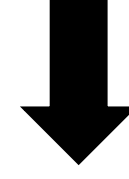


Oral diseases disproportionately affect the most vulnerable and disadvantaged populations with people of low socioeconomic status carrying a higher burden of oral diseases throughout the life course

High economic burden of oral diseases

> 380 billion

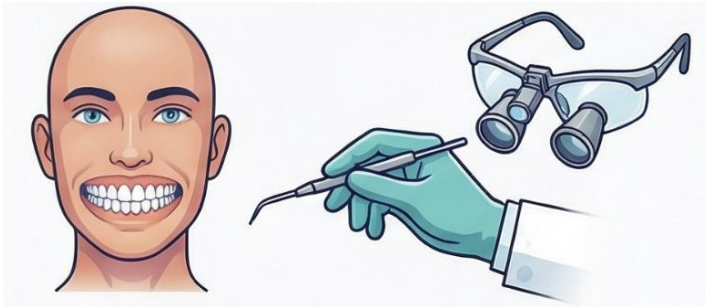
US\$ is spent for the main oral diseases in 2019



This represents about 4.8% of global direct health expenditures

Limitations of conventional dental care approaches

Conventional dental care



(Manual, Reactive)



Variable accuracy (observer bias)

Generalized one-size-fits-all approach

Time consuming manual process

Limited access/rural gaps

Conventional Pillars



Accuracy: Variable



Prediction: Minimal Ability



Access: Limited

AI-Enabled Pillars



Accuracy: High Consistency/Precision



Prediction: Strong Predictive Modeling



Access: Scalable Tele-dentistry

AI-driven dental care



(Data-driven, Proactive)



Early detection of subclinical changes

Individualized transition to precision dentistry

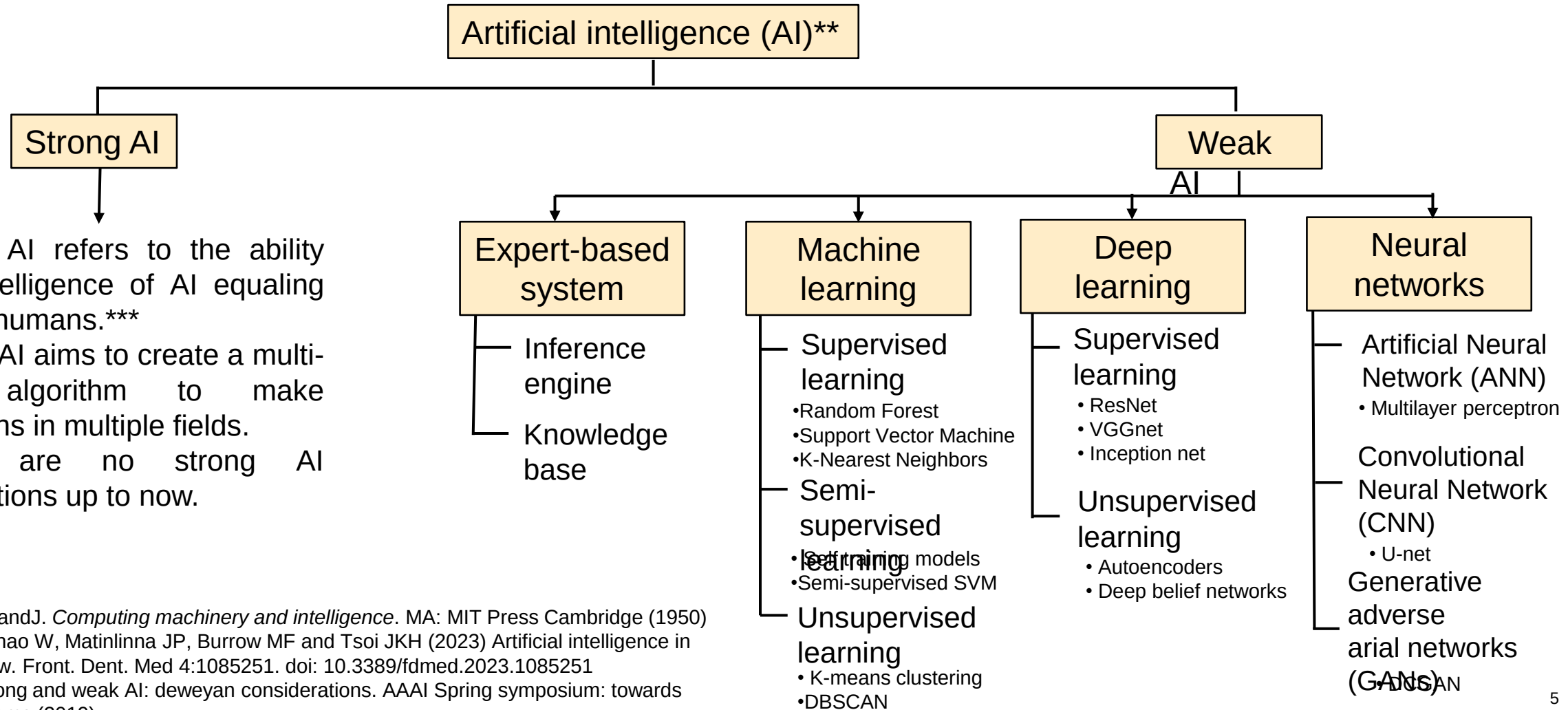
Rapid automated workflows

Scalable access via tele-dentistry

Introduction to Artificial intelligence

Artificial intelligence (AI) is not a new term. Alan Turing wrote in his paper “Computing Machinery and Intelligence”^{*} in the 1950 issue of *Mind*:

“I believe that at the end of the century (20th), the use of words and general educated opinion will have altered so much that one will be able to speak of machines thinking without expecting to be contradicted.”



^{*}Turing AM Haugeland J. *Computing machinery and intelligence*. MA: MIT Press Cambridge (1950)

^{**}Ding H, Wu J, Zhao W, Matinlinna JP, Burrow MF and Tsoi JKH (2023) Artificial intelligence in dentistry—A review. *Front. Dent. Med* 4:1085251. doi: 10.3389/fdmed.2023.1085251

^{***}Flowers JC. Strong and weak AI: deweyan considerations. *AAAI Spring symposium: towards conscious AI systems* (2019).

