DEVELOPING AN INNOVATIVE PEDIATRIC DENTAL CHARTING SYSTEM AND ITS CLINICAL APPLICATION

PhD thesis

Ashfaq Akram

Clinical Medicine Doctoral School

Semmelweis University

Consultant: Dr. Melinda Madléna DMD, C.Sc.

Official reviewers:
Dr. Beáta Kerémi DMD, Ph.D
Dr. Ildikó Szántó MD, Ph.D

Head of the Final Examination Committee:
Dr. Károly Cseh MD, D.Sc

Members of the Final Examination Committee:
Dr. Zsolt Németh MD, Ph.D
Dr. Emil Segatto DMD, Ph.D

Budapest, 2015

1. INTRODUCTION

Complete primary dentition is composed of 20 teeth. There are 10 teeth in each maxillary and mandibular arch which are further divided into right and left halves, also known as right and left quadrants. Thus the whole mouth has four quadrants and each quadrant contains five teeth in case of primary dentition.

Five primary teeth are arranged from midline to backward as two incisors, followed by one canine and then two molars. Primary dentition has neither premolar class nor third molar type when compared to permanent dentition.

Primary teeth are identified by multiple solicited methods which are commonly employed in dental charting. Tooth notation methods are included in dental curricula and used to communicate dental information among dental health care providers. Most commonly used tooth notations are described briefly.

1.1 Zsigmondy - Palmer notation method

Adolf Zsigmondy from Hungary proposed this system in 1861 and used numbers 1-8 for permanent teeth and Roman numerals I, II, III, IV, V for primary teeth with quadrant grid. Later an American dentist Palmer replaced numerals with English letter A-E to indentify primary teeth. They are marked starting from midline to away. Thus letter 'A' means deciduous central incisor and 'E' indicates deciduous 2nd molar.

1.2 FDI (International Dental Federation) tooth notation

This is a two digit numbering system in which the first number represents a tooth's quadrant and second number represents the number of tooth from midline to away (distal). FDI system identifies primary teeth by 51-55, 61-65, 71-75, 81-85 for upper right , upper left, lower left and lower right respectively. The quadrants are numbered 5-8 and primary teeth are numbered 1-5. This system is commonly practiced in many countries.

1.3 Universal numbering system

This system provides identification to primary teeth by letters (A to T) starting from upper right 2nd molar as #A, and moving clockwise around the arch to the lower right 2nd molar as # T. This is widely used in US and Canada. In past, codes such as d1 to d20 were given to all deciduous teeth starting from deciduous upper right 2nd molar (d1) and moving in a clockwise direction to deciduous lower right 2nd molar as (d20) at lower right quadrant.

1.4 Haderup tooth notation

Haderup (1891) introduced a tooth notation method in 1902, using plus (+) and minus (-) signs to indicate maxillary and mandibular teeth respectively. Primary teeth were given codes as 01- 05 with plus and minus sign. The code 01meant 'deciduous central incisor' and deciduous 2nd molar had a code 05. Plus sign (+) with numeric code (+01) was referred as deciduous upper central incisor.

1.5 Woelfel system for deciduous teeth

This is similar to Universal numbering system. It recognizes the primary teeth by using numbers (1-20) and letter 'D' which are written such as 1D - 20D starting from deciduous upper right 2nd molar to deciduous lower right 2nd molar in a clockwise direction.

Most commonly a dental notation is not mentioned in performing oral examination or writing a treatment bill or making a referral note. It is considered understood matter. It creates confusion or more likely leads to make an error in the execution of patient's dental problem. For example, letter 'A' is deciduous central incisor in Palmer notation and it is deciduous 2nd molar when Universal system is considered. Mixed dentition contains both permanent and deciduous teeth. Thus, for example, permanent right lateral incisor is #12 in FDI system and same number (#12) is maxillary left first premolar (Universal system). A referral note by FDI system, #24 means upper left first premolar whereas 24 is the lower left central incisor in Universal system. There is no standard system of dental charting around the world and variations among dental schools, public and private dental hospitals are found in terms of dental notation (Scheila 2014). The formal way of communicating

dental information is the referral letter being used by dental health professionals. However, there is no standard in terms of selection of a tooth notation also. General dentists and specialist do not use the same tooth notation when they communicate among each other (Ricketts et al.2003). For example, orthodontists and oral surgeons mostly use Palmer notation and Universal numbering system respectively in USA. In Palmer notation, upper right first premolar is tooth #4 which is tooth number 5 (Universal system) for oral surgeons (Pogrel 2003).

