PERMANENT TOOTH ERUPTION AND ITS VALUE IN AGE ASSESSMENT - A STUDY ON 290 SCHOOL CHILDREN IN TAMILNADU

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CERTIFICATE

This is to certify that the dissertation entitled **"PERMANENT TOOTH ERUPTION AND ITS VALUE IN AGE ASSESSMENT A STUDY ON 290 SCHOOL CHILDREN IN TAMILNADU"** is the embodiment of bonafide work done by **DR. S. SAJEEV** under my guidance and supervision in partial fulfillment of regulations for M.D. (Forensic Medicine) post graduate degree examinations of Tamilnadu Dr. MGR. Medical University, Chennai, Tamilnadu.

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DECLARATION

I, **Dr. S. SAJEEV**, solemnly declare that the dissertation titled **"PERMANENT TOOTH ERUPTION AND ITS VALUE IN AGE ASSESSMENT A STUDY ON 290 SCHOOL CHILDREN IN TAMILNADU**" has been prepared by me.

This is submitted to the Tamilnadu Dr.M.G.R. Medical University in partial fulfillment of rules and regulations for the M.D. Degree (Forensic Medicine)– Branch XIV

Place: Madurai

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INTRODUCTION

The estimation of age has important medicolegal aspects. Medical men are sometimes called upon in the court to give their expert opinion about the age of individuals, specifically boys and girls within the first two decades of life. The determination of age is necessary in the following cases:

1. For identification of an individual, living or dead.
2. In criminal cases in connection with the offences of rape, Kidnapping, infanticide.
3. In criminal cases involving children, to determine whether the child has reached an age at which the law holds it responsible for its acts, and if so, what sort of restraint should be imposed upon it.
4. In civil cases in the making of wills, and employment under the Indian Factories Act.
5. Sometimes to determine whether an employee in a government or semi-government organization has reached the age of superannuation.

VARIOUS METHODS OF AGE ESTIMATION

REVIEW OF LITERATURE

The principal means which enable one to form a fairly accurate opinion about the age of an individual, especially in earlier years, are:

1. Teeth
2. Ossification of bones
3. Height
4. Weight
5. Minor signs

1. Teeth: The tooth offer positive help in determination of age by:

(a) Stage of dentition: (1) Eruption of Temporary teeth.

(2) Eruption of Permanent teeth.

(b) Secondary changes due to wear and tear with advancing years

2. Ossification of bones: This criteria is helpful for determining age until ossification is completed. Tables have been worked out for the ages of appearance and fusion of epiphyses by different workers in different parts of India. It has been found that the age at which the union of epiphysis takes place in Indians is about 2- 3 years earlier than in

Europeans. It has also been reported that the epiphyseal union occurs earlier in females than in males.

In ascertaining the age of young persons radiographs of any of the main joints of the upper or the lower extremity of both sides of the body should be taken, and by comparing the ossification status with the standard reference tables, an opinion can be given about the age. But too much reliance should not be placed on this table as it merely indicates an average and is likely to vary in individual cases even of the same province owing to the eccentricities of development. The range of error may be up to 3 years(Modi, N. J.,1979).

3. **Height:** In the first year after birth, body length increases by about 50%; thereafter the annual increment decreases throughout youth, with the exception of the adolescent spurt. The adolescent spurt begins at about 10-11 years in girls and 12-13 years in boys and in both sexes lasts approximately 2 years. After the conclusion of the spurt, there is marked slowing of growth: girls reach 98% of their final height by the average of 16 years, whereas boys reach the same stage by 17 years. Up to the time of adolescence there is little difference in the average heights of boys and

girls, where as by the age of 14 years, the balance is reversed (Osborn, J.W. 1981).

4. **Weight:** Unlike growth in stature, the most rapid increase in weight occurs soon after birth. The rate very quickly decreases and in the ensuing 20 years, the birth weight increases by some 20 times. By the end of the first year, the birth weight has tripled, and by the end of the second it has quadrupled, subsequently settling down to a relatively steady annual increase, until the adolescent spurt. Body weight does not achieve adult value until after stature has attained adult proportions (Osborn. J. W., 1981).

5. MINOR SIGNS: These signs do not pin point the age, but give a rough idea.

These signs include the appearance of hair on the pubic region and in the axillae, the development of breasts in girls, deepening of voice in boys, all these occurring during the adolescence. Certain signs like graying of hair, arcus senilis, wrinkles on the face are signs of advancing age (Modi, N.J., 1979).

RELATIONSHIP BETWEEN DIFFERENT MEASURES OF AGE

During adolescence, there is a close correlation between skeletal age and the age at which secondary sex characters appear. There is also a close correlation between the time at which secondary sex characters appear and the height spurt. By contrast, there is relatively little information for the pre-adolescent period. Information is particularly lacking on the degree of correlation between dental and skeletal age within any single chronological age group.

Height and skeletal age are not well correlated either with each other or with dental age. Nevertheless, people who have advanced dental development (Particularly of the canines) in the immediate pre-adolescent years, generally have an early height spurt, early menarche, early closure of the tibial epiphyses and early growth of pubic hair (Osborn, J.W., 1981).