Workflow of AI in schematic format

Data input and language models



Text

Large Language Models understand and generate human language, performing tasks like text generation and analysis



Audio



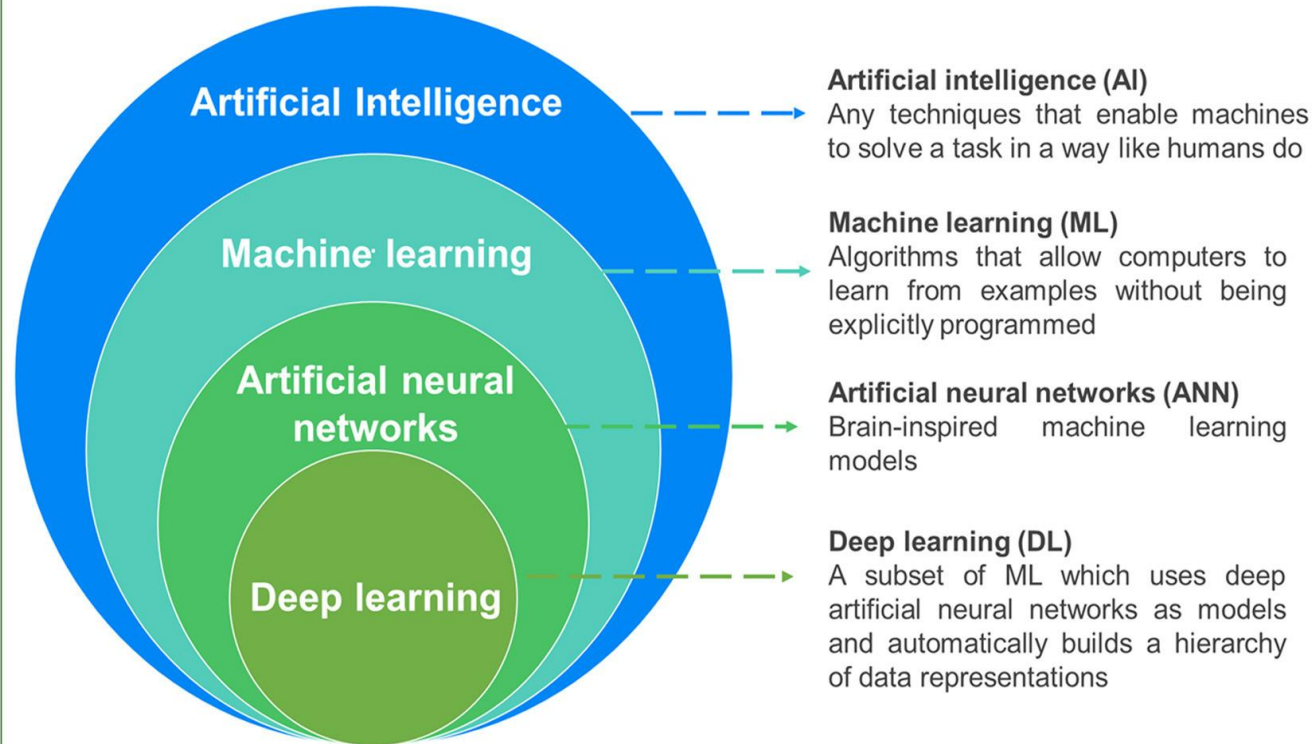
Image



Video

Large Vision Models process visual data like images and video, while Multimodality Models handle diverse data types like text and images, integrating techniques for tasks involving different modalities

Artificial Intelligence



Output

- 1 **Diagnosis**
- 2 **Prediction**
- 3 **Treatment**
- 4 **Classification**

AI tools utilized in dental applications

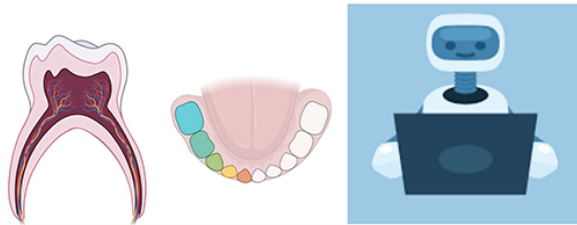
Technology	Definition	Common Applications in Dentistry
ML	Algorithms that learn patterns from data	Caries prediction, periodontal disease classification
DL	Subset of ML using neural networks with multiple layers	Radiograph interpretation, lesion detection
CNNs	Specialized for image recognition	Cephalometric analysis, panoramic X-ray diagnosis
NLP	Understanding and generating human language	Chart review, auto-generated reports, patient communication bots
Computer vision	Visual data processing and interpretation	Tooth segmentation, restoration design, intraoral imaging analysis
Reinforcement learning	Learning through trial-and-error with feedback	Robotics, AI-guided surgical maneuvers

ML, machine learning; DL, deep learning; NLP, natural language processing; CNNs, convolutional neural networks

Integration of AI component in dental practice

Appointment triage and pre visit screening

AI chat-bots could collect symptoms and perform risk stratification of patients



Detecting dental caries from radiographs

AI assisted caries detection software can highlight suspicious lesions on radiographs, flag early enamel lesions



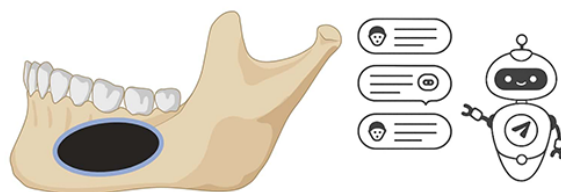
Growth and development prediction

Predict eruption timelines, root development stages or need for space maintainers.



