KNOWLEDGE SHARING SYSTEM FOR DENTAL EXTRACTION IN ORDER TO ASSIST DENTAL DOCTORS AND ASSISTANTS

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Abstract- Even though tooth extraction is one of the common surgical procedures in the dental field, it needs an extensive knowledge and practical experiences when handling the dental extraction equipment such as dental extraction forceps. Otherwise, it will be more complex or even in a worse case as it may cause damages to patients' mouth area. Hence, it is very important to have a sound knowledge of the instruments to be used, especially on extraction forceps. So, the knowledge of extraction forceps should be disseminated properly. After identifying this need, as a first stage, we gathered the information regarding the dental extraction forceps from the experts in the field. Then we started developing ontology as a second stage. Protégé OWL Ontology Editor 5.1 was used for this purpose. Finally, the developed ontology was evaluated in two folds; by using inbuilt tools and by ontology experts as an iterative approach. We strongly believe that our novel approach on dental extraction forceps ontology can support the dental students, dentists as well as their assistants to improve the knowledge and helpful in learning practices. Our next step is to model the ontology for whole extraction process and to develop a knowledge management system portal on dental extraction forceps.

Keywords- dental forceps, ontology, knowledge sharing

I. INTRODUCTION

A tooth is one of the hardest parts in most of the vertebrates which is a calcified structure and is situated inside jaws (Wikipedia, 2017). A dental extraction is the removal of teeth from its socket in the jaws (Kolosovas-Machuca et al., 2016). There are many reasons for dental extractions, but it is mainly done if a tooth has been damaged by decay or broken (Anyanechi and Chukwuneke, 2012). There are two types of extractions performed in the dental field:

i. A simple extraction, which is performed on a tooth which is visible inside the mouth. In a simple extraction procedure, the dentist will hold the tooth with specialized pliers called "extraction forceps" and move them front and back in order to loosen the tooth from the jaw before getting rid off the tooth (J. F. Cclyer, 1986, Wikipedia, 2017).

ii. A surgical extraction, which is a more complex like other surgical procedure.

The forceps is an exaggerated version pair of pliers. In general, forceps which are designed for the extraction of anterior (front) teeth in the maxilla (upper), the blades and handles are in the same line while for the maxilla posterior (back) teeth the handles form a curve with the blades. In forceps used for the extraction of mandibular (lower) teeth, the blades and handles are at an angle of approximately ninety degrees between them (J. F. Cclyer, 1986).

Sometimes different terminologies are used to express the same concept. Due to the unstructured, incomplete, general nature and varied formats of the information, the knowledge is not reaching everybody (Walisadeera et al., 2015). Further, computers need to understand the meaning or semantics of the information clearly. Semantic web enables this understanding of computers (Choksi and Jinwala, 2015). Ontologies are the powerful mechanism for representing knowledge presented in the semantic web (Vasanthapriyan et al., 2017b). Therefore, ontology can be used to find a response to queries within a specified context in the domain of dental extraction (Walisadeera et al., 2013, Vasanthapriyan et al., 2017b).

The aim of this work is to contribute to an improvement in the management and usage of dental extraction forceps in hospitals by developing an ontology-driven solution which organizes and describes clearly the related knowledge.

II. LITERATURE REVIEW AND RELATED WORKS

One of the commonest surgical procedure in the dental surgery is tooth extraction (Anyanechi and Chukwuneke, 2012). Dentists need to be very careful when performing tooth extraction. Even though enough efforts are applied to perform tooth extractions some accidents may happen when proper instruments are not used (Balaji, 2013). Sometimes it may lead to slipping of the forceps from the tooth to affect the other tooth or jaw or even partial removal of the tooth (Heimann, 1977).

All the tooth in human is not in the same shape and size. So, each tooth needs to be extracted using different types of dental extraction forceps. Choosing the appropriate extraction forceps is the important part for the protection of jaws and another neighboring tooth which will be affected if the forceps slips away while extracting. If the specific extraction forceps are not used for a tooth, then there will be more complications (Tevfik OLurel, 2014) such as incomplete extraction in which a tooth root remains in the jaw, prolonged bleeding, swelling, bruising, nerve injury or even extraction of the wrong tooth (Wikipedia, 2017).

