The Use of Ontology in Dental Restorative Treatment Decision Support System

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Purpose of the study

• Generate caries treatment options based on patient disease conditions and oral anatomical locations.

• How? -> use ontologies for treatment options generations
Approach

• Define the correlations between disease-treatment-anatomy
Ontologies

• FMA (Foundational Model of Anatomy)
  – General anatomy-related ontology
  – Used only those tooth-concepts
    • Gingival_groove
    • Bony_part_of_maxilla

• OBO RO (Relation Ontology)
  – 10 relations used
  – RO is used to semantically link tooth anatomy, diseases, and treatments.
    • Treatment (Amalgam Filling) has participant Disease (Dentine Caries)
Terminologies

- UMLS (Unified Medical Language System)
  - Integrated system of terminology, classification and coding standards, developed by National Library of Medicine, US.
  - But no comprehensive restorative treatment ontology or classification system -> manually created treatment options using UMLS concepts

- KCD (Korean Classification of Diseases)
  - Korean version of ICD-10 (International Classification Diseases)
    - Used only the concepts related to dental caries
    - Dentine Caries
# Categories of Dental Restoration Concepts (BFO)

<table>
<thead>
<tr>
<th>Class</th>
<th>Occurrents</th>
<th>Dependent Continuants</th>
<th>Independent Continuants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Amalgam Filling</td>
<td>Dentin Caries</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Composite Resin Filling</td>
<td>Enamel Caries</td>
<td>Tooth</td>
</tr>
<tr>
<td></td>
<td>Gold Inlay Restoration</td>
<td>Pulpitis</td>
<td></td>
</tr>
<tr>
<td>Individual</td>
<td>Mr. Park’s Amalgam Filling</td>
<td>Mr. Park’s Pulpitis</td>
<td>Mr. Park’s Tooth</td>
</tr>
</tbody>
</table>
Concept Representation - tooth

- **Tooth**
  - Anterior: those shown when you smile, incisors and canine teeth,
  - Posterior: those involved in chewing: premolar and molar teeth

(OWL-2-based Manchester DL syntax)
Class: Tooth
  EquivalentTo: Anterior_Tooth or Posterior_Tooth
DisjointClasses: Anterior_Tooth, Posterior_Tooth
Concept Representation - Components

• Four components of a tooth
  – Dentin, enamel, cementum, pulp

• Dentin
  – Dentine SubClassOf Portion_Of_Substance_Of_tooth (in FMA)

• Dentin_of_lower_central_secondary_incisor_tooth
  – Dentine_of_lower_central_secondary_incisor_tooth SubClassOf Dentine
Concept Representation – has_participants

• RO has_participant relation
  – Used to link treatment alternatives (occurrents) with diseases (dependent continuants)
  – Renamed to “is_Indication” (dental indication)

ObjectProperty: is_Indication
  SubPropertyOf: has_participant
  Domain: Treatment
  Range: Disease

Class: Amalgam_Filling
  SubClassOf: Direct_Intracoronal_Restoration
    is_Indication some Dentine_Caries
    located_in some Posterior_Tooth
    located_in some (not (Esthetic_zone_of_oral_cavity))
Concept Representation - restoration

• Intra-coronal restoration
  – Direct Intra-coronal Restoration
    • Amalgam Restoration
    • Composite Resin Restoration
    • Glass ionomer Restoration
  – Indirect Intra-coronal Restoration
    • Inlay/onlay (Gold, Porcelain, Resin)

• Extra-coronal restoration
  – Dental Implants
  – Denture
Concept Representation – Tooth surface

• Tooth Surface

  – Buccal surface (surface of a tooth adjacent to the cheeks)
  – Lingual surface (adjacent to the tongue)
  – Occlusal surface (the chewing surface)
  – Mesial surface (adjacent to the front neighboring tooth)
  – Distal surface (adjacent to the back neighboring tooth)
Concept Representation – Tooth surface

• Tooth Surface definition

Class: $Surface_{of\_Tooth}$
  EquivalentTo: $Buccal\_Surface\_of\_Tooth$ or $Occlusal\_Surface\_of\_Tooth$ or $Lingual\_Surface\_of\_Tooth$ or $Mesial\_Surface\_of\_Tooth$ or $Distal\_Surface\_of\_Tooth$

Class: $Proximal\_Surface\_of\_Tooth$
  EquivalentTo: $Mesial\_Surface\_of\_Tooth$ or $Distal\_Surface\_of\_Tooth$

Class: $Gold\_Inlay\_Restoration$
  SubclassOf: $is\_Indication$ some $Dentin\_Caries$
    located_in some $Posterior\_Tooth$, located_in some $Proximal\_Surface\_of\_Tooth$
Caries Treatment Plan DSS

Ontologies are used to generate these options.
Treatment Plan Support System

**Tooth Information**

- **Tooth Number:** [ ]
- **Tooth State:** [ ]
- **Treatment Plan:** [ ]

**Esthetic Value**
- [ ]

**Price**
- [ ]

**Number Of Visit**
- [ ]

**Treatment Options**

- **Caries of Dentine**
  - [0%] Caries_of_dentine: 0%
  - [0%] Amalgam Restoration: 19%
  - [0%] Nothing: 0%
  - [0%] CADCAM_Inlay/Onlay: 8%
  - [0%] Porcelain Laminate: 10%
  - [0%] Esthetic Adhesive Restoration: 0%
  - [0%] Glass Ionomer Restoration: 18%
  - [0%] Resin Inlay/Onlay: 8%
  - [0%] Porcelain_Inlay/Onlay: 8%
  - [0%] Composite Resin Restoration: 10%

**Other**
- Name: see
- Age: 34
- Sex: Woman
- Marriage: married
- Visit Path: advertising
# Treatment Plan Support System

![Treatment Plan Support System Interface](image)

**Tooth Information**

- **Tooth Number**: No11
- **Tooth State**: Caries_of_dentine
- **Treatment Plan**: 

  - Esthetic Value: 
    - Price: 
    - Number of Visit: 
    - Esthetic Value: 

**Treatment Options**

<table>
<thead>
<tr>
<th>Treatment Options</th>
<th>C4.5</th>
<th>AHP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nothing</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>PorcelainLaminate</td>
<td>0%</td>
<td>29%</td>
</tr>
<tr>
<td>EstheticAdhesiveRestoration</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>GlassIonomerRestoration</td>
<td>0%</td>
<td>43%</td>
</tr>
<tr>
<td>CompositeResinRestoration</td>
<td>100.00%</td>
<td>26%</td>
</tr>
</tbody>
</table>

**Indication**: Some Caries_of_dentine and located in some No11
Treatment Plan Support System

Beauty is major concern

Price is major concern
Conclusions

- Used ontology to generate restorative treatment plans, based on disease and caries location

- The purpose of the restorative treatment DSS is to be used as a consultation tool during dentist-patient encounters.

- Next steps
  - Clinician evaluation
  - Ontology expansion:
    - Ontological representation of clinical guidelines for caries treatment planning
    - Currently, the system contains only concepts needed for caries treatment planning, but other areas of dental specialties such as prosthodontics and orthodontics will be added