Multiple tooth notations or lack of one common tooth notation increase the risk of misunderstanding and hamper the global dental epidemiology. The most frequent cause of wrong tooth extraction was cognitive failure and miscommunication in Korea (Chang et al. 2004). In Israel, most of the malpractice cases were associated with wrong tooth extraction, most errors occurred during the extraction due to confusion and miscommunication between clinicians within and between clinics or dental practices (Peleg et al. 2010).

To reduce dental malpractice cases arising because of multiple tooth notations within dental office or among dental practices, many efforts were made to develop a standard global dental charting system. The intention was to develop such notation which could be used by all dental institutes and practices. For this purpose, the abbreviations, UR, UL, LR, LL, for upper right, upper left, lower right, lower left respectively were suggested instead of using Zsigmondy's grid (Grace 2000). The Roman numerals I, II, III, IV, V for primary teeth were replaced by A, B, C, D, and E letters(Huszár 1989). Furthermore, Palmer notation and FDI were combined such as UL7#17 but it complicated the dental information when multiple teeth were used. The facts show that there is lack of globally accepted standard system of tooth notation for dental charting and communication of dental information of patients within and outside dental community around the globe. Simonsen (1995) and Elderton (1989) emphasized long time ago to have a global notation system. Therefore we intended to produce a new tooth notation. This new tooth notation records permanent as well deciduous teeth. Here we will focus more on its deciduous section.

2. OBJECTIVES

Primary objective of this study was to develop a new tooth notation that could be used in dental charting for identification of primary teeth. Thus objectives of this study were:

- **To develop a new tooth notation (MICAP) system**

This covers the conceptual framework of the new system to represent all primary teeth. Identification of a single or multiple teeth of both right and left sides were covered in this aspect.

- **To make MICAP notation computer applicable**

This is a requirement of a tooth notation system that it should be computer friendly. Various methods were suggested to produce the format of new notation in computer.

- **To develop a lesson plan on MICAP system**

To implement in dental curriculum, a lesson plan is required on new tooth notation.

- **To assess the format of MICAP by undergraduate dental students**

It was aimed to assess the learning outcome and prospective adoptability of undergraduate dental students to identify primary teeth by using MICAP notation after having a demonstration on MICAP format.

- **To assess the format of MICAP by dental health professionals**

It was aimed to assess learning of MICAP format to mark primary teeth by dental specialists, dentists and dental allied health personals. Their feedbacks on its prospective use in dental charting and communicating dental information were also targeted.

3. METHODS

3.1 Development of new notation (MICAP) system for primary teeth

Three primary tooth classes are deciduous incisor, deciduous canine, and deciduous molar. These tooth classes have their subtypes which are 'central incisor, lateral incisor, canine, 1st molar and 2nd molar (Woelfel and Schied 2002). Deciduous central incisor is closest to midline and deciduous 2nd molar is the farthest from midline.

A tooth notation mostly describes both primary and permanent teeth because in dental practice all practitioners come across with primary as well as permanent teeth. The new tooth notation 'MICAP' was developed by using tooth classes and their types. MICAP is the abbreviation of '**M**-molar, **I**-incisor, **C**-canine, **A**-Akram and **P**-premolar (Akram et al. 2015c, 2011). The new tooth notation emphasizes tooth classes and their types for identification of intended upper and lower teeth.