Early detection of developmental defects

Automatic labelling of suspected lesions would be useful during child screening



Workflow automation and documentation

AI Dental charting, diagnostic notes, suggesting recall intervals

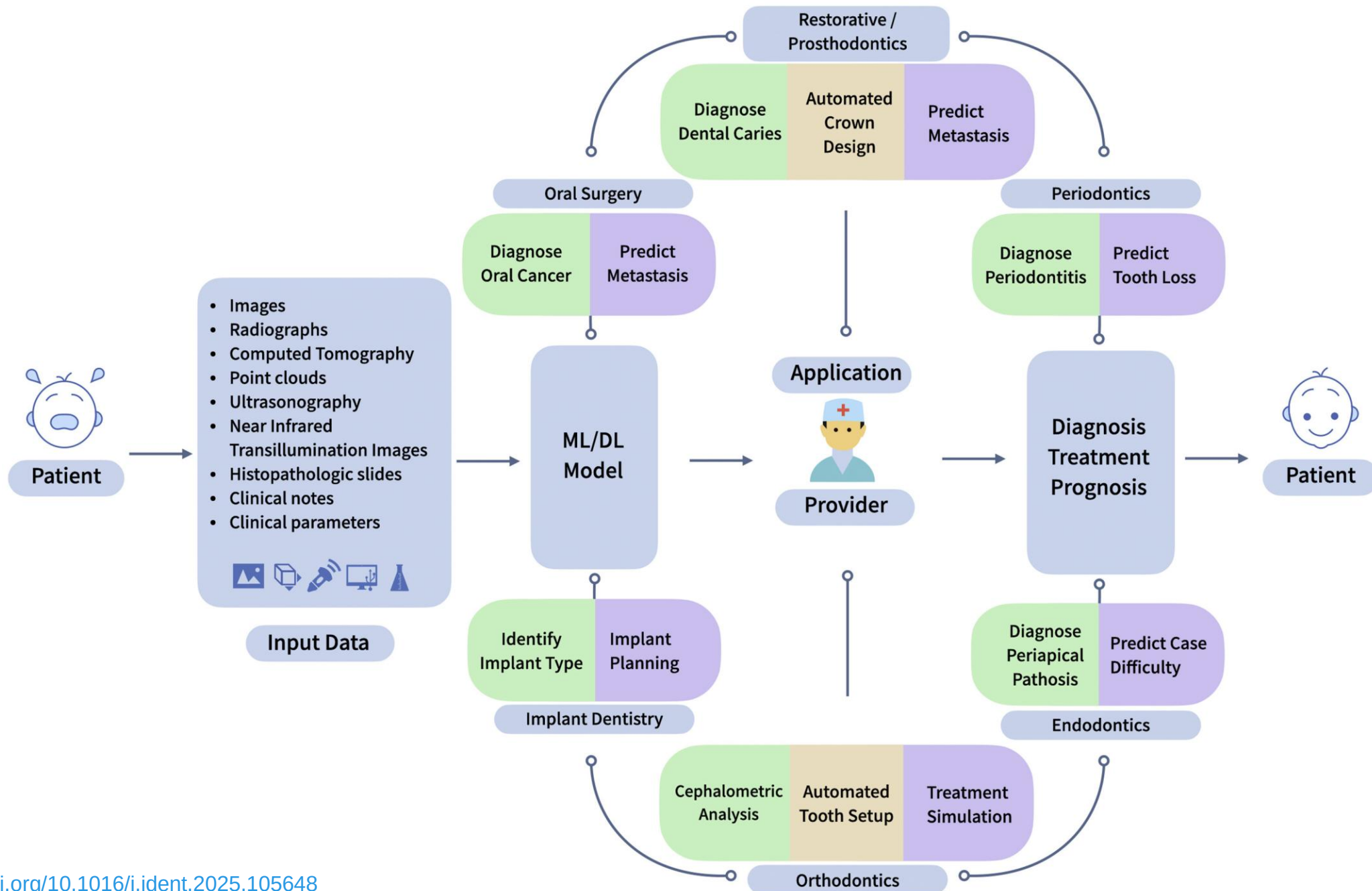


Parental communication tools

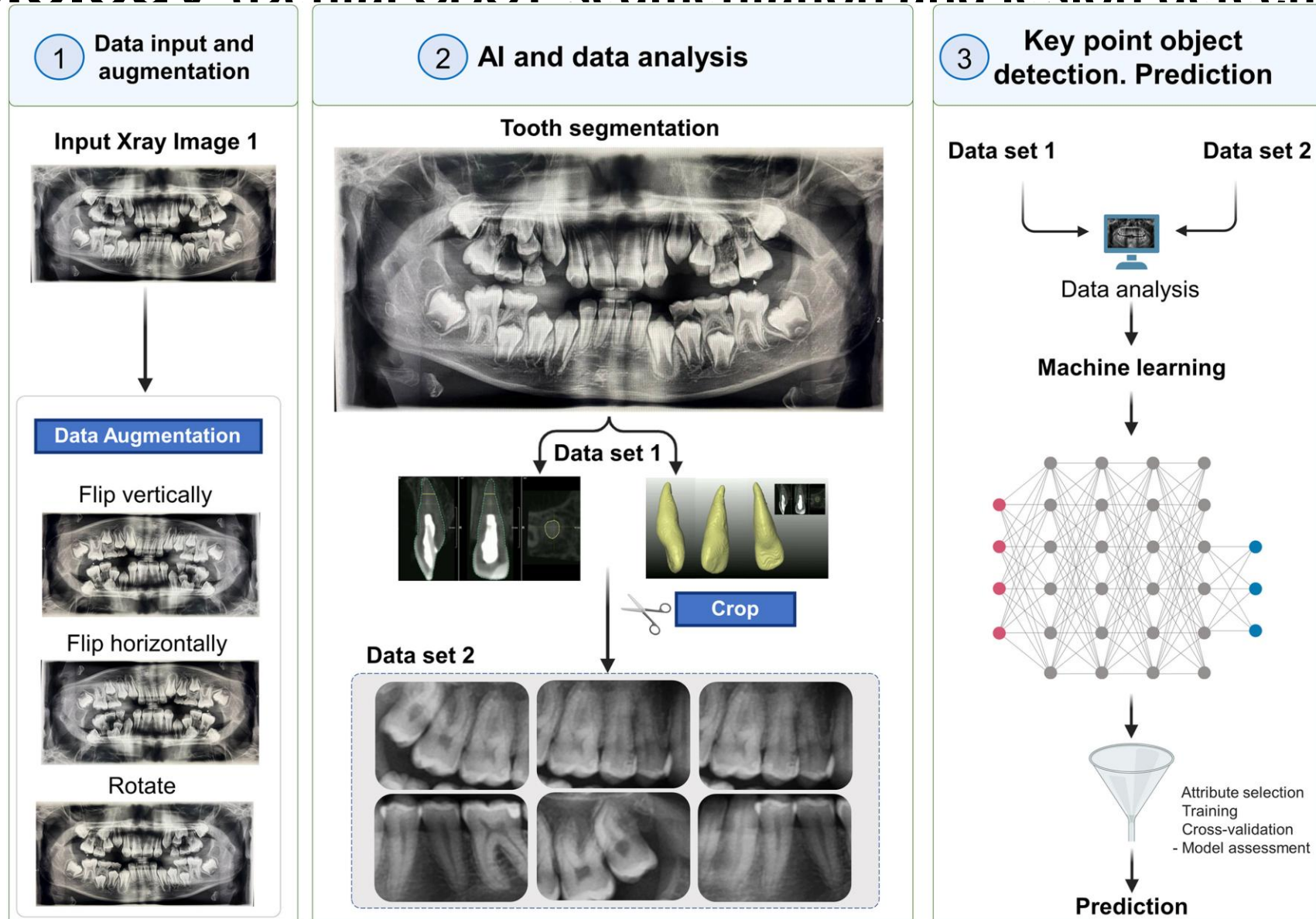
Show disease progression simulations, print simplified reports for parents



