Implementing SNOMED CT Expressions
Expo 2016 Tutorial

Presentation Overview

- Introduction
- Compositional Grammar
- Data entry and display
- Storage and retrieval
- Exchange
- Query
- Summary
- Discussion
Introduction

SNOMED CT Concepts

A clinical idea with a unique SNOMED CT identifier

- Distributed as part of SNOMED CT
- Linked by descriptions to terms that provide a human-readable representation of the meaning of the concept
- Related to one another by defining relationships that provide a machine-processable representation of that meaning
Example of a SNOMED CT Concept

- Fracture of tibia (disorder)
  - SCTID: 31978002
  - Fully defined, Active
  - Term
    - F: Fracture of tibia (disorder)
    - B: Fracture of tibia
  - Acceptability (US)
    - Preferred

<table>
<thead>
<tr>
<th>Type</th>
<th>Destination</th>
<th>Group</th>
<th>Chart/Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is a (attribute)</td>
<td>Injury of tibia (disorder)</td>
<td>0</td>
<td>Inferred</td>
</tr>
<tr>
<td>Is a (attribute)</td>
<td>Fracture of lower leg (disorder)</td>
<td>0</td>
<td>Inferred</td>
</tr>
<tr>
<td>Finding site (attribute)</td>
<td>Bone structure of tibia (body structure)</td>
<td>1</td>
<td>Inferred</td>
</tr>
<tr>
<td>Associated morphology (attribute)</td>
<td>Fracture (morphologic abnormality)</td>
<td>1</td>
<td>Inferred</td>
</tr>
</tbody>
</table>

SNOMED CT Concept Identifiers

- Concept identifiers can be used to record a clinical idea, or link instances of information about a clinical idea

Example

The concept identifier 31978002 can be used as a code in …
- A patient record to indicate the patient has a fractured tibia
- Clinical knowledge resources to provide links to advice about assessment and treatment of fractures of the tibia
- Data retrieval queries to select patients who have had a fractured tibia
- A data analysis report to identify the incidence of fractures of the tibia
SNOMED CT Expression

A structured combination of one or more concept identifiers used to represent a clinical meaning.

Example - Right hip
182201002 |Hip joint| 272741003 |Laterality| = 24028007 |Right|

Use Cases
1. Expressions in health records
2. Expressions in messages
3. Precoordinated concept definitions
4. Expression associations with LOINC

SNOMED CT Precoordinated Expression

An expression containing a single concept identifier

The meaning is represented by the predefined meaning of a single concept

Example
• Can be just an identifier
  • 31978002
• Can optionally include an associated term
  • 31978002 |Fracture of tibia|
SNOMED CT Postcoordinated Expression

An expression containing two or more concept identifiers

The meaning is represented by the combination of the meanings of the included concepts

Example

- “Fracture of left tibia” can be represented as
  - 31978002 |Fracture of tibia| : 272741003 |Laterality| = 7771000 |Left|

- Terms can be omitted to shorten expression
  - 31978002 : 272741003 = 7771000

SNOMED CT Postcoordinated Expressions

May refine the meaning of a concept by applying a more specific value to one or more defining relationships

Example

- The concept 31978002 |Fracture of tibia| has relationship
  - 116676008 |Associated morphology| = 72704001 |Fracture|

- ‘Open fracture of tibia’ can therefore be represented as
  - 31978002 |Fracture of tibia| :
    - 116676008 |Associated morphology| = 52329006 |Fracture, open|

- Terms can be omitted to shorten expression
  - 31978002 : 116676008 = 52329006
SNOMED CT Postcoordinated Expressions

May refine the meaning of a concept by applying values to other attributes permitted by the SNOMED CT concept model

Example

- 31978002 Fracture of tibia is a subtype of 404684003 Clinical finding
- Concept model permits subtypes of 404684003 Clinical finding to have a 42752001 Due to attribute
- ‘Fracture of tibia due to fall on ice’ can therefore be represented as
  - 31978002 Fracture of tibia : 42752001 Due to = 75354000 Fall on ice
- Terms can be omitted to shorten
  31978002 : 42752001 = 75354000

