YONSEI UNIVERSITY

BITEMARK: Traceable Multimodal Reasoning for Structured Orthodontic Reporting

Yoonha Eo

Department of Artificial Intelligence,

College of Computing, Yonsei University

Bite2Text

odin-workshops.org

MICCAI2026

MICCAI2026

Contents

I. Background and Motivation

II. BITEMARK Framework Overview

III. Intraoral Photograph Analysis

IV. Intraoral Scan Analysis

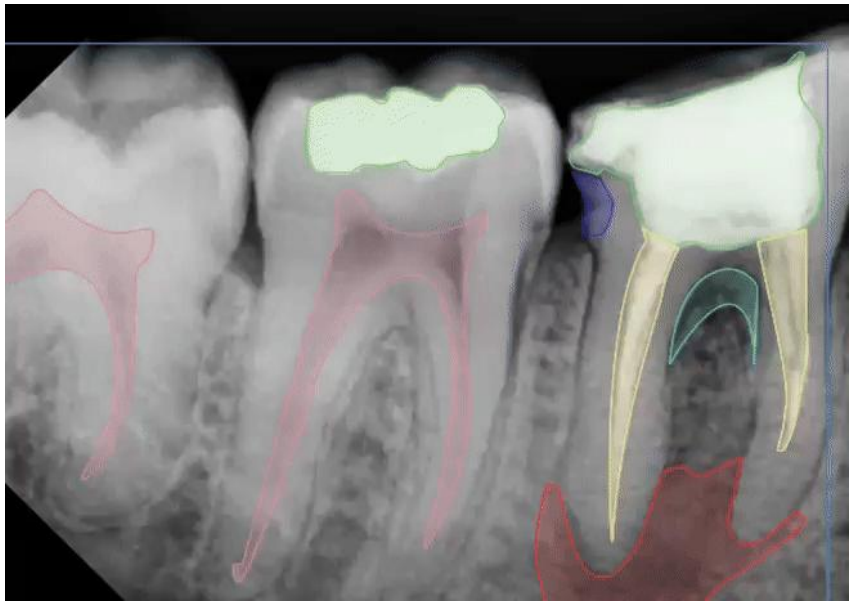
V. Task-Level Evaluation and Method Selection

