

STORAGE, QUERYING AND VISUALISATION OF CLINICAL DENTAL RECORDS

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Abstract - Dental examinations of school aged children have been carried out by Health Authorities in the UK for many years. As well as collecting epidemiological data during the surveys, the state of each tooth surface has been recorded. The entire dental record of each child is stored as a single ASCII string of characters within a file. Although a programme exists to organise the numerical data into a more understandable visible matrix, it is still difficult to visualise the information as a whole. Moreover, detailed analysis of many dental records is not possible. This paper considers a method of displaying the data in the more usual standard clinical pictorial form, and of storing them in a more efficient way to allow further data analysis to be performed.

Keywords - Dental chart, relational database

I. INTRODUCTION

A vast amount of dental epidemiological data has been collected by Health Authorities in the UK over many years. The collected data include detailed dental information recording the state of the surface of each tooth. Currently stored in a DOS based survey program, the dental data record can be transformed from a single string stored in a file into a two-dimensional matrix and displayed on the screen.

The dentition in the oral cavity is conveniently divided into four quadrants, the upper left and right quadrants, and the lower left and right quadrants. As the data for each quadrant is coded and represented by the same numerical definitions within the data file, and as clinically each quadrant potentially contains the same number and type of deciduous and/or permanent teeth (two incisors, one canine, two premolars and three molars), then for the convenience of further discussion and illustration the paper will focus on the upper right quadrant of the oral cavity. By convention, the upper right dental quadrant is shown on the left side of a standard dental chart. When held up in front of the patient by the clinician the left side of the chart corresponds to the right side of the patient oral cavity.

The survey data, which is the subject of this paper, focuses on school aged children. Hence the third molar is not represented in the data or the matrix.

Fig. 1 shows a simplified dental file along with the definition of the numerical values, whilst Fig. 2 illustrates the displayed matrix.

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1- ---2- 1--3- 12-4-55--5-3---61234-77777
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Fig 1. Dental data record

(ID)7	6	5	4	3	2	1
D	7	1	-	-	-	-
O	7	2	3	5		
M	7	3	-	5	1	1
B	7	4	-	-	2	-
L	7	-	-	-	-	-

-	sound	3	unrestorable	6	missing (caries)
1	caries 1	4	filled/decayed	7	missing other
2	caries 2	5	filled	8	unerupted

(ID = tooth 1-7)	(D=Distal)	(O=Occlusal)
(M=Mesial)	(B=Buccal)	(L=Lingual)

Fig 2. Example displayed matrix with key definitions

Previous research [1,2] has examined the storage of the collected epidemiological data within a dynamic relational database. Due to the way the dental data is currently stored it is not amenable to further analysis. This paper proposes an alternative method of storing and displaying the dental data within a relational database.

II. DISPLAY REQUIREMENTS

Standard clinical dental charts represent premolars and molars with a five-sided symbol (Fig. 3a), representing the mesial, distal, occlusal, lingual and buccal surfaces of the tooth. An anterior tooth is represented as a four-sided symbol as the tooth has no occlusal surface (Fig. 3b).

By overlaying the symbols with simple shapes such as rectangles and lines (Figs. 3c and 3d) and changing the visibility, line thickness and shading of the shapes according to the data contained within the dental data record, it is possible to create a pictorial display of the dental tissues.

Translating the single string dental record to a more understandable graphical representation is a relatively simple programming task, however the visual impact and clarity of information displayed to the clinician is evident as illustrated in Fig. 4. The actual display in the implemented database appears in Fig.5.

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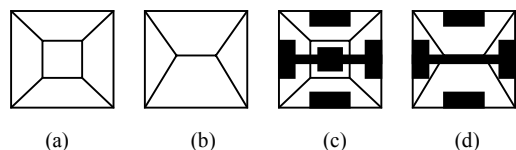


Fig. 3. Symbolic representation of dentition

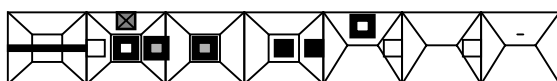


Fig. 4. Translation of dental data record to dental chart

III. TRANSLATION OF THE DENTAL DATA

Consider the algorithm required to translate the dental data record in Fig. 1 into a dental chart. Each tooth is represented as a six character string: the first character represents the tooth identifier (1-7), the next five characters represent the state of each tooth surface (Distal, Occlusal, Mesial, Buccal, Lingual), as illustrated below:

<TOOTH>DOMBL

An anterior tooth has no occlusal surface and so has no state representation for that particular surface. The third character for an anterior tooth is therefore represented with a space. The objects or symbols representing restorations or dental decay (as illustrated in Fig. 3) can be numbered 1-5 in the order DOMBL, each surface corresponding to one character in the dental data record.

A simple programme loop can now be constructed that takes the dental data record one character at a time and transforms the corresponding object for each tooth to an appropriate state. The object can be hidden or made visible, and the border and fill colours can be changed as appropriate to give a pictorial representation of the tooth surface. The final representation of the example dental data record appears in Fig. 5.

IV. DATABASE REQUIREMENTS

As discussed, the translation of a single dental data record to a pictorial representation can be achieved with no change to the data structure. Therefore in an epidemiological database used as a read-only source of information, the dental record can be stored as a single attribute of the person.