The new system is based on names of tooth classes. Three tooth classes (incisor, canine and molar) are common in primary and permanent dentition while permanent dentition has an additional tooth class which is premolar (P). In other words, permanent teeth encapsulate primary teeth. Therefore the letter 'P' is a part of name of tooth notation. Practically we would not use letter 'P' premolar in description of primary dentition but it is added to make part of name of tooth notation. Hence we would use the term MICAP as method rather than its segregation based on its alphabet combination for primary teeth.

MICAP notation comprises letters and digits to indicate tooth classes and their types respectively. It is a method to identify and designate human primary teeth by using the first letter of their names which are divided into four parts (upper and lower, right and left) by imaginary horizontal and vertical lines respectively.

Thus the upper case letters 'I- incisor, C- canine and M- molar' are taken as primary stem of the method. Since incisor, canine and molar tooth classes are also present in permanent dentition; lower case letter 'd' is added to differentiate these classes from the permanent

ones. This way we say the **dI** (deciduous incisor), **dC** (deciduous canine), **dM** (deciduous molar) are ANAASEA letters for deciduous teeth.

Each tooth class has its subtypes. Regarding tooth types, two (2) incisors, **one** (1) canine and **two** (2) molars are present in each quadrant of upper and lower jaw. The digits (2, 1, 2) are called TOT digits. TOT digit represents the type of same tooth class which nature has given to human. e.g. 1 represents the first molar, 2 represents the second molar. Here digits 1,2 are TOT digits for deciduous molar (dM) class.

3.1.1 Four quadrants of ANAASEA letters

Imaginary horizontal and vertical lines passing through the mid and tip respectively, divide each and every ANAASEA letter into four quadrant as maxillary (upper) right, maxillary (upper) left and mandibular (lower) left and mandibular (lower) right (Figure 1).

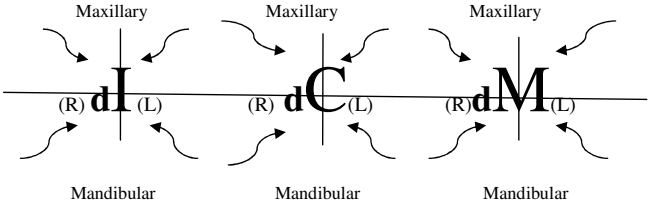

Figure 1.

Four quadrants of MICAP notation

Imaginary horizontal and vertical lines divide each ANAASEA letter into four segments. Upper segments represent maxiallary and lower segments show mandibular segments. From computer language point of view, we could say, upper as superscript and lower as subscript. There are right (R) and left (L) halves also (Figure 1.). Division of each ANAASEA letter into four quadrants is patient's view i.e. patient's right corresponds to right of ANAASEA letter (Akram et al. 2015c, 2012, 2011).

3.1.2 Rule of printing of TOT digits for deciduous incisors

Incisor teeth are two in each quadrant of maxillary and mandibular arch, so TOT digits (1,2) indicating central and lateral incisors respectively are superscripted at right and left corner and subscripted on right and left corner of ANAASEA letter **dI.** The superscripted and subscripted digits show maxillary and mandibular incisors respectively which are present in four quadrants. This is shown in Figure 2.

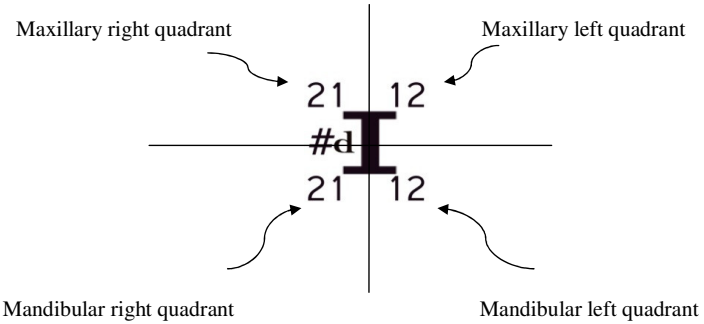

Figure 2.

Conceptual framework of MICAP notation for deciduous incisors

Letter 'dI' shows deciduous incisors. The digits (1,2) represent central and lateral incisor respectively. The digits written as 21, 12 either upper or lower corner of '#d**I'** are read separately as one (1), two (2); instead of twenty one (21) or twelve (12). The sign **#** indicates the number of types of particular class of a tooth. Here it means the incisor tooth number. (Imaginary horizontal and vertical line are shown here just for understanding purpose) (Akram et al. 2015a, 2015c, 2012, 2011).