VI. Structured Findings and Report Assembly

VII. Q&A

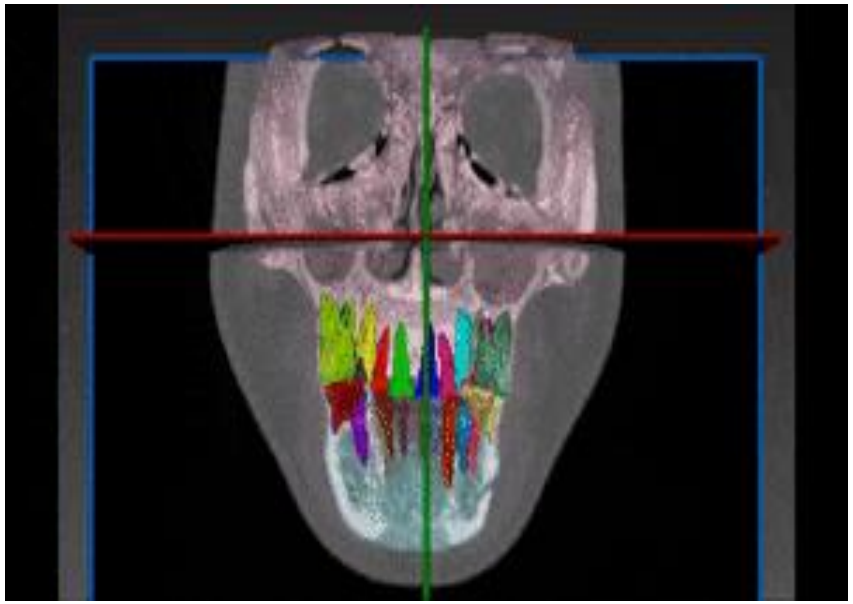
AI Software in Dental Radiology

Bitewing Anatomy Segmentation



CBCT Root Canals Segmentation

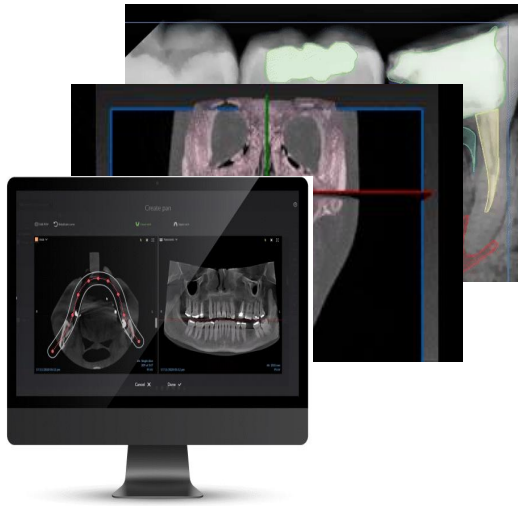
CBCT Full Head Segmentation



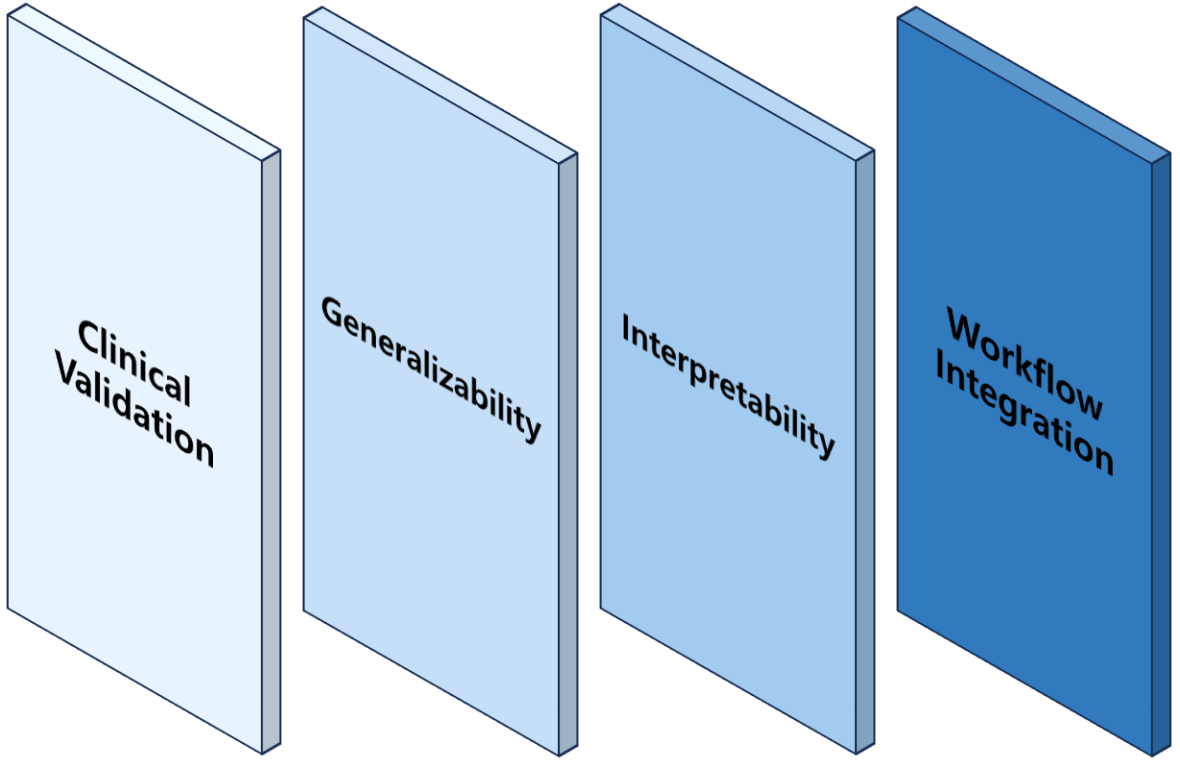
Contents Source:

https://aidentglobal.com/event
https://dexis.com/en-ae/orthopantomograph-op-3d-ex
https://www.rsipvision.com/dental-segmentation/

Barriers to Clinical Diagnosis



Deep Learning Solutions



Routine Clinical Diagnosis

Despite the progress of deep learning in dentistry,
major challenges remain before these systems can be reliably used for clinical diagnosis.

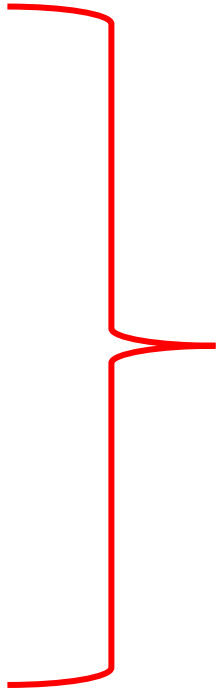
What’s holding AI back?

Lack of Explainability

- Black-box Decision Making
- Opaque Reasoning
- Hidden Representations
- Weak Feature Attribution
- Uncertain Causality
- Poor Traceability
- Limited Interpretability
- Faithfulness Gap
- Grounding Gap
- Post-hoc Explanation
- Spurious Correlation
- Unverifiable Evidence
- Low Clinical Transparency
- ……

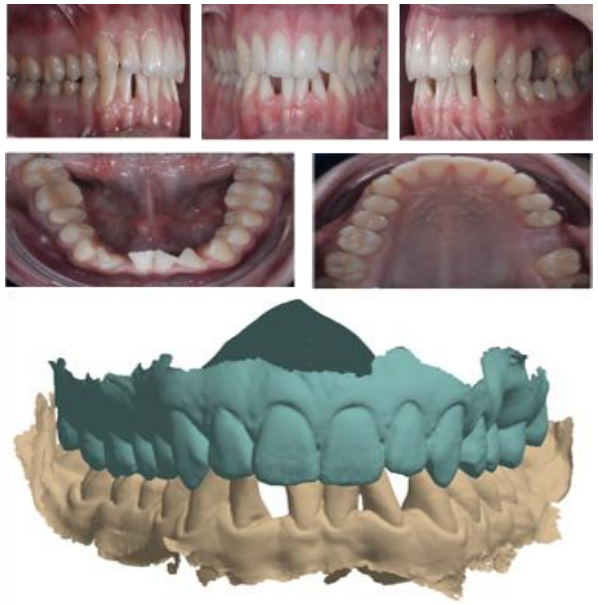
Lack of Explainability

- Black-box Decision Making
- Opaque Reasoning
- Hidden Representations
- Weak Feature Attribution
- Uncertain Causality
- Poor Traceability
- Limited Interpretability
- Faithfulness Gap
- Grounding Gap
- Post-hoc Explanation
- Spurious Correlation
- Unverifiable Evidence
- Low Clinical Transparency
- .....



Unknown Decision Logic

Input



Output

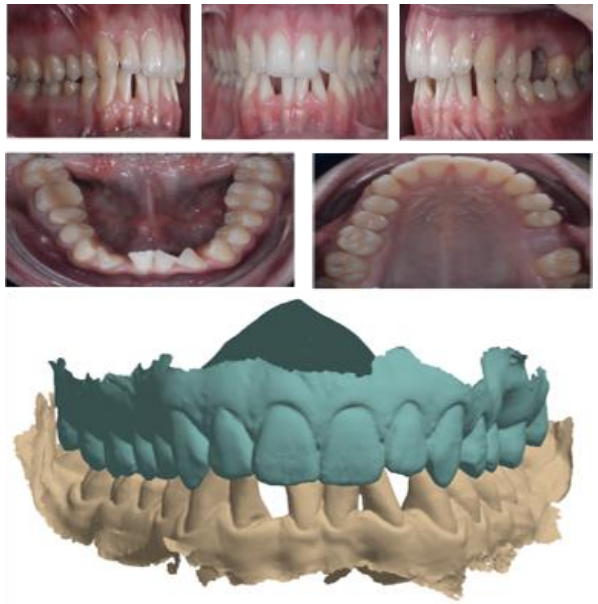
Vision-Language Model

REPORT

The patient presents on the right a full Class II molar and canine relationship, while on the left a full Class II canine relationship is present (molar relationship not definable due to the absence of tooth 26). The transverse relationships appear within normal limits; no crossbites are present. Overjet is markedly increased, overbite is within normal limits. The midlines are deviated. In the lower arch, wide diastemas are present.