Advantages of Postcoordination

- Scope coverage and terminology size
  - Coverage to an adequate level of specificity does not require every possible concept to exist
  - Reduces the need for “combinatorial explosion” in concept numbers
- Terminology maintenance
  - The maintenance burden is related to terminology size
- Structured data entry
  - Ability to represent refined content is not dependent on specific concepts existing
  - Expressions can be constructed in a consistent manner rather than searching hundreds of similar terms for precisely the correct one
- Consistent retrieval
  - Less dependency on modelling of individual concepts
  416098002 Drug allergy = 246075003 Causative agent = 372725003 Penicillin V
Disadvantages of Postcoordination

- Human readability
  - Extreme postcoordination can lead to loss of natural terms
  - Example - ‘Procedure with method of excision and procedure site of appendix’ may be better expressed as ‘Appendectomy’
- Data entry
  - Users may need to construct expression by selecting multiple options rather than simply typing or choosing the term they want
- Storage and Exchange
  - Expressions that have an unspecified number of refinements are less easy to store, manipulate and exchange than simple codes
- Retrieval
  - Several postcoordinated expressions may mean the same
  - Queries need to process expressions rather than simple codes

Conclusions about Pre and Post Coordination

- Both pre and postcoordination have benefits
- A successful terminology should
  - Enable postcoordination to add flexibility
  - Include precoordinated concepts for commonly used meanings
  - Avoid attempting to identify an absolute boundary of what may or may not be precoordinated
  - Deal with the issues raised by alternative representations
    - The key issue is detection of equivalence$^1$ and subsumption$^2$ of alternative expressions

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$^1$: Equivalence is when two expressions have the same meaning
$^2$: Subsumption is when the meaning of one expression is a subtype of the meaning of the other
Pre and Post Coordination with SNOMED CT

- SNOMED CT supports both pre and postcoordination
  - No absolute boundaries between them
- SNOMED CT enables computation of equivalence and subsumption between alternative representations
  - For example, the postcoordinated expression
    \[22253000 \text{Pain} : 363698007 \text{Finding site} = 56459004 \text{Foot}\]
  - is a subtype of the precoordinated concept
    - 10601006 \text{Pain in lower limb}
  - because this precoordinated concept is defined as
    \[22253000 \text{Pain} : 363698007 \text{Finding site} = 61685007 \text{Lower limb structure}\]
  - and
    - 56459004 \text{Foot} is a subtype of 61685007 \text{Lower limb structure}
Compositional Grammar

Compositional Grammar – ABNF Syntax

expression = ws [definitionStatus ws] subExpression ws
definitionStatus = equivalentTo / subtypeOf
equivalentTo = "==="
subtypeOf = "<<<"
subExpression = focusConcept [ws ";" ws refinement]
focusConcept = conceptReference *(ws "+" ws conceptReference)
conceptReference = conceptId [ws ";" ws term ws ";" ]
conceptId = sctId
term = nonwsNonPipe *( SP nonwsNonPipe )
refinement = (attributeSet / attributeGroup) *( ws ["," ws] attributeGroup )
attributeGroup = ";" ws attributeSet ws ";"
attributeSet = attribute +(ws "," ws attribute)
attribute = attributeName ws ";" ws attributeValue
attributeName = conceptReference
attributeValue = expressionValue / QM stringValue QM / ";" numericValue

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Compositional Grammar – Examples (1)

▪ Fracture of tibia
  31978002 |Fracture of tibia|

▪ Spray suspension
  421720008 |Spray dose form| + 7946007 |Drug suspension|

▪ Right hip
  182201002 |Hip joint| : 272741003 |Laterality| = 24028007 |Right|

▪ Replacement of the right hip
  397956004 |Prosthetic arthroplasty of the hip| :
  363704007 |Procedure site| = (182201002 |Hip joint| :
  272741003 |Laterality| = 24028007 |Right|)

Compositional Grammar – Examples (2)

