

DEVELOPING AN INNOVATIVE PEDIATRIC DENTAL CHARTING SYSTEM AND ITS CLINICAL APPLICATION

PhD thesis

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1. THE LIST OF ABBREVIATIONS

ADA:	American Dental Association
ANAASEA:	Asia, North America, South America, Europe, Africa (continents name)
ASP:	Application Service Provider
C:	Canine
CDT:	Current Dental Terminology
CI:	Confidence Interval
CMD:	Command
COHRI:	Consortium for Oral Health Research and Informatics
Ctrl:	Control
Ctrl+S:	Control +Save
d:	deciduous
dC:	deciduous Canine
df:	Degree of freedom
dI:	deciduous Incisor
dM:	deciduous Molar
DDS:	Dental Diagnostic System
DLT:	Digital Learning Tool
<i>e</i> :	Electronic
EZ:	Electronic Z (refers to diagnostic codes)
EHR:	Electronic Health Record
FDI:	International Dental Federation
HEC:	Higher Education Commission
HTML:	Hypertext Markup Language
i.e.	that is
I:	Incisor
ICD:	International Classification of Diseases
ICT:	Information and Communication Technology
IT:	Information Technology
L:	Left
LL:	Lower Left

LR:	Lower Right
M:	Molar
MICAP:	M-molar, I-incisor, C-canine, A-Akram, P –pre-molar
Mol:	Molaris
MS:	Microsoft
OR:	Odds Ratio
P:	Premolar
R:	Right
Scup:	Superior
Sin:	Sinister
SNODENT:	Systematized Nomenclature of Dentistry
SPSS:	Statistical Package for the Social Sciences
TOT:	Two –One –Two (primary dentition has two incisor, one canine and two molar)
TOTT:	Two-One-Two-Three (permanent dentition has two incisor, one canine, two premolar and three molar).
UL:	Upper Left
UR:	Upper Right
US:	United States
UK:	United Kingdom
URL:	Uniform Resource Locator
WHO:	World Health Organization

2. INTRODUCTION

Human teeth are arranged in two arches. One is called maxillary arch, mainly made up of maxilla, and other one is called mandibular arch because it is made up of mandible. The teeth located in the maxillary and mandibular arches are called as maxillary and mandibular teeth respectively. The maxillary and mandibular teeth are also known as upper and lower teeth respectively.

Human life has two dentitions throughout life; one during childhood called the primary dentition and one that last almost the rest of the life after a certain period of childhood called the permanent dentition (Woelfel and Schied 2002). The complete permanent dentition is composed of 32 teeth while complete primary dentition has 20 teeth. In permanent dentition there are 16 teeth in the maxillary arch and 16 in the mandibular arch. Primary dentition has 10 teeth in each arch. Maxillary and mandibular arches are divided into right and left halves that are also known as right and left quadrants. Thus the whole mouth has four quadrants and each quadrant contains one fourth of all teeth in that dentition.

Primary dentition has five teeth in each quadrant which represent three classes; incisor, canine and molar (Woelfel and Schied 2002). The primary tooth classes (namely incisor and molar) are further subdivided into types based on location as central incisor, being close to mid line and lateral incisor next to central incisor and 1st primary molar and 2nd primary molar. Canine has no type. In each quadrant, five primary teeth are arranged from midline to backward as two incisors, followed by one canine and then two molars. The permanent teeth are arranged from midline to backward as two incisors, followed by one canine. Then two premolars and three molars are in the back. The permanent dentition has an extra class called premolar and a tooth type such as 3rd molar. Primary dentition has neither premolar class nor third molar type.

Primary and permanent teeth are identified by multiple methods which are solicited by relevant governing dental bodies. They are commonly employed in dental charting procedure. They are included in dental curricula of dental schools and taught to students of undergraduate dental degree and dental allied health programmes across the world. They are used to communicate dental information among doctors and dental specialists in dental practice.

2.1 Dental notation

A tooth notation is a method to record and communicate dental information. In the early era of dentistry, teeth names were used during oral examination. At that times, Latin and German names were prescribed which were lengthy for example, Molaris Secundus Superior Sinister (Havale et al. 2015). Later when dentistry flourished and different specialties originated then abbreviations of teeth names were preferred, for example (e.g.) Mol.II Scup. Sin for Molaris Secundus Superior Sinister. In early 19th century, numbers were suggested to communicate dental information.

2.1.1 Importance of dental notation

It is a system to identify teeth in a specific way

- to write down the problem /diagnosis and treatment of dental patients.
- to make a referral note for another doctor (specialists) for the sake of wellness of patients.
- to make a referral /claim note for insurance company / financial body for the sake of getting treatment charges.

2.1.2 Various tooth notations

Many tooth notations have been originated. Most notations use numbers when referring to a particular tooth and they divide the mouth into four quadrants which are indicated as if one is viewing the patient from the front. The most commonly used systems are explained to have a review before the new tooth system is described.

2.2 Zsigmondy - Palmer notation

2.2.1 Brief history

Identification of teeth and recording dental information were a dilemma during oral examination in the initial era of dentistry. In the beginning, teeth were identified by full names which were derived from Latin and German languages. An example of Latin notation is Mol.II Scup. Sin which is the abbreviated form of Molaris Secundus Superior Sinister (Havale et al. 2015). Later when dental specialties were formulated, issue was how to communicate dental information with other dental professionals. Then idea of a tooth notation came into existence and a Hungarian dentist, living in Vienna, Adolf Zsigmondy described the first tooth notation in 1861 (Zsigmondy 1861, 1874, Huszár 1989). Later, during an annual meeting of American Dental Association, an

Ohio dentist Corydon Palmer modified its deciduous part (Palmer 1870) and it became Zsigmondy - Palmer notation. This is the oldest notation but still widely used in many countries. It is commonly known as Palmer notation.

2.2.2 Brief description of tooth notation

In Zsigmondy - Palmer notation the 'Zsigmondy grid (┘ └ ┐ ┑)' is used to record the quadrants of tooth positions. The digits 1 through 8 are used for permanent teeth. The teeth are given numbers starting from midline to away. Primary teeth were given the Roman numerals (I, II, III, IV, V) codes (Ash and Stanley 2005). Later, an American dentist Corydon Palmer modified its deciduous part using upper case letters 'A, B, C, D, E' for primary teeth (Palmer 1870).

2.2.3 Identification of teeth

This method divides the mouth into four quadrants i.e. maxillary right quadrant, maxillary left quadrant, mandibular right quadrant and mandibular left quadrant.

Primary teeth are marked by letters A-E. There are five primary teeth in each quadrant and letters are assigned such as:

- Deciduous central incisor A
- Deciduous lateral incisor B
- Deciduous canine C
- Deciduous 1st molar D
- Deciduous 2nd molar E

Permanent teeth are numbered from 1 to 8. Central incisor being the first and it goes back to third molar being the 8th number.

- Central incisor : 1
- Lateral incisor : 2
- Canine : 3
- 1st premolar : 4
- 2nd premolar : 5
- 1st molar : 6
- 2nd molar : 7
- 3rd molar : 8

Each tooth number / letter sits inside an L shaped symbol (\lrcorner \llcorner \lrcorner \llcorner) as shown in figure 1.

Palmer Notation															
Permanent Teeth															
upper right								upper left							
8 _J	7 _J	6 _J	5 _J	4 _J	3 _J	2 _J	1 _J	L ¹	L ²	L ³	L ⁴	L ⁵	L ⁶	L ⁷	L ⁸
8 _J	7 _J	6 _J	5 _J	4 _J	3 _J	2 _J	1 _J	┐ ₁	┐ ₂	┐ ₃	┐ ₄	┐ ₅	┐ ₆	┐ ₇	┐ ₈
lower right								lower left							
Deciduous Teeth															
upper right								upper left							
			E _J	D _J	C _J	B _J	A _J	L ^A	L ^B	L ^C	L ^D	L ^E			
			E _J	D _J	C _J	B _J	A _J	┐ _A	┐ _B	┐ _C	┐ _D	┐ _E			
lower right								lower left							

Figure 1.

Zsigmondy - Palmer notation (Zsigmondy 1861, 1874, Palmer 1870)

Permanent and deciduous teeth are shown in Zsigmondy - Palmer notation. The L shape Zsigmondy sign indicates the quadrant of the mouth. The “L” is right side up for the teeth in upper right whereas the backward “L” is used for upper left teeth. For bottom quadrants, the “L” is upside down. Numbers starts 1 through 8 and indicate central incisor to 3rd molar for permanent teeth as they are located in each quadrant. Lower section of the figure 1 shows letters A- E with Zsigmondy sign for primary teeth. Letter A is deciduous central incisor and E is the deciduous 2nd molar of respective quadrant in respect to cross sign.

2.2.4 Advantages of Zsigmondy - Palmer notation

Some of the advantages of Palmer notation are summarized:

- There are fewer chances of mistake during dental charting because the teeth are designated by numbers (permanent teeth) and upper case letters (deciduous teeth).
- It is easy to understand.
- It records permanent teeth by numbers (1-8)
- It records deciduous teeth by upper case letters (A-E).
- It is easy to record teeth manually i.e. user friendly.
- It can be communicated in a quick way because of numbers and letters.
- It can be used in computer but required special software because of its cross sign.

2.3 FDI (International Dental Federation) tooth notation

2.3.1 Brief history

FDI tooth notation was devised by J Viohl (Viohl 1966) and recognized as a notation of FDI by its committee in a meeting held in Romania in 1970. This is also known as ISO 3950 notation.

2.3.2 Identification of teeth

According to FDI system, quadrants are numbered from 1 to 4 for permanent teeth, starting with upper right to the lower right in a clockwise direction. Teeth are numbered from 1 to 8 in each quadrant starting with '1' being the permanent central incisor and it is continued to '8' being the permanent 3rd molar. Thus permanent teeth are recognized by 11-18 (upper right quadrant), 21-28 (upper left quadrant), 31-38 (lower left quadrant) and 41-48 (lower right quadrant).

Primary teeth are identified in similar way. There are four quadrants because in each quadrant same tooth classes and their types are located.

The four quadrants for primary teeth are marked in a clockwise direction such as:

- Deciduous maxillary (upper) right quadrant : 5
- Deciduous maxillary (upper) left quadrant : 6
- Deciduous mandibular (lower) left quadrant: 7
- Deciduous mandibular (lower) right quadrant : 8

Combining the quadrant and tooth numbers, the primary teeth are identified by digits 51 to 55, 61 to 65 for upper right and upper left quadrants respectively (Figure 2). The teeth of lower left and lower right quadrants are indicated by 71-75, 81-85 digits respectively.

Permanent Teeth															
Upper Right								Upper Left							
18	17	16	15	14	13	12	11	21	22	23	24	25	26	27	28
48	47	46	45	44	43	42	41	31	32	33	34	35	36	37	38
Lower Right								Lower Left							

Primary teeth									
Upper Right					Upper Left				
55	54	53	52	51	61	62	63	64	65
85	84	83	82	81	71	72	73	74	75
Lower Right					Lower Left				

Figure 2.

FDI - two digit notation (Sandham 1983)

In FDI system, the quadrants for primary teeth are 5-8 and teeth are numbered from 1-5. Upper right is '5' and '8' is the lower right quadrant in a clockwise direction. Numbering of teeth is started from midline to distally (away from midline). Primary teeth with their respective quadrant numbers are shown in bottom part of the figure 2.

Example 55 = Deciduous upper right 2nd molar

65 = Deciduous upper left 2nd molar

By combining quadrant and tooth numbers, teeth are recorded during oral examination and communicated for sharing dental information. The FDI system is commonly used in many countries (Peck and Peck 1993, Elderton 1989, Sandham 1983).

2.3.3 Advantages of FDI system

- It is user friendly.
- It is easy to understand.
- It segregates the quadrant in an easy way.
- It is easy to communicate dental information via this system.
- It designates both permanent and deciduous teeth only by numbers.

2.4 Universal numbering system

2.4.1 Brief history

This notation system was introduced by Delta dental insurance company (Pogrel 2003). This was adopted by American Dental Association (ADA) and being in practice as official tooth notation of ADA since 1975 (Schwartz and Stege 1977).

2.4.2 Identification of teeth

The system provides identification of primary teeth by letters (A to T) starting from the upper right 2nd molar as #A, and moving clockwise around the arch to the lower right 2nd molar as # T. This notation system is a continuous alphabet letters (A - J) for maxillary deciduous teeth and (K - T) for mandibular primary teeth (Figure 3).

Permanent teeth are given individual numbers from 1 to 32 starting with the upper right third molar (1) and moving clockwise around the arch to the lower right third molar (32). This notation method is widely used in the United States (US) and Canada because of insurance purposes (Pogrel 2003). Universal system for primary teeth is shown in figure 3.

Maxillary right	Maxillary left
A B C D E	F G H I J
T S R Q P	O N M L K
Mandibular right	Mandibular left

Figure 3.

Universal numbering method (Cunningham 1883, Havale et al. 2015)

Primary teeth are identified by letters A-T starting from deciduous upper right 2nd molar (A) to deciduous lower right 2nd molar (T).

In the past, primary teeth were given the numbers 1d to 20d in same manner like permanent teeth. But later numbers and letters were replaced by only English letters (A-T) starting from deciduous upper right 2nd molar to deciduous lower right 2nd molar.

For example: A = Deciduous upper right 2nd molar

T = Deciduous lower right 2nd molar

2.4.3 Advantages of Universal numbering method

- It is easy to understand because of numbers.
- It is user friendly manually as well as electronically.
- It differentiates permanent and deciduous teeth by numbers and letters.
- It is easy to communicate dental information for dental insurance purposes.

2.5. Haderup tooth notation

2.5.1 Brief history

Viktor Haderup from Denmark introduced this tooth notation method in 1891 (Haderup 1891). This is similar to Zsigmondy – Palmer notation and still taught in Danish dental schools.

2.5.2 Identification of teeth

This notation uses plus (+) and minus (-) signs to indicate maxillary and mandibular teeth respectively. Thus +1 indicates the upper left central incisor and 1- indicates the lower right central incisor. For primary teeth, zero (0) is added to the left side of the numerals and are numbered 01 to 05. Haderup system for primary teeth is shown in figure 4.

Maxillary teeth

05+, 04+, 03+, 02+, 01+	+01, +02, +03, +04, +05,
05-, 04-, 03-, 02-, 01-	-01, -02, -03, -04, -05

Mandibular teeth

Figure 4.**Haderup notation**

Haderup system describes primary teeth by numbers (01 to 05) and differentiates upper and lower teeth by plus (+) and negative (-) signs.

2.5.3 Advantages of Haderup method

- This method is computer friendly.
- This is easy to understand because of digits and plus and minus signs.

2.6. 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 upper right quadrant to lower right quadrant in a clockwise direction (Figure 5).

UPPER RIGHT					UPPER LEFT				
1D	2D	3D	4D	5D	6D	7D	8D	9D	10D
20D	19D	18D	17D	16D	15D	14D	13D	12D	11D
LOWER RIGHT					LOWER LEFT				

Figure 5.**Woelfel system for primary teeth**

This system describes primary teeth by continuous numbers 1-20 with upper case letter 'D' (Havale et al. 2015, Scheid 2007). Deciduous upper right 2nd molar is marked as 1D. This process continues to deciduous upper left 2nd molar as 10D. Lower primary teeth are denoted from deciduous lower left 2nd molar as 11D and moves towards midline then from midline to away where the last primary tooth (deciduous lower right 2nd molar) is marked as 20D.

This is somewhat different from Universal numbering system where upper case letters (A- T) are used to describe primary teeth. In past, Universal system adopted a similar pattern of Woelfel method with lower case 'd'.

2.7 Consequences of multiple efforts to make a global notation system

Tooth notations record, print and communicate dental information. As mentioned in previous sections, for identification of teeth and communication of dental problems, multiple tooth notations are being employed in different parts of the world. For example, in Great Britain, most of the practitioners use Palmer notation (Blinkhorn et al. 1998). But many authors around the world strongly recommended FDI two digit system (Peck and Peck 1993, Elderton 1989, Sandham 1983). In US, Universal numbering system is widely used by oral surgeons while Palmer notation is a choice of orthodontists (Pogrel 2003).

