

ELECTRONIC PATIENT RECORD FOR DENTAL CHARTING

**Abdul Razak Hussain¹, Alina Abd Aziz²,
Norazlin Mohammed³, Syahida Mohtar⁴**

^{1,2,3,4}Faculty of Information and Communication Technology,
Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya,
76100 Durian Tunggal, Melaka.

Email: ¹razak@utem.edu.my, ²angelina_aziz@yahoo.com

ABSTRACT

The use of electronic patient records has a great positive potential to improve clinical practice and patient safety. These improvements can be realized through improved legibility and communication, standardized documentation, streamlined storage and consistent reporting. This paper addresses the development of an electronic patient record for dental charting as an alternative means towards a user-friendly and patient-centered dental environment. It considers prevalent dental charting practices, proposes a patient dental database and presents a dental charting application prototype, capable of capturing and displaying patient dental records. Data from this database is mapped and can be further manipulated through the patient's interactive dental chart. This interactivity not only offer quick-to-comprehend interfaces, but also reduces miscommunications. It will affect positively the legibility of dental records, enables a standardized documentation and a more consistent reporting.

KEYWORDS: *electronic patient record, dental charting.*

1.0 INTRODUCTION

Coined as the “application of computer and information science to improve dental practice, research and program administration” (Eisner, 1999), dental informatics promises a synergistic combination between dentistry and information technology given appropriate effort and investment (Schleyer and Spallek, 2001) (Thyvalikakath *et.al.*, 2008). Advances in computer technology in dentistry are certainly beneficial both during routine tasks (Farman *et.al.*, 2008) and decision making (Nagy *et.al.*, 2008)(Marotta *et.al.*, 2007), as shown qualitatively (Song *et.al.*, 2010)(Schleyer *et.al.*, 2007) and economically (Langbeer *et.al.*, 2008).

As part of an ongoing research on electronic dental information system that consists of modules such as registration, charting, appointment, treatment plan and billing, this paper focuses on the charting module. It proposes an alternative way on how a patient's dental records are captured, handled and manipulated through the use of computer charting in order to improve the data reliability. Interactivity through the use of a touch-sensitive computer screen contributes positively towards an improved dental workflow.

During a typical dental examination, a dentist must identify the patient's teeth and verbally conveys the teeth conditions to an assistant who then updates the patient's dental card. Both the dentist and the assistant must adhere to a designated set of symbols or notations not only to identify twenty deciduous (primary) teeth in a child and thirty two permanent teeth in an adult, but also to indicate the various teeth conditions and status. The convenience offered by the paper-based dental recording has certain main disadvantages namely miscommunication between the dentist and the assistant and lack of visual interactivity. Several other shortcomings of the current dental recording practices include missing/misplaced/damaged cards, long retrieval time, increased storage space, illegible/blurred handwritings, inconsistent notations/remarks, tedious housekeeping and cumbersome reporting activities.

Switching from the paper-based recording to electronic dental charting reduces the time taken for a patient dental examination through quick-to-comprehend, user-friendly interfaces. It reduces, not only miscommunication between dentists and their assistants, but also provides reliable and consistent patient dental records towards the implementation of an electronic dental information system.

2.0 EXPLORATORY PHASE

2.1 Dental Charting Notation

In order to avoid possible miscommunications during the dental examinations, both the dentists and assistants must refer to the same tooth numbering system or dental charting notations. By doing so, they increase the accuracy and consistency in the identification and specification of a tooth. There are three major dental charting notations that are commonly practiced (Hussain, 2009):

- a. Universal Numbering notation (American Dental Association) – It is widely accepted in the United

States. The primary teeth identification starts from the second molar on the upper right, lettered from 'A' until 'J', moving along the upper arch. It continues from the second molar on lower left until the second molar on the lower right, from letter 'K' until 'T'. The permanent teeth are numbered from 1 (upper right third molar) to 16 (upper left third molar) following the upper arch and continuing down to the lower jaw, from 17 (lower left third molar) until 32 (lower right third molar). A patient's teeth are numbered from 1 (upper right third molar) to 16 (upper left third molar) following around the upper arch and continuing down to the lower jaw, from 17 (lower left third molar) until 32 (lower right third molar).