In theory, most texts describing the design of relational databases [3,4] argue that a domain should contain a single atomic value or concept. SQL [5] itself provides string manipulation functions that would in theory allow elements contained within the single string to be examined [6]. However, it has been found that if the single dental string is normalised and the data duplicated in two additional relations

TOOTH and SURFACE, the analysis of data is greatly simplified.

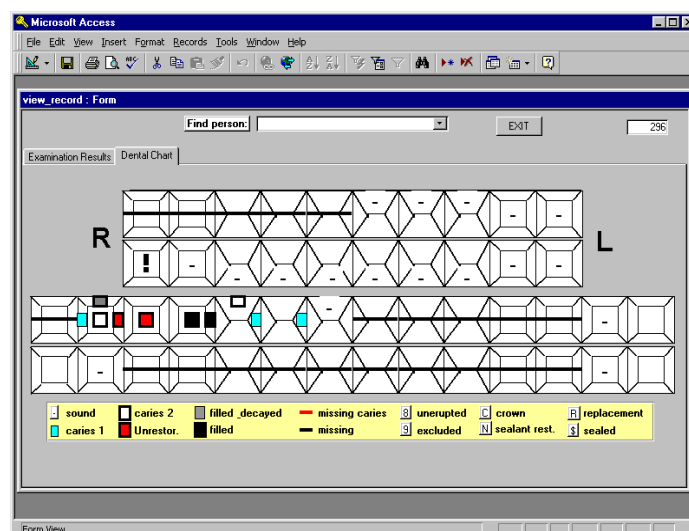


Fig. 5. Illustrating the Database Dental Display Screen

A One : Many relationship exists between person and tooth, and between tooth and surface. Thus the single example dental data record is stored as an attribute of person in order to allow the dental chart to be produced. Each tooth is represented in the TOOTH table, TOOTH.ID being the foreign key domain maintaining the relationship to PERSON [7]. Each tooth has four or five surfaces depending on the type of tooth.

We could now represent each tooth surface in the SURFACE table, TOOTH.TOOTHID being the foreign key domain maintaining the relationship to TOOTH. SURFACEID represents the surface (see Fig. 2 for an explanation of surface names) and STATUS represents the data from the DENTALDATA domain. For each person per quadrant, there would be seven entries in the TOOTH table and thirty-two entries in the SURFACE table. Analysis of the data collected shows that over 70% of tooth surfaces are sound. If we change the definition of our SURFACE table to store non-sound surfaces, then we can remove all tuples of sound status (-).

Thus in the example data shown in Fig. 6, the record for person ID = 15 has seven records in TOOTH and no records in SURFACE. Record ID = 16 has seven records in TOOTH and fifteen records within the SURFACE table.

Further improvement in the storage of records in the SURFACE table can be considered. A posterior missing tooth has five entries within the table, each entry representing a missing surface. Logically, however, it is only necessary to represent one surface as being missing. Refinements to the

data greatly reduce the number of records that need to be stored.

V. MANAGING DIFFERENT DATA FORMATS

On further examination of the dental data, changes in the format of the records have occurred over time. Different symbols have been used in various versions of the survey programme to represent the state of the tooth surfaces.

PERSON

ID	Dentaldata
15	1- ---2- ---3- ---4-----5-----6-----7-----
16	1- ---2- 1--3- 12-4-55--5-3---61234-77777

TOOTH

ToothID	ID*	Quad	Tooth
1	16	UR	1
2	16	UR	2
3	16	UR	3
4	16	UR	4
5	16	UR	5
6	16	UR	6
7	16	UR	7

SURFACE

SurfaceID	ToothID*	Status
M	2	1
M	3	1
B	3	2
O	4	5
M	4	5
O	5	3
D	6	1
O	6	2
M	6	3
B	6	4
D	7	7

Fig. 6. Normalised Relations with Example Data

This serves as an unnecessary complication as far as the clinician is concerned. One approach to this inconsistency is to translate the data as it is stored in the original file structure into the new database structure, so that all the data conforms to the standard symbolic representations outlined within the paper.

VI. ANALYSIS OF THE NORMALISED DATA

Data stored in the normalised tables TOOTH and SURFACE offer better querying properties than the single dental data record. For example, to find all person records where the upper right 6 is sound, records are selected from the TOOTH table where

Quad = 'UR' and
tooth = 6 and
ToothID NOT IN surface

Similarly, to construct a query to find all records where all four 4's (first permanent premolars) have been extracted but other teeth are present (possibly indicating extractions for orthodontic treatment), the design of the TOOTH table allows the quadrant to be ignored and therefore search for the presence of the first premolar in all quadrants.

It is also a simple task to construct queries to COUNT the number of decayed tooth surfaces per person. The data therefore has become far more manageable and simpler to interrogate.

VII. DISCUSSION

Duplicating the dental data within the database offers two advantages. Firstly the single domain DENTALDATA within the PERSON table can be used to display the data in a pictorial form that the clinician can more readily understand.

Normalising the data to third normal form, and storing the values in two further relations TOOTH and SURFACE allows the data to be queried using SQL statements. Combining the available dental data with other data domains, such as age, gender or location allows us to search for patterns of dental disease.

The database is capable of manipulating and presenting the data in many ways not possible beforehand. It is envisaged that this will prove to be a useful management tool to aid the future provision and planning of dental services.

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