3.2 Presentation of deciduous teeth by MICAP notation

All primary teeth located in upper and lower arches like Figure 3. shows.

Figure 3.

Complete deciduous dentition by MICAP notation

The letters d**I, dC, dM** indicate all three classes of deciduous teeth which are presented in each quadrant of maxillary and mandibular jaws (Figure 3). The digits (1,2) written as superscript and subscript on letters (dI, dC, dM) show upper and lower teeth respectively. The sign "#" differentiates among tooth classes (Akram et al. 2015a, 2015c, 2012, 2011).

3.2.1 Guiding principles of MICAP notation

- Letters d**I,** d**C,** d**M** represent deciduous incisor, deciduous canine and deciduous molar respectively.
- Digits (1,2) show the relevant tooth types. For example, 1 means deciduous central incisor and 2 shows deciduous lateral incisor. Deciduous canine is marked by 1. Deciduous first and second molar are indicated by 1 and 2 respectively.
- The letters (dI, dC, dM) and digits (1,2) are called ANAASEA letters and TOT digits respectively for deciduous teeth.
- The lower case letter "**d**" is always written on left side of letter (I, C, M) to indicate the respective deciduous tooth class.
- Superscripted and subscripted TOT digits show maxillary and mandibular teeth respectively.
- TOT digits are written smaller than ANAASEA letters to clarify upper or lower teeth in case manual charting is done.
- TOT digits are always pronounced separately. For example $\#dM_{12}$ is pronounced as deciduous lower left first and second molar.

- In text matter, sign "#" is written in the beginning so that TOT digits of different classes may not be mixed and it would facilitate in dental communication (Akram et al. 2012).

3.3 MICAP system and its computer application

MICAP system has 'superscript and subscript' features which are available on most commonly used Microsoft Word Office. A simple and easier way to write superscript and subscript is by clicking the icon 'X_2 /X^2 located on tool bar of MS Word. Other way is to use π Equation and **e^x Script**. In addition, software of MICAP format was prepared by HTML and C+ programme to create superscript and subscript feature for this study (Akram et al. 2015a, 2015c).

3.4 Methods for lesson plan on MICAP notation

Lesson plan in the form of one hour lecture was delivered as pilot study in Islamic international dental college, an institute of Riphah international university – Islamabad – Pakistan. The final year undergraduate dental students (n=40) participated voluntarily. The lesson plan had components such as learning objectives, currently used solicited tooth notations, formation of MICAP system, application as dental charting method and summary (Akram et al. 2012). Simple descriptive statistical method (average) was used for analysis purpose.

3.5 Methods for assessment of clinical application of MICAP by undergraduate dental students

Various tooth notations are taught in preclinical years mostly in 2nd year of the programme. We chose undergraduate dental students (n= 176; Male: 48, Female: 128) of Islamic international dental college – Riphah international university, Islamabad, Pakistan - where the earlier version (lesson plan) of MICAP was carried out. The informed consents were obtained by students before taking part in the study. They translated MICAP format into

word form and vice versa after having a lecture and video demonstration on MICAP format.

Deciduous molar and canine teeth were presented in MICAP format [#$_2$dM #dC^1] in mock *e* dental charting. They were to be translated (identified) into word form. Three primary teeth 'deciduous maxillary left 2nd molar, deciduous mandibular left central incisor and deciduous maxillary right canine' were to be written back to MICAP format. In addition, a short questionnaire based on five point likert scale (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree) was added in the tool to obtain perception on adaptation of MICAP for pediatric dental charting and communication of dental information through MICAP system (Akram et al. 2015c). Person chi square test was chosen for analysis purpose in addition to descriptive analysis in SPSS version 20. Statistical significance level ($p < 0.05$) was chosen.