Unknown Decision Logic

Input



Output

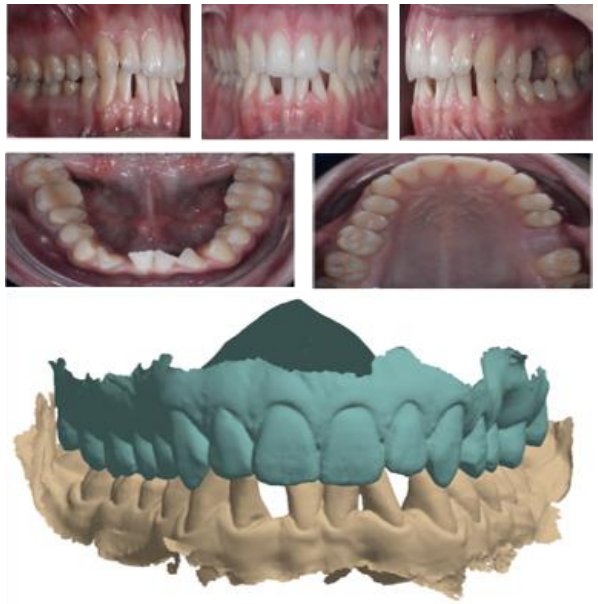
Single Mutimodal Model

REPORT

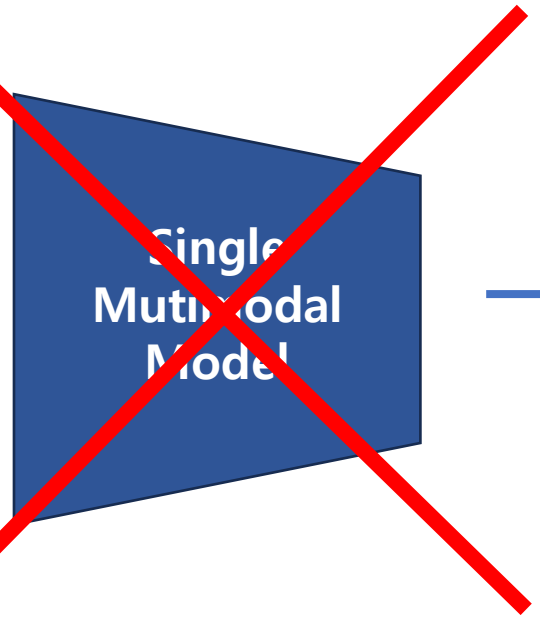
The patient presents on the right a full Class II molar and canine relationship, while on the left a full Class II canine relationship is present (molar relationship not definable due to the absence of tooth 26). The transverse relationships appear within normal limits; no crossbites are present. Overjet is markedly increased, overbite is within normal limits. The midlines are deviated. In the lower arch, wide diastemas are present.

Unknown Decision Logic

Input



Output

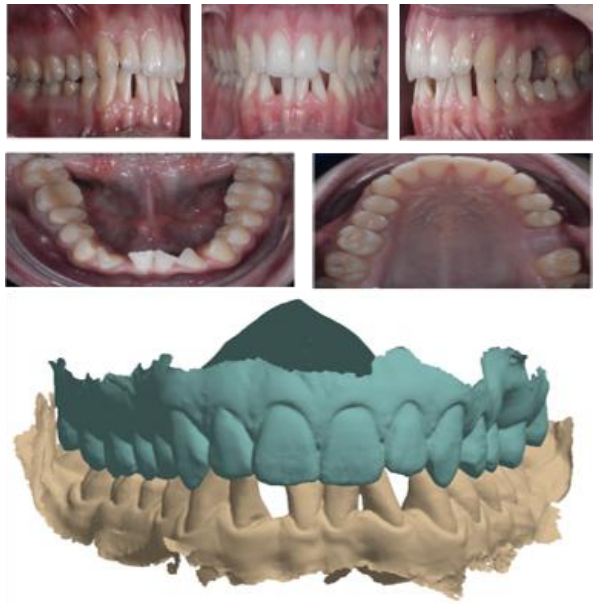


REPORT

The patient presents on the right a full Class II molar and canine relationship, while on the left a full Class II canine relationship is present (molar relationship not definable due to the absence of tooth 26). The transverse relationships appear within normal limits; no crossbites are present. Overjet is markedly increased, overbite is within normal limits. The midlines are deviated. In the lower arch, wide diastemas are present.

Unknown Decision Logic

Input



Multimodal Task

Output

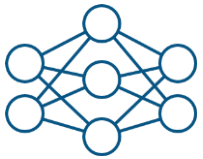
REPORT

The patient presents on the right a full Class II molar and canine relationship, while on the left a full Class II canine relationship is present (molar relationship not definable due to the absence of tooth 26). The transverse relationships appear within normal limits; no crossbites are present. Overjet is markedly increased, overbite is within normal limits. The midlines are deviated. In the lower arch, wide diastemas are present.

Traceable Multimodal Pipeline

BITEMARK: Traceable Multimodal Pipeline

Intraoral Photograhs



View classifier

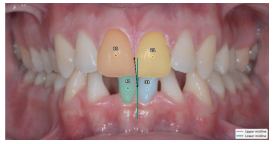
Frontal

Right Buccal

Left Buccal

Upper Occlusal

Lower Occlusal



Midline

Crowding

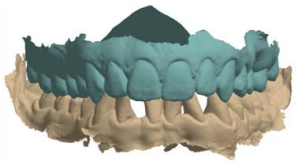
Structured Findings

```
summary_rows = [
  {"item": "Midline",
   "view": "front",
   "result": "Deviated"},

  {"item": "Crowding",
   "view": "upper",
   "result": "None to mild"},

  ...
]
```

Deterministic Sentence Assembly

REPORT

The patient presents on the right a full Class II molar and canine relationship, while on the left a full Class II canine relationship is present (molar relationship not definable due to the absence of tooth 26). The transverse relationships appear within normal limits; no crossbites are present. Overjet is markedly increased, overbite is within normal limits. The midlines are deviated. In the lower arch, wide diastemas are present.