Further, if proper extraction forceps are used by the dentist, his or her extraction will be easy as each extraction forceps are made by using the knowledge of physics. For example, extraction forceps are made smaller in size for children in order to apply less force and larger in size for adults in order to apply more force. If we take another example, the tooth on deep end in the jaw (wisdom tooth) needs a different mechanism to extract than the tooth in the front part of the jaw (incisors) (J. F. Cclyer, 1986). So extraction forceps are made "L" shape for the deeper end and straight for central area. Therefore, usage of specific extraction forceps for the specific tooth is very important for patients' health as well as for the easiness of the dentist.

Modelling knowledge by using ontologies in the medical domain is an active research field (Garcia-Valverde et al., 2014). Even though health sector is being supported by number of biomedical ontologies such as GALEN, the Unified Medical Language Source, the Systemic Nomenclature of Medicine which focus on general scope of the biomedical domain (Kuziemsky and Lau, 2010), and the Gene Ontology (GO) which is one of the earliest and most frequently used vocabularies (Hu et al., 2016), there are a very few ontology on dental domain on the health sector. Ontology-based systems provide reusable terminology resources and they can be used to improve the management of complex systems for different context information which can be captured and validated (Garcia-Valverde et al., 2014).

In order to integrate the knowledge, it has to be seamless and unaffected by the technological issues related to knowledge representation. In most of the knowledge ontologies, the experience of domain experts is key to design the ontologies (Chen et al., 2017). Semantic representations help in these issues and enable interoperability. For a particular domain, unambiguous description of the objects and their relationship can be described by using domain ontology (Rao et al., 2014). According to Gruber (Gruber, 1995), "ontology provides a structured view of domain knowledge and act as a repository of concepts in the domain". This structured view is essential to facilitate knowledge sharing, knowledge aggregation, information retrieval, and question answering. Therefore, ontology can be used in the domain of dental to find the specific response to queries.

The use of ontologies in the health domain mainly focussed on the representation and re-organization of medical terminologies. The most significant benefit that ontologies in the health sector are its ability to support the integration of knowledge and data (Pisanelli, 2004). Even though ontologies are used in the information system (IS) design, the ontology development in the health sector is more challenging because of its complexity and the level of detail in it (Kuziemsky and Lau, 2010). Even though there is some previous work which has evidenced knowledge sharing methods for various domains such as software testing (Vasanthapriyan et al., 2017b, Vasanthapriyan et al., 2017a), economics (Yoo and No, 2014) etc., a very little

research into dental knowledge sharing using domain ontologies has been conducted.

Having discovered this research gap we have focused on our attention on developing a dental extraction forceps ontology to represent information needs according to tooth extraction context. That is, we intend to develop an ontology-based knowledge framework to manage extraction forceps-related knowledge. This would assist the doctors and their assistants in the dental hospitals to manage extraction forceps knowledge.

III. METHODOLOGY

Our main focus is on simple extraction, more specifically in extraction forceps because these extraction forceps plays an important role in tooth extraction (J. F. Cclyer, 1986). Grounded theory was used for data collection. Two dentists with extensive knowledge of dental (mainly on extraction) and an expert on ontology engineering took part. After interviewing them, the dental extraction problems were identified. The Competency Questions (CQs) were developed after collecting needed information. CQs are a set of questions that the ontology must be capable of answering using its axioms (Grüninger and Fox, 1995). CQs work as requirement's specification of the dental extraction forceps ontology. Our ontology aims to answer competency questions. Some of them shown in table 1.

We get the relevant data in order to answer these CQs through an extensive literature survey and expert collaboration. We categorized the "Person" into two; "Adult" and "Child". The "Parts" of the tooth is divided into "Crown" and "Root". "Positions" also categorized as "Upper", "Lower", "Left" and "Right". Tooth have "Specific Names". They were classified into "Molar", "Premolar", "Canine" and "Incisor". There are three international standard systems for naming teeth:

i. The universal numbering system,

ii. The palmer notation method and

iii. The two-digit FDI world dental federation notation.

In this paper, we followed two-digit FDI world dental federation notation developed by International Association for Dental Research. It provides a system for designating teeth or areas of the oral cavity using two digits (Park and Kim, 2006). We declared these notations into "ToothNotation" class. Since there are no standards for forceps classification, we formalized the forceps into two main categories; Crown Forces and Root Forceps. Here what we meant by the crown is the full tooth which includes both parts; crown and root. Further, we divided each forceps into many subclasses. The high-level class hierarchy is shown in Figure 1. The ontology was implemented by using the Protégé-OWL Ontology Editor 5.1. Part of the dental extraction forceps ontology is shown in figure 2.