Overview of AI application in diverse dental specialties



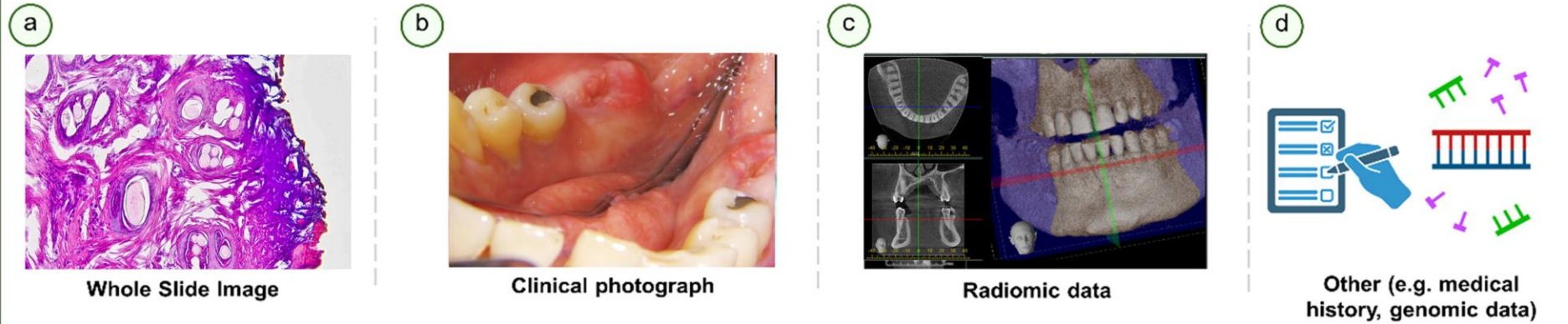
Schematic representation of AI integration in dental biology (Dental CBCT segmentation and lesion detection)



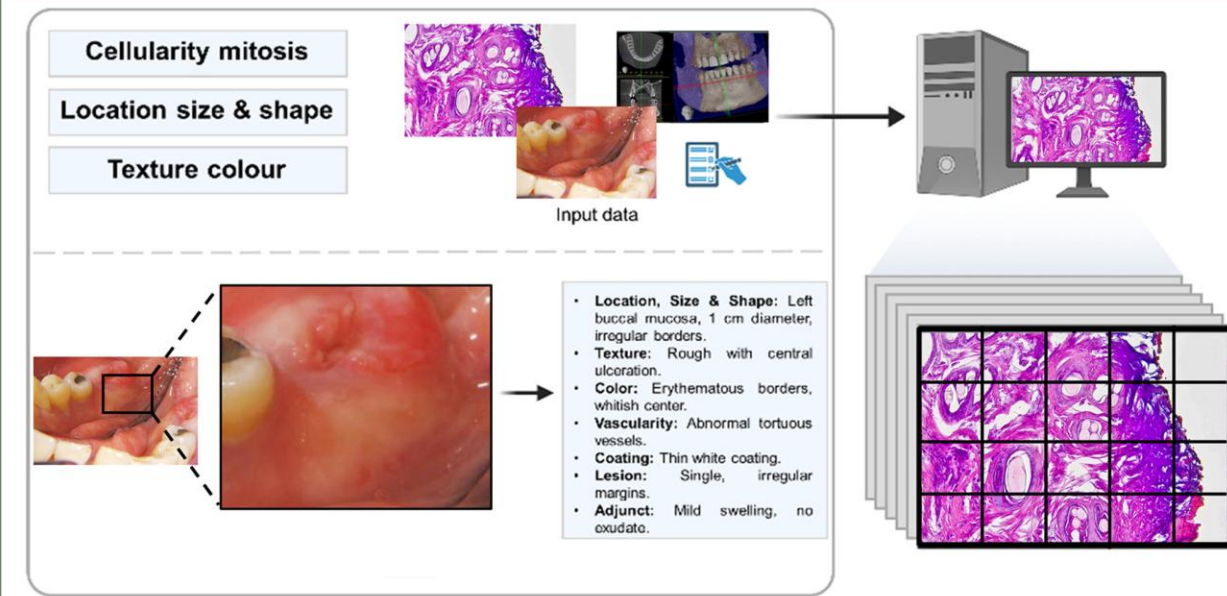
Schematic representation of AI integration in dental biology

(Feature extraction from primary diagnostic imaging modalities to aid outcome prediction in biology)

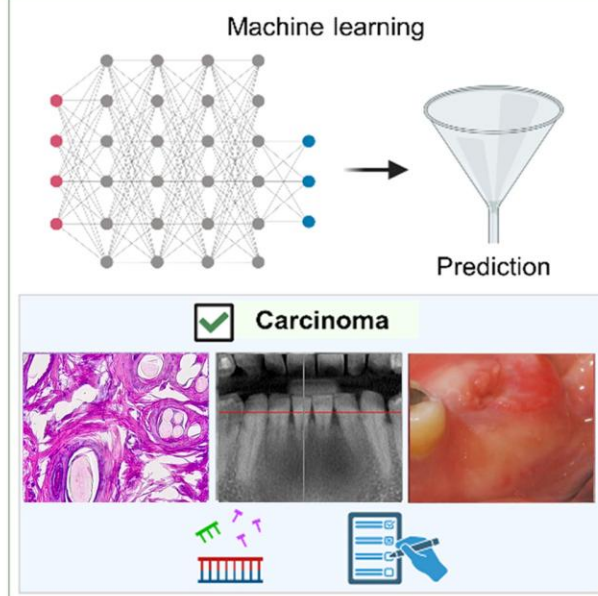
1 Step: Data collection from different sources



2 Step: Feature extraction and Image patches

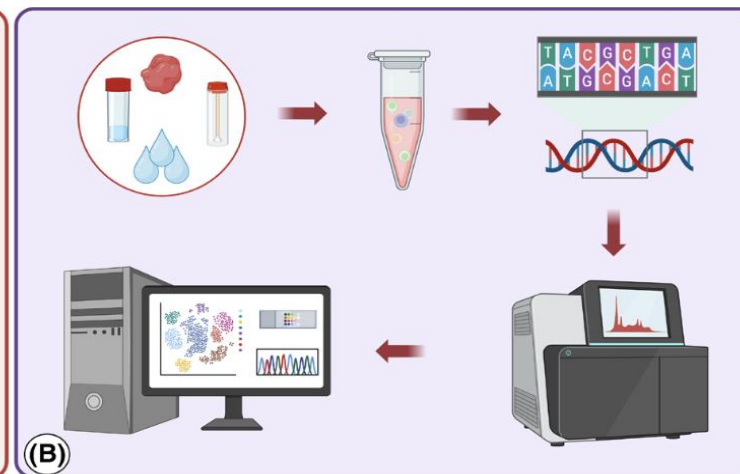
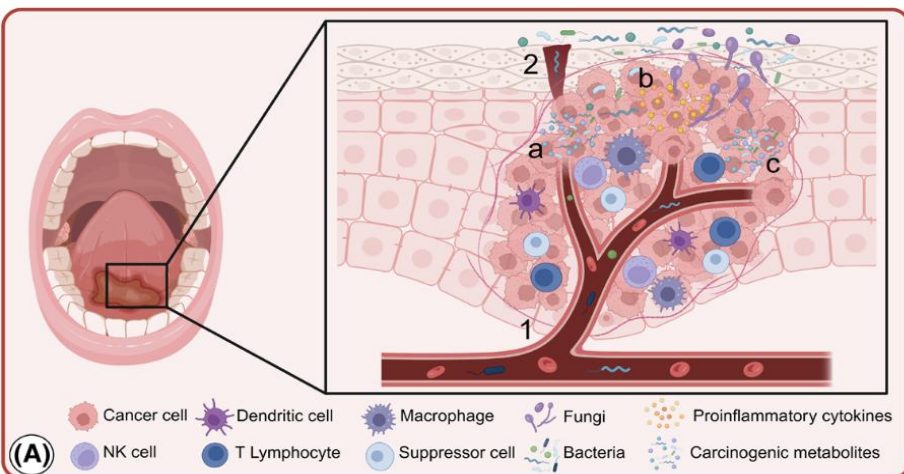