▪ Excision of gallbladder and exploration of bile duct
  7138802 |Procedure| :
  {260686004 |Method| = 129304002 |Excision|,
  405813007 |Procedure site - Direct| = 28231008 |Gallbladder structure|},
  {260686004 |Method| = 281615006 |Exploration|,
  405813007 |Procedure site - direct| = 2873000 |Bile duct structure|}

▪ Amoxicillin 500 mg capsule
  27658006 |Amoxicillin| :
  {111115 |Has basis of strength| = (111115 |Amoxicillin only| :
  111115 |Strength magnitude| = #500,
  111115 |Strength unit| = 258684004 |mg|)}
EHR System Design – Data Entry and Display

EHR System Design – Storage and Retrieval
Data Entry and Display

Data Entry and Display – Precoordinated

- Free text
- Semi-structured
- Structured
  - Radio buttons
  - Check boxes
  - Value lists
  - Spatial diagrams

Symptoms:
- Normal blood glucose
- Decreased blood glucose
- Increased blood glucose
- High blood pressure
- Fever
- Head ache

Select from List
- X-ray
- Abdominal X-ray
- X-ray of chest wall
- MRI
- MRI of abdomen

Location:
- Left upper arm
Data Entry and Display – Postcoordinated

- Free text and semi-structured
  - With Natural Language Processing (NLP)
- Structured
  - Predefined library of clinical phrases
    - Mapped to SNOMED CT expressions
  - Information model with expression templates
    - Radio buttons, check boxes, value lists, spatial diagrams
  - Expression builder
    - Form or grammar
Data Entry and Display – Free Text with NLP

- Allows clinicians to write free text notes in their preferred style
- May include complex sentences, abbrevs, spilling errors
- Postcoordination allows capture of more complete meaning
  - Allows context to be captured to avoid incorrect query results
    - e.g. certainty, temporality and subject relationship
  - Allows qualifying attributes to provide more specificity
    - e.g. severity, laterality, finding site
- MRCM can be used to find postcoordination opportunities

Data Entry and Display – CNLP with Clinithink
Data Entry and Display – CNLP with Clinithink

243796009 |Situation with explicit context| : 

{246090004 |Associated finding| = (363346000 |Cancer| : 

{363698007 |Finding site| = 28231008 |Gallbladder structure|, 

116676008 |Associated morphology| = 367651003 |Malignant Neoplasm (Morphology)|)

), 408732007 |Subject relationship context| = 394857004 |Maternal grandfather|,

408731000 |Temporal context| = 410512000 |Current or specified|,

408729009 |Finding context| = 410515003 |Known present|}
Machine Readable Concept Model – MRCM

Represents the SNOMED CT Concept Model in a form that can be read and processed by a computer.

Use Cases:
1. Precoordinated terminology development
2. Expression, constraints, queries and template development
3. Natural Language Processing
4. Terminology binding

Reference sets:
1. MRCM domain – lists domains to which attributes may be applied
2. MRCM attribute domain – associates attributes with domains
3. MRCM attribute range – associates attributes with ranges
4. MRCM module scope – specifies set of MRCM refsets that apply

MRCM Example

MRCM domain

MRCM attribute domain

MRCM attribute range

The patient has cancer of the gallbladder.

{ 363346000 |Cancer| : 363698007 |Finding site| = 28231008 |Gallbladder structure|, …}
Expression Constraint

A computable rule that can be used to define a bounded set of clinical meanings.

Use Cases

1. Terminology binding
2. Intensional reference set definitions
3. SNOMED CT content queries
4. SNOMED CT MRCM

Example

Lung disorders with morphology a type of edema

< 19829001 | Disorder of lung | :
116676008 | Associated morphology | = << 79654002 | Edema |

Data Entry and Display – Postcoordinated

- Free text and semi-structured
  - With Natural Language Processing (NLP)
- Structured
  - Predefined library of clinical phrases
    - Mapped to SNOMED CT expressions
  - Information model with expression templates
    - Radio buttons, check boxes, value lists, spatial diagrams
  - Expression builder
    - Form or grammar
Data Entry and Display – Library of Clinical Phrases