Currently used tooth notations (Palmer, FDI and Universal) identify permanent as well as deciduous teeth. Thus it can be seen that they have two components. One component is associated with permanent and other with primary teeth. Above that, both components of each tooth notation are different within their structures. For example, the component of FDI related to permanent teeth has numbers(11-18) , (21-28) , (31-38) ,(41-48) in four quadrants and numbers for primary teeth are (51-55),(61-65),(71-75),(81-85). Palmer notation has numbers (1-8) for permanent teeth and alphabet letters (A-E) for primary teeth. Similarly, Universal numbering system has numbers (1-32) for permanent teeth and letters (A-T) for primary teeth. Thus, Palmer and Universal are alpha numeral systems while FDI is purely numeral system in their own identity.

Each tooth notation is complete in its own integrity but due to globalization of the world, this is the demand of each tooth notation to be computer friendly. This factor was

recognized in early 70's in an annual meeting of FDI which was held in Berlin. It is clear FDI and Universal systems are computer friendly because of numeral digits which are easy to type. Zsigmondy-Palmer notation had difficulty in the beginning because of its cross sign. Later, a lot of work of Information Technology (IT) was done to prepare special software to make it computer friendly (Lewis 2000, McCormack 1991).

The currently used three tooth notations are complete in their entity and computer friendly. A referral based service between general dentists and consultants is well established in all dental specialties especially in hospitals. The formal way of communicating dental information is the referral letter which is used by dental health professionals. However, there is no standard in terms of selection of a tooth notation. General dentists and specialist do not use the same tooth notation when they communicate among each other (Ricketts et al. 2003). For example, in US, orthodontists and oral surgeons mostly use Palmer notation and Universal numbering system respectively. In Palmer notation, upper right first premolar is tooth#4 which is tooth number 5 (Universal numbering 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 or between clinics / dental practices (Peleg et al. 2010).

A particular notation in dental charting and referral notes are not mentioned when a procedure is performed in general dental practice. 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 communication gap in dental practices especially in referring doctors to specialists does exist. Tooth errors usually occur as a result of poor communication within a dental practice or between dentists in different practices. Several surgeons involved in the same operation or multiple procedures in one operation are known risk factors. Other factors include unclear tooth notation, incorrect patient identification or a missing molar tooth or mixed dentition could increase risk. In other words, the usage of multiple tooth notation systems is directly or indirectly one of the considerable reasons of dental malpractice (Janice et al. 2007, Lee et al. 2007). Wrong tooth extractions are continued to occur in dental practice. In university dental hospital of Manchester despite of introduction of a checklist, there were five incidences of wrong tooth extractions from 2009 to 2012 (Saksena et al. 2014). Shifer and Shifer 2013) also emphasized to have a fixed dental notation system when they found a wrong extraction of their orthodontic patient who was referred to oral surgeon for extraction of tooth as part of orthodontic treatment. Orthodontic used Palmer notation in referral letter and Oral surgeon considered it as FDI system.

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, 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 on the importance of thinking 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.

3. OBJECTIVES

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

3.1 To develop a new notation (MICAP) system

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

3.2 To make MICAP system 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.

3.3 To develop a lesson plan on MICAP system

To implement in dental curriculum, a lesson plan is required on new notation method. The various components of a lesson plan were highlighted and its assessment was mentioned from this aspect.

3.4 To assess the format of MICAP by undergraduate dental students

It was aimed to assess the learning outcome of undergraduate dental students to identify primary teeth by using MICAP system after having a demonstration on MICAP format. Furthermore, the perception on prospective use of MICAP in dental charting and communication of dental information were also targeted.

3.5 To assess the format of MICAP by dental health professionals

From clinical practice point of view, to assess learning of MICAP format to mark primary teeth by dental specialists, dentists and dental allied health personals were aimed. Their feedback on its prospective use in dental charting and communicating dental information were also targeted.

4. METHODS






4.1 Developing a new notation (MICAP) system for primary teeth

4.1.1 Primary tooth classes and their types

Primary dentition has three tooth classes namely deciduous incisor, deciduous canine and deciduous molar. Three tooth classes are further sub divided into their types such as deciduous central incisor, deciduous lateral incisor, deciduous canine (it is tooth class and tooth type), deciduous first molar and deciduous second molar (Woelfel and Schied 2002). The primary tooth classes and their types are shown (Table 1.).

Table 1.

Primary tooth classes and their types

NO	Tooth class	Types of tooth class	
1	Deciduous incisor		Deciduous central incisor
			Deciduous lateral incisor
2	Deciduous canine		Deciduous canine
3	Deciduous molar		Deciduous 1 st molar
			Deciduous 2 nd molar

Three primary tooth classes (deciduous incisor, deciduous canine, deciduous molar) and their sub types though have different eruption period and pattern but once they are erupted, they are identified from midline to distally or away from midline in this way (deciduous central incisor , deciduous lateral incisor , deciduous canine , deciduous 1st molar and deciduous 2nd molar). Deciduous central incisor is closest to midline and deciduous 2nd molar is the farthest from midline.

4.2 Mixed dentition

First primary tooth erupts at age of six month. All twenty primary teeth complete their eruption in two – three years. At the age of six years, permanent teeth start appearing and replacing primary teeth until at the age of 12 -14 years. Life of primary teeth is very short as compared to permanent teeth which stay till last span of human life.

Between primary and permanent dentitions there is a mixed dentition which contains both primary and permanent teeth. Mixed dentition has longer span than sole primary dentition.

4.3 Permanent dentition

In permanent dentition, there are four tooth classes which have their subtypes likewise primary dentition. But there is an additional tooth class and tooth type. The four tooth classes and their subtypes (tooth types) are tabulated (Table 2.).

Table 2.

Permanent tooth classes and their types

NO	Tooth class	Types of tooth class
1	Permanent incisor	Permanent central incisor
		Permanent lateral incisor
2	Permanent canine	Permanent canine
3	Permanent premolar	Permanent 1 st premolar
		Permanent 2 nd premolar
4	Permanent molar	Permanent 1 st molar
		Permanent 2 nd molar
		Permanent 3 rd molar

Primary dentition is replaced by permanent dentition which has four tooth classes (permanent incisor, permanent canine, permanent premolar and permanent molar). Permanent tooth classes are subdivided into their types from midline to distally such as: central incisor, lateral incisor, canine, 1st premolar, 2nd premolar, 1st molar, 2nd molar and 3rd molar (Woelfel and Schied 2002). A term ‘TOTT’ shows **t**wo incisors, **o**ne canine, **t**wo premolars, **t**hree molars (Akram et al. 2012). However, permanent dentition if needed hereafter to mention a fact, the names ‘incisor (I), canine (C), premolar (P), molar (M)’ will be used in this dissertation.

4.4 Name of new tooth notation (MICAP)

This is evident that a tooth notation describes both primary and permanent teeth because in dental practice, all practitioners come across with primary as well as permanent teeth.

A new tooth notation ‘MICAP’ has been developed by using tooth classes and their types which were described in previous section. MICAP is the abbreviation of ‘**M**-molar, **I**-incisor, **C**-canine, **A**-Akram (family name of the dentist) and **P**-premolar’ (Akram et al. 2011). The new tooth notation emphasizes on tooth classes and their types for identification of intended upper and lower teeth. We agree in primary dentition, there is no premolar class but the name of new tooth notation mentions premolar in its name. Our attention is to develop a tooth notation which could be used for both primary and permanent teeth.

The new system is based on names of tooth classes and since three tooth classes (incisor, canine and molar) are common in primary and permanent dentition but 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 the part of name of tooth notation.

In primary dentition, there is no premolar class but for sake of name of tooth notation, P will be used. Hence, we would use the term MICAP as method rather than its segregation based on its alphabet combination for primary teeth. In this dissertation, MICAP will focus more on its section related to primary teeth.

4.5 Format of MICAP notation for primary teeth

4.5.1 Brief history of teeth name

There are 5 primary teeth (tooth types) in each quadrant of maxillary and mandibular arch which are divided into three classes named as deciduous incisor, deciduous canine and deciduous molar. Name of tooth classes (incisor, canine, molar) were derived from Latin words. Incisor was derived from ‘incidere’, canine from ‘dentes canini’ and molar

from ‘molaris dens’. However, incisor, canine and molar are now standard dental terminologies.

Primary tooth classes ‘incisor and molar’, except canine, contain more than one tooth per quadrant and are subdivided into types and arranged from midline to backward in each quadrant of maxillary and mandibular arch as; two incisors, followed by one canine then two molars in the back.

4.5.2 ANAASEA letters of MICAP notation

The names of primary tooth classes are used as founding factor in the new tooth notation. The first letters of all primary tooth classes [**dI** (deciduous incisor), **dC** (deciduous canine), **dM** (deciduous molar)] are used as basic guideline in developing the new tooth notation. The letters dI, dC, dM representing each tooth class are called ANAASEA letters for primary teeth. Deciduous incisor, deciduous canine and deciduous molar are the naturally occurring tooth classes which are constant in humans of all continents. Therefore the ANAASEA is the abbreviation of first letter of continents such as; A- Asia , NA- North America, SA- South America, E- Europe, A- Africa (Akram et al. 2012). The ANAASEA letters make the alpha component of the new tooth notation.

4.5.3 TOT digits of MICAP notation

There are **two** deciduous incisors, **one** deciduous canine and **two** deciduous molars in each quadrant of upper and lower jaws. Further detailing is that two deciduous incisors are central and lateral incisors. Deciduous canine is only one canine and two deciduous molars are 1st and 2nd molars. The numbers are allotted to primary teeth as they occur in oral cavity from midline to away such as:

- Deciduous central incisor = 1
- Deciduous lateral incisor = 2
- Deciduous canine = 1
- Deciduous 1st molar = 1
- Deciduous 2nd molar = 2

The primary tooth types are allotted the number either 1 or 2 based on their natural location in each quadrant of the oral cavity. These numbers (2,1,2) are called TOT digits. The TOT digits show two deciduous incisors, one deciduous canine and two deciduous molars. In other words **I** – (two deciduous incisors) , **O** - (one deciduous canine), **M** – (two deciduous molars) make the TOT which represents the type of same tooth class which nature has given to human of all continents, for example (e.g.) *I* represents the first deciduous molar, 2 represents the second deciduous molar (Akram et al. 2011).

The digits are allotted to deciduous teeth (Table 3.).

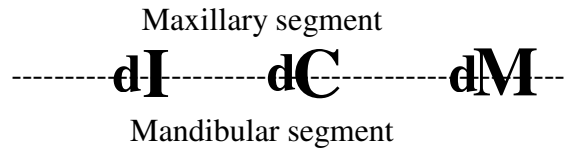
Table 3.
Tooth types and allotted numbers

Deciduous tooth class	Type of deciduous tooth class	Allotted TOT digit
Deciduous incisors	Deciduous central incisor	1
	Deciduous lateral incisor	2
Deciduous canine	Deciduous canine	1
Deciduous molars	Deciduous first molar	1
	Deciduous second molar	2

TOT digits of MICAP notation represent the tooth types within the same tooth class. They are allotted to tooth types as they appear from midline to away. Thus central incisor is allotted *I* (one) and lateral incisor is marked by 2 (two). Similarly deciduous first molar and second molar are allotted ‘1 and 2’ respectively. One (*I*) is allotted to canine because it is single in each quadrant.

4.6 Maxillary and mandibular segments of MICAP notation

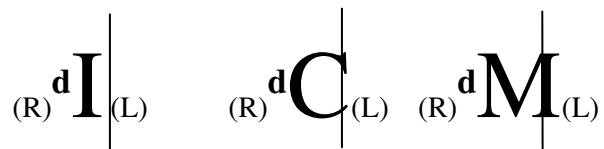
All three classes of primary teeth are identified by letters dI, dC, dM called as ANAASEA letters and each ANAASEA letter is divided into an upper part (maxillary segment) and lower part (mandibular segment), by an imaginary horizontal line which passes through the mid of each ANAASEA letter as illustrated (Figure 6.).

**Figure 6.****Maxillary and mandibular segments**

Imaginary horizontal line divides the ANAASEA letters into an upper (maxillary) and lower (mandibular) segments (Akram et al. 2011). Horizontal line produces two (an upper and a lower) compartments which would be considered ‘superscript and subscript’ respectively. Superscript represents maxillary (upper) and subscript shows the mandibular (lower) segment of respective ANAASEA letters.

4.7 Right and left segments of MICAP notation

Each ANAASEA letter (**dI**, **dC** and **dM**) for primary teeth is divided into right and left half by imaginary vertical line passing through the tip of each of them as shown (Figure 7.).

**Figure 7.****Right and left halves of ANAASEA letters**

Imaginary vertical lines divide each ANAASEA letter into right (R) and left (L) half (Akram et al. 2011).

4.8 MICAP notation and four quadrants

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 as shown in figure 8.

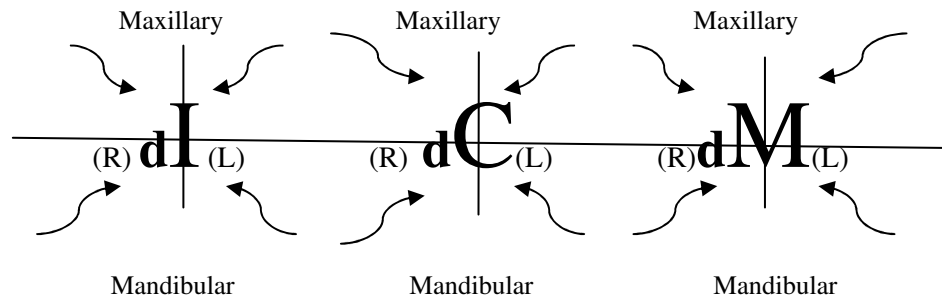


Figure 8.

MICAP - four quadrants

Division of each ANAASEA letter into four quadrants by imaginary horizontal and vertical lines as shown above is patient's view i.e. patient's right corresponds to right of ANAASEA letter (Akram et al. 2011). Four compartments obtained by this way represent four quadrants of oral cavity. In each quadrant, deciduous incisor, canine and molar are present. By getting four quadrants, TOT (2,1,2) digits which represent the tooth types of each tooth class (dI, dC, dM) within each quadrant are printed at upper corner and lower corner at both sides which are explained in next section.

4.9 Rule of printing of TOT digits at ANAASEA letters

TOT digits, allotted to appropriate type of each class of primary teeth are printed at upper right and left corner as well as lower right and left corner of ANAASEA letters. In other words, the allotted TOT digits which are superscripted at upper corner of both right and left side of a given ANAASEA letter indicate maxillary teeth of both right and left side of that particular **class** and its types. The allotted TOT digits which are subscripted at both right and left side of a particular ANAASEA letter would indicate both sides of mandibular teeth of appropriate class and its type. The rule of printing of TOT digits at each ANAASEA letter is explained in detail.

4.9.1 Rule of printing of TOT digits for deciduous incisors

Incisor teeth are two in each quadrant of maxillary and mandibular arches. TOT digits (1,2) indicating central and lateral incisors respectively are superscripted at upper right and left corner and subscripted at lower right and left corner of ANAASEA letter **dI**.

Superscripted TOT digits show relevant maxillary incisors and subscripted digits indicate mandibular incisors. Incisor teeth are eight in total and four are located on right and same number on the left side. Four quadrants of ANAASEA letter (dI) and TOT digits are shown in figure 9.

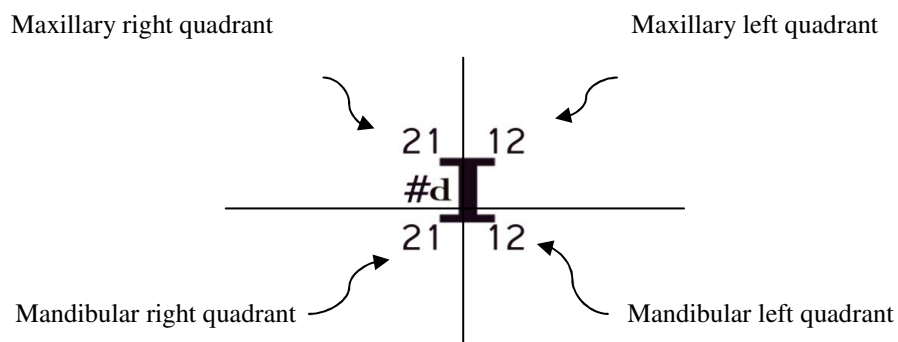


Figure 9.