3.6 Methods for assessment of clinical application of MICAP by dental health professionals

Dental specialists, general dentists, and dental paramedics (N=225) from Penang (Malaysia) and Islamabad (Pakistan) participated in a cross sectional study. They were divided into two groups. Group A included dental specialists (n= 44) and general dentists (n=60). Group B had dental assistants (n=58), dental hygienist (n=38), dental technician (n=25). An inclusion criterion was to be involved in dental practice for at least one year as clinician / academician / supporting worker. MICAP was demonstrated by video to both groups before they participated in the study. The written consents were obtained and data were collected from September 2014 to December 2014.

Mock *e* dental charting based on MICAP notation had two teeth in MICAP format [#$_2$dM #dC^1] which were to be translated to word form. Three teeth 'deciduous maxillary left 2nd molar, deciduous mandibular left central incisor, deciduous maxillary right canine' were to be converted (written) to MICAP format. In addition, a closed end questionnaire based on five point likert scale (1= strongly disagree, 2=disagree, 3= not sure, 4 =agree, 5 =strongly

agree) was added to obtain the perception on the prospective suitability of the new notation in dental charting and its usage as source of dental communication (Akram et al.2015a).

Frequencies, cross tabs, Pearson chi square and simple logistic regression were applied in SPSS version 20 to analyze data on various aspects. Level of statistical significance was $P<0.05$).

4.0 RESULTS

4.1 Analysis of development of new notation (MICAP) for primary teeth

The new tooth notation describes the teeth by using alphabet letters which indicate the tooth classes, e.g. deciduous incisor is presented by "dI". Similarly, deciduous canine and deciduous molar are marked by "dC" and "dM" respectively. The respective tooth types are indicated by digits. For example deciduous central incisor by 1 and deciduous lateral incisor by 2. There is no continuity of tooth types by digits. A suggested model for general practice and periodontal charting for deciduous as well as permanent teeth were published (Akram et al. 2011).

The difference in MICAP format for primary and permanent teeth is letter 'd'. An example is "#dM^{12}" and "#$_1$M" where former is deciduous molar and latter is permanent molar (Akram et al. 2012).

4.2 Analysis of MICAP notation for computer application

MICAP tooth notation can be used manually as well as electronically. MICAP notation for deciduous teeth involves digits (1,2) which are superscripted and subscripted on "dI, dC, dM" letters. The various options for digits 'to be superscripted and subscripted on specific letters' are available in MS Word.

Superscripted digits indicate upper teeth while subscripted digits show lower teeth. Example: #dM_2 –this is an example of subscript (deciduous lower left 2nd molar) where digit 2 is written below # M**.** #P^{12} is an example of superscript where '12' are written above #P.

Software of MICAP notation was developed by HTML and C+ programme to record identification of primary teeth by study participants. MICAP system could be produced on computers for *e* dental charting. Using the software, deciduous maxillary right canine was written in MICAP format as $\#^{1}$dC. Similarly, maxillary deciduous left 2nd molar and mandibular deciduous left central incisors were written as # dM^{2} #dI1 (Akram et al. 2015a,

2015c). We can say in referral note that Mr XYZ having problem in $\#dM^{2}$ is referred for extraction. We focused on MICAP format rather than dental charting design. A section of MICAP software is shown in Figure 4.

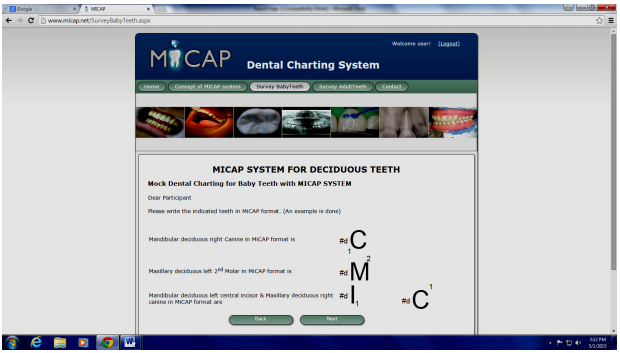

Figure 4.