3 Step: Diagnosis prediction



P. Charoenlarp, O. Silkosessak-Chaiudom, V.Vipismakul
Atypical periosteal reaction and unusual bone involvement of ameloblastoma: a case report with 8-year follow-up
Imaging Sci Dent, 51 (2021), pp. 195-201, [10.5624/isd.20200264](https://doi.org/10.5624/isd.20200264)

AI in oral microbiome & oral cancer



(A) Interactions between microorganisms and the tumor microenvironment in oral squamous cell carcinoma (OSCC):

(1) Bacteria and fungi can enter the tumor site through the bloodstream or (2) from nearby tissues like periodontal pockets. (a) Their presence can contribute to a cancerous environment by producing harmful metabolites, (b) triggering inflammation (c) disrupting the balance between cell growth and cell death

(B) Data Collection and High-throughput Sequencing Pipelines:

This panel depicts the process of collecting and analyzing microbiome samples (from oral tissues or fluids) using high-throughput sequencing technologies.

(C) Machine Learning (ML) for Cancer Prediction:

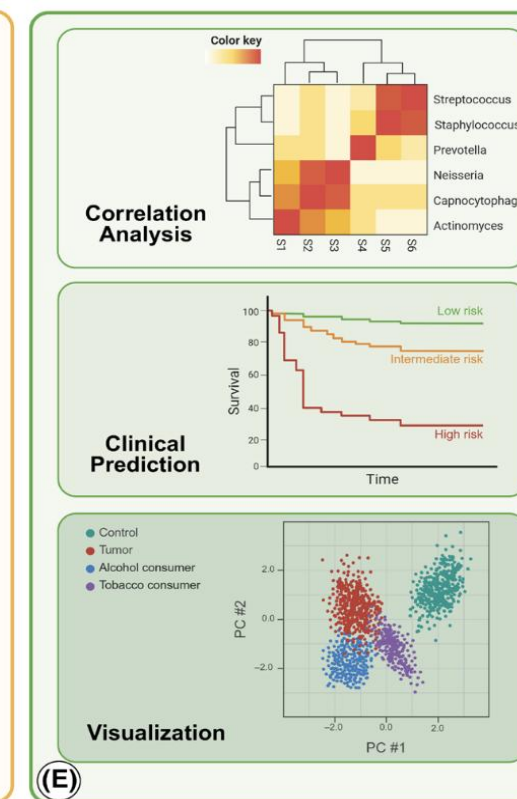
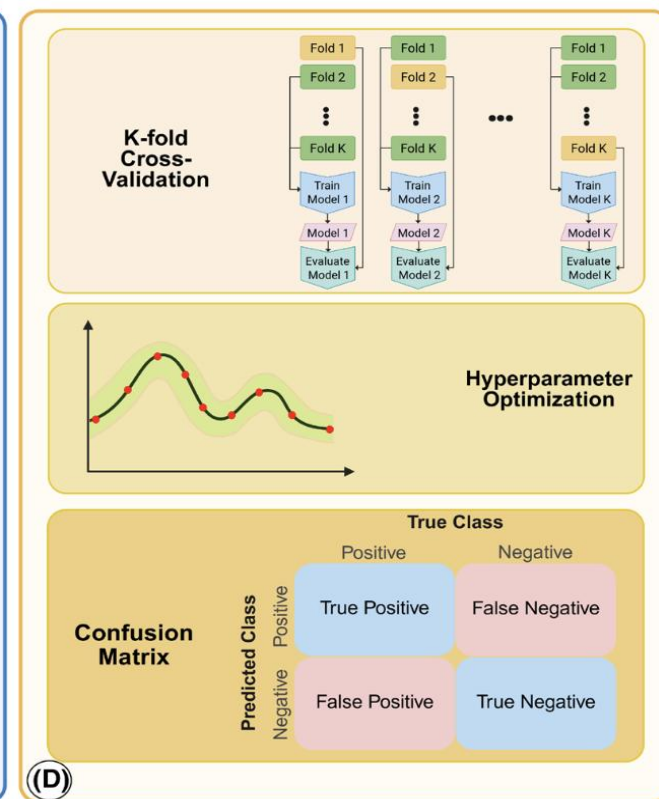
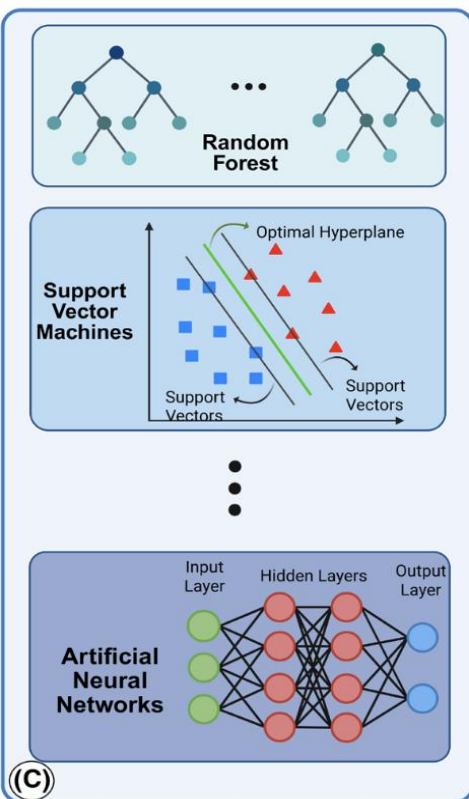
This panel explains how ML algorithms (e.g., random forest, support vector machines, artificial neural networks) are used to analyze microbiome data and predict cancer outcomes.