Display of deciduous incisor

TOT digits written as 21, 12 either superscript or subscript at ANAASEA letter '**dI**' indicate deciduous central and lateral incisor of four quadrants. TOT digits (21, 12) are read separately as one (1), two (2); instead of twenty one (21) or twelve (12). The sign hash (#) indicates the number of types of particular class of tooth. Here it means the incisor tooth number. (Imaginary horizontal and vertical lines are shown here just for understanding purpose).

4.9.2 Rule of printing of TOT digits for deciduous canine

There is one canine tooth in each quadrant of maxillary and mandibular arches. TOT digit (1) is printed at upper right and left corners as well as lower right and left corners of ANAASEA letters (dC) which shows the maxillary and mandibular canines respectively.

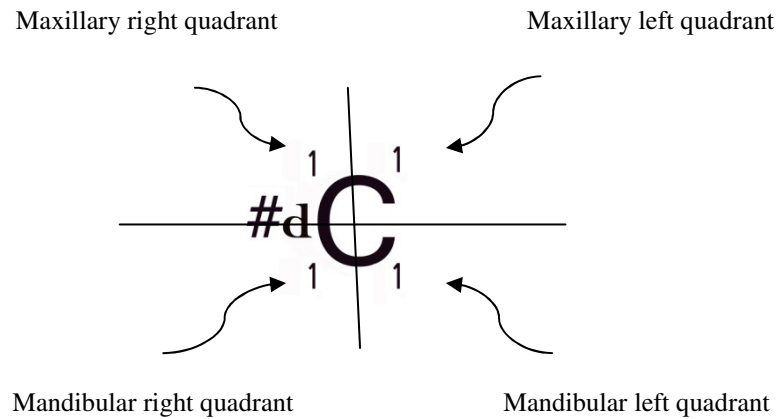


Figure 10.

Display of deciduous canine

There are four canine teeth, one (1) in each quadrant (maxillary right and left; mandibular right and left). The sign # indicates the number of type of particular class of tooth. Here it means the canine tooth number. (Imaginary horizontal and vertical lines are shown just for understanding purpose) (Figure 10.).

4.9.3 Rule of printing of TOT digits for deciduous molars

Four deciduous molar teeth are located on upper and same number on the lower side (Figure 11.).

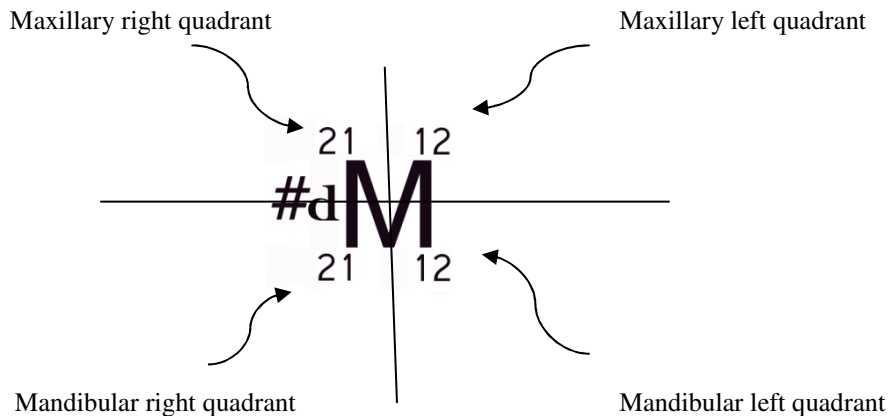


Figure 11.

Display of deciduous molar

There are two deciduous molars in each quadrant of maxillary and mandibular arches. TOT digits (1,2) indicating first and second molars respectively are printed at upper right and left corner as well as lower right and left corner of ANAASEA letter **dM** to mark maxillary and mandibular molars respectively, present in four quadrants. TOT digits written as 21, 12 either upper or lower corner of ANAASEA letter **dM** indicate deciduous first and second molar. They are read as one (1), two (2) separately instead of twenty one (21) or twelve (12). The sign # indicates the number of types of particular class of tooth. Here it means the molar tooth number. (Imaginary horizontal and vertical lines are shown just for understanding purpose (Akram et al. 2012)).

4.10 Complete presentation of deciduous teeth in MICAP notation

After describing the process of identification of each primary tooth class by ANAASEA letter and their types by TOT digits. We are able to identify all primary teeth this way.

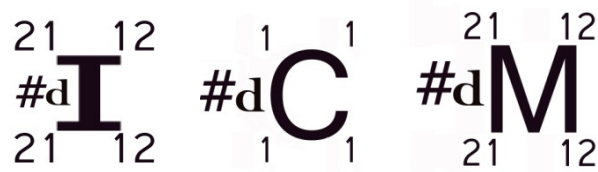


Figure 12.

MICAP Notation for deciduous teeth

Three primary tooth classes are identified by letters such as dI (deciduous incisor), dC (deciduous canine), and dM (deciduous molar). The particular tooth class is shown by capital letter of its initial name. The letter 'd' shows deciduous tooth class or tooth type. The tooth types of each tooth class are marked by the digit / number which it takes from its position in the oral cavity (Figure 12.). For example, *I* shows deciduous central incisor and 2 - deciduous lateral incisor in respect of 'dI' (Akram et al. 2012).

All twenty primary teeth located in upper and lower arches are identified by ANAASEA letters and TOT digits which represent tooth classes and their types. Relevant TOT digits are printed as superscript and subscript at both sides of associated ANAASEA letters.

4.11. Fundamental rules of MICAP notation for deciduous teeth

- Letters **dI**, **dC**, **dM** represent all three classes of deciduous teeth which are present in each quadrant of maxillary and mandibular jaw. These letters represent each tooth class present in primary dentition. Thus dI represents deciduous incisor while deciduous canine and deciduous molar are indicated by dC and dM respectively.
- Upper case letter 'I, C, M' are used to indicate incisor, canine, molar respectively.
- Digits (1,2) show the relevant tooth types, e.g. *I* means deciduous central incisor and 2 would show deciduous lateral incisor. Deciduous canine is one so *I* would be used. 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 for deciduous teeth.

- The lower case letter “**d**” is always written along with letter (I, C, M) to indicate the respective deciduous tooth class (Akram et al. 2012).
- The letter “d” is always written in the left side of each ANAASEA letter after the sign # whenever the MICAP tooth notation is used for deciduous teeth.
- In MICAP text matter, the sign (#) is written in the beginning so that TOT digits of different classes may not be misinterpreted in communication (Akram et al. 2011).
- Superscripted and subscripted TOT digits show maxillary and mandibular teeth respectively.
- TOT digits are always pronounced separately. For example #dM₁₂ is pronounced as deciduous lower left first and second molar (Akram et al. 2011, 2012).
- TOT digits are written smaller than ANAASEA letters to clarify the upper or lower teeth in case manual charting is done. In electronic charting, TOT digits are superscripted for upper teeth and subscripted for lower teeth.

4.12 MICAP notation and its computer application

Patient complaints are still recorded manually in many countries, however more and more dental practices including individuals, institutions and organizations have adopted computerized dental recording. Therefore a tooth notation is required to be computer friendly.

MICAP tooth notation system can be used manually as well as electronically. This system for deciduous teeth involves the usage of letters (dI, dC, dM) and digits (1,2) which can be typed in computer. While using computer, the digits (1,2) are to be subscripted and superscripted with respective letters (dI, dC, dM). In word processing and scientific notation, a subscript and superscript is defined as a digit or symbol that appears below and above the line respectively.

#dM₂ —this is an example of subscript where the digit 2 is written below the line. #dC¹ is an example of superscript where digit one (1) is written above the line. MICAP system is made compatible to today’s and future’s demand. Few procedures are described to show its usage by computer.

4.13 Various MS Word methods to write MICAP notation

MICAP notation for primary teeth is the combination of letters 'd' and I, C, M which are written as dI, dC, dM and represent deciduous incisor, deciduous canine and deciduous molar (dM) respectively. These letters are commonly written in typing a text message on word file or power point even email.

The digits (1,2) are either written superscript or subscript to show a particular tooth type. Typing superscript and subscript is possible on various methods.

4.13.1 Option 1: TOT digits as superscript and subscript

- Open Microsoft Office Word 2010.
- Open the document where "MICAP text" is supposed to be written for communication.
- On required text of the document, press '**Shift 3**' to write the symbol hash (#)
- Write the required tooth class by pressing key 'd' and capital 'I, C or M'.
- Type the appropriate digit on right or left side of the ANAASEA letter e.g. #2dI.
- Select 2 by pressing **Ctrl** (Control) and + key and release the keys, 2 becomes subscript. Example is #₂dI.
- To make 2 as superscript , press **Ctrl** , **shift** and = keys [#²dI].



Figure 13.

Computer keys to write superscript and subscript

The figure just shows the keys on computer key board which can be used to write a TOT digit either subscript or superscript (Figure 13.). This is one of the Microsoft (MS) Word procedures for subscript and superscript.

Mac book which uses different software does provide subscript and superscript facility (Figure 14). The procedure is almost same like MS but in Macbook, the keys are 'Command (CMD) =' for subscript and 'CMD +' for superscript.



Figure 14.

Macbook keys to show subscript and superscript

The keyboard of Macbook is shown (Figure 14) and three keys are highlighted with red which are used to write superscript and subscript. The detail of procedure is written above which is similar to Microsoft (MS) Word.

4.13.2 Option 2: TOT digits as superscript and subscript

- Open the MS Office Word (2007/2010/2013).
- Type the document where ‘MICAP text’ is required to be written.
- Press “**Shift 3**” to write the symbol hash (#).
- Type the appropriate ANAASEA letter, by pressing ‘**Caps Lock**’ or press shift key with the letter to get capital letter.
- Write the appropriate TOT digit(s) along ANAASEA letter(s) either on left or right side.
- Highlight the TOT digit(s).
- Click either “**X₂ or X²**” located on the home ribbon to make the appropriate TOT digit/s as Subscripted and Superscripted respectively on required left or right side as shown in figure 15.

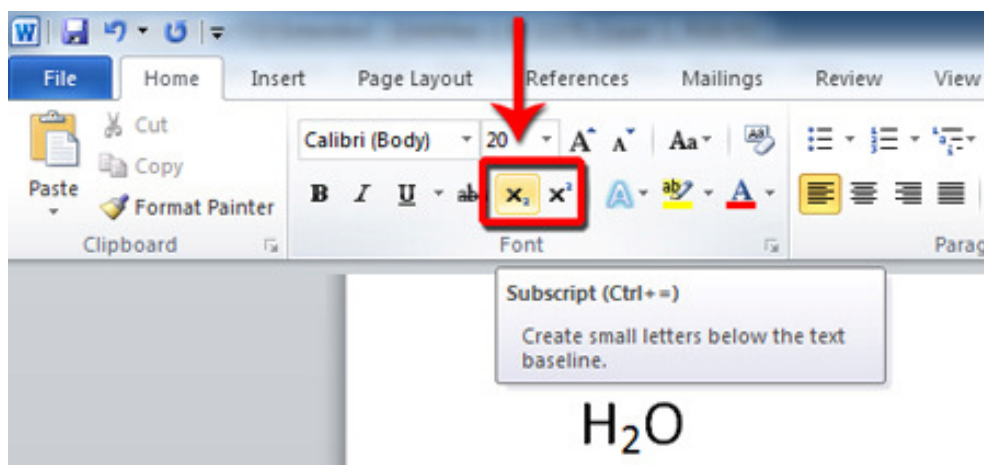


Figure 15.

Home page showing subscript and superscript icon –MS-Word

Home page has icon X_2 X^2 and by clicking either one produces the required subscript or superscript result.

- Adjust, if required, the font size according to text of document by highlighting the 'MICAP text'.
- Click the 'SAVE' button or press '**Ctrl+S**' (Control + Save) to save the MICAP text.
- Then continue to type the required text material.
- Any mistake can be rectified by using the '**Delete**' key.
- #dM₂ [deciduous lower left 2nd molar].
- #dM² [deciduous upper left 2nd molar].

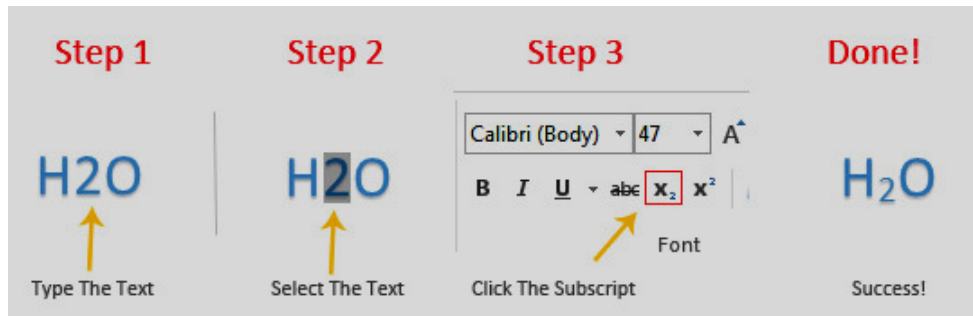


Figure 16.

Snapshot to show subscript on MS Word

Tool bar has sign X_2 X^2 and by clicking either one produces the subsequent result. In snapshot, formula of water (H_2O) is used. Two (2) is subscripted at letter H in figure 16. By this way, we can produce TOT digit (1,2) as subscript and superscript on ANAASEA letter to show maxillary and mandibular teeth.

4.13.3 Option 3: TOT digits as superscript and subscript

There is another option in AbiWord for superscript and subscript.

- Get home page in Open Office.
- Type the required ANAASEA letter and TOT digit(s).
- Click **Format** menu on the tool bar.
- Select **text formatting** and then select **superscript** or **subscript**.
- The selected TOT digit becomes subscript or superscript.

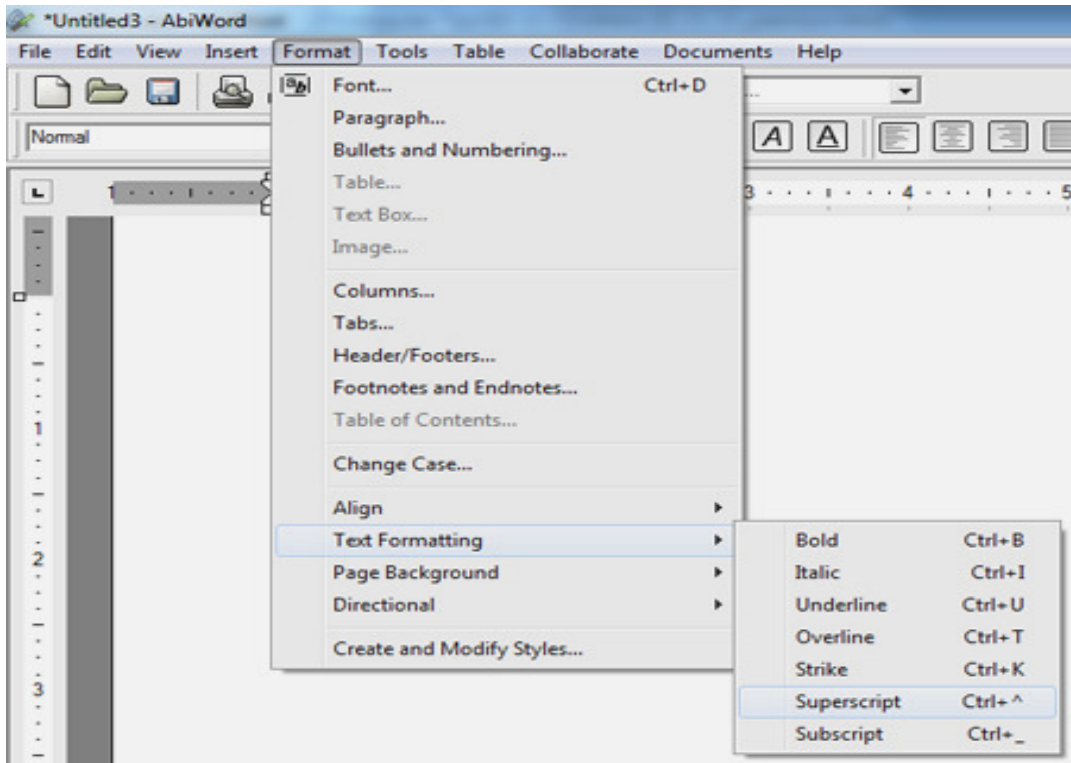


Figure 17.

Subscript and superscript in Open Office

Another way to write superscript and subscript is shown in figure 17. From tool bar, select '**text formatting**' and click it. Another bar appears and then '**Select**' either superscript or subscript (Figure 17.).