A section of MICAP notation for deciduous teeth

A section of MICAP software showing the relevant digits on ANAASEA letters is shown on computer screen. Deciduous lower right canine [$\#_{1}$dC] , deciduous upper left 2nd molar [$\#dM^{2}$], deciduous lower left central incisor [$\#dI_{1}$] and deciduous upper left canine [$\#dC^{1}$] have been shown in figure 4. (Akram et al. 2015c).

A suggested periodontal dental charting was published in an earlier version of MICAP (Figure 5.) (Akram et al. 2011).

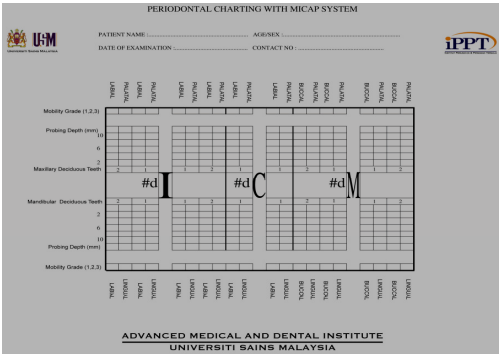

Figure 5.

Periodontal charting for primary teeth by MICAP notation

The suggested model anticipates the measure of periodontal pocket in children. The primary teeth are written by using dI, dC, dM and digits (1,2) as superscript and subscript. Columns on both sides provide the measurement of pocket depth in millimeter (mm) (Figure 5.) (Akram et al. 2011).

4.3 Analysis of lesson plan on MICAP notation

Regarding pilot study on lesson plan, majority (72.5 %) agreed that MICAP was easy to understand and more than 50 percent considered MICAP to be unique in its contents. The responses of students for 'dental charting' and its prospective 'scope in clinical application' were 65 % and 52.5 % respectively. One third students (n=13, 32.5%) were not sure whether MICAP could be used in clinical practice (Akram et al. 2012).

4.4 Analysis of assessment of clinical application of MICAP by undergraduate dental students

Approximately 80% of the students translated MICAP format and vice versa correctly. Clinical students had a better association (p = 0.001) to translate $\#_2$dM (deciduous mandibular right 2nd molar) and write correctly 'deciduous maxillary left 2nd molar' (p = <0.001) into MICAP format [$\#dM^2$] as compared to preclinical students. Odds ratio [*OR*

95% *CI*: 0.278(0.131, 0.591)] showed the preclinical students were poorer to write correctly 'deciduous mandibular left central incisor' into MICAP format [#dI_1]. In addition, clinical students had more association for response on 'MICAP could be adopted in dental charting'(X^2: 18.8, p=0.001) (Akram et al. 2015c).

Majority of students (n= 134, 76.1%) were able to translate [#$_2$dM] as 'deciduous mandibular right 2nd molar'. Similarly, the given MICAP format [#dC^1] was translated correctly (n= 142, 85.5%) as 'deciduous maxillary left canine'. However, no significant difference (P>0.05) was found between male and female students (Akram et al. 2015c).Regarding the prospective adoptability of MICAP notation for deciduous dental charting were also evaluated. More than fifty percent of the students (n = 93, 52.8%) agreed on this anticipated purpose while a small number of participants (n= 11, 6.3%) disagreed for the same statement. However, the study participants who strongly recommended were double than those who disagreed on the adoptability of MICAP for pediatric dental charting. Comparing the two groups, clinical students had more association in favor of MICAP system to be adopted in dental charting (p=0.001). A quite number of students (n=49, 27.8%) were not sure whether MICAP could be used to transmit deciduous dental information. Male and female from both groups responded equally for such purpose. (Akram et al. 2015c).

4.5 Analysis of assessment of clinical application of MICAP by dental health professionals

4.5.1 Identification of teeth in MICAP format by dentists and dental specialists

Dental specialists and dentists (> 90 percent) were able to identify and write MICAP format for primary teeth e.g., #$_2$dM was translated as deciduous mandibular right 2nd molar and 'deciduous maxillary right canine' was written #^{1}dC (MICAP format). However, a statistical significant difference was found between specialists and dentists in the correct write up of 'deciduous maxillary right canine' into #^{1}dC (p=0.031 (Akram et al. 2015a).