- b. FDI World Dental Federation notation (FDI World Dental Federation) – It is known as the FDI Two-Digit notation or as the ISO 3950 notation. This notation is also used by the World Health Organization (WHO). The first digit represents the patient's mouth quadrant, and the second digit indicates the tooth type in each quadrant. For the permanent teeth, the quadrants are numbered 1 to 4, clockwise from the upper right quadrant. The quadrants for deciduous teeth are numbered from 5 to 8 in a similar sequence. For the primary teeth, there are five teeth in each quadrant, numbered from 1 to 5 (Figure 1). There are eight teeth in each quadrant for the permanent teeth; each is numbered from 1 to 8, beginning from the center front tooth (incisor) to the rear teeth (third molar) (Figure 1).
- c. Palmer Notation (Phinney and Halstead, 2004) – the patient's mouth is sectioned symmetrically into four quadrants and each quadrant is represented by a symbol: upper right (\lrcorner), upper left (\llcorner), lower right (\lrcorner) and lower left (\llcorner). In each quadrant, beginning from the front towards the back, adult teeth are numbered from 1 to 8 and children teeth are labeled 'A' through 'E'.

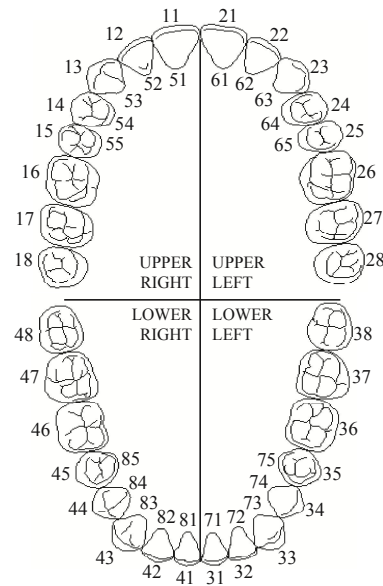


Figure 1 The FDI teeth numbering for deciduous (primary) teeth (5X, 6X, 7X, 8X) and permanent teeth (1X, 2X, 3X, 4X).

2.2 Current Dental Examination Practices

In a typical public dental clinic, a patient has to complete the patient details form during his/her first visit to the clinic. The front desk staff will store the details in the current system and the patient will be given a unique registration number. A patient then has to wait before his/her number is called upon. The patient will be assigned to a dentist (not necessarily the same one) for each visit unless prior appointment is made.

During the check-up and treatment, the dentist dictates the patient's dental conditions to the dental assistant who will record the details in the patient dental card. It is very important for the assistant to understand the dental charting card and know what or where to write or draw in order to ensure that the details are recorded correctly and legibly for future treatment purposes. If a patient changes clinic or requires a referral, the patient's dental card has to be located, retrieved, copied or transmitted accordingly.

3.0 DESIGN

3.1 Database and Tooth Data Model

The main entities in the conceptual relational database design are Patient, Tooth and DentalChart. While Patient and Tooth store details about the patients and teeth respectively, DentalChart holds details about the patients' teeth. A more complete data model can be found in (Acharya *et.al.*, 2009). There are two types of teeth, namely the four- and five-surfaced teeth. Each tooth has different surface names that are drawn from seven distinct surface names – labial, mesial, distal, palatal, lingual, buccal and occlusal (Figure 2). The labial surface is directed towards the cheek or lips. The mesial surface is directed towards the throat while distal surface of teeth is in direct opposite of the mesial surface. The palatal/lingual surface is closest to the tongue; for upper teeth (quadrant 1 and 2) this is called the palatal surface and for lower teeth (quadrant 3 and 4) this is called the lingual surface. The buccal surface is closest to the cheek. The occlusal surface is for five-surfaced teeth.