Intraoral Scans

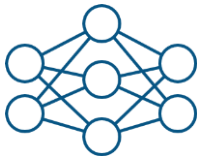
3D TeethLand Segmentation

Surface Mesh & Tooth/Landmarks

Geometric Measurement & Rule-Based Decision

Traceable Multimodal Pipeline: Intraoral Photographs

Intraoral Photograhs



View classifier

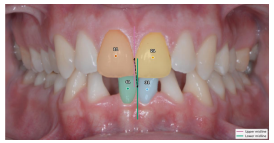
Frontal

Right Buccal

Left Buccal

Upper Occlusal

Lower Occlusal



Midline

Crowding

Structured Findings

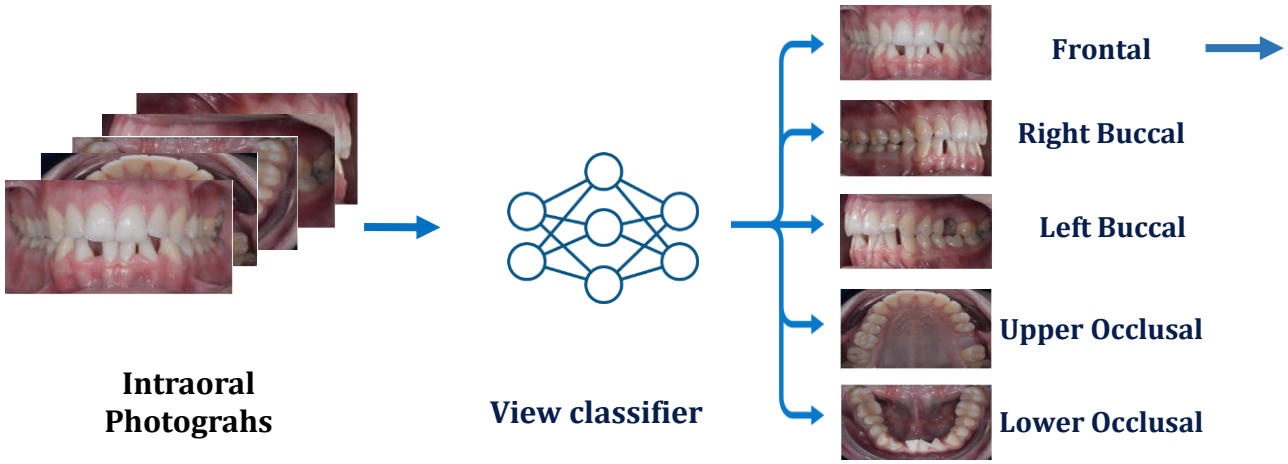
```
summary_rows = [
  {"item": "Midline",
   "view": "front",
   "result": "Deviated"},

  {"item": "Crowding",
   "view": "upper",
   "result": "None to mild"},

  ...
]
```

Deterministic Sentence Assembly

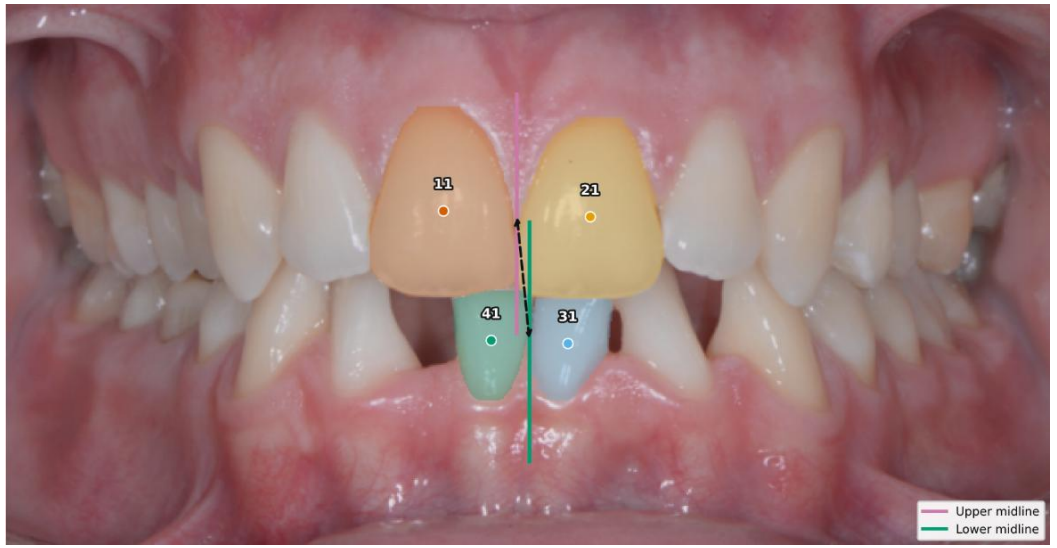
REPORT

The patient presents on the right a full Class II molar and canine relationship, while on the left a full Class II canine relationship is present (molar relationship not definable due to the absence of tooth 26). The transverse relationships appear within normal limits; no crossbites are present. Overjet is markedly increased, overbite is within normal limits. The midlines are deviated. In the lower arch, wide diastemas are present.

Midline: Intraoral Photographs



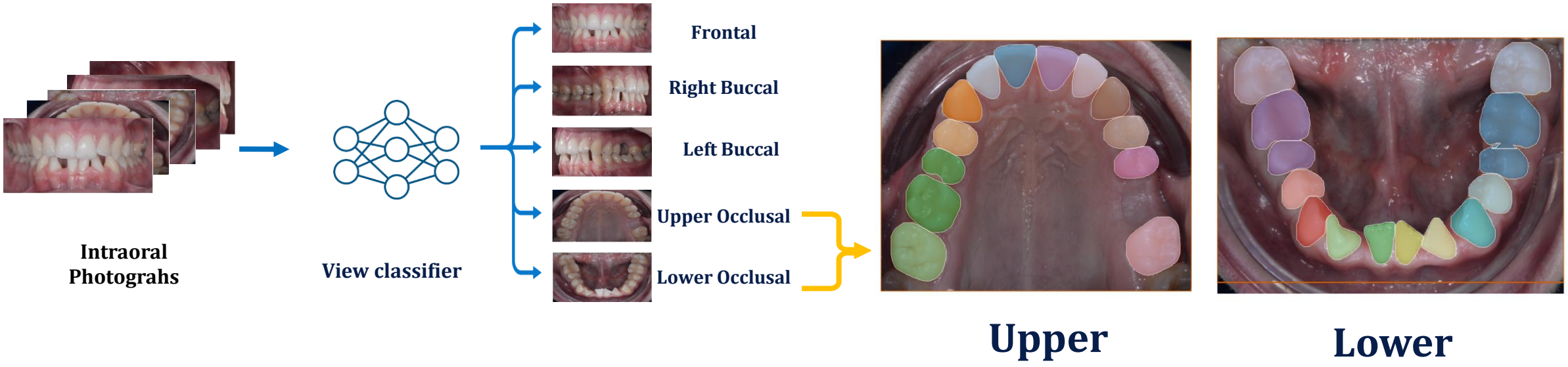
Midline



Teeth (#11,21,31,41) mask centers define the two midlines. Displacement is normalized by mean incisor width.