4.5.2 Identification of teeth in MICAP format by dental paramedics

Among dental paramedics, more than fifty percent dental technicians converted correctly 'deciduous maxillary left 2nd molar' into MICAP format [#dM^2]. However, a higher (81.0) percentage of dental assistants was unable to write the 'deciduous mandibular left central incisor' into MICAP format [#dI$_1$] (Akram et al. 2015a).

Comparing dental assistants and dental hygienists, simple logistic regression test showed that there was no significant association of correct translation of [#dC^1] (p=0.097). However, comparing dental assistants and dental technicians, dental technicians were better in both translation of MICAP format as well as conversion into MICAP format (p<0.05) (Akram et al. 2015a).

4.5.3 Perception on MICAP system as dental charting and source of communication

From descriptive statistics, approximately forty percent dental specialists and doctors responded positively on the prospective use of MICAP notation for pediatric practice (Akram et al. 2015a). The paramedics responded positively but a little less than the doctors. A small numbers of participants from both doctors and paramedics even rejected the role of MICAP in dental charting. However, a quite large number of specialists, doctors and paramedics were uncertain about its prospective use in dental charting as well as communication source of dental information Neither gender nor location were observed significant differences in identification of MICAP format (Akram et al. 2015a).

5.0 CONCLUSIONS

5.1 Developing a new tooth notation (MICAP)

The new tooth notation uses letters (dI, dC, dM) and digits (1,2). Letters show tooth classes while digits show their subtypes. For example, deciduous incisor (dI) has subtypes which are central incisor (1) and lateral incisor (2). In other words, each tooth class is given a full entity. For example, # $_2$dM is deciduous mandibular right 2nd molar. Similarly #dC^1 is deciduous upper left canine (Akram et al. 2015a, 2015c).

MICAP is based on recognized standard dental terminologies. Taking consideration of currently used notations; upper right canine could be marked by three different digits [#13, #3 #6] in FDI, Palmer and Universal systems respectively. MICAP system shows it #^{1}C. The letter 'C' indicates canine. The digit 1 is superscript and printed on right side to C so it is maxillary (upper) right canine (Akram et al. 2012).

Since these tooth classes and their types are taught in beginning of a dental curriculum. It was seen in a study where students, dental paramedics, dentists and dental specialists correctly identified MICAP format and vice versa (Akram et al. 2015a, 2015c).

5.2 MICAP notation is computer friendly

MICAP text includes letters (dI,dC, dM) , digits (1,2) and sign (#) as core components. All these components are available in computer keys. There are many options to write digits as superscript or subscript. Other than MS Word, software of MICAP notation was made as prototype which provided the pathway to write MICAP text electronically (Akram et al.2015a, 2015c).

MICAP is computer friendly (Akram et al, 2015c, 2012, 2011). Therefore it can be suggested for *e* dental charting. For different kinds of dental problems, a template was proposed (Akram et al. 2011). The template had format for permanent as well as primary teeth. It means that it could be used either for primary or permanent dentition (Akram et al. 2015a, 2015c, 2011).

5.3 MICAP notation can be adopted for academic purpose (Lesson plan)

Deciduous incisor, deciduous canine and deciduous molar are standard primary tooth classes (Akram et al. 2015a, 2015c, 2012, 2011). A lesson plan was developed which explained its structure, its formation and method to identify different primary teeth. Majority of clinical undergraduate dental students gave their feedback about its contents as simple and understandable (Akram et al. 2012).

5.4 Assessing the format of MICAP notation by undergraduate dental students

The results of our study proved that MICAP format can be translated and written. Majority of students were able to write and identify MICAP format just by one lecture and short video. It meant its formation was easy to understand. Its application as prospective dental charting was also supported by students (Akram et al. 2015c).