4.13.4 Option 4: TOT digits as superscript and subscript

- Open Microsoft Office Word 2010.
- Open the document where "MICAP text" is supposed to be written for communication.
- Click "**Insert**" on the main menu.
- This opens the screen with icon "**Equation**" as shown in figure 18.

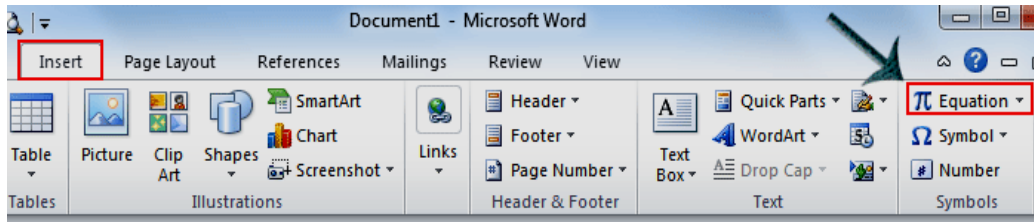


Figure 18.

π Equation on tool bar

Tool bar has icon equation (arrow in figure 18). By clicking this icon, another bar appears which contains different options for superscript and subscript.

- Click icon “π”, the equation ribbon will appear on screen in figure 18.
- Click ‘**Insert new equation**’ which opens a new bar.
- Click the “**e^x Script**” on equation ribbon which opens further equation tools of subscript and superscript.
- Select the appropriate and most suitable equation tools to write superscript or subscript or superscript/subscript at the same time either right side or left side of an ANAASEA letter. To get the symbol on both sides you need to highlight the middle equation and select the other superscript/subscript set as shown in figure 19.
- Write the appropriate ANAASEA letter and its relevant TOT digit in the equation box as superscript and subscript
- Adjust the font size according to text of document by highlighting the MICAP text and then choose the required ‘Font’.
- Click the ‘**SAVE**’ button or press **Ctrl+S** to save the MICAP text.
- Any mistake can be rectified by using the ‘**Delete**’ key.

Once ANAASEA letters and TOT digits have been written, continue to type the other text as routinely.

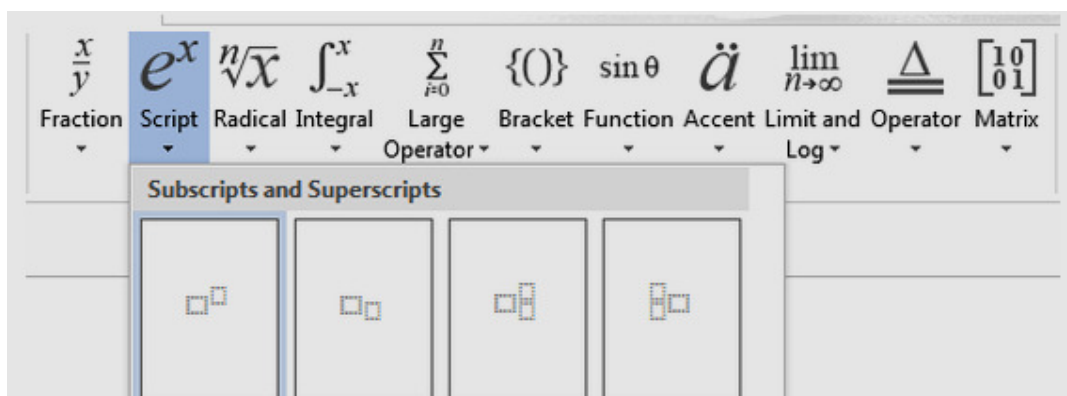


Figure 19.
Equation editor procedure

Equation editor provides facility to write subscript and superscript simultaneously available in MS Word tool bar. #**dm¹₂** is MICAP text which has been written by using equation editor method. This MICAP text represents deciduous upper left first and lower left second molar (Figure 19).

4.13.5 Option 5: TOT digits as superscript and subscript

- Open MS Word (2007/2010)
- Open the document where “MICAP text” is supposed to be written for communication.
- On required text of the document, press “**Shift 3**” to write the symbol hash (#).
- Click “**Insert**” on the main menu.
- Click the button ‘**Text Box**’ and choose ‘simple text box’.
- Remove the default text inside text box by pressing ‘**Delete**’ key.
- Adjust the size of ‘text border’ according to required appropriate size.
- Click ‘**Insert**’ again from main menu.
- Adjust the font size according to text of the document by highlighting the ‘MICAP text’ and then choose the required ‘Font’.

- To remove the text border, move the mouse anywhere at the border and right click on the mouse which opens the drop menu. Choose '**Format Text Box**' from drop menu.
- Inside 'Format Text Box- dialogue window' choose 'No Color' on "**Fill**" and "**Line Color**" and then press '**OK**'.
- Click the '**SAVE**' button or press **Ctrl+S** to save the MICAP text. #dM₂.
- Any mistake can be rectified by using the '**Delete**' key. Once ANAASEA letter and TOT digits have been written, continue to type the other text as routinely.

TOT digits as superscript / subscript written in this way are helpful to move same MICAP text within a line or from one line to another line or one paragraph to another paragraph or one page to another page or, if required, can be typed with different MICAP text that will save time and make interpretation fast. However this method does not produce an appropriate look.

4.14 Specific software for electronic (*e*) write up of MICAP notation

MICAP notation involves superscript and subscript in its write up. In previous section, few procedures were described to write superscript and subscript. Here we describe another procedure which was meant to write MICAP text and was uploaded *online*.

- MICAP software was created by Hypertext Markup Language (HTML) and C+ programme. There were many specific codes related to computer programming which are beyond of this subject to mention here.
- Login page of the MICAP software was created by using a 'Stored Procedure' in Application Service Provider (ASP) which was ASP.Net C#. The making of this software was specifically associated with Microsoft software specialists.
- Software had a brief description of MICAP notation titled as 'MICAP system for deciduous teeth' which described briefly the concept of notation. The four quadrants of MICAP notation were explained to provide framework knowledge of MICAP to the users (study participants). The software had a video

demonstration also to help participants to understand the new system. The video was linked via 'You tube'. A login was required to participate in the study.

- After description of system, participants were required to identify two MICAP formats for deciduous teeth [#dC¹ #2dM] and translate three primary teeth given in word form (deciduous mandibular left central incisor, deciduous maxillary right canine, deciduous maxillary left 2nd molar) into MICAP format. Lastly there was five point likert scale to get the feedback by users.

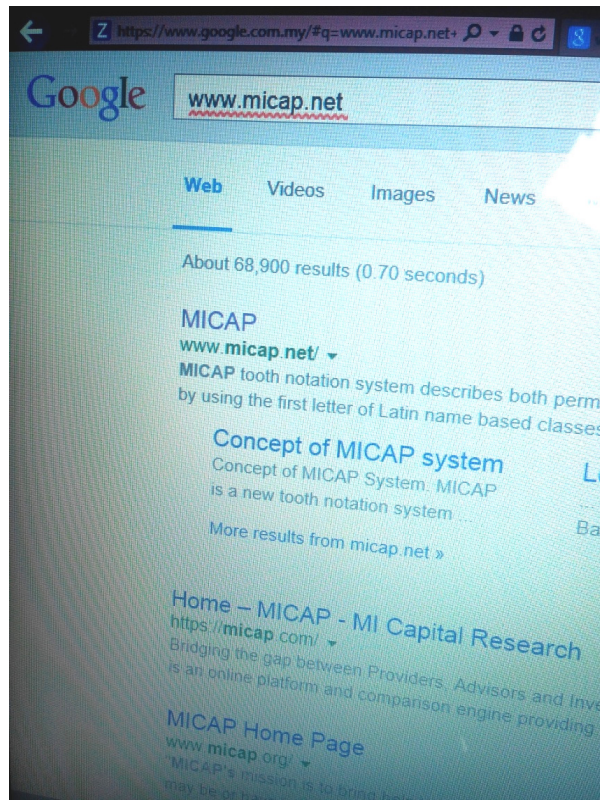


Figure 20.

Software MICAP uploaded *online*

Software MICAP notation was uploaded Online for one year period which was from August, 2014 to August 2015. The Uniform Resource Locator (URL) of web address was <http://www.micap.net> (Figure 20.).

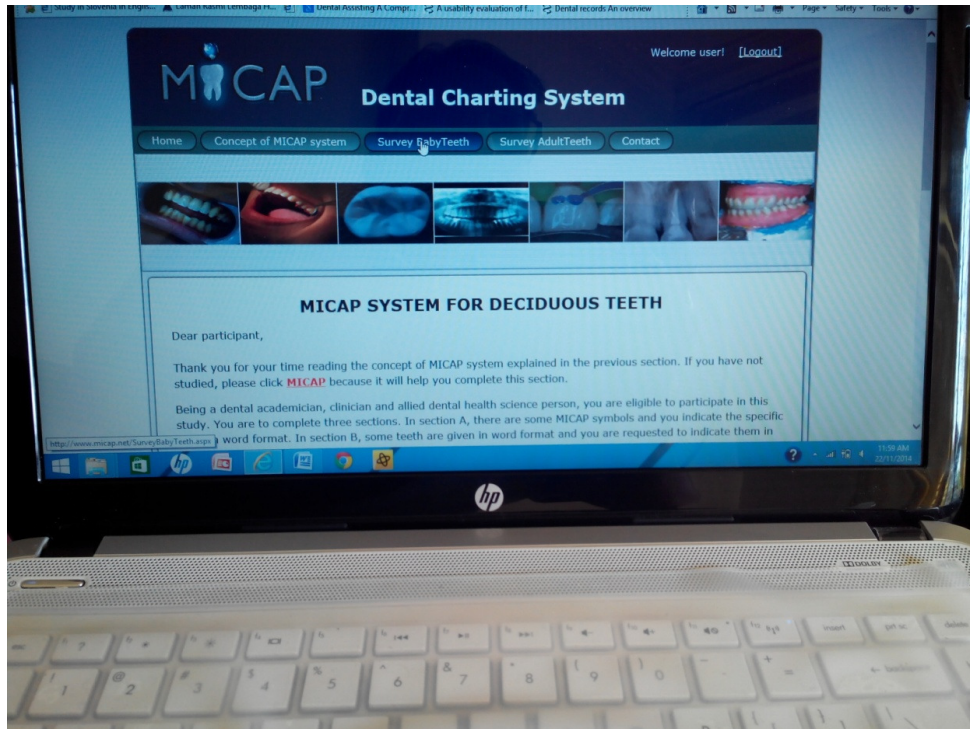


Figure 21.

Software MICAP – deciduous teeth section

This is a component of software of MICAP notation which was used as study tool to get on MICAP write up electronically. The title ‘MICAP system for deciduous teeth’ described briefly the concept of notation (Figure 21). The four quadrants of MICAP notation were explained to provide knowledge to the users (study participants). A video demonstration of MICAP system was uploaded via ‘You Tube’.

After this page, there was identification of two MICAP formats for deciduous teeth [#dC¹ #₂dM] and three primary teeth given in word form (deciduous mandibular left central incisor, deciduous maxillary right canine, deciduous maxillary left 2nd molar) which were supposed to be written in MICAP format by users. Lastly there was five point likert scale to get the feedback by users. Figures (20-22.B) show snapshot of MICAP software.

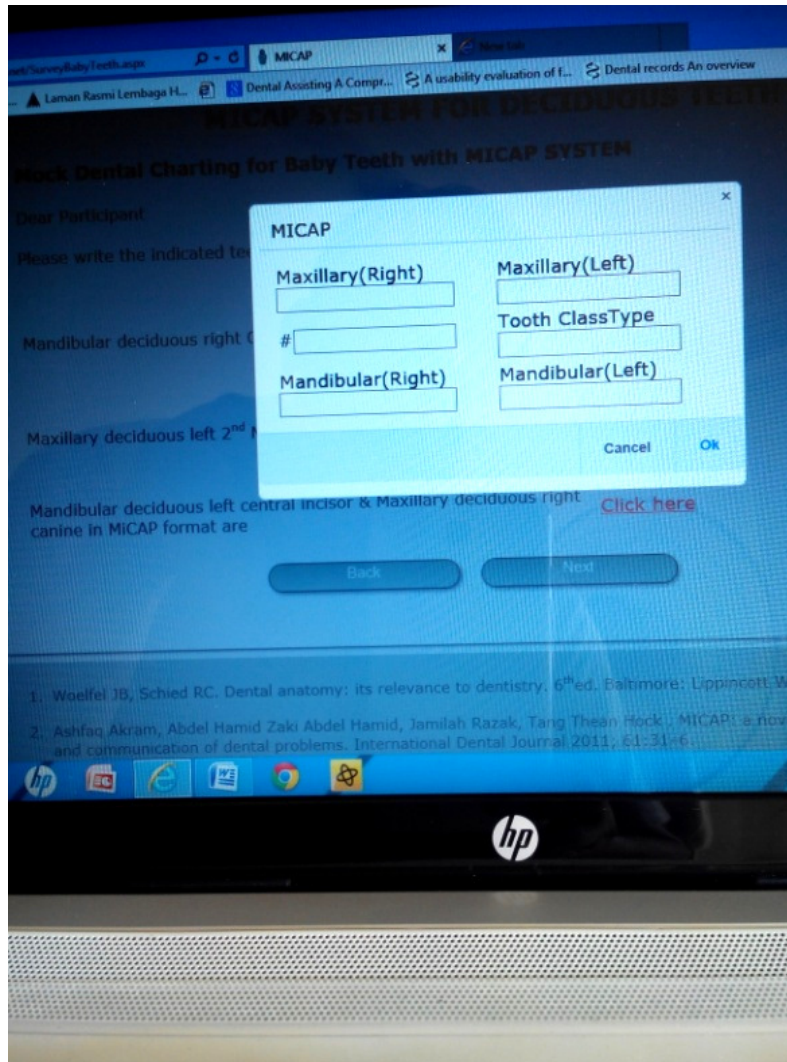


Figure 22.A

Format of subscript and superscript on MICAP software

MICAP software contained three rows with six boxes. Middle row boxes were meant to write tooth class for example dC (deciduous canine). The upper two boxes were for upper right and upper left quadrants and lower two boxes were for lower right and lower left quadrants where a relevant tooth type was to be printed. The sign [#] was inbuilt in the software (Figure 22.A) (Akram et al. 2015a, 2015c).

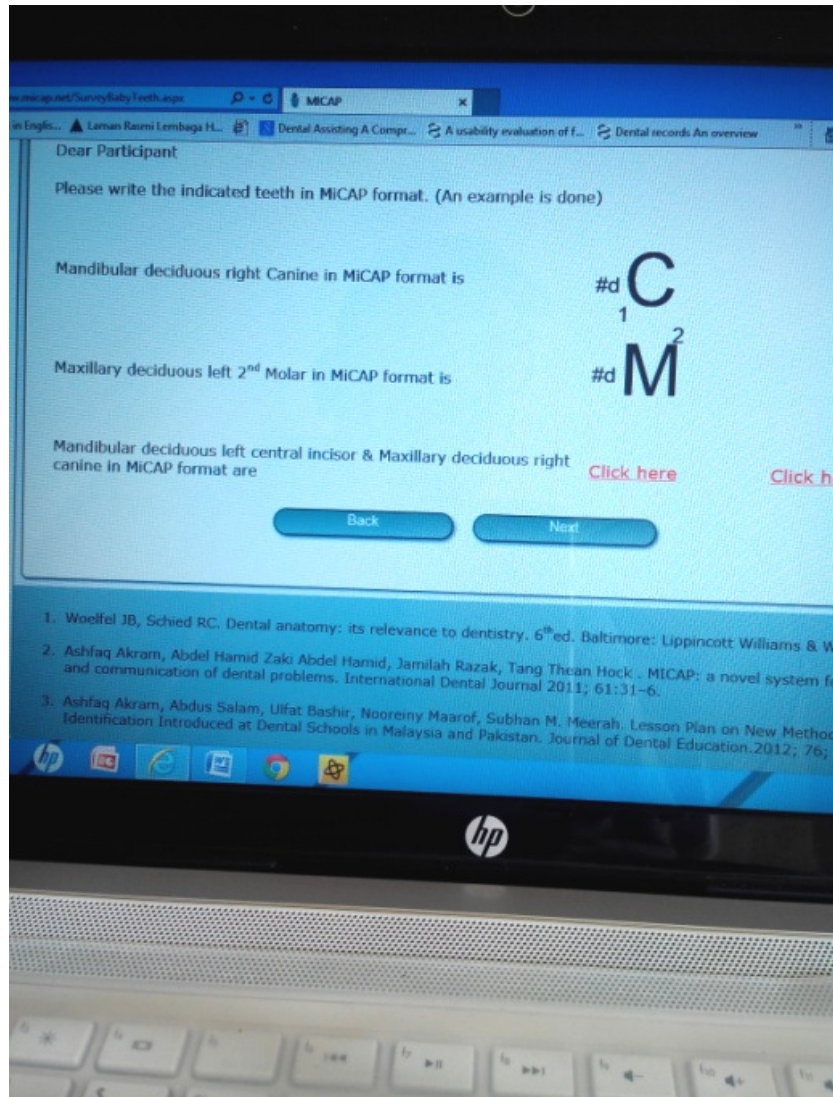


Figure 22.B

Display of subscript and superscript on MICAP software

The required MICAP format appeared as #₁dC and #dM². The former was deciduous lower right canine and later one was deciduous upper left 2nd molar (Figure 22.B).