<table>
<thead>
<tr>
<th>Clinical Phrase</th>
<th>SNOMED CT Expression</th>
</tr>
</thead>
<tbody>
<tr>
<td>FH of gastric bleeding</td>
<td>416471007</td>
</tr>
<tr>
<td>Pain in left elbow</td>
<td>74323005</td>
</tr>
<tr>
<td>Severe abdominal pain</td>
<td>21522001</td>
</tr>
<tr>
<td>Suspected gastric ulcer</td>
<td>444433005</td>
</tr>
<tr>
<td>Suspected gastric bleeding</td>
<td>444433005</td>
</tr>
</tbody>
</table>

Data Entry and Display – Library of Clinical Phrases

- Can be displayed using precoordinated techniques
  - Radio buttons
  - Check boxes
  - Value lists
  - Spatial diagrams
- New phrases can be added without waiting for a new SNOMED CT release
- Value lists may get long
- Phrases are predefined
  - Less flexible
Data Entry and Display – Postcoordinated

- Free text and semi-structured
  - With Natural Language Processing (NLP)
- Structured
  - Predefined library of clinical phrases
  - Mapped to SNOMED CT expressions
  - Information model with expression templates
    - Radio buttons, check boxes, value lists, spatial diagrams
  - Expression builder
    - Form or grammar

Data Entry and Display – Model with Template

- Disorder:
  - Select…
    - Labyrinthitis
    - Otitis externa
    - Otitis media

- Severity:
  - Mild
  - Moderate
  - Severe

- Episodicity:
  - First episode
  - Old episode
  - New episode

Disorder: 65363002 |Otitis media|:
  246112005 |Severity| = 6736007 |Moderate|,
  246456000 |Episodicity| = 255217005 |First episode|
Data Entry and Display – Model with Template

Expression Template

An incomplete expression containing ‘slots’ to be filled later.

Use Cases:
1. SNOMED CT concept authoring
2. SNOMED CT expression authoring
3. Terminology binding

Template Slots:
- Some slots are removed [[ … ]]
- Some slot are replaced [[ + …]]
- Slots may contain
  - Slot name: @name
  - Reference to value: $codedField
  - Cardinality: 0..*
  - Value constraint: + (< 404684003 |Clinical finding|)
Expression Template – Examples

Example 1: **CT of X**

71388002 |Procedure| : [[1..1]]

{ 260686004 |Method| =
312251004 |Computed tomography imaging action|,
405813007 |Procedure site - Direct| =
[[+(<<442083009 |Anatomical or acquired body structure|)]] }

Example 2: **Family history of disease X in family member Y**

413350009 |Finding with explicit context| : [[1..1]]

{ 246090004 |Associated finding| =
[[+(< 404684003 |Clinical finding|)],
408732007 |Subject relationship context| =
[[+(<< 125676002 |Person (person)|)],
408729009 |Finding context| = 410515003 |Known present|,
408731000 |Temporal context| = 410511007 |Current or past (actual)| }

Data Entry and Display – Postcoordinated

- Free text and semi-structured
  - With Natural Language Processing (NLP)
- Structured
  - Predefined library of clinical phrases
    - Mapped to SNOMED CT expressions
  - Information model with expression templates
    - Radio buttons, check boxes, value lists, spatial diagrams
  - Expression builder
    - Form or grammar
Data Entry and Display – Expression Builder

- Form-based expression builder
  - With expression template
    - Form may be automatically generated from template

413350009 |Finding with explicit context|:
{246090004 |Associated finding| = [[+$Finding]],
408732007 |Subject relationship context| = [[+$Relationship]],
408729009 |Finding context| = 410515003 |Known present|
408731000 |Temporal context| = 410511007 |Current or past (actual)|}

Expression Builder

<table>
<thead>
<tr>
<th>Focus Concept(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disease</td>
</tr>
<tr>
<td>Clinical finding</td>
</tr>
<tr>
<td>Disease</td>
</tr>
<tr>
<td>Procedure</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finding site</td>
<td>Endocrine system</td>
</tr>
</tbody>
</table>