5.5 Assessing the format of MICAP notation by dental health professionals

Dental specialists and dentists (> 90%) understood the MICAP format. They were able to translate MICAP format [$\#_2$dM #dC^1] as deciduous lower right 2nd molar and deciduous upper left canine respectively (Akram et al. 2015a). They could write MICAP format from given teeth name 'deciduous mandibular left central incisor' as #dI$_1$. Similarly dental paramedics understood the format of MICAP notation (Akram et al. 2015a).

In summary, our results give evidence that the format of new notation for primary teeth is simple. The method is easy to understand. The new notation (MICAP) can be written electronically (Akram et al. 2015 a, 2015c, 2011) and manually (Akram et al. 2015b). Overall, the new notation (MICAP) has the capacity to identify primary as well permanent teeth and could be suggested as alternate dental charting method for clinical practice.

6.0 Bibliography of the candidate's publications

6.1 Bibliography of the candidate related to thesis

Akram A, Fuad MDF, Bashir U, Pandiyan NJ, Chakravathy K, Visnumukkala TR, Madlena M. (2015a) An assessment of clinical application of a new tooth notation for primary teeth. J Int Dent Med Res, 8: 7-14.

Akram A, Fuad MDF, Bashir U, Vishnumukkala TR, Madlena M. (2015b) Learning of format of new tooth notation system - a pilot study. Int J Dent Sci Res, 3: 92-95.

Akram A, Visnumukkala TR, Tariq S, Fuad MDF, Visnumukkala S, Madlena M. (2015c) Identification of primary teeth by 'MICAP' a new tooth notation system. Pediatr Dent J, 25: 39-44.

Akram A, Abdus S, Ulfat B, Nooreiny M, Subhan M M. (2012) Lesson plan on new method of teeth identification introduced at dental schools in Malaysia and Pakistan. J Dent Educ, 12: 1691-1696. **IF: 0.989**

Akram A, Abdel Hamid ZAH, Razak J, Hock TT. (2011) MICAP – a novel system for identification and communication of dental problems. Int Dent J, 61: 31-36. **IF: 0.963**

6.2 Other publications

Salam A, **Akram A**, Mohamad N, Siraj HH. (2015) Measures of educational environment in a higher educational institute using Dundee ready educational environment measure – DREEM. Int Med J, 22: 98-102.

Salam A, **Akram A**, Bujang SM, Yaman MN, Kamarudin MA, Siraj HH, Mohamad N. (2014) Educational environment in a multicultural society to meet the challenges of diversity. J Appl Pharm Sci, 4: 110-113.

Akram A, Mohamad N, Abdullah D, Hashim N. (2013) Trends of final year dental students on medication for pulpitis & apical periodontitis. IOSR J Dent Med Sci, 5: 66-69.

Akram A, Zamzam R, Mohamad NB, Abdullah D, Meerah SM. (2012) An assessment of prescription writing skill of undergraduate dental students in Malaysia. J Dent Educ, 76: 1527-1531**.** **IF: 0.989**

Ali K, **Akram A**, Akhtar MU. (2012) Case-report- an unusual case of chronic suppurative osteomyelitis of the mandible. Arch Orofac Sci, 7: 37-41.

Akram A, Mohamad N, Meerah TSM, Zamzam R, Abdullah D. A pilot study - an action research to acquire clinical skill. Procedia - Soc Behav Sci, 60: 236-240. www.sciencedirect.com/science/journal

Akram A*, Abdelhamid AHZ, Joshi SC, Ban AAH, Pant I. (2009) Radiotherapy complications and preventive measures in oral cancer –review article. J Arab Med Res Soc, 4: 223-230. www.asmr.eg.net/journal.htm

Rehmatullah K, **Akram A***, Muhammad R, Yunous J, Ban A A H. (2009) Management of endodontically treated anterior teeth with minimal coronal structure. Biohealth Science Bulletin, 1: 24-28. www.amdi.usm.edu.my/bsb

Shtawa A AB Z, Abdul Hameed B A*, Hashim H, **Akram A**. (2009) The effects of education and gender based behavior towards oral health in a Malaysian town. Biohealth Science Bulletin, 1: 48-52. www.amdi.usm.edu.my/bsb