4.15 Methods for MICAP notation as lesson plan

A tooth notation is taught in preclinical years as lesson plan for academic purpose. It provides a theory and framework concept of the notation which is used later in clinical practice in dental charting procedure. The new notation (MICAP) is not part of a dental curriculum but it was intended to be a prospective notation method.

For this purpose, its lesson plan was conducted from academic purpose view to gets its initial feedback from dental students.

A cross sectional study was carried out to receive the perception of the new notation at Islamic International Dental College, Islamabad, Pakistan. Final (clinical) year undergraduate dental students (n=40) participated voluntarily (Akram et al. 2012). The study was approved by the ethics committee of the college. The lesson plan in the form of one hour lecture was delivered by an experienced lecturer.

4.15.1 Components of lesson plan

The lesson plan had components:

- Learning outcomes (objective)
- Currently used solicited tooth notations (FDI notation, Universal numbering and Palmer notation) also known as Background)
- Formation of MICAP system
- Application of MICAP as dental charting method
- Summary and feed - back of students.

4.15.2 Close end questionnaire

At end of lecture, a close end questionnaire using five point likert scale, Strongly Disagree (SD=1), Disagree (D=2), Not Sure (NS=3), Agree (A=4), Strongly Agree (SA=5) was used to obtain the perception of students on MICAP tooth notation system.

Data were analyzed by descriptive statistical method (average) using SPSS 18.0 for Windows software package.

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

In an undergraduate dental programme, various tooth notations are taught in preclinical years mostly in 2nd year of the programme and students practice them in a process of oral examination called dental charting, from 3rd year (clinical year) to their whole professional life. Undergraduate dental students (n=176) of Islamic International Dental College, Islamabad, Pakistan, were chosen where earlier version (lesson plan) of MICAP was carried out two years back. The said college is a leading private dental college which is affiliated with Riphah International University – a renowned university and categorized as A by Higher Education Commission (HEC) of Pakistan. Study participants were divided into Group A (pre- clinical n =85) and Group B (clinical n=91), based on their phase of study. An ethical approval was obtained by the ethics committee of college. The informed consents were obtained by students before taking part in study.

4.16.1 Mock dental charting

Mock *e-* dental charting based on MICAP notation for deciduous teeth was developed by using HTML and C+ programme. Five primary teeth, out of twenty, were selected randomly. Among five teeth, stratified random sampling method was adopted for two teeth to be “translated from MICAP format to word form” and three teeth to be “written from word to MICAP format”. One tooth class (deciduous incisor) was used as an example to demonstrate the MICAP format.

Deciduous mandibular right second molar and deciduous maxillary left canine were presented in MICAP format [#₂dM #dC¹] to be translated (identified) into word form. Three primary teeth in word form ‘deciduous maxillary left 2nd molar, deciduous mandibular left central incisor and deciduous maxillary right canine’ were to be mirrored 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 which focused on possible adaptation of MICAP for pediatric dental charting and communication source of dental information (Akram et al. 2015c).

4.16.2 Study design

This was an observational cross sectional study. Mock dental charting based on MICAP format was the instrument. An hour lecture and a short video were employed to explain the formulation of MICAP system and its prospective application in clinical usage. After the lecture and video session, *group A and B* completed the procedure. Data were collected and marked in the guideline of MICAP as published in earlier version by primary author.

4.16.3 Statistical analysis

The two groups were compared by applying Pearson chi square test in Statistical Package for Social Sciences (SPSS) version 20. Analysis involved the values of Confidence Interval (CI), Degree of Freedom (*df*), Odds Ratio (OR). In addition, descriptive analysis was also performed for demographic factors and five point likert questionnaire. Statistical significance level ($p < 0.05$) was chosen.

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

4.17.1 Study design and population

Dental notation is equally important for health professional as for undergraduate dental students. Basically undergraduate students learn tooth notation during their study period and later they apply it during their dental practice.

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). Dental specialists comprised of pedodontists (n=9), endodontists (n=12), restorative dentists (n=15) and orthodontists (n=8). For analysis purpose, they were combined as dental specialists due to small number from each respective speciality. *Group B* had dental assistants (n=58), dental hygienist (n=38), dental technician (n=25) (Akram et al. 2015a). An inclusion criterion was to be involved in dental practice for at least one year as clinician / academician / supporting worker.

MICAP system 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.

4.17.2 Study instrument

Mock *e* MICAP dental chart had five primary teeth. Among five teeth, two teeth were to be “translated from MICAP forma [$\#_2dM \#dC^1$] to word form” and three teeth “deciduous maxillary left 2nd molar, deciduous mandibular left central incisor, deciduous maxillary right canine” were to be converted (written) to MICAP format. The focus was learning of MICAP notation rather than other common features of a dental charting. 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).

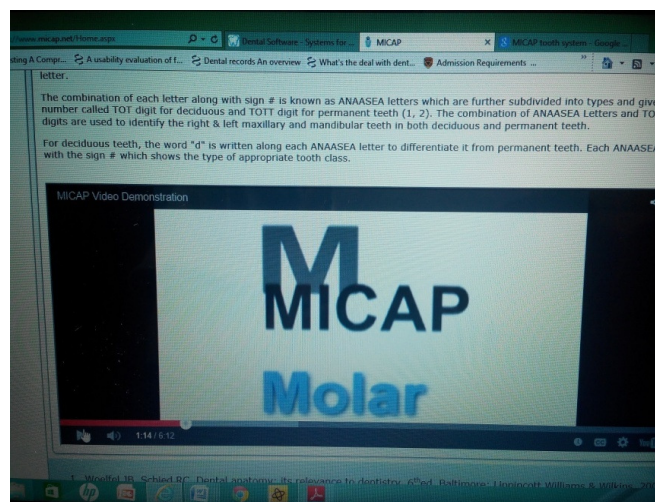


Figure 23.

Video demonstration of MICAP system

A video demonstration of MICAP system was incorporated with website www.micap.net through *You tube* link (Figure 23.). This video gave the concept of MICAP formation. It described the four quadrants of ANAASEA letters and write up of TOT digits to represent all teeth located in four quadrants of the mouth.

4.17.3 Statistical analysis

SPSS version 20.0 was used for analysis. Pearson chi-square and simple logistic regression were used to analyze doctors and dental paramedics groups respectively. In addition, frequency and cross tabs were applied in SPSS version 20 to analyze various aspects of data related to demographic factor and perception on MICAP notation for communication and dental charting purposes. Statistical significance level ($p < 0.05$) was chosen.

5. RESULTS

5.1 Prospective application of MICAP system for dental practice

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 is marked as (dC) and deciduous molar by (dM). 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 of dental charting was described using MICAP notation. Its purpose was to identify the dental problems associated with either deciduous or permanent teeth because a tooth notation plays a key role in dental charting. The suggested model shows both permanent and deciduous teeth because in general dental practice cannot be limited just up to primary dentition. The suggested model of dental charting has been shown in figure 24. (Akram et al. 2011).



Dental Charting with MICAP Tooth Notation System

Patient's Name: ----- Contact No: -----

Age/Sex: ----- Date of Examination: -----/-----/-----

Permanent Teeth	$\begin{matrix} 21 & 12 \\ \# & \mathbf{I} \\ 21 & 12 \end{matrix}$	$\begin{matrix} 1 & 1 \\ \# & \mathbf{C} \\ 1 & 1 \end{matrix}$	$\begin{matrix} 21 & 12 \\ \# & \mathbf{P} \\ 21 & 12 \end{matrix}$	$\begin{matrix} 321 & 123 \\ \# & \mathbf{M} \\ 321 & 123 \end{matrix}$
Deciduous Teeth	$\begin{matrix} 21 & 12 \\ \# & \mathbf{I} \\ 21 & 12 \end{matrix}$	$\begin{matrix} 1 & 1 \\ \# & \mathbf{C} \\ 1 & 1 \end{matrix}$	-	$\begin{matrix} 21 & 12 \\ \# & \mathbf{M} \\ 21 & 12 \end{matrix}$
Restoration				
Caries				$\begin{matrix} 2 \\ \# & \mathbf{M} \end{matrix}$
Pulpitis			$\begin{matrix} \# & \mathbf{P} \\ 2 \end{matrix}$	
Periapical infection				$\begin{matrix} \# & \mathbf{M} \\ 3 \end{matrix}$
Extraction				
Over Hang restoration				
Restoration with caries				
Obturation Done/RCT				
Missing tooth				
Crown				
Bridge(Pontic)				
Bridge(abutment)				
Impacted/Tilted tooth				
Unerupted tooth				
Over erupted tooth				
Attrition				
Traumatic injury				

* Contents given in the boxes can be modified/altered/added/omitted.

Figure 24.

A suggested model of dental charting by MICAP notation (Akram et al. 2011)


Both permanent and deciduous dentitions come across by general dentists and specialists in dental practice. Therefore MICAP notation for permanent and primary teeth has been shown (Figure 24). A tooth problem can be marked by this notation. For

example, caries has been marked for upper right 2nd molar #²M (Akram et al. 2011). Similar way deciduous teeth can be marked for any dental problem associated with one or multiple teeth.

5.2 Prospective application of MICAP notation for periodontal charting

A template based on MICAP notation for periodontal examination was also suggested (Figure 25).


PERIODONTAL CHARTING WITH MICAP SYSTEM



UNIVERSITI SAINS MALAYSIA

PATIENT NAME : AGE/SEX :

DATE OF EXAMINATION : CONTACT NO :



IPPT
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	MAXILLARY				MANDIBULAR			
	LABIAL	PALATAL	LABIAL	PALATAL	LABIAL	PALATAL	LABIAL	PALATAL
Mobility Grade (1,2,3)								
Probing Depth (mm)								
Maxillary Deciduous Teeth	2	1	1	2	1	2	1	2
	#d I				#d C			
Mandibular Deciduous Teeth	2	1	1	2	1	2	1	2
	#d I				#d M			
Probing Depth (mm)								
Mobility Grade (1,2,3)								

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Figure 25.

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 are on both sides which provide the measurement of pocket depth in millimeter (mm) (Akram et al. 2011).

Measuring of periodontal pocket is indicated for periodontal health. A space of pocket is present between the gum and the tooth before it attaches. The presence of gum disease deepens this space. The pocket depth must be measured, recorded and monitored over time in order to check and evaluate gum health. MICAP provides a possible solution of measuring periodontal pocket on record.

5.3 Identification of permanent teeth by MICAP notation

Dental practice encompasses deciduous and permanent dentition. MICAP system has the capacity to identify permanent teeth also. The method is shown (Figure 26).

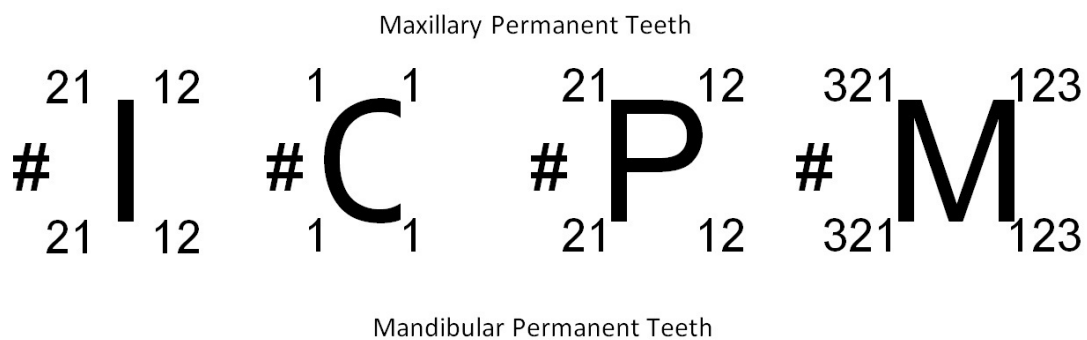


Figure 26.

Presentation of permanent teeth by MICAP notation (Akram et al. 2011)

The permanent tooth classes are incisor, canine, premolar and molar. They are indicated by letters **I**, **C**, **P**, **M**. Each tooth class has its own subtypes except canine. For example, Molar tooth class is marked by letter **M** and it has three types; first molar, second molar and third molar which are indicated by digits (1, 2, 3). Each quadrant of mouth contains three molar. Therefore digits '123' are superscripted and subscripted on both side of letter **M** to represent upper and lower and right and left side molars. The digits written on letter **M** as 123 or 321 are **not** read as 'one twenty three' or 'three twenty one'. They are read as first molar, second molar and third molar (Akram et al. 2011).

Various permanent teeth were compared in terms of their identification with respect to a particular tooth notation. A summary of few teeth is given in table 4.

Table 4.
Comparison of three other notations with MICAP notation (Akram et al.2012)

Tooth Class / Types	FDI System	Palmer Notation	Universal System	MICAP system
Mandibular left canine	# 33	# 3	#22	# C ₁
Maxillary left first molar	# 26	# 6	# 14	# M ¹
Maxillary right third molar	#18	# 8	# 1	# ³ M
Mandibular left lateral incisor	#22	#2	#10	# I ₂
Maxillary right first premolar	# 14	# 4	# 5	# ¹ P
Mandibular right central incisor	#11	#1	#8	# ₁ I

FDI, Palmer and Universal notations use numbers / digits for permanent teeth. For example ‘mandibular left canine can be identified by three different digits [#33, #3, #22] for FDI, Palmer and Universal notations respectively. On contrast, #C₁ is the identification by MICAP (Akram et al. 2012).

5.4 Identification of mixed dentition by MICAP notation

MICAP notation provided a solution for mixed dentition also (Figure 27.).

$$\begin{array}{ccccccc} \overset{2}{\#} \overset{2}{d} \overset{1}{I} \overset{1}{\subscript{1}} & \overset{1}{\#} \overset{1}{I} \overset{1}{\subscript{2}} & \overset{1}{\#} \overset{1}{d} \overset{1}{C} \overset{1}{\subscript{1}} & \overset{1}{\#} \overset{1}{C} \overset{1}{\subscript{1}} & \overset{2}{\#} \overset{2}{d} \overset{2}{M} \overset{2}{\subscript{1}} & \overset{1}{\#} \overset{1}{P} \overset{1}{\subscript{2}} & \overset{1}{\#} \overset{1}{M} \overset{1}{\subscript{1}} \end{array}$$

Figure 27.

A suggested method for mixed dentition by MICAP notation (Akram et al. 2011)

To mark teeth in mixed dentition, we would write first a primary tooth then its permanent successor tooth/ teeth. In the figure 27, it can be seen ‘deciduous incisor’ followed by ‘permanent incisor’ are written by MICAP method (Akram et al. 2011). This is a general rule but any tooth class can be written at any order because of uniqueness of contents.

5.5 Analysis of MICAP notation and its computer application

Superscript and subscript features of MICAP can be produced by MS Word. They were discussed in ‘Methods’ section. Here an example is given in figure 28. which shows a possible marking of multiple teeth by MICAP notation.

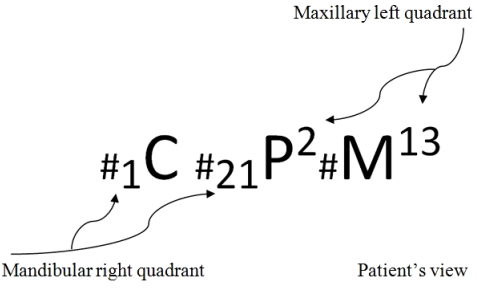
MICAP text for understanding purpose	MICAP text for clinical practice
 <p>Maxillary left quadrant</p> <p>Mandibular right quadrant</p> <p>Patient's view</p> <p>#1C #21P² #M¹³</p>	<p>#1C #21P² #M¹³</p>

Figure 28.