Since we are designing with OWL 2 Web Ontology Language for the semantic web, we use Description Logic (DL) which is a decidable fragment of FOL for our scenario. The competency questions were evaluated to check whether the developed ontology meets the dentists' requirements in the design process. In order to query the ontology, the DL expressions have been used. For this purpose, we used the DL query facility which is available in Protégé OWL Ontology Editor 5.1. Some of the DL query and their answers are shown in Table 2.

Table 1. Font sizes for this publication

Competency questions
What is the position of central incisor of a child in the mouth?
Which tooth is in the upper left side of an adult?
Which extraction forceps are needed to extract the root of left second premolar of an adult?
Which extraction forceps are needed to extract the normal left central incisor of a child?
Which teeth are in the upper left side of an adult?
What is the tooth of lower left central incisor of a child in the mouth?
Which extraction forceps are S-shaped?
What type of movement is applied to the third molar of the upper left side of an adult
What type of dentition is for a child?

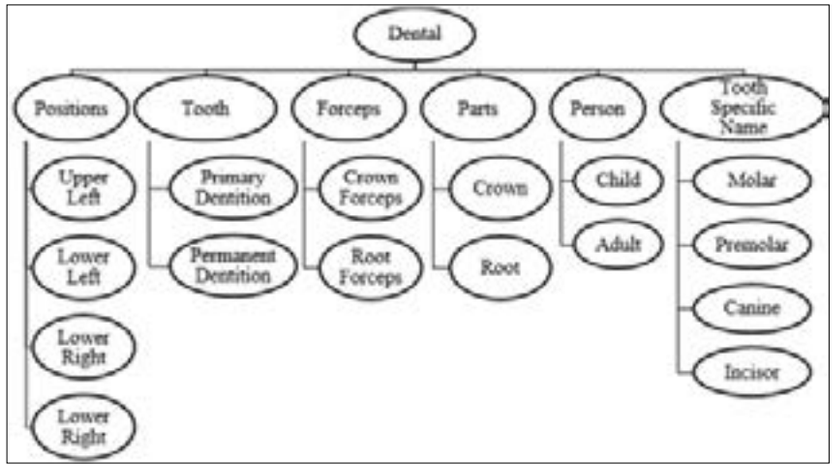

Figure 1. The high-level class hierarchy of dental extraction forceps ontology

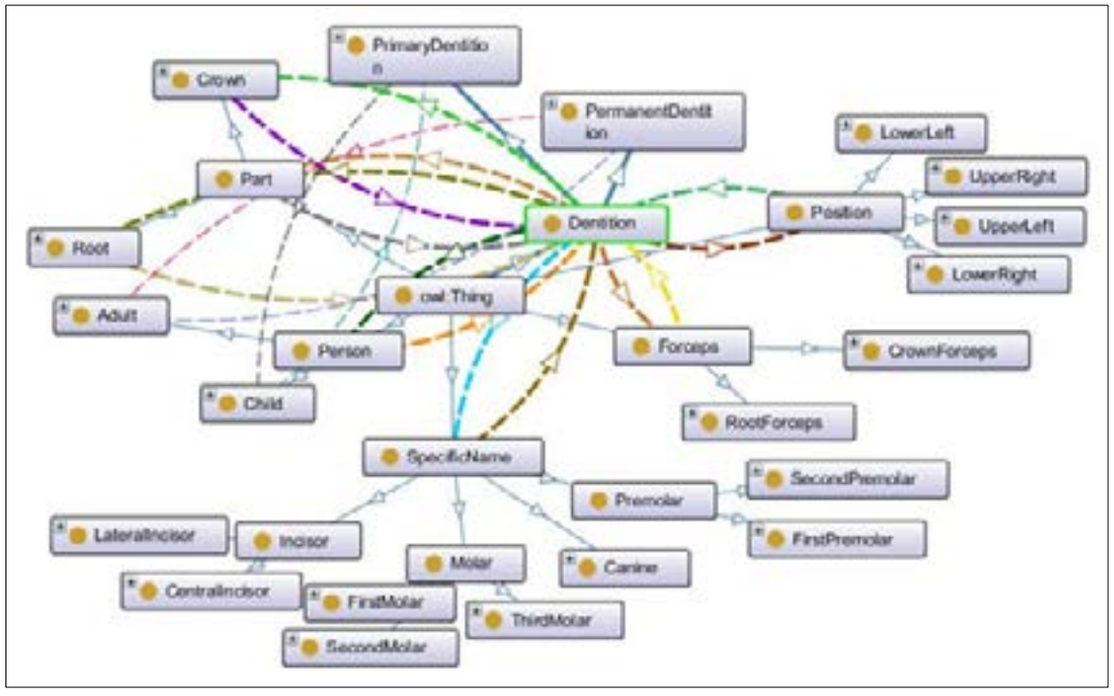

Figure 2. Part of the dental extraction forceps ontology

Table 2. DL query and their answers

Competency questions	DL query	Answers
What forceps are used to pluck T55 dentition?	Forceps and hasUsedToPluck value T55	Instances (2) • ChildUpperMolarCF • ChildUpperRF
What are the dentitions which consist of specific name canine?	Dentition and hasSpecificName value Canine	Instances (8) • T13 • T53 • T23 • T63 • T33 • T73 • T43 • T83
What is the position of T34 dentition?	Position and isPositionOf value T34	Instances (1) • LowerLeft
What is the specific name of T28 dentition?	SpecificName and isSpecificNameOf value T28	Instances (1) • ThirdMolar

In order to avoid the defects when using the ontology, its quality should be verified and validated (Poveda-Villalón et al., 2012). So, the evaluation of the ontology was conducted at the last stage of our methodology which is done by experts in the field ontology and by using inbuilt FaCT++ 1.6.5 reasoner. Further, in order to detect potential pitfalls which will lead to errors in modelling, we used an online ontology evaluator called OOPS! which is available at http://oops.linkeddata.es/ (Poveda-Villalón et al., 2012). This evaluator evaluates the developed ontology in five aspects; (i) human understanding, (ii) logical consistency, (iii) modelling issues, (iv) real-world representation and (v) semantic applications for the developed ontology.

IV. DISCUSSION

Tooth extraction is one of the common surgical procedure in the field of dental, which mainly depends on the knowledge and experience of the dentists. Great importance on knowledge for dental extraction forceps is given in this research. An ontological approach to representing the necessary dental extraction forceps knowledge within the dentists' context was developed.