Range	Midline Classification
$D < 0.063$	Centered
$0.063 \leq D < 0.16$	Slightly Deviated
$D \geq 0.16$	Deviated

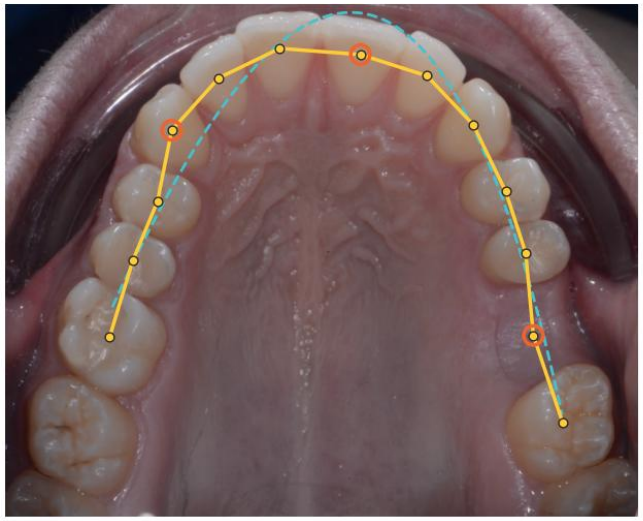
Crowding: Intraoral Photographs

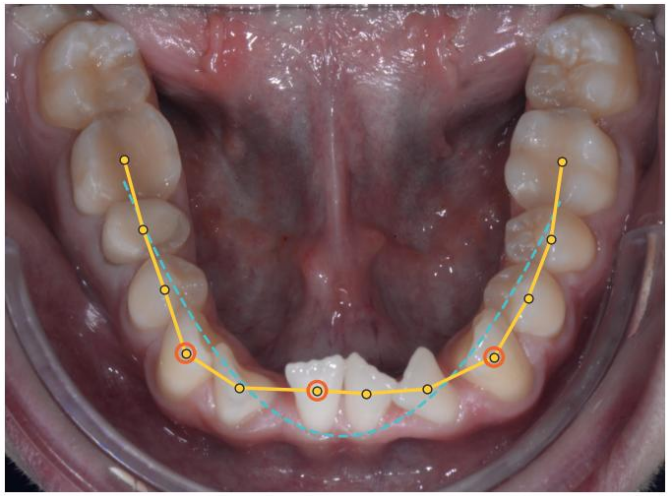


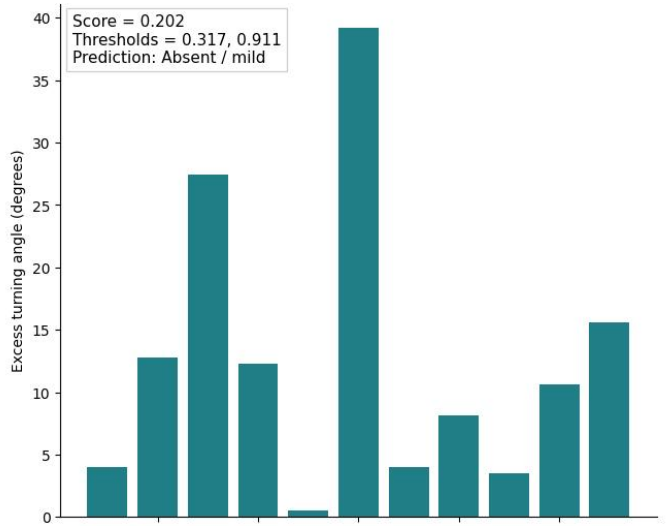
Crowding: Intraoral Photographs

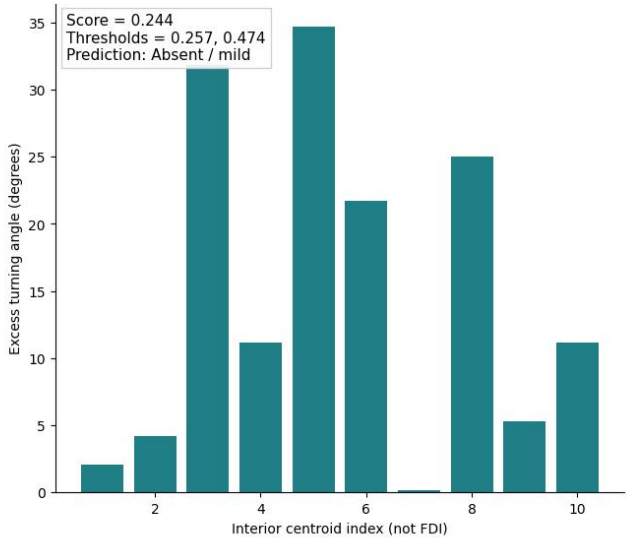
Upper

Lower



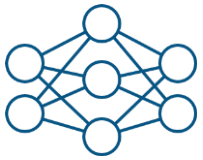






Traceable Multimodal Pipeline

Intraoral Photograhs



View classifier

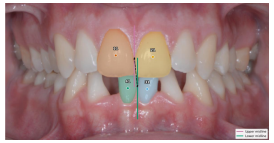
Frontal

Right Buccal

Left Buccal

Upper Occlusal

Lower Occlusal



Midline

Crowding

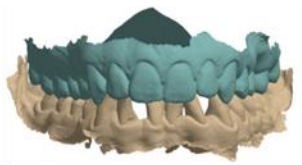
Structured Findings

```
summary_rows = [
  {"item": "Midline",
   "view": "front",
   "result": "Deviated"},

  {"item": "Crowding",
   "view": "upper",
   "result": "None to mild"},

  ...
]
```

Deterministic Sentence Assembly

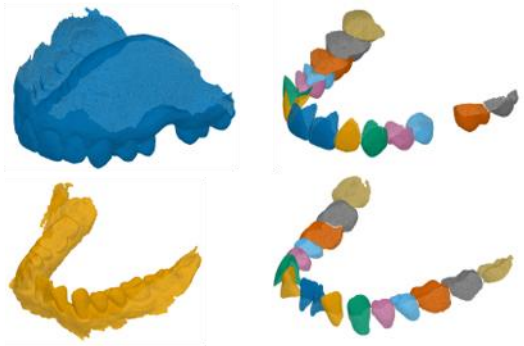
REPORT

The patient presents on the right a full Class II molar and canine relationship, while on the left a full Class II canine relationship is present (molar relationship not definable due to the absence of tooth 26). The transverse relationships appear within normal limits; no crossbites are present. Overjet is markedly increased, overbite is within normal limits. The midlines are deviated. In the lower arch, wide diastemas are present.