Multiple teeth marked by MICAP notation (Akram et al. 2011)

The left column shows a view for understanding purpose where maxillary and mandibular segments with left or right halves are indicated. The right column is for general practice. Identification of mandibular right canine, maxillary left 2nd premolar, mandibular right 1st and 2nd premolar and maxillary left 1st and 3rd molar is shown in MICAP format (Akram et al. 2011).

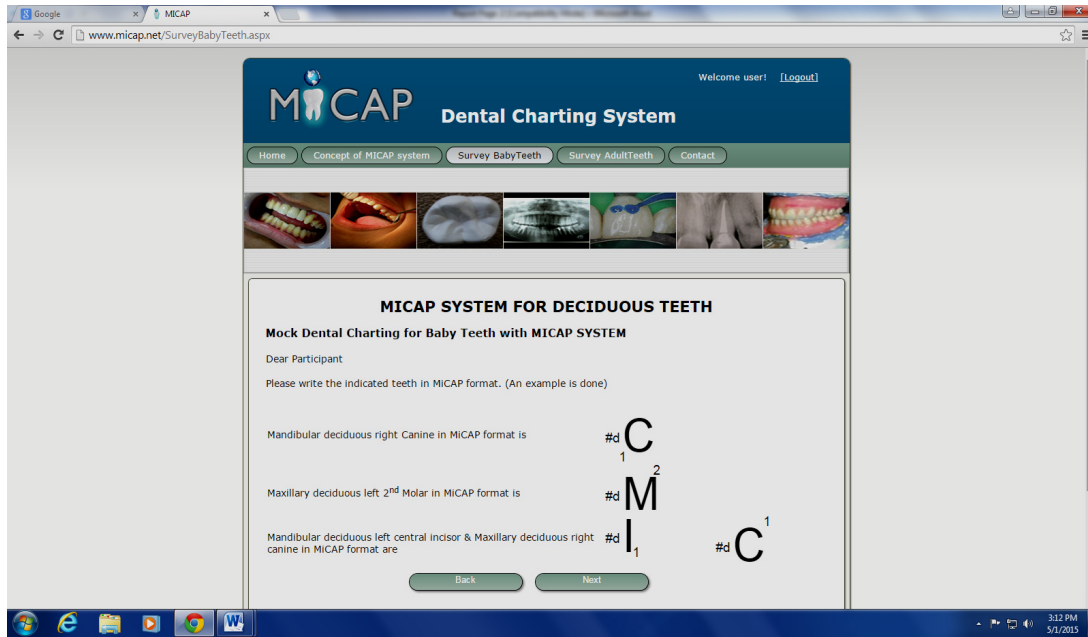


Figure 29.

A section of MICAP software for deciduous teeth

MICAP software shows the appearance of TOT digits (1,2) on ANAASEA letters (dI,dC,dM) on a computer screen. TOT digits could be seen as superscript and subscript. There is 'd' also with C, M and I to indicate respective deciduous tooth class (Figure 29.) (Akram et al. 2015c).

Software of MICAP notation was created to record identification of primary teeth as pilot prototype to get the evidence of its (MICAP) computer compatibility. The software which was developed by HTML and C+ programme indicated that MICAP system could be produced on computers for electronic (e) dental charting. Deciduous mandibular right canine was written in MICAP format as #₁dC. Similarly the deciduous maxillary left 2nd molar and deciduous mandibular left central incisors were written as #dM² #dI₁. We can say in referral note that Mr XYZ having problem in #dM² is referred for extraction. We focused on MICAP format rather than dental charting design.

5.6 Analysis of lesson plan on MICAP notation

Results of final year clinical dental students (n =40, male =15 (37.5%), female =25 (62.5%)) showed that majority of students agreed that MICAP notation was easy to understand (n=29, 72.5%) (Table 5.).

Regarding perception on 'MICAP and its contents more than 50 percent (n=22.55%) agreed MICAP to be unique in its contents. A considerable number of students (n=8.22%) were strongly perceived (agreed) by its contents as unique (Table 5.).

The responses for manual 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).

Perception of undergraduate clinical dental students was obtained and majority of students gave a positive feedback towards its contents and simplicity. The aspect of MICAP as prospective new dental charting system was greeted by majority of students (n= 26, 65%). However, a limited number of students (n=2, 5%) were not sure about its clinical application as dental charting notation.

Table 5.

Perception of undergraduate students on MICAP as lesson plan (Akram et al. 2012)

Factors	Strongly disagree n (%)	Disagree n (%)	Not sure n (%)	Agree n (%)	Strongly agree n (%)
MICAP is easy to understand	01 (2.5)	01 (2.5)	05 (12.5)	29 (72.5)	04 (10)
MICAP is unique in its contents	-	04 (10)	06 (15)	22 (55)	08 (20)
Dental charting is easy by MICAP	01 (2.5)	02 (5)	08 (20)	26 (65)	03 (7.5)
MICAP is applicable in clinical practice	01 (2.5)	02(5)	13 (32.5)	21 (52.5)	03 (7.5)

The table 5. shows the results of a pilot study on perception of undergraduate dental students on MICAP notation as a lesson plan for academic purpose. The majority of students found the new notation to be simple. It was easy to understand and unique in its contents (Akram et al. 2012).

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

5.7.1 Preclinical and clinical phase based assessment of MICAP method

The undergraduate dental students [N=176, Male: 48, Female: 128] out of 241, participated in the study. Approximately 80% of the students were able to translate correctly the teeth written in MICAP format and vice versa. However, clinical students had a better association to translate [X^2 , 95% CI: 11.82, 0.278 (0.131, 0.591), $p = 0.001$] #₂dM (deciduous mandibular right 2nd molar) and write correctly ‘deciduous maxillary left 2nd molar’ [X^2 , 95% CI: 16.98, 0.186 (0.79, 0.437), $p = <0.001$] into MICAP format [#dM²] as compared to preclinical students (Table.).

The Odds Ratio (OR) and Confidence Interval (CI) values [OR 95% CI: 0.278(0.131, 0.591)] showed the preclinical students were poorer to notify correctly ‘deciduous mandibular left central incisor’ into MICAP format [#dI₁] (Table 6) (Akram et al. 2015c).

No	Assessment	Deciduous Tooth Class	Pre clinical (n = 85)		Clinical (n = 91)		χ^2 (df)	OR (95% CI)	P value
			Correct n (%)	Incorrect n (%)	Correct n (%)	Incorrect n (%)			
1	To identify MICAP deciduous format	Incisor*	-	-	-	-	-	-	-
		#dC ¹	59 (78.7)	16 (21.3)	83 (91.2)	8 (8.8)	5.23(1)	0.355 (0.143, 0.885)	0.022
		# ₂ dM	55 (65)	30 (35.3)	79 (86.8)	12 (13.2)	11.82(1)	0.278 (0.131, 0.591)	0.001
2	To write in MICAP deciduous format	deciduous mandibular left central incisor	58 (68.2)	27 (31.8)	81 (89.0)	10 (11)	11.43(1)	0.265 (0.119, 0.590)	0.001
		deciduous maxillary right canine	78 (91.8)	7 (8.2)	83 (91.2)	8 (8.8)	0.017(1)	1.074 (0.372, 3.101)	0.895
		deciduous maxillary left 2 nd molar	56 (65.9)	29 (34.1)	83 (91.2)	8 (8.8)	16.98(1)	0.186 (0.79, 0.437)	<0.001

Table 6.

Comparison of pre clinical and clinical students for identification and write up of deciduous teeth in MICAP format

Out of five deciduous teeth, two teeth were given in MICAP format to identify to which tooth classes the MICAP format indicated them. Three teeth were in simple word form and were to be written in MICAP format. *Incisor was used as example to demonstrate notation method. Chi square test showed a significant better skill of clinical students ($p = <0.001$) as compared to pre-clinical students to identify and translate MICAP format for primary teeth (Akram et al. 2015c).

5.7.2 Gender based assessment of MICAP method

Male students were better in correct translation of MICAP format of dC^1 ($n= 39$ (86.7%) as compared to females ($n= 103=85.1\%$) as shown in table 7. However, there was no statistically difference in correct translation between male and female students ($p >0.05$).

Other variables showed similar results. For example, deciduous mandibular left central incisor was correctly written into MICAP format ($\#dI_1$) by male students ($n=38$, 79.2%) and female students ($n=101$, 78.9%). The p value =0.9 showed no statistical difference between male and female students (Table 7.) (Akram et al. 2015c).

Students	Skill to be assessed	Deciduous Tooth Classes	Correct Gender (%)	Incorrect Gender (%)	χ^2 (df)	OR (95% CI)	P Value
Undergraduate dental students N = 176	Identification of MICAP deciduous format	#dC ¹	M 39 (86.7)	6 (13.3)	0.063 (1)	1.14 (0.42,3.07)	0.802
			F 103 (85.1)	18 (14.9)			
		# ₂ dM	M 37 (77.1)	11 (22.9)	0.033 (1)	1.08 (0.49,2.35)	0.86
			F 97 (75.8)	31 (24.2)			
	Write up of MICAP deciduous format	deciduous mandibular left central incisor	M 38 (79.2)	10 (20.8)	0.001 (1)	1.02 (0.45,2.29)	0.970
			F 101 (78.9)	27 (21.1)			
		deciduous maxillary right canine	M 45 (93.8)	03 (6.2)	0.44 (1)	1.55 (0.41,5.18)	0.508
			F 116 (90.6)	12 (9.4)			
		deciduous maxillary left 2 nd molar	M 38 (78.9)	10 (20.9)	0.001 (1)	1.02 (0.45,2.29)	0.970
			F 101 (78.9)	27 (21.1)			

Table 7.

Gender based assessment of MICAP notation method by undergraduate dental students.

Male students (n= 37, 77.1%) were able to translate [#₂dM] as 'deciduous mandibular right 2nd molar' as compared to female students (n=97, 75.8%). Similarly, the given 'deciduous maxillary right canine' was correctly converted into MICAP format by male students (n= 45, 93.8%) which was slightly higher than female students (n= 116, 90.6%). However, no significant difference (P>0.05) was found between male and female students (Akram et al 2015c).

5.7.3 Students' perception on dental charting and dental communication by MICAP notation

The perceptions of two groups of students showed that more than fifty percent 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 male and female from both groups equally responded for such purpose. However, clinical students ($p=0.001$) had more association in favor of MICAP system to be adopted in dental charting (Table 8.).

Table 8.

Perception on dental charting and communication of information by MICAP system

No	Statement	Type of Consent	Total students N= 176 (%)	Preclinical (n = 85)	Clinical (n =91)	χ^2 (df)	P value
				n (%)	n (%)		
1	MICAP is applicable in deciduous dental charting	Strongly agree	21 (11.9)	06(7.1)	15 (16.5)	18.8 (4)	0.001
		Agree	93 (52.8)	37 (43.5)	56 (61.5)		
		Not sure	50 (28.4)	31 (36.5)	19 (20.9)		
		Disagree	11 (6.3)	10(11.8)	01 (1.1)		
		Strongly disagree	01(0.6)	01 (1.2)	00(0.0)		
2	MICAP is able to transfer deciduous dental information	Strongly agree	34(19.3)	10 (11.8)	24 (26.4)	15.3 (3)	0.002
		Agree	78 (44.3)	33 (38.8)	45 (49.5)		
		Not sure	49(27.8)	30 (35.3)	19 (20.9)		
		Disagree	15(8.5)	12(14.1)	03(3.3)		
		Strongly disagree	-	-	-		

The response of students on MICAP notation as ‘dental charting tool’ and ‘source of communication of dental information’ has been summarized. Analysis of questionnaire of five point likert scale showed that clinical students had more association (X^2 : 18.8, $P=0.001$) for response on ‘MICAP could be adopted in dental charting’ (Table 8.) (Akram et al. 2015c).

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

5.8.1 Identification of deciduous teeth in MICAP format by dentists and dental specialists

Study group A consisted of specialists and general dentists. The specialists were able to identify up to 95% correctly the format of MICAP (#dC¹ translated as deciduous upper left canine). In terms of converting MICAP format into word form, ‘deciduous maxillary right canine’ was written 100 % correct by specialists. The specialists’ percentage of correct translation as well as conversion was found to be more than 90 percent except translation of #₂dM into deciduous lower right 2nd molar (Table 9.) (Akram et al. 2015a).

Majority of general dentists were also able to identify MICAP format and write correctly the word form of teeth into MICAP format. The percentage of general dentists was up to 90% for deciduous maxillary right Canine converted to be as #¹dC except identification of #₂dM (78.7%) shown in (Table 9.) (Akram et al. 2015a).

Over all, most of the dental specialists and dentists were able to translate (identify) and write the format of MICAP system for primary teeth e.g. #₂dM was translated as ‘deciduous mandibular right 2nd molar’ and ‘deciduous maxillary right canine’ was written #¹dC (MICAP format). A statistical significant difference between specialists and dentists was found in the correct write up ‘deciduous maxillary right canine’ into #¹dC (p value =0.031). Neither gender nor location based significant differences in identification of MICAP format and vice versa by doctors and specialists were observed.

No	Elements to be assessed	Type of Tooth Class	Dentists (n = 60)		Specialists (n = 44)		Total n=104		χ^2 (df)	OR (95% CI)	P value*
			Correct n (%)	Wrong n (%)	Correct n (%)	Wrong n (%)	Correct n (%)	Wrong n (%)			
1	Translated MICAP deciduous format	# ₂ dM	47 (78.7)	13 (21.7)	37 (84.1)	7 (15.9)	84 (80.8)	20 (19.2)	0.54(1)	1.46 (0.53, 4.03)	0.462
		#dC ¹	52 (86.7)	08 (13.3)	42 (95.5)	02 (4.5)	94 (90.4)	10 (9.6)	2.25(1)	3.23 (0.65, 16.03)	0.133
2	Converted word form to MICAP deciduous format	deciduous maxillary left 2 nd molar	51 (85.0)	09 (15.0)	40 (90.9)	04 (9.1)	91 (87.5)	13 (12.5)	0.81 (1)	1.76 (0.51, 6.15)	0.368
		deciduous mandibular left central incisor	49 (81.7)	11 (18.3)	41 (93.2)	03 (6.8)	90 (86.5)	14 (13.5)	2.89(1)	3.07 (0.80, 11.74)	0.089
		deciduous maxillary right canine	54 (90.0)	06 (10.0)	44 (100.0)	0 (0.0)	98 (94.2)	6 (5.8)	4.67(1)	0.90 (0.83, 0.98)	0.031

Table 9

Identification of deciduous teeth using MICAP method by dentists and specialists

Majority of dentists and specialists $\geq 80\%$ understood MICAP method. They were able to write deciduous teeth in MICAP format and translate the format into word form correctly. However in terms of correct translation and conversion of various deciduous teeth, * Pearson chi-square analysis showed no significant difference ($P > 0.05$) between dentists and specialists except deciduous maxillary right canine to be written as [#¹dC] (Akram et al. 2015a).

5.8.2 Doctor's 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. A small number of doctors even rejected the role of MICAP in dental charting. Furthermore, a quite large number of doctors were uncertain about its prospective use in dental charting. They were also not sure it could be used as communication source of dental information. (Akram et al. 2015a).

Table 10.
Perception of doctors on MICAP notation as dental charting and communication source

No	Statement	Type of Consent	Dentists (n = 60)	Specialists (n = 44)	All participants N= 104 (%)	χ^2 (df)	P value
			n (%)	n (%)			
1	Pediatric dental charting is possible by MICAP system	Strongly agree	05 (8.3)	06 (13.6)	11 (10.6)	1.03 (4)	0.905
		Agree	25 (41.7)	16(36.4)	41 (39.4)		
		Not sure	19 (31.7)	15 (34.1)	34 (32.7)		
		Disagree	09 (15.0)	06 (13.6)	15 (14.4)		
		Strongly disagree	02 (3.3)	01(2.3)	03 (2.9)		
2	Pediatric dental information can be communicated by MICAP system	Strongly agree	04 (6.7)	03 (6.8)	07 (6.7)	2.79 (4)	0.593
		Agree	21 (35.0)	10 (22.7)	31 (29.8)		
		Not sure	25 (41.7)	23(52.3)	48 (46.2)		
		Disagree	09 (15.0)	08 (18.2)	17 (16.3)		
		Strongly disagree	01 (1.7)	00 (0.0)	01 (1.0)		

The table 10. shows more than 40% dentists and dental specialists considered MICAP system could be used for pediatric dental charting. Regarding communication of dental information via MICAP notation, more than 35 % agreed that MICAP could be used for

dental communication. However, participants who were not sure about it were more than agreed personals.