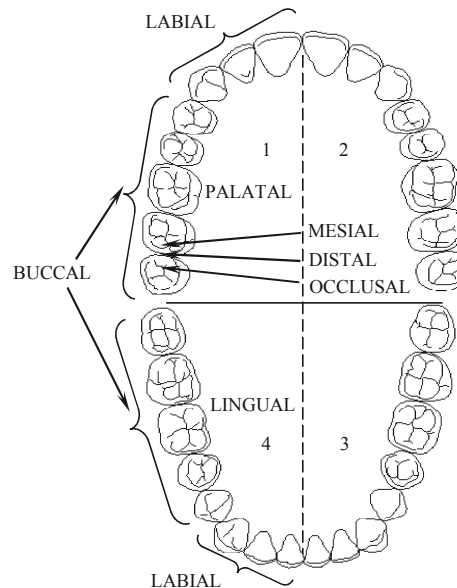


Figure 2 The teeth surfaces for five- and four-surfaced teeth.

All four-surfaced teeth (11-13, 21-23, 31-33, 41-43) have no occlusal surfaces. Those in quadrants 1 and 2 have labial, mesial, distal and palatal surfaces, while those in quadrants 3 and 4 have labial, mesial, distal and lingual surfaces.

All five-surfaced teeth (14-18, 24-28, 34-38, 44-48) have occlusal surfaces. Those in quadrants 1 and 2 have all surfaces except the labial and lingual surfaces. Those in quadrants 3 and 4 have all surfaces except the labial and palatal surfaces.

Figure 3(a) illustrates a five-surfaced tooth template for pre-molars and molars while Figure 3(b) is a four-surfaced tooth template for incisors and canines.

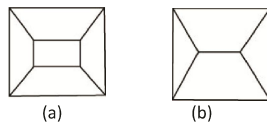


Figure 3 The tooth template for (a) five-surfaced tooth, (b) four-surfaced tooth.

The layout of our interactive dental chart (Figure 4) is based on the FDI World Dental Federation two-digit notation. Adult (permanent) teeth are arranged in the second and third rows (11-18, 21-28, 31-38, 41-48) and children (deciduous) teeth are placed on the first and fourth rows (51-55, 61-65, 71-75, 81-85).

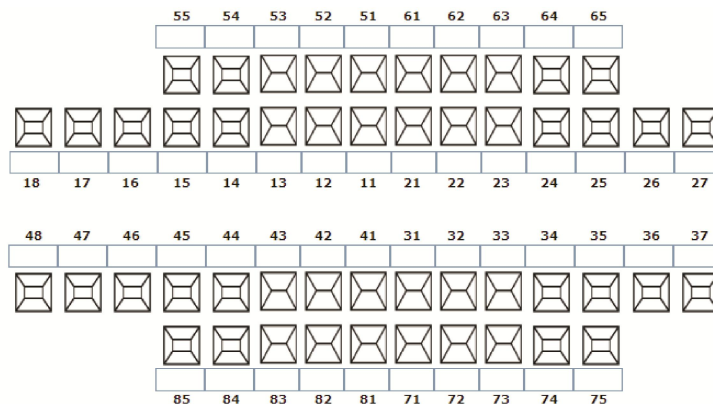


Figure 4 The dental chart template representing adult and children teeth.

All the surfaces of a tooth need to be properly mapped into our relational database table, DentalChart (Figure 5). There are at least twelve columns or attributes in the table: VisitID, Date, PatientID, ToothID, Buccal, Palatal, Mesial, Distal, Occlusal, Lingual, Labial and Tooth_Score. These attributes reflect a patient's dental conditions recorded during each check-up or treatment. In this table, VisitID will be an auto-generated the primary key, while PatientID is the foreign key referring to the patient identification from the Patient table.

Chart_ID	Date	Patient_ID	Tooth_ID	Buccal	Palatal	Mesial	Distal	Occlusal	Lingual	Labial	Tooth_Score
1	8/7/2009...	870422055310	17	7	0	9	0	0	N/A	N/A	2
2	10/8/2009...	610430055469	24	8	9	0	0	0	N/A	N/A	1
3	10/8/2009...	911022055656	43	N/A	N/A	7	7	N/A	0	0	1
4	11/9/2009...	610430055469	24	8	9	8	8	0	N/A	N/A	3
5	11/9/2009...	870422055310	44	7	N/A	0	9	9	0	N/A	3

Figure 5 A snap shot of the DentalChart table.

The codes for tooth surface and tooth score are obtained from existing local public dental clinics (Table 1).