Intraoral Scans

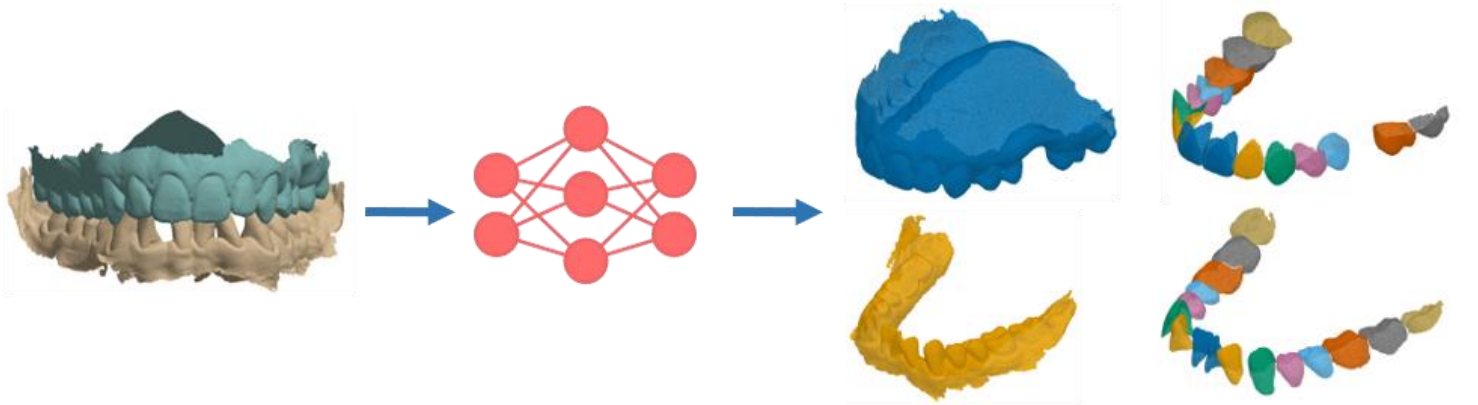
3D TeethLand Segmentation



Surface Mesh & Tooth/Landmarks

Geometric Measurement & Rule-Based Decision

Traceable Multimodal Pipeline : Intraoral Scans



Traceable Multimodal Pipeline : Intraoral Scans

Surface Mesh & Tooth/Landmarks

Molar Relationship

Anterior Bite

Transverse Bite

Canine Relationship

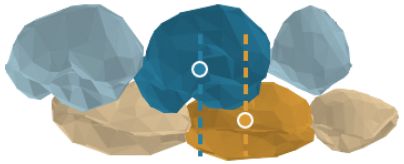
Missing Teeth/ Curve of Spee & Wilson

Overjet

Molar Relationship : Intraoral Scans

Molar Relationship

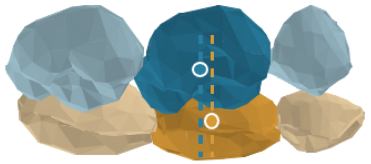
Class I



Upper and lower posterior surfaces show the selected Class I alignment.

Posterior → Anterior

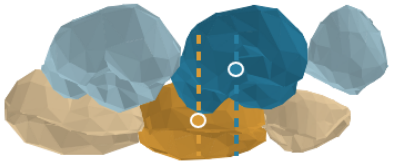
Class II edge-to-edge



An intermediate sagittal alignment.

Posterior → Anterior

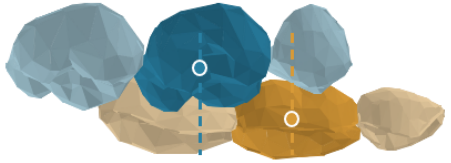
Class II full



Upper molar is shifted toward the anterior lower teeth.

Posterior → Anterior

Class III

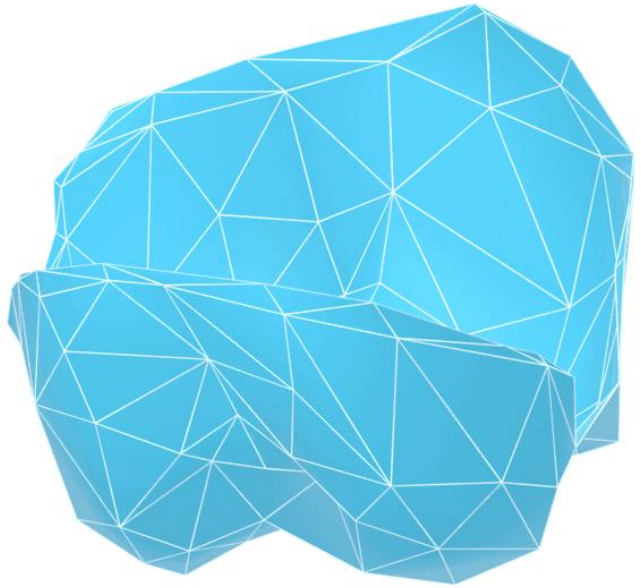


Upper molar is shifted toward the posterior lower teeth.