5.8.3 Identification of teeth in MICAP format by dental paramedics

Among dental paramedics, a higher (81.0) percentage of dental assistants was unable to write ‘deciduous mandibular left central incisor’ into MICAP format [#dI₁]. In contrast, more than fifty percent dental technicians converted correctly ‘deciduous maxillary left 2nd molar’ into MICAP format [#dM²]. MICAP format for two teeth [#₂dM #dC¹] which were to be translated as ‘deciduous lower right 2nd molar’ and ‘deciduous upper left canine’ respectively. Higher number of dental technicians translated correctly the MICAP format as compared to dental hygienists and dental assistants. Dental assistants were poorer than dental hygienists and dental technicians in terms of writing MICAP format (Table 11.).

Table 11.

Descriptive statistics for dental paramedics (Akram et al. 2015a)

Population	*Translation of MICAP format into word form				**Conversion of word form into MICAP format					
	Molar n (%)		Canine n (%)		Molar n (%)		Incisor n (%)		Canine n (%)	
	Correct	Wrong	Correct	Wrong	Correct	Wrong	Correct	Wrong	Correct	Wrong
Dental Assistants (n =58)	17 (29.3)	41 (70.7)	21 (36.2)	37 (63.8)	15 (25.9)	43 (74.1)	11 (19.0)	47 (81.0)	23 (39.7)	35 (60.3)
Dental Hygienists (n =38)	19 (50.0)	19 (50.0)	18 (47.4)	20 (52.6)	14 (36.8)	24 (63.2)	14 (36.8)	24 (63.2)	23 (60.5)	15 (39.5)
Dental Technicians (n =25)	14 (56.0)	11 (44.0)	14 (56.0)	11 (44.0)	13 (52.0)	12 (48.0)	10 (40.0)	15 (60.0)	14 (56.0)	11 (44.0)
Total N = 121	50 (41.3)	71 (58.7)	53 (43.8)	68 (56.2)	42 (34.7)	79 (65.3)	35 (28.9)	86 (71.1)	60 (49.6)	61 (50.4)

The table 11. shows the comparison of three groups ‘dental assistants, hygienist and technicians’. Dental technicians were better in recognizing MICAP format and vice versa as compared to other two groups (Akram et al. 2015a).

* #₂dM #dC¹ [MICAP format] were to be translated as deciduous lower right 2nd molar and deciduous upper left canine respectively.

**Deciduous maxillary left 2nd molar, deciduous mandibular left central incisor, deciduous maxillary right canine [word format] were to be converted into MICAP format (#dM² #dI₁ #¹dC) respectively (Table 11).

5.8.4 Association in identification of MICAP notation by dental paramedics

Simple logistic regression test was done for comparison between dental assistants and dental hygienists and it showed there was no significant association of correct translation of [#dC¹] ($p = 0.097$). However, comparing dental assistants and dental technicians, later were relatively better ($p < 0.05$) in both translation of MICAP format as well as conversion into MICAP format except translation of [#dC¹] into ‘deciduous maxillary left canine’ ($p = 0.097$) and conversion of ‘deciduous maxillary right canine’ into MICAP format ($p = 0.172$) (Table 12.) (Akram et al. 2015a).

Table 12.**Identification and translation of MICAP notation among dental paramedics**

No	Factor to be assessed	Deciduous tooth class	Study population (n = 121)				
			Dental Assistant*	Dental Hygienist		Dental Technician	
			<i>OR</i> (95% <i>CI</i>)	<i>OR</i> (95% <i>CI</i>)	<i>P</i> Value	<i>OR</i> (95% <i>CI</i>)	<i>P</i> Value
1	Translation of MICAP format	# ₂ dM	1	2.41 (1.03,5.65)	0.043	3.07 (1.16,8.10)	0.024
		#dC ¹	1	1.59 (0.69, 3.64)	0.097	2.24 (0.86,5.82)	0.097
2	Conversion of word form into MICAP format	deciduous maxillary left 2 nd molar	1	1.67 (0.69, 4.04)	0.254	3.10 (1.16,8.27)	0.023
		deciduous mandibular left central incisor	1	2.49 (0.98, 6.31)	0.054	2.84 (1.01, 8.01)	0.047
		deciduous maxillary right canine	1	2.33 (1.01, 5.39)	0.047	1.93 (0.75, 5.00)	0.172

*Dental assistant group was the reference in Simple logistic regression test. Dental technicians were the best among the three who identified MICAP format correctly and vice versa. Dental technicians were better from dental hygienists and dental assistants in translating the MICAP format and write up of MICAP format (Akram et al. 2015a).

5.8.5 Perception of dental paramedics on MICAP system as dental charting and communication source

The feed-back of dental paramedic study participants was obtained in five point likert scale. It had two components. One was about prospective use of MICAP notation as pediatric dental charting. The second was its use as source of communication of dental information.

Table 13.
Perception of dental paramedics on MICAP notation as dental charting and communication source

NO	Statement	Type of Consent	Dental Assistant (n = 58)	Dental Hygienist (n = 38)	Dental Technician (n = 25)	Participant N= 121 (%)	χ^2 (df)	P value
			n (%)	n (%)	n (%)			
1	Pediatric dental charting is possible by MICAP notation	Strongly agree	02 (3.4)	02 (5.3)	03(12.0)	07 (5.8)	7.79 (8)	0.453
		Agree	19 (32.8)	11(28.9)	10 (40.0)	40 (33.1)		
		Not sure	23 (39.7)	12(31.6)	04(16.0)	39 (32.2)		
		Disagree	12 (20.7)	09(23.7)	06(24.0)	27(22.3)		
		Strongly disagree	02 (3.4)	04(10.5)	02(8.0)	08 (6.6)		
2	Pediatric dental information can be communicated by MICAP notation	Strongly agree	02 (3.4)	02 (5.3)	03(12.0)	07 (5.8)	9.18 (8)	0.327
		Agree	16(27.6)	05 (13.2)	07(28.0)	28(23.1)		
		Not sure	26 (44.8)	17(44.7)	08(32.0)	51(42.1)		
		Disagree	13 (22.4)	10(26.3)	06(24.0)	29 (24.0)		
		Strongly disagree	01 (1.7)	04 (10.5)	01(4.0)	06 (5.0)		

Regarding MICAP notation to be used as pediatric dental charting, dental technicians were higher than remaining two groups (dental assistants, dental hygienists) who agreed for it (n =10, 40%). The maximum participants who were not sure about MICAP notation as dental charting tool were dental assistants (n= 23, 39.7%) (Table 13.) (Akram et al. 2015a).

Perception was also obtained on ‘MICAP notation to be used as dental communication source’. Dental technicians agreed on this aspect also as major group (n=7, 28%). Both dental hygienist and dental assistants were almost equally not sure on this aspect (Table 13.) (Akram et al. 2015a).

6. DISCUSSION

6.1 Relevant aspects of developing a new computer friendly dental notation (MICAP)

The new tooth notation 'MICAP' is able to present all primary upper and lower teeth using letters [#dI #dC #dM] and digits (1, 2) written as superscript and subscript. The letters (dI, dC, dM) represent all three deciduous tooth classes. The digits allocated for tooth types are; (central and lateral incisor (1, 2), canine (1), first and second molar (1, 2) which are written superscript and subscript along respective tooth classes (dI, dC, dM).

MICAP is a new concept and less published data is available to verify results for discussion. The first question may arise. Is MICAP notation computer friendly? MICAP tooth notation for primary teeth uses letters dI, dC, dM and digits (1,2). The allotted digits are printed appropriately as superscript and subscript on letters dI, dC, dM. All characters are available in Microsoft window 7, 8 and 10, even old versions of window like XP, Vista etc. However, in writing both upper and lower teeth of a particular tooth class, the digits (1,2) may not appear up and down position in same alignment e.g., #dM¹²₁ [deciduous upper left 1st and 2nd and lower left 1st molar]. For this purpose, 'Equation editor function' of Microsoft Word is available (Lewis 2000). # dM_2^1 is MICAP text which has been written by using equation editor method. This MICAP text represents deciduous upper left first and lower left second molar. This is a little complex procedure but it solves the issue described in detail earlier (Methods sections) for upper and lower molar teeth.

Universal system and Palmer notation use alphabet letters for primary teeth. For example, B is maxillary right 1st molar (Universal system) and same letter (B) is 'lateral incisor' in Palmer notation. It could be upper right (UR), upper left (UL) or lower right (LR) and lower left (LL). Its position depends on selected grid (┘ ┐ └ ┌) which is used in Palmer notation. The special grid made it difficult to be used in computer. Microsoft created 'Word Equation Editor' and its function was suggested to replace the special grid of Palmer notation with underline or over line (Lewis 2000).

Smith and Dodson (2003) suggested to denote the teeth of vertebrate by first letters such as 'In, Cn, Pm, Mm' and 'in, cn, pm, mm' for upper and lower teeth respectively. Referring to their terminology 'in' used for lower incisor complicated the referral note with preposition 'in'. However in MICAP system for primary teeth, the letters dI (deciduous incisor), dC (deciduous canine), dM (deciduous molar) are used. These are standard dental terminologies which are taught in all dental curricula. The digits (1,2) are subscripted to indicate the lower teeth. For example, #dI₂ indicates the deciduous mandibular left lateral incisor. The subscript characters indicate the lower teeth and in addition to subscripted digits the sign # makes the tooth identification clearer from any text written in word form.

Electronic Health Record (EHR) is increasingly being adopted by dental institutions and individual health providers. Factors such as improved quality, fast communication, efficiency and patient safety make it a big attraction for health care providers (Blumenthal and Glaser 2007, Chaudhry et al. 2006, Haux 2006, Hillestad et al. 2005). The technology used in EHR empowers the users to effectively and efficiently complete work tasks with a higher level of success and satisfaction. As we have seen that MICAP letters and digits can be written by multiple methods of MS Word. They can be added in EHR or a new EHR can be created by applying MICAP method. Simple prototype software was prepared to write upper and lower teeth and it was described in methodology section. The study participants (dental students) used the software to write superscript and subscript of given teeth.

The use of electronic dental charting in present era makes the requirement of a tooth notation system to be computer friendly so that dental information could be recorded easily and transmitted whenever required. The new tooth notation 'MICAP' is able to present all primary upper and lower teeth using letters [#dI #dC #dM] and digits (1, 2) written as superscript and subscript. The letters (dI, dC, dM) represent all three deciduous tooth classes. The digits allocated for tooth types are; (central and lateral incisor (1,2), canine (1) and first and second molar (1, 2) which are written as superscript and subscript along respective tooth classes (dI, dC, dM). Various simple methods are available in MS Word to write the digits as superscript and subscript on letters (dI, dC, dM).

FDI and Universal systems are based on digits which have no problem in electronic dental charting. An 'alphanumeric dental notation for primary teeth' has recently been introduced (Havale et al. 2015). According to this system numbers indicate the quadrant while lowercase letters designate the tooth type. This system uses lowercase letters (a - e) and digits 1-4 showing upper right to lower right quadrants in a clockwise direction. Primary teeth are indicated as: upper right quadrant ('1a -1e), upper left quadrant (2a -2e), lower left quadrant (3a-3e), lower right quadrant (4a-4e). This system would be combined with FDI two digit when mixed dentition has to be marked. An example of this can be : 11,12, 1c,1d,1e,16,21,2b,2c,2d,2e,26. This could be easy to communicate and there is no such special software is required. The questions may arise if currently used numerical or alphanumerical tooth notation systems are computer friendly then why we need another tooth notation system (MICAP). The new system (MICAP) uses the standard dental terminologies. For example, canine is a standard dental terminology and there is always one canine in each quadrant. Similarly when we write #dM², the 'd' stands for deciduous, 'M' for molar and 2 for second. Since 2 is superscripted on left side of M, hence it is maxillary of left side. Generally we say it is deciduous maxillary left second molar. Using standard terminologies which are core values of each dental curriculum around the world would minimize mistakes in dental communication and enhance its acceptance globally.

Standardized terminologies such as the International Classification of Diseases (ICD) have been in use for over a century in medicine (WHO/ICD web). But in dental profession, standardized dental diagnostic terms have not yet achieved widespread traction (White et al. 2011). Systematized Nomenclature of Dentistry (SNODENT) was created earlier containing almost 6000 terms and designed to be a diagnostic companion to the Current Dental Terminology (CDT).

In 2007, the Consortium for Oral Health Research and Informatics (COHRI) was formed to standardize shared data and develop efficiencies and tools within the EHR to help educate students, care for patients and conduct innovative research (Stark et al. 2010). One long term goal of COHRI was to implement standard dental diagnostic codes. Most of dental schools use EHR and document 'codes' as free text note or unstructured format or manual

chart entries. Thus COHRI recognized that a major gap existed in dentistry (Goldberg et al. 2005). To address the gap created by the absence of an acceptable and readily available standardized dental terminology a workgroup of COHRI developed the Electronic Z (EZ) terminology codes in 2009 which originally consisted of 13 diagnostic categories, 80 subcategories and 1158 dental diagnostic terms which were considered as unique terms (Kalendarian et al. 2011, Stark et al. 2010). These EZ codes were then incorporated into EHR which allowed for their use in a consistent way. Our initial effort for MICAP notation could be considered an EZ code. This development of the dental diagnostic terminology is a critical first step; the terminology must also be adopted by dental care providers and used effectively in order to fully realize its benefits. This was an initial effort for MICAP to be adopted by undergraduate dental students, dental health care providers including dental paramedics.

Other than EZ codes, a system of four digit with numeric codes for dental diagnoses was developed which provided the specific codes at the level of patients (Leake et al. 1999). But it showed the diagnosis ratio of a particular disease among the patients who attended the dental health care centre. Later, for effective health care delivery, the diagnostic codes were suggested to make them worldwide accepted to retrieve effective filing and billing purposes for the benefit of patients (Phantumvanit et al. 2002). The current notation system describes the teeth codes which are practically global. The tooth classes are standard in primary and permanent dentition and almost same except premolar and 3rd molar which are additional in permanent dentition. The names of teeth are dental terminologies which are constant in all dental curricula and may suggest to be used globally in future.

Comparing to other notations, 16 means upper right first molar (FDI system) or '1a' means upper right deciduous central incisor (Havale system). Students from US may memorize and practice to recognize lower left lateral incisor as #23. In case of MICAP system, when we say 'upper right first molar' the letter 'M' and digit '1' are the primary core facts where '1' is written as superscript on right side of 'M' such as #¹M.

A brief summary is given (Table 14.) considering FDI, Universal system with reference of MICAP notation.

Table 14.**Common digits between FDI and Universal compared with MICAP system**

MICAP system	FDI system	Common Digits	Universal system	MICAP system
# ¹ I	Maxillary right central incisor	#11	Maxillary left canine	# C ¹
# ¹ P	Maxillary right first premolar	#14	Maxillary left second molar	# M ²
# C ¹	Maxillary left canine	#23	Mandibular left lateral incisor	# M ¹
#P ¹	Maxillary left first premolar	#24	Mandibular left central incisor	# I ₁
#I ₁	Mandibular left central incisor	#31	Mandibular right second molar	# ₂ M
#I ₂	Mandibular left lateral incisor	#32	Mandibular right third molar	# ₃ M

The table 14. shows a clear evidence of unique identification of MICAP notation as compared to FDI or Universal system (Akram et al. 2015b). The table shows permanent teeth only. However deciduous teeth could also be compared.

We also suggest further study to compare MICAP with other notation methods. One limitation of our study is that learning practice of write up and translation of this system was not compared with other currently used dental notations. An alternative methodology would be to compare MICAP with FDI and Universal systems either randomized clinical trial or pre post design.

6.2 Relevant aspects of assessment of format of MICAP notation by undergraduate dental students

MICAP system is a novice system which is neither taught in any dental curriculum nor practiced anywhere in the world. Almost 80% students recognized the MICAP format and converted multiple primary tooth types – one from each deciduous tooth class (incisor, canine and molar) correctly giving an indication that notation is simple and mind cognitive. The participants were demonstrated by a short video on the formation of MICAP system.