Designing this type of ontology is not a simple task, because we need to gain vast domain knowledge. In this paper, we have explained how we designed and developed the ontology to organize domain knowledge by meeting particular access requirements effectively. Using this approach, dental extraction forceps ontology to include information needs to be identified for dental extraction activities to be designed.

The validation and evaluation have been done separately. We validated the ontology in terms of accuracy and quality by using the FaCT++ reasoner which is and inbuilt tool in Protégé-OWL Ontology Editor 5.1 and by using web-based tool OOPS!. We evaluated the ontology with the help of ontology expert by examining the deficiencies of the artifacts we used. Based on Ontology experts' responses, comments, and suggestions the ontology was redeveloped.

V. CONCLUSION

Tooth extraction is one of the common surgical procedures in the field of dental, which mainly depends on the knowledge and experience of the dentists. Therefore, in this research, great importance is given to knowledge for dental extraction forceps, and the potential benefits of managing dental extraction forceps knowledge. An ontological approach is needed to represent the necessary dental extraction forceps knowledge within the dentists' context (Vasanthapriyan et al., 2017a). Identification of the suitable dental extraction forceps for the given case is resolved by developing a domain ontology on dental extraction forceps. Our dental extraction forceps ontology not only solves the problem of selection of right dental extraction forceps but also, it provides a valuable knowledge sharing method for dental students and other researchers.

Designing the ontology in the dental domain is not a simple task. The complexities in the dental extraction domain and the need to gain vast domain knowledge made this task tedious. This research presents dental extraction forceps ontology which represents dental extraction forceps domain knowledge. It includes dental extraction forceps concepts, their properties, and their relationships. We strongly believe that our dental extraction forceps ontology can support the dental hospitals, dental students and other active researchers in this field to improve the sharing of knowledge and experiences.

Our future works have two main parts. Firstly we are planning to expand our research to the whole extraction process which includes all the devices used in the extraction process. Secondly, the development of a knowledge management portal for our expanded research in order to disseminate the knowledge on the dental extraction process. Even though there are some works on knowledge sharing such as software testing (Vasanthapriyan et al., 2017b), economics (Yoo and No, 2014) etc., a very little research has been conducted on the dental domain. So our plan is to develop a knowledge management portal in the domain of dental extraction.

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