Posterior → Anterior

1. Start with the STL tooth surface

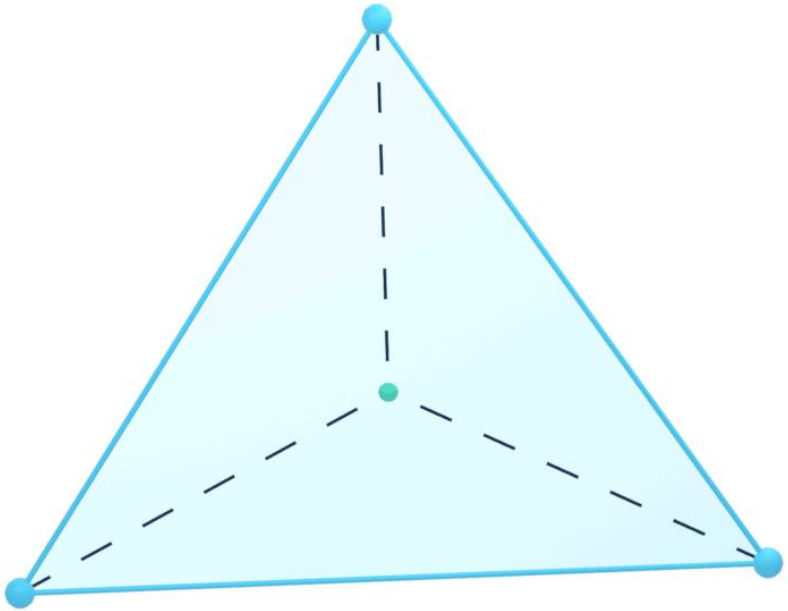
Each triangular face supplies three surface samples



Upper first molar

2. Construct the three interior points

Place each point halfway from a vertex to the centroid



Green point: triangle centroid

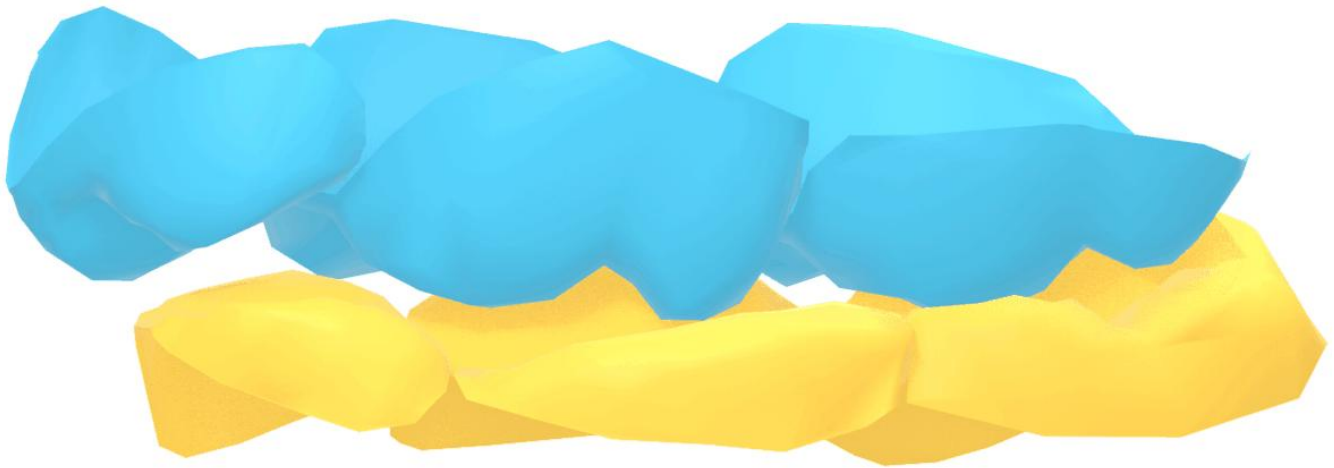
3. Select the upper-molar query band

Retain points at or below the area-weighted Q65 height

Blue: selected query points Gray: excluded points

4. Find the nearest opposing surface

For each upper query point, search lower 45, 46, and 47



Upper 16: query tooth Lower 45, 46, 47: opposing surfaces

Traceable Multimodal Pipeline : Intraoral Scans

Surface Mesh & Tooth/Landmarks

Molar Relationship

Anterior Bite

Transverse Bite

Canine Relationship

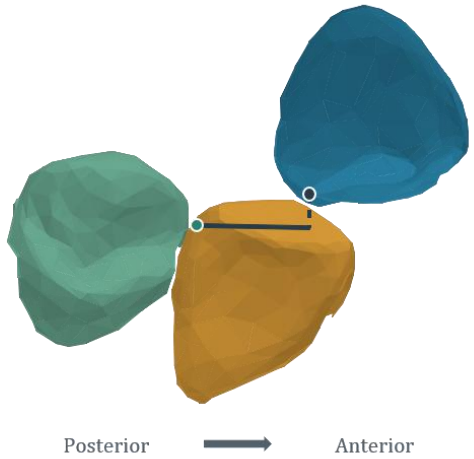
Missing Teeth/ Curve of Spee & Wilson

Overjet

Canine Relationship : Intraoral Scans

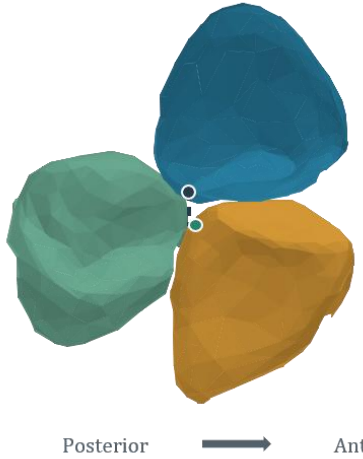
Canine Relationship

Class II



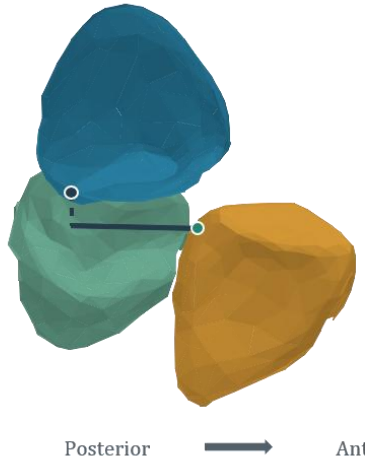
Upper canine tip lies anterior to the lower canine–premolar reference.

Class I



Upper canine tip is near the lower canine–premolar reference.

Class III



Upper canine tip lies posterior to the lower canine–premolar reference.

Traceable Multimodal Pipeline : Intraoral Scans

Surface Mesh & Tooth/Landmarks

Molar Relationship

Anterior Bite

Transverse Bite

Canine Relationship

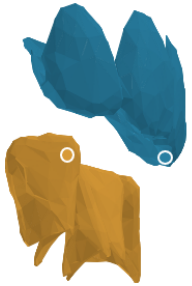
Missing Teeth/ Curve of Spee & Wilson

Overjet

Anterior Bite : Intraoral Scans

Anterior Bite

Open bite



Posterior → Anterior

A vertical gap separates the upper and lower incisal edge bands.