(D) ML Model Training and Evaluation:

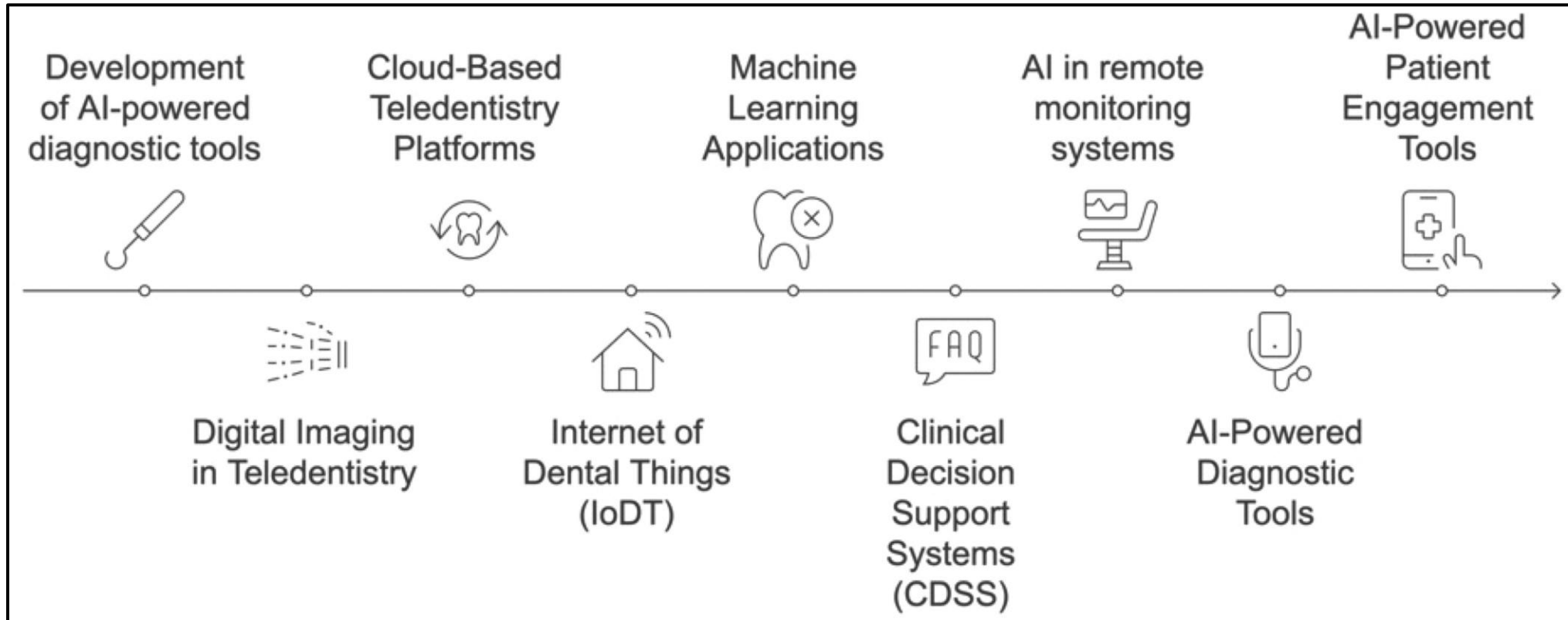
This panel highlights the importance of ensuring the accuracy and reliability of the ML models.

(E) Data Visualization and Correlation Analysis:

This panel describes how data visualization techniques are used to identify patterns in the microbiome data to identify specific microbial signatures associated with OSCC progression



AI in



- Several important milestones have emerged with the implementation of AI into teledentistry.

1st- FDA's approval of AI diagnostic tools. The acceptance of AI devices like Videa Perio Assist (VPA) validated the effectiveness of AI in dental diagnostics, indicating a significant innovation.

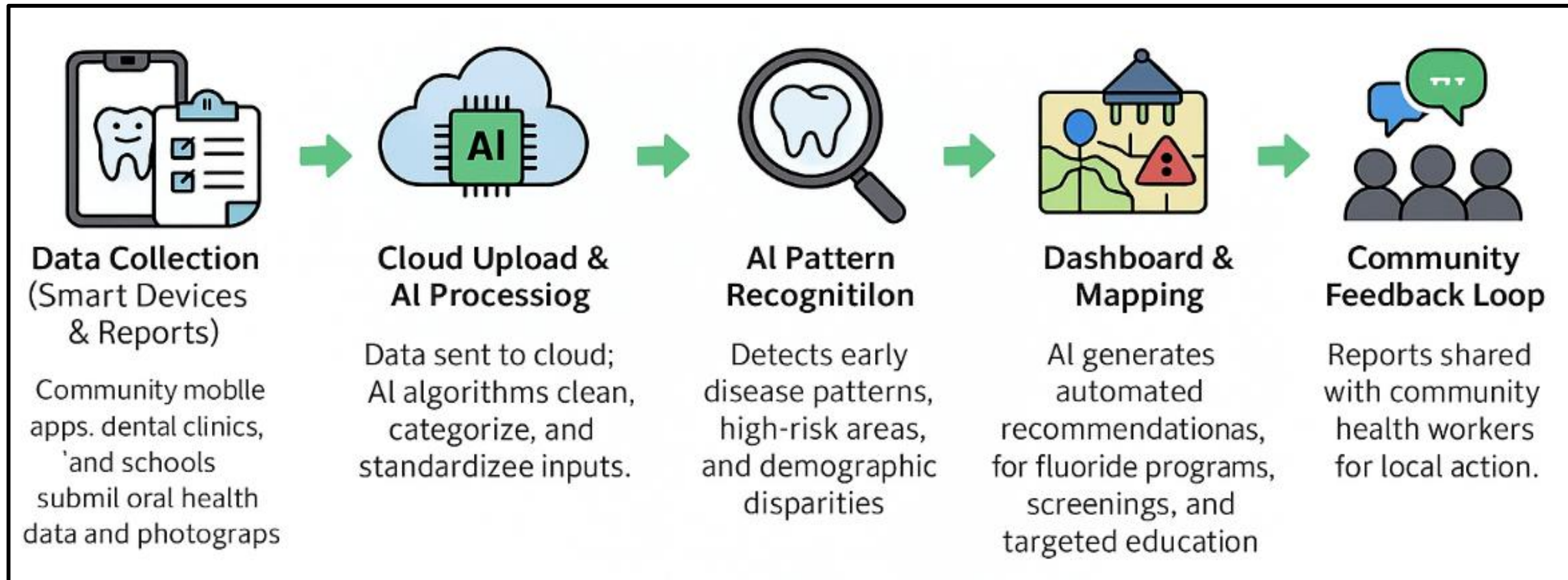
2nd - Innovations in [Clinical Decision Support Systems](#) (CDSS) are another important milestone. AI-enabled CDSS deliver evidence-based recommendations, improving treatment planning and outcomes.