This was similar to the results of a study in which dental students learnt the crown designing by computer aided technology. The students spent less time in preparing the crown as compared to conventional teaching of crown designing (Douglas et al. 2014). The use of Digital Learning Tool (DLT) improved clinical skills of dental students to detect caries (Luz et al. 2014).

From our data, we found clinical students performed better in teeth identification in new format using mock *e* dental charting. One reason of better performance by clinical students could be their more clinical exposure on dental charting as compared to preclinical students. The aspect of computer usage might have a role because studies have shown an increased trend of Information and Communication Technology (ICT) among dental students especially among clinical students (Jalaleddin et al. 2013, Lamis and Zaid 2005).

MICAP notation is a set of codes which can be used in *e* dental charting to record and communicate dental problems. A set of terminology known as Dental Diagnostic System (DDS) has been incorporated in EHR and found effective. Reed et al. (2015) found a positive impact of using the DDS terminology in an EHR on the critical thinking skills of preclinical dental students. This is in accordance to our study results where dental students learnt a set of dental terminology (MICAP) (Akram et al. 2015c).

From the results of our study (Table 6.) dental students of clinical phase were better as compared to students of preclinical phase in learning of MICAP format (Akram et al. 2015c). In many dental curricula, more likely trend is to expose the dental students in their preclinical phase on the simulated items / extracted teeth for upcoming clinical procedures to make them competent for clinical procedures (Shetty et al. 2014). Likewise, we expect that if more chair side training is conducted for MICAP system, it would enhance the skills of preclinical students also to identify the teeth in oral diagnosis using the new system as dental charting system.

6.3 Relevant aspects of assessment of MICAP notation by dental health professionals

Dental team members were able to identify and write MICAP format with the help of video demonstration. Studies have shown the effectiveness of learning new technique by video teaching method. For example, for an introductory dental public health course, affective learning outcomes in dental students were seen who were taught by video (Chi et al. 2014). Similarly dental students found videos affective tool to learn prosthetic clinical procedures (Kon et al. 2015). Likewise, our participants learnt the format of MICAP through video method.

In contrast to dental surgeons and specialists, paramedics performed poorer than dental specialists and dentists. The reason could be less level of their education and especially, lack of interest in new system because the new notation method is not a part of dental curriculum at the moment.

There could be a question more likely from orthodontists, what would be the solution when there is mixed dentition. The solution is, first indicate the primary tooth and then its successor permanent tooth. The difference in MICAP format for primary and permanent teeth is the letter 'd'. An example is #dM¹² and #₁M where former is deciduous molar and latter is permanent molar (Akram et al. 2012).

Dental hygienists undertake a number of activities such as dental charting, fissure sealing and radiographs autonomously without dentists' referral. They perform activities such as dental charting which is highly reviewed or validated in case of referral patients using a certain tooth notation (Turner et al. 2011, Demko et al. 2008). The new dental notation was recognized better ($p=0.043$) by dental hygienists than dental assistants (Akram et al. 2015a). A higher score of translating and write up of MICAP format by dental specialists, dentists, dental hygienists and technicians showed that MICAP notation was easy to understand (Akram et al. 2015a). Higher percentage of learning of a new teaching modality supports the effectiveness of video method (Chi et al. 2014, Kon et al. 2015).

The use of 3-D dental charting (Schleyer et al. 2007) enhances the charm of dental practice especially to children because the images appear in different angles and colors and attract the users. The new notation system is blended with numbers and letters in superscript and subscript, it could be adopted in 3D charting with multiple colors of letters and digits. We suggest specific colors to be allocated especially deciduous teeth to give attraction and a specific sign as a standard to identify different or certain primary teeth and this would help understand not only staff but also to children. It would be an additional difference between deciduous and permanent teeth other than what has been proposed in earlier version of MICAP notation in terms of ANAASEA letters (Akram et al. 2012).

MICAP system has the full potential to notify primary teeth by dental health care professionals. Our initial studies show it can be written electronically and manually. The format of its deciduous section was supported by majority of undergraduate dental students and dental health providers. It was found in a pilot study that youngsters were good learner of MICAP notation (Akram et al. 2015b). In early era of FDI implementation, researchers found old staff was not eager to learn the notation (Blinkhorn et al. 1998).

6.4 Relevant aspects of dental communication by MICAP notation

Survey is a method which is used to measure satisfaction, perception and evaluations of study participants or end users of a product (Viitanen et al. 2011). Being inexpensive to administer and procured quick results are its major advantages. Closed end surveys provide specific information by user's experience. The results from our studies indicated a positive feedback for MICAP notation as dental charting tool (Akram et al. 2015a, 2015b, 2015c).

Referring to number and alphabet based notations (FDI, Universal, Palmer) different numbers for the same tooth or vice versa may complicate the clinical scenario once communicated for any dental related purpose. For example, # 14 is maxillary right first premolar (FDI system) and same digit is maxillary left first molar (Universal system). Letter 'A' is deciduous upper right second molar (Universal) and same letters when referred to Palmer notation is deciduous central incisor (Akram et al. 2015c). Referring to

MICAP, letters I, C, P, M and relevant digits (1,2,3) are to be either superscripted or subscripted to indicate the desired tooth or teeth.

A 'hash' (#) sign is added to differentiate MICAP format from non-dental word format. Permanent tooth classes are identified by letters 'I – incisor, C – canine, P – premolar and M – molar'. It is difficult to differentiate pronoun 'I' and ANAASEA letter 'I' for incisor. Once we add 'hash #' sign, it differentiates the pronoun 'I' from tooth class '#I (incisor)' (Akram et al. 2012). Moreover, with # sign, we can write multiple tooth classes. An example of multiple teeth identified by MICAP method is #₁C #₂₁P²#M¹³ which represents canine, premolar and molar permanent tooth classes (Akram et al. 2011). Similarly deciduous upper left canine and deciduous lower right 2nd molar can be written like #dC¹ #₂dM.

The use of CDT has increased the adaptation of *e* charting because it allows health providers to electronically create, store, organize, edit and retrieve patients' oral health information. Majority of general dentists use computers in their dental offices which make the opportunity to adopt *e* charting. MICAP notation using standard terminology is in align with CDT. It could help health care providers to document the types and frequency of tracking and facilitating data sharing across sites (O'Malley et al. 2005, Leake et al. 1999).

7. CONCLUSIONS

7.1 Developing a new tooth notation (MICAP)

MICAP system was developed by 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 called as ANAASEA letters which are divided into four parts (upper and lower and 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 can say the tooth classes 'dI (deciduous incisor), dC (deciduous canine), and dM (deciduous molar)' make the foundation of the new system.

The tooth types are marked by number within their own category. For example, deciduous central incisor is marked as 1 and lateral incisor as 2. This is the same case when deciduous molar is considered. Digits (1 and 2) are used for first molar and 2nd molar respectively. In other words, numbering is not continuous starting from either mid line or most distally. Each tooth class is given a full entity. The numbers 1, 2 indicate the tooth types of the respective tooth class. For example, #₂dM is deciduous mandibular right 2nd molar. Similarly #dC¹ is deciduous upper left canine (Akram et al. 2015a, 2015c).

The new notation (MICAP) is based on recognized standard dental terminologies. For example, incisor is incisor in every dental curriculum. 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 notation shows it #¹C. 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 the beginning of a dental curriculum. Students understand and learn very well. It was seen in our cross sectional study where dental students, dental paramedics, dentists and dental specialists correctly identified

MICAP format and vice versa (Akram et al. 2015a, 2015c). Results from (Tables 6, 8-11) give evidence of its standard dental terminology.

7.2 MICAP notation is computer friendly

Letters (dI,dC, dM) , digits (1,2) and sign (#) are core components of MICAP text. For identification of permanent teeth, letters (I, C, P, M) digits (1, 2, 3) and sign # are required (Akram et al. 2015a, 2015b, 2015c, 2012, 2011).

The digits are superscripted and subscripted with reference to appropriate letters. The superscripted digits show maxillary (upper) teeth and subscripted digits indicate mandibular (lower) teeth with respect to that particular tooth class (deciduous incisor, deciduous canine, deciduous molar). For example #dM² indicates deciduous upper left 2nd molar. There are various methods in MS Word to make digits as superscript and 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) as well as manually (Akram et al. 2015b). Here we write few MICAP formats by using MS Word.

#dM² [deciduous upper left 2nd molar]

#₁dC [deciduous lower right canine]

#dI² [deciduous upper left lateral incisor]

#dM₂¹ [deciduous upper left first and lower left 2nd molar]

All these methods supports MICAP notation to be computer friendly. That's why some other benefits could be enlisted as:

- MICAP notation is adoptable in *e* dental charting

Computer adoptability of MICAP notation (Akram et al, 2015a, 2015c, 2011) makes it a powerful tool 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. 2011).

- MICAP notation can be used for dental communication

MICAP notation is computer friendly. Its text is differentiated from word text by sign [#]. This sign shows the “MICAP text” has been described for either one or more than one tooth class. MICAP system being computer friendly, may be used to refer a patient, make medical bills, an appointment with dental specialist or any other formal/informal communication within or outside the dental community. For example, a patient XYZ is advised and referred to the oral surgeon for extraction of upper left 3rd molar (#M³) (Akram et al. 2011). A billing report in word text can also be made that a glass inonomer filling was done on #dI².

Majority of study participants gave positive feedback via a five point likert scale survey about MICAP notation to be used as prospective dental charting and communication tool from academic and clinical practice view (Tables 5, 8, 10) (Akram et al. 2012, 2015a, 2015c).

7.3 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). Undergraduate dental students learnt MICAP format by getting lecture and a short video description (Akram et al. 2015c). It can be concluded that MICAP notation can be adopted for academic purpose.

7.4 Analysis of assessing the format of MICAP notation by undergraduate dental students

Format of MICAP for primary teeth includes letters (dI, dC, dM) and digits (1,2). The digits are superscripted and subscripted. The results of our study showed that its format can be translated and vice versa. For example, deciduous lower right 2nd molar can be written in MICAP format [#₂dM]. It meant its formation was easy to understand. Its application as prospective dental charting was also supported by students (Table 8.) (Akram et al. 2015c).

7.5 Analysis of assessing the format of MICAP notation by dental health professionals

Majority of dental specialists and dentists $\geq 90\%$ understood its format. They were able to translate MICAP format and vice versa (Akram et al. 2015a). For example, 'deciduous mandibular left central incisor' was written as #dI₁. Similarly dental paramedics understood the format of MICAP notation (Akram et al. 2015a).

In summary, our results give evidence of clear format of new notation for primary teeth. Its method is easy to understand which was expressed by a pilot study of delivering a lecture. Its format was practiced by undergraduate dental students who learnt its format by lecture and a short video description. The dental health professionals (doctors and dental paramedics) also learnt its format successfully.

From methods and results, it can be concluded that new tooth notation (MICAP) system has a proper conceptual framework to mark all primary as well as permanent teeth (Akram et al. 2011, 2012). It was written electronically for primary teeth (Akram et al. 2015 a, 2015c) and manually for permanent teeth (Akram et al. 2015b). It can be incorporated in most of Microsoft (MS) windows because various methods are available to use MICAP by MS Word. It provides an alternate way to identify primary teeth even permanent teeth (Akram et al. 2015a, 2015b, 2015c). Therefore, the new notation (MICAP) has the capacity to identify primary teeth and could be suggested as alternate dental charting method for clinical practice.

8. SUMMARY

Developing an Innovative Pediatric Dental Charting System and its Clinical Application

Background: FDI two digit system, Universal numbering and Palmer notation are commonly used to identify deciduous teeth, although it can cause certain problems in the practice. **Aim:** To develop and assess practicality of a new notation, to mark deciduous teeth, which can be applied easily in the every-day practice. **Materials & Methods:** **a) *Developing a new pediatric tooth notation:*** It is developed by using Latin based name of tooth classes ‘deciduous incisor (dI), deciduous canine (dC) and deciduous molar (dM)’ which are further subdivided into their *exact* tooth types and indicated by digits such as central incisor (1), lateral incisor (2), canine (1), first molar (1) and second molar (2). The digits (1,2) are written on right and left side as superscript and subscript in relation to their respective tooth classes to represent maxillary and mandibular teeth respectively. In new notation, the letters dI, dC, dM and digits (1,2) are termed as ANAASEA letters and TOT digits respectively. New method was called MICAP (M-molar, I-incisor, C-canine, P-premolar – as representative of deciduous molar) system. **b) *Assessing the practicality of new tooth notation by preclinical and clinical students:*** A video demonstration of MICAP format was prepared. A mock dental chart based on MICAP format was the tool. Dental specialists (n=44), doctors (n=60), dental allied health persons (n=121) and undergraduate dental students (n=176) wrote five teeth in MICAP format and vice versa in a cross sectional study after video demonstration and lecture. In addition, perception on ‘MICAP-as dental charting tool and communication source’ was obtained. MICAP software was prepared with HTML’ & C+ programme and uploaded on website on www.micap.net. Data were analyzed by *Chi square & one way ANOVA*. **Results:** Majority of participants ($\geq 80\%$) translated MICAP format correctly and vice versa. Clinical students were significantly better than preclinical students ($p \leq 0.05$). Dental technicians identified MICAP format better than dental hygienist and dental assistants. More than 80 % of doctors and dental specialists wrote MICAP format correctly. **Conclusions:** MICAP format can be used in practice as a new dental charting notation. Assessing the system majority of participants applied successfully and responded positively for its prospective use.

9. ÖSSZEFOGLALÁS

Új fogjelölési rendszer kifejlesztése és klinikai alkalmazása a gyermekfogászatban

Bevezetés: A tejfogak jelölésére a fogorvosi gyakorlatban az FDI (Nemzetközi Fogorvosegyesület) által ajánlott kétszámjegyű jelölés széles körben használatos, azonban számos hibalehetőséget rejt magában. **Célkitűzésünk** volt olyan új jelölési rendszert kifejleszteni, és értékelni, amely szemléletesebb és könnyen alkalmazható a mindennapi gyakorlatban. **Módszerek:** a) *A tejfogak jelölésére szolgáló rendszer kifejlesztése:* a jelölés a tejfogak latin nevének felhasználásán alapul, a következők szerint: „deciduous incisor (dI), deciduous canine (dC), deciduous molar (dM)”, mely további alcsoportokra osztható a fog pontosabb meghatározása szerint: középső metsző (1), laterális metsző (2), szemfog (1), első moláris (1) és második moláris (2). A jelölés jobb és baloldali, felső vagy alsó indexben történő elhelyezése szerint a meghatározás tovább pontosítható attól függően, hogy melyik oldali felső, vagy alsó fogakról van szó. Az új rendszerben a dI, dC, dM és az 1-es 2-es kódoknak speciális jelentésük van külön-külön. Az új rendszert MICAP-nak (M-molar, I-incisor, C-canine, P-premolar –amelyek a maradófogazat reprezentánsai) neveztük el. b) *A gyakorlati alkalmazhatóság értékelése:* video filmet készítettünk a MICAP rendszerről az előzőekben leírtak demonstrálására. Fogászok (n=44), fogorvosok (n=60) egyéb fogászati szakemberek (121) és fogorvostanhallgatók (n=176) bevonásával teszteltük a rendszert, a résztvevők 5 fog jelölését végezték el tejfogazatban a MICAP szisztéma szerint a videoval egybekötött előadást követően, preklinikai és klinikai vizsgálatok alkalmával. Ezen kívül értékelniük kellett a rendszer alkalmazhatóságát. Az adatokat khi négyzet próbával, egymintás ANOVA teszttel elemeztük. A MICAP software HTML & C+ program segítségével készült és web oldalként feltöltésre került (www.micap.net). **Eredmények:** a résztvevők többsége ($\geq 80\%$) megfelelően alkalmazta a MICAP formátumot. A hallgatók körében a klinikai vizsgálatok szignifikánsan sikeresebbek voltak, mint a preklinikaiak ($p \leq 0,05$). A fogtechnikusok sikeresebben alkalmazták a jelölőrendszert, mint a dentál higiénikusok és az asszisztensek. A fogorvosok és fogászok több, mint 80%-a megfelelően használta a MICAP szisztémát. **Konklúziók:** A MICAP rendszer alkalmas a tejfogak jelölésére a gyakorlatban. Kipróbálásakor a résztvevők többsége sikeresen alkalmazta a rendszert és pozitívan fogadta jövőbeni használatát.

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