64572001 |Disease|:
363698007 |Finding site| =
113331007 |Endocrine system|
Data Entry and Display – Compositional Grammar

- Form-based expression builder
  - With expression template
  - Without expression template
- Compositional Grammar expression editor
  - Authoring support may include
    - Syntax validation, MRCM conformance checking, auto-populating terms, concept searching (filtered based on MRCM rules), auto-suggestions for operators or characters

---

57177007 | Family history with explicit context |
246090004 | Associated finding | = 73211009 | Diabetes mellitus |
408732007 | Subject relationship context | = 444301002 | Mother of subject |
408731000 | Temporal context | = 410511007 | Current or past (actual) |
408729009 | Finding context | = 410515003 | Known present |

---

Data Entry and Display – Display Options

1. Display using originally authored and stored form
2. Add in terms that have been omitted
3. Replace existing terms with local-dialect PTs or FSNs
4. Use different font colors and whitespace
5. Display term shown to the user when entering expression
6. Use form to display focus concept and attribute values

---

Expression
Family history of diabetes mellitus in mother of subject

Subject relationship context
Mother of subject

Temporal context
Current or past (actual)

Finding context
Known present
Data Entry and Display – Description Generation

- Automatic term generation
  - Can be used to provide a more clinician friendly term
  - Simple approach is to use a description template

**EXPRESSION TEMPLATE**

57177007 | Family history with explicit context: |
| (246090004 | Associated finding | = | 73211009 | Diabetes mellitus | |
| 408732007 | Subject relationship context | = | 444301002 | Mother of subject | |
| 408731000 | Temporal context | = | 410511007 | Current or past (actual) | |
| 408729009 | Finding context | = | 410515003 | Known present | |

**DESCRIPTION TEMPLATE**

Family history of [[$Disease.PT | ]] in [[$Relationship.PT | ]] 

Family history of diabetes mellitus in mother of subject

---

Storage and Retrieval
Storage and Retrieval – Precoordinated

- Always store the SNOMED CT concept id
  - Provides machine readable interoperability
  - Code field must support up to 18 characters
    - Max length of SNOMED CT extension ids
- Preferably store term selected or displayed
  - Provides human readable clinical interoperability
- Never rely on the description id for interoperability

Storage and Retrieval – Postcoordinated

Options

1. Use a separate field for focus concept and each attribute value
   - Use if a fixed expression template can be defined
2. Store the expression string as the code in patient record
   - Flexible - allows a variety of expressions to be stored
   - Code must support long expression strings (>56 chars)
   - May be stored without terms or spaces to reduce length
     - 31978002 |Fracture of tibia| : 272741003 |Laterality| = 7771000 |Left|
     - 31978002:272741003=7771000
   - Should also store human readable display term
3. Store an expression id as the code in patient record,
   expression repository stores expressions for each id
   - Shorter identifiers in patient record
   - Index expressions to improve retrieval time
   - Can be local or shared across organizations
   - Can precompute subsumption hierarchy
Storage and Retrieval – Expression Repositories

- Example expression repository design
  - Expression
    - id: SCTID
    - effectiveTime: Time
    - active: Boolean
    - moduleld: SCTID
    - expression: String
  - Expression Link
    - id: SCTID
    - effectiveTime: Time
    - active: Boolean
    - moduleld: SCTID
    - sourceId: SCTID
    - destinationId: SCTID
    - typeId: SCTID

A generated clinical term could be added OR an Expression Description table could be used to support multiple synonyms.