3rd - AI-powered chatbots and virtual assistants that can help patients communicate and engage, making dental care more accessible

Challenge associated with AI implementation in teledentistry

Challenge	Description	Impact on teledentistry proposed	Solution
Infrastructure and Connectivity Issues	Limited broadband access and unstable connections hinder telecommunication and data transfer	Reduces the effectiveness of remote consultations and diagnostics	Invest in robust telecommunication infrastructure and explore satellite internet solutions for rural areas
Lack of Professional Readiness and Training	Dental professionals may lack the necessary skills and knowledge to effectively use AI technologies	Results in underutilization of AI tools, leading to inefficiencies in practice	Implement comprehensive training programs and continuous education initiatives focused on AI applications in dentistry
Data Security and Privacy Concerns	The handling of sensitive patient information raises concerns about data breaches and unauthorized access	Erodes patient trust and could lead to legal repercussions for dental practices	Adopt strong cybersecurity measures, including encryption, regular audits, and compliance with regulations like HIPAA
Integration with Existing Systems	Difficulty in integrating AI solutions with current dental practice management systems can disrupt workflows	Causes delays in adoption and may lead to resistance from practitioners	Develop standardized APIs and interoperability frameworks to facilitate seamless integration of AI tools
Cost and Financial Considerations	High costs associated with implementing AI technologies may deter practices from adopting them	Limits access to advanced technologies, particularly for smaller practices or those in underserved areas	Explore funding opportunities, grants, or partnerships to subsidize costs for dental practices adopting AI solutions

AI in oral public health surveillance and real time tools



DHIS2

 **Power BI**

 **WHO**
Oral Health

 **Google Cloud**
AutoML

Real-time examples of some AI applications in dental

biology

Automates routine operations and provides smart insights for practice management

Care stack

Provides 24/7 patient assistance and optimizes front desk operations

AI chatbot

Enhances diagnostics and patient education with AI-powered imaging

Overjet

Improves accuracy and streamlines workflows with AI-driven analysis

Videahealth

High-performance deep learning algorithm used in dentistry for real-time object detection and segmentation in imaging

YOLO (You Only Live Once)