Table 1 Codes for Tooth Score and Tooth Surface Condition

Tooth Score	Code	Tooth Surface	Code
Sound		Decayed	7
Decayed	D(d)	Filled	8
Missing	M	Have Fissure Sealant (HFS)	9
Filled	F(f)	Need Fissure Sealant (HFS)	10
For Extraction	X(x)		
Impacted			
Unerupted			

3.2 Interface

Changes/updates made to a tooth surface will be indicated with a shaded surface (red in colour). An updated tooth has one or more surfaces shaded (in red) as shown in Figure 6(a) and Figure 6(b).

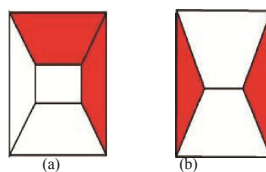
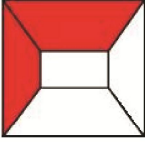


Figure 6 Shaded surfaces (in red) of an updated tooth.

Besides amending the tooth surface condition, users are allowed to enter the tooth score value. Details of a tooth surface condition and tooth score is illustrated in Figure 7.



Tooth No. :
 Tooth Score :

Buccal :	<input type="text" value="7"/>	Occlusal :	<input type="text" value="0"/>
Palatal :	<input type="text" value="0"/>	Lingual :	<input type="text" value="N/A"/>
Mesial :	<input type="text" value="9"/>	Labial :	<input type="text" value="N/A"/>
Distal :	<input type="text" value="0"/>		

Figure 7 Details for tooth surface condition and tooth score.

When an update is completed, the patient's dental record can be displayed as shown in Figure 8. The tooth score is shown in an adjacent box.

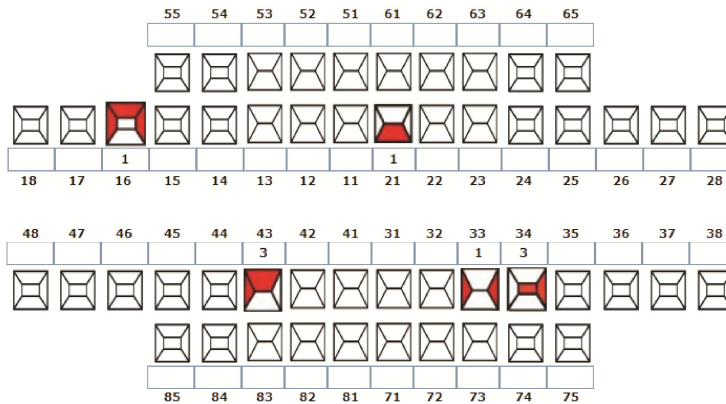


Figure 8 The updated dental chart with corresponding scores

4.0 PROTOTYPING

We have developed a prototype system using selected touch-sensitive monitor with Microsoft SQL Server 2005 as the database management system integrated with Microsoft VB.NET 2005 for the graphical user interface purposes. The following figures highlight the screen shots from the prototype. Figure 9 shows the Main Menu where users need to log in.

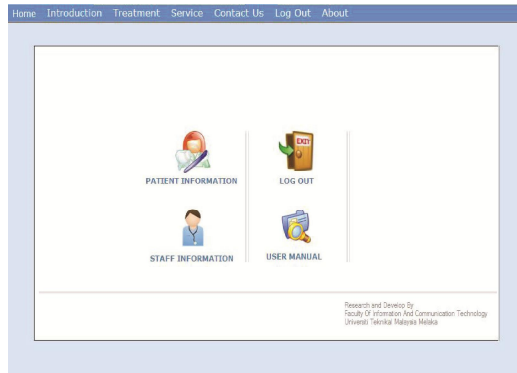


Figure 9 The Main Menu Interface

Once the dentist have logged in, he can search or view his patient dental record through the Dental Chart interface (Figure 10).