Normal bite

Posterior → Anterior

Incisal overlap is present without excessive vertical coverage.

Inverted bite

Posterior → Anterior

Lower incisors project ahead of the upper incisors.

Deep bite

Posterior → Anterior

The upper incisors cover a larger vertical portion of the lower incisors.

Traceable Multimodal Pipeline : Intraoral Scans

Surface Mesh & Tooth/Landmarks

Molar Relationship

Anterior Bite

Transverse Bite

Canine Relationship

Missing Teeth/ Curve of Spee & Wilson

Overjet

Transverse Bite : Intraoral Scans

Transverse Bite

Cross bite

Lingual → Buccal

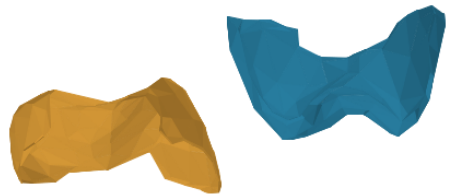
The upper posterior tooth sits farther inward than the lower tooth.

Normal

Lingual → Buccal

The upper tooth lies slightly outward while the two transverse intervals overlap.

Scissor bite



Lingual → Buccal

The upper tooth sits far outward with little transverse interval overlap.

Traceable Multimodal Pipeline : Intraoral Scans

Surface Mesh & Tooth/Landmarks

Molar Relationship

Anterior Bite

Transverse Bite

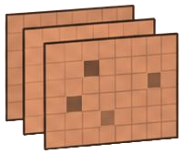
Canine Relationship

Missing Teeth/ Curve of Spee & Wilson

Overjet

Curve of Spee/Wilson & Overjet : Intraoral Scans -> PointTransformer V3

FDI-Labeled Point Cloud

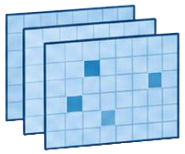


PointTransformer V3

Classification Head

Curve of Spee & Wilson Decision

Registered Dual Arch Point Cloud



PointTransformer V3

Classification Head

Overjet Decision

Task-level Results for Method Selection

Finding	PTv3 A/F1	Alternative A/F1	Selected route
Right sagittal	.750/.715	.833/.823	IOS geometry
Left sagittal	.700/.628	.833/.823	IOS geometry
Anterior bite	.600/.460	.915/.936	IOS geometry
Transverse bite	.750/.476	.880/.817	IOS geometry
Midline	.450/.437	.809/.801	IOP geometry
Curve of Spee	.719/.698	.657/.587	PTv3
Curve of Wilson	.677/.676	.573/.574	PTv3

Structured Findings : Over 28 Classes

Template

Overbite: Normal | Increased | Decreased | Open bite

Crowding (upper/lower):
None-to-mild | Mild/moderate | Moderate/severe

Molar relationship (right/left):
Class II full | Class II edge-to-edge | Class I | Class III

Canine relationship (right/left):
Class I | Class II | Class III | Not assessable

Overjet: Normal | Deep | Negative

Dental midline: Centered | Slightly deviated | Deviated

Transverse bite: Normal | Cross bite | Scissor bite

Lower curve of Spee: Normal | Increased

Lower curve of Wilson: Normal | Increased

Missing teeth:
Absent FDI identifiers among 28 permanent teeth, excluding third molars

Deterministic Report Assembly

Structured findings

```
summary_rows = [
  {"item" : "Molar relationship"  ,
   "view" : "right" ,
   "result" : "Class II Full" },

  {"item" : "Canine relationship"  ,
   "view" : "right" ,
   "result" : "Class II" },

  {"item" : "Midline" ,
   "view" : "front" ,
   "result" : "Deviated" },

  ...
]
```

Rule-based assembly

Right molar : Full Class II

Right canine : Class II

↓

A [full Class II] molar relationship and a [Class II] canine relationship on the right.

Midline: Deviated

↓

The dental midlines are [deviated] relative to each other.

⋮

Deterministic Report Assembly

Structured findings

```
summary_rows = [
  {"item" : "Molar relationship"  ,
   "view" : "right" ,
   "result" : "Class II Full" },

  {"item" : "Canine relationship"  ,
   "view" : "right" ,
   "result" : "Class II" },

  {"item" : "Midline" ,
   "view" : "front" ,
   "result" : "Deviated" },

  ...
]
```

Rule-based assembly

Right molar : Full Class II
Right canine : Class II

↓

A [full Class II] molar relationship and a [Class II] canine relationship on the right.

Midline: Deviated

↓

The dental midlines are [deviated] relative to each other.

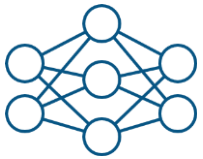
⋮

REPORT

The patient presents on the right a full Class II molar and canine relationship, while on the left a full Class II canine relationship is present (molar relationship not definable due to the absence of tooth 26). The transverse relationships appear within normal limits; no crossbites are present. Overjet is markedly increased, overbite is within normal limits. The midlines are deviated. In the lower arch, wide diastemas are present.

BITEMARK: Traceable Multimodal Pipeline

Intraoral Photograhs



View classifier

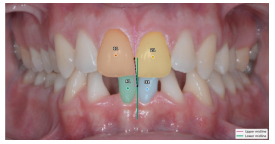
Frontal

Right Buccal

Left Buccal

Upper Occlusal

Lower Occlusal



Midline

Crowding

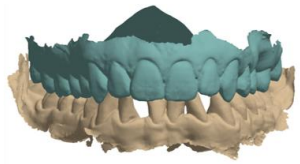
Structured Findings

```
summary_rows = [
  {"item": "Midline",
   "view": "front",
   "result": "Deviated"},

  {"item": "Crowding",
   "view": "upper",
   "result": "None to mild"},

  ...
]
```

Deterministic Sentence Assembly

REPORT

The patient presents on the right a full Class II molar and canine relationship, while on the left a full Class II canine relationship is present (molar relationship not definable due to the absence of tooth 26). The transverse relationships appear within normal limits; no crossbites are present. Overjet is markedly increased, overbite is within normal limits. The midlines are deviated. In the lower arch, wide diastemas are present.



Intraoral Scans

3D TeethLand Segmentation

Surface Mesh & Tooth/Landmarks

Geometric Measurement & Rule-Based Decision

Q & A

Contact Info

Yoonha Eo

yoonhaeo@yonsei.ac.kr / +82-10-4555-3309