Bola AI

Streamlines charting processes with voice-activated periodontal charting

Planmeca Romexis

Optimizes imaging workflows and patient interactions with AI

Dentrix Detect AI

Integrates AI into existing Dentrix systems for enhanced diagnostics

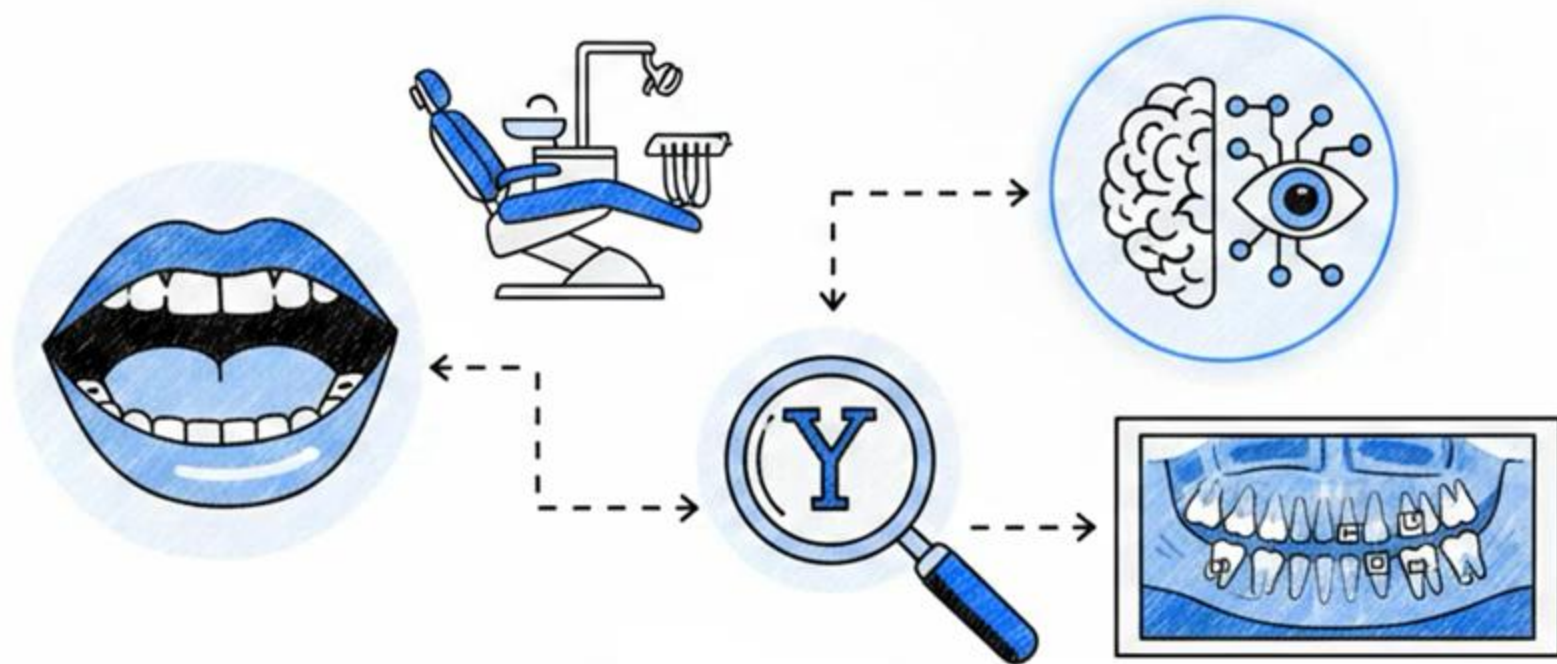
Diagnocat

Facilitates precise diagnostics with AI-based 3D image analysis

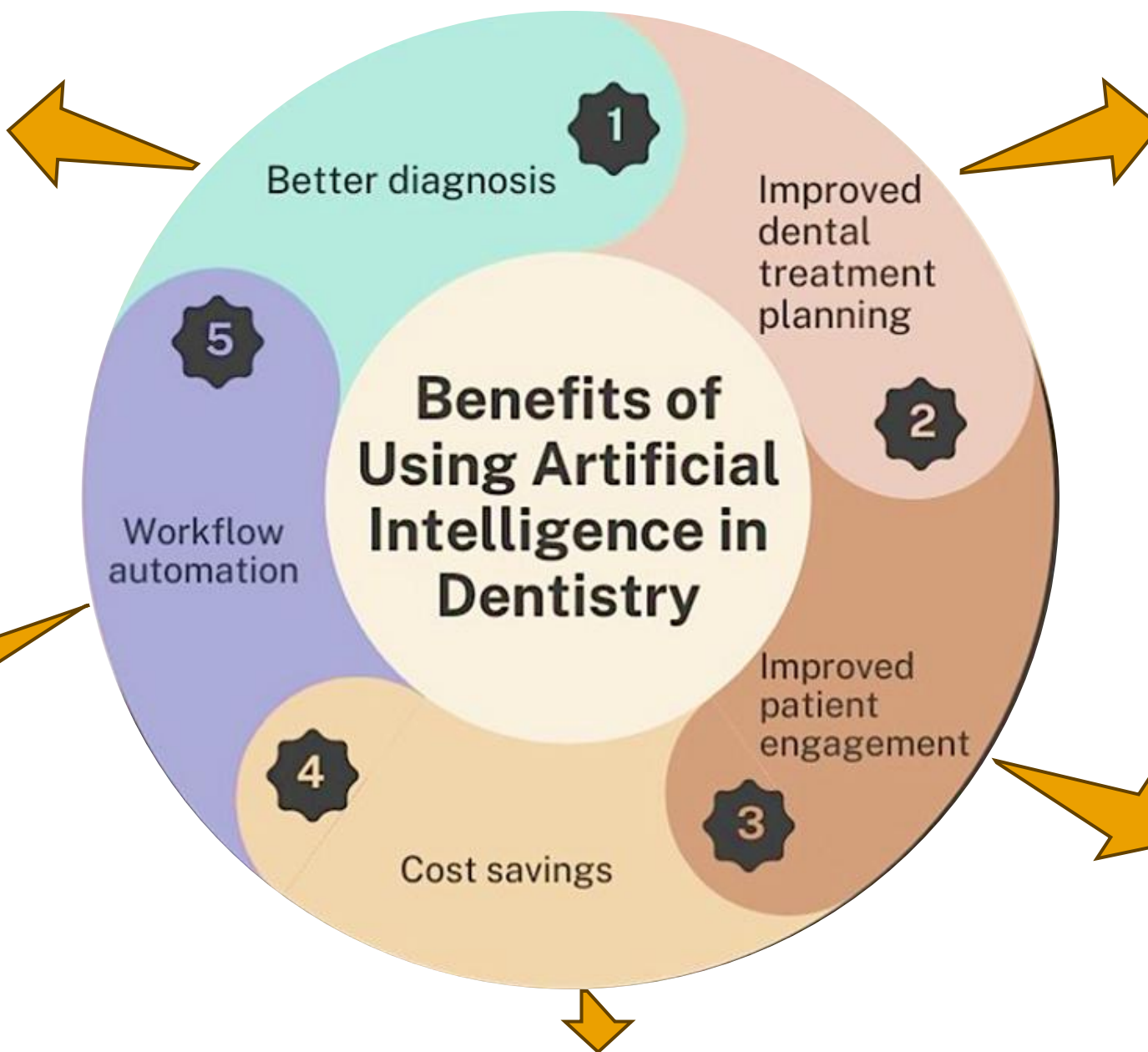
Pearl

Augments diagnostic confidence and office management with AI-powered X-ray analysis

AI in Dentistry



AI surpasses humans in analyzing intraoral images, CBCT, and x-ray scans to detect abnormalities, gum diseases, cavities, etc.



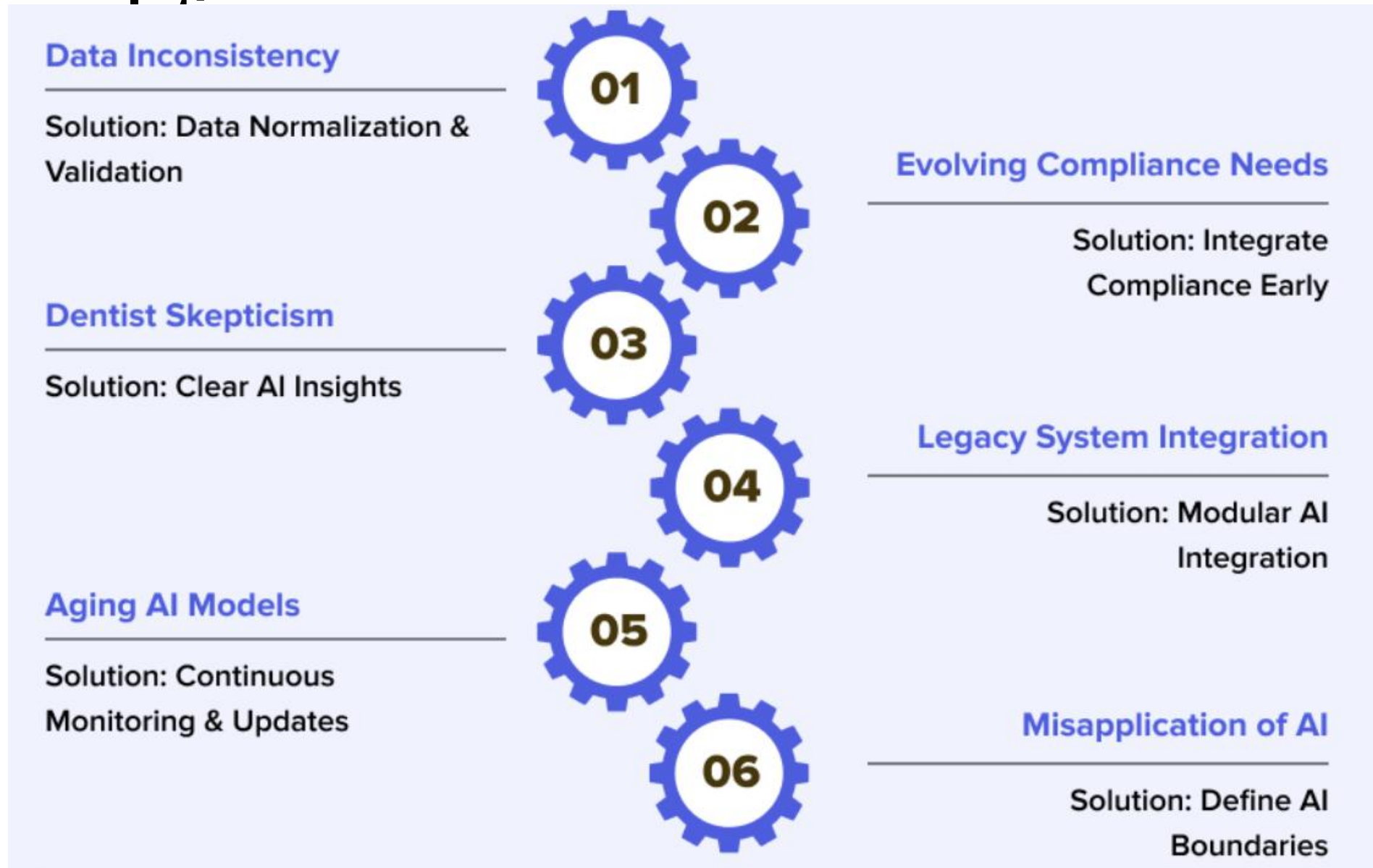
Using algorithms and outcomes of past procedures, dental AI can predict how orthodontic treatments will affect the patient and suggest better treatment planning.

AI in dentistry can improve workflow automation by handling billing, paperwork work and insurance checks.

Dental AI tools can improve patient engagement by sending automated appointment reminders & follow-up texts, and being available 24/7, helping simplify appointment scheduling and more.

AI can save costs by reducing errors in manual entries, appointment bookings, and ensuring 24/7 availability without adding extra staff.

Challenges of AI in dentistry and potential



AI in Dental Biology



**“The future of dentistry lies not in replacing clinicians w
but in integrating AI to augment human decision-makin**



**For Future Collaboration and Ideas,
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