Storage and Retrieval – Expression Repositories

- Example expression repository functions
  - Retrieve an id for a given expression
  - Retrieve an expression for a given id
  - Compute subsumption hierarchy
  - Test two expressions for subsumption
  - Return attribute value in an expression
  - Prepopulate repository with a set of expressions matching a given expression template
  - Generate a term for a given expression
Exchange – Precoordinated

- Coded datatype is populated as defined – e.g.

```xml
<Condition xmlns="http://hl7.org/fhir">
  <id value="#example"/>
  <verificationStatus value="#generated"/>
  <code>
    <!-- The problem is a bacterial infection -->
    <coding>
      <system value="http://snomed.info/sct"/>
      <version value="http://snomed.info/sct/990000000000207008/version/20160731"/>
      <code value="#97628006"/>
      <display value="#Bacterial infectious disease"/>
    </coding>
    <text value="#Disease caused by bacteria"/>
  </code>
  <subject>
    <reference value="#Patient/pr100"/>
    <display value="#value"/>
  </subject>
  <dateRecorded value="#2016-07-18"/>
  <assertor>
    <reference value="#Practitioner/pr200"/>
  </assertor>
</Condition>
```
Exchange – Postcoordinated

- Options
  1. Place full expression in ‘code’ attribute of relevant field
  2. Place a unique expression id in ‘code’ attribute of relevant field
     - Requires a shared expression repository to be in place
  3. Decompose expression into separate codes that can be placed into different fields in message

Exchange – Postcoordinated

- Expression string is populated in the ‘code’ field – e.g.

```xml
<Condition xmlns="http://hl7.org/fhir">
  <id value="example"/>
  <verificationStatus value="generated"/>

  <code>
    <display value="Fracture of left tibia"/>
<code>
  <text value="Fracture of left tibia"/>
</Condition>
```

> "31978002:272741003=7771000000000000000000007008/version/20160731"/> "Fracture of left tibia"/>"
Exchange – Postcoordinated

- Expression string is populated in the ‘code’ field – e.g.

```
<Condition xmlns="http://hl7.org/fhir">
  <id value="example"/>
  <verificationStatus value="generated"/>
  <code>
    <!-- The problem is a bacterial infection -->
    <coding>
      <system value="http://snomed.info/sct"/>
      <version value="http://snomed.info/sct"/>
      <code value="157681000003164"/>
      <display value="Fracture of left tibia"/>
    </coding>
    <text value="Fracture of left tibia"/>
  </code>
  <subject>
    <reference value="Patient/patient1"/>
    <display value="value"/>
  </subject>
  <asserted>
    <reference value="Practitioner/practitioner1"/>
  </asserted>
</Condition>
```

If using a shared Expression Repository, the pre-coordinated approach can be used. The ‘code’ is then populated with the expression identifier, and resolved by the receiving system.
Querying – Precoordinated

- SNOMED CT editions can be classified prior to release
  - Inferred relationships are distributed and available for systems to query and reason over
  - Subsumption can be tested easily using transitive closure
- Query Techniques
  - Subsets
  - Subsumption
  - Defining relationships
  - Description logic reasoning
- Query Languages
  - Expression Constraint Language
  - SQL, OQL, SPARQL

Querying - Postcoordinated

- Supports different ways to express the same meaning
### Querying - Postcoordinated

- Supports different ways to express the same meaning

**Example 1:**
- 28012007 | Closed fracture of shaft of tibia |

**Example 2:**
- 125605004 | Fracture of bone |
  - 363698007 | Finding site |
  - 52687003 | Bone structure of shaft of tibia |
  - 116676008 | Associated morphology |
  - 20946005 | Fracture, closed |

**Example 3:**
- 64572001 | Disease |
  - 363698007 | Finding site |
  - 52687003 | Bone structure of shaft of tibia |
  - 116676008 | Associated morphology |
  - 20946005 | Fracture, closed |

**Example 4:**
- 423125000 | Closed fracture of bone |
  - 363698007 | Finding site |
  - 52687003 | Bone structure of shaft of tibia |

**Example 5:**
- 6990005 | Fracture of shaft of tibia |
  - 116676008 | Associated morphology |
  - 20946005 | Fracture, closed |

### Querying – Postcoordinated

- **Approach 1 – Expression template**
  - Use an expression template with predictable slots
  - Allow queries over the values that fill each ‘slot’

- **Approach 2 – Expression normalization**
  - Use expressions normalization techniques for subsumption testing
    - Replace fully defined concepts with proximal primitive parents and defining relationships