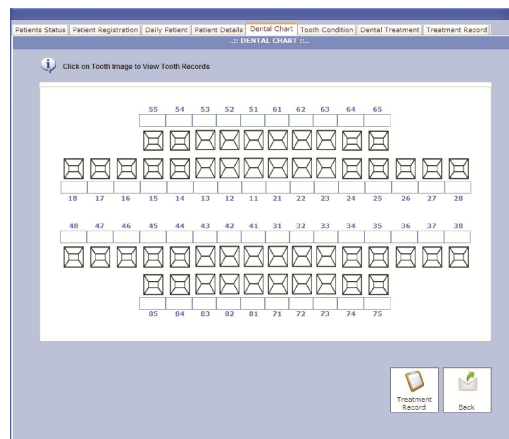


Figure 10 The Dental Chart Interface

In order for the dentist to update a tooth condition, he may click or touch the tooth display in the Dental Chart interface to view detailed tooth surface conditions in the Dental Treatment interface (Figure 11). The dentist may view details of an updated tooth (Figure 12) or the entire patient teeth details (Figure 13).

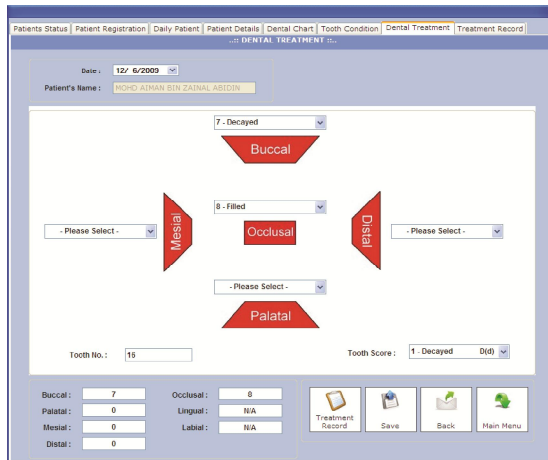


Figure 11 The Dental Treatment Interface

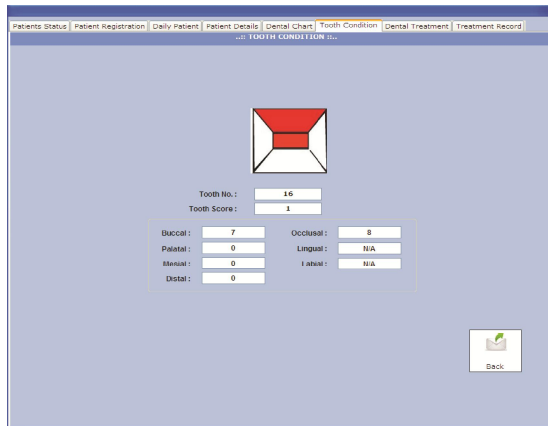


Figure 12 The Tooth Condition Interface

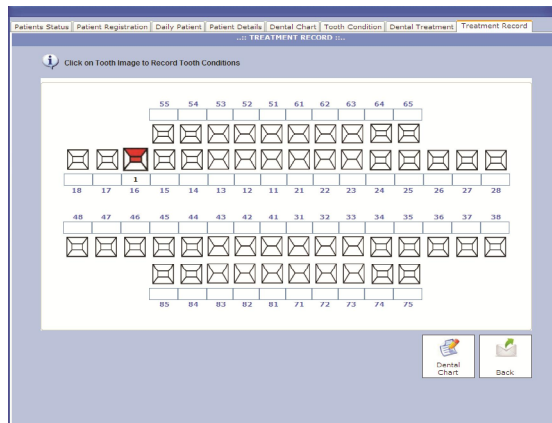


Figure 13 The Treatment Record Interface

Initial system prototype trial runs indicated favorable results. We have also gathered useful and constructive remarks that will be incorporated in the subsequent prototypes.

5.0 CONCLUSIONS AND FUTURE WORK

Interactive dental charting facilitates significantly the capturing and manipulation of the patient dental records. Besides its easy-to-use and informative outlook, it also increases the correctness and consistency of data. This module serves as the central role to other modules such as the appointment, treatment and billing modules. Dentists will benefit from the interactive dental records through the ability to perform further data manipulation and query.

Although the initial prototype looks promising, the complete system can only be realized upon the completion of other modules. Further work on several issues has been identified as follows: 1). The usage of open source or alternative software to overcome slow screen refresh, 2). Improvement on the data model to ease further manipulation or query, 3). Inclusion of a more appropriate dental notations or symbols, instead of the red shaded notation, 3). Improvement on the patients' data security, integrity and privacy, 4). Possibility of applying smart patient identification using RFID-related technology, and 5). Conformity with Health Level 7 (HL7) standards.

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