- **Approach 3 – Description Logic**
  - Convert expressions to OWL and use DL reasoner (Fact++, ELK)
    - Transform expression to conform to concept model
    - Group all ungrouped attributes which are ‘groupable’

- **Approach 4 – Preclassified expression repository**
  - Use a DL reasoner to preclassify a shared repository
  - Query expressions using precoordinated approaches
Querying – Expression Template

- **Expression template**
  
  \[
  \begin{align*}
  &\text{[[ + (< 404684003 \text{Clinical finding}) @\text{finding} ]] : 363698007 \text{ [Finding site]} = \\
  &\quad (\text{[[ + (< 52530000 \text{Body region structure}) @\text{site} ]] : 272741003 \text{ [Laterality]} = \text{[[ + (< 182353008 \text{Side}) @\text{side} ]] })
  \end{align*}
  \]

- **Diagnosis**
  
  125667009 |Contusion| : 363698007 |Finding site| =
  83738005 |Index finger structure| : 272741003 |Laterality| = 7771000 |Left|

- **Query**
  
  For the given patient, find the \$site and \$side of all diagnoses where \$finding = 125667009 |Contusion|

Note: Precoordinated concepts must be decomposed into the template for consistent querying.

---

Querying – Expression Normalization

- **Diagnosis** (predicate expression)
  
  125667009 |Contusion|:
  363698007 |Finding site| = (83738005 |Index finger structure| : 272741003 |Laterality| = 7771000 |Left|)

  **Predicate In Normal Form**
  
  64572001 |Disease|: {116676008 |Associated morphology| = 308492005 |Contusion - lesion|, 363698007 |Finding site| = (83738005 |Index finger structure| : 272741003 |Laterality| = 7771000 |Left| )}

- **Query** (candidate expression)
  
  416462003 |Wound|

  **Candidate In Normal Form**
  
  64572001 |Disease|:
  {116676008 |Associated morphology| = 13924000 |Wound|}
Querying – Description Logic

- **Diagnosis** (in compositional grammar)
  
  ```
  125667009 |Contusion| :
  363698007 |Finding site| = ( 83738005 |Index finger structure| :
  272741003 |Laterality| = 7771000 |Left| )
  ```

- **Diagnosis** (in OWL 2 EL)
  
  
  ```
  'Contusion (disorder)'
  and ('Role group (attribute)' some
  (('Associated morphology (attribute)' some 'Contusion - lesion
  (morphologic abnormality)') and
  ('Finding site (attribute)' some
  ('Index finger structure (body structure)' and
  ('Laterality (attribute)' some 'Left (qualifier value)')))))
  ```

- **DL Query / SPARQL**
  Subclasses of 'Wound (disorder)'

Querying – Preclassified Expression Repository

```graph

416462003 |Wound|

125667009 |Contusion|

125667009 |Contusion| :
363698007 |Finding site| = 7569003 |Finger structure|

125667009 |Contusion| :
363698007 |Finding site| = 83738005 |Index finger structure|

125667009 |Contusion| :
363698007 |Finding site| = ( 83738005 |Index finger structure| :
272741003 |Laterality| = 7771000 |Left| )

125667009 |Contusion| :
363698007 |Finding site| = 29707007 |Toe structure|

125667009 |Contusion| :
363698007 |Finding site| = 78883009 |Big toe structure|
```

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Summary

Summary – SNOMED CT Expressions

A structured combination of one or more concept identifiers used to represent a clinical meaning

- Data entry and display
  - Free text with NLP
  - Predefined library of clinical phrases
  - Information model with expression templates
  - Expression builder
- Storage and retrieval
  - Separate fields for each attribute value
  - Expression string in code field
  - Expression ids and expression repository
- Exchange
  - Expression string or id in code field
- Query
  - Expression template, normalization, DL reasoner
  - Preclassified expression repository supports simple subsumption
Links to Further Information

- Technical Implementation Guide
  - http://snomed.org/tig
- Data Search and Entry Guide
  - http://snomed.org/searchguide
- Compositional Grammar
  - http://snomed.org/scg
- Expression Constraint Language
  - http://snomed.org/ecl

Questions and Discussion