AGE ESTIMATION BASED ON DENTITION

The examinations of the stage of formation and the progress of age changes in the teeth constitute an important source of information regarding age. Tooth formation is the standard choice for estimating age as it shows less variability than do other developmental features (Stewart, 1963).

One of the earliest dental age estimations was carried out in 1881 on teeth from victims of the fire in Vienna.

Information about age, as obtained from teeth, may depend on many factors with the result that investigations are being carried out by a number of methods, Anatomical, radiographical and even microscopical examinations can be of value. The teeth may be examined in situ in the jaw, or following extraction, either singly or together with other teeth from the same individual.

A great number of tooth changes take place, nearly all of which have been utilized. Such changes are abrasion, some types of defects, changes in the supporting tissues, and changes in the pulp. In addition, chemical changes in enamel and dentine have been related to the chronological age. The number of teeth and their state varies

considerably. All methods only permit estimations to be carried out when the teeth are relatively intact, so that badly carious or otherwise destroyed teeth generally are of little value (Gustafson, G., 1966).

Based on dental development, one can estimate age with accurate results from some months in-utero up to the age of twenty years. This may be the case up to twelve years, but between twelve and twenty years estimations are based only on the development of the root of the third molars. Since these are more variable in development and eruption than the other teeth of the permanent dentition there is less reliability in assessment.

The accuracy of an age estimation obtained from examination of the teeth varies with the age of the dentition under assessment. During the development of the teeth, up to about 15 years of age, accuracies of about plus or minus 1 year can be obtainable. During the early part of this period in certain circumstances, microscopic examination of the incremental patterns in the teeth may provide means of obtaining an accuracy of plus or minus a few days. After tooth development is complete, the only methods available involve the estimation of the progress of ‘wear’ and ‘ageing’ processes in the teeth. These changes

proceed at varying rates, and when estimating the age of an adult dentition the best accuracy that can be obtained, is to estimate an age as being in a range of plus or minus ten years (Johnson, 1971).

Thus, during the early stages of development with many forming tooth to act as ‘age markers’, age estimations can be made to a higher accuracy than later in life when only ‘age’ or ‘wear’ changes are available (Cameron. J.M and Sims. B.G., 1974).

METOHDS OF DENTAL AGE ASSESSMENT

The chronological age of the children with uncertain birth records are often estimated by evaluating the individuals somatic maturity. Owing to a comparatively low variability of tooth formation in relation to the chronological age, it seems that methods based on stages of tooth formation are more appropriate in assessment of chronological age than those based on other indicators of somatic development (Lewis. A.B., Garn.S.M. 1960)

The age assessment methods may be divided into two groups, according to the state of development of the dentition. One group of methods suitable for the period spanning the development of the teeth, the other group applicable to the adult fully formed dentition.

I. Age Assessment Methods Applied to the Forming Dentition:

a. The use of charts prepared from population surveys :

The deciduous dentition commences calcification at 20-30 weeks of gestational age. Tooth formation continues until the completion of the second deciduous molar, at about 31/2- 4 years of age. The permanent

dentition commences mieralization just before birth, progressively replaces the deciduous dentition from 7 to 15 years, and is itself complete by 20 – 25 years of age. Thus at any time from up to the end of the second decade the jaws contain one or more partly formed teeth. The state of development of the forming teeth will reflect the age of the individual. Hence an age assessment may be made by examination of the degree of the tooth formation for all the teeth in a given jaw.

In practice the jaws are radiographed and the state of development of the whole dentition compared with the stages shown on standard charts. These charts are based on dental surveys of cross sections of the population and show the progressive states of dental development for each year of age.

1. Schour and Massler produced the first chart in 1941, based on a survey of jaw sections from thirty American children carried out by Logan and Kroffeld (1933). The Schour and Massler chart consists of a series of drawings illustrating twenty-one chronological stages of dental development spanning the period of four months before birth to twenty-one years of age. Radiographs taken of the jaws for

identification are compared with the chart, and the drawing which most nearly approximates to the stage gives an indication of age. If the state of development shown in the radiograph falls between two drawings intermediate age estimation is made.

2. Moorrees, Fanning and Hunt (1963) published charts based on a radiographic survey which give details of the development of both the deciduous and the permanent dentition. Radiographs from 380 American school children were used in their study of the permanent dentition and from 246 children in their study of the deciduous dentition. They divided the progress of tooth formation in to a series of radiographic land marks. When the stage of formation of a tooth on the specimen radiograph is compared with the chart, not only is the average for attaining the land mark indicated, but also the range of two standard deviations represents the age range in which 95 percent of the population would be expected to reach the appropriate developmental land mark.

3. Gustafson and Koch published a chart cited by Johanson (1971) covering the development of the dentition from eight months before birth to 16 years of age. The chart is based on pooled data collected from 19 sources published between 1909 and 1964, including Ross (1909), Logan and Kronfeld (1933), Schour and Massler (1941), and Lysell, Magnusson and Thilander (1964).

    Four land marks in the process of development of each tooth are recorded:

    1. The commencement of Mineralization,
    2. The completion of Crown formation,
    3. The completion of Tooth eruption,
    4. The termination of Root formation.

Each land mark is represented graphically on the chart by a small triangle. The apex represents the average age of attaining the land mark, and the angles at the base indicate the earliest and latest ages for the land marks found in the survey (fig-1).

Of the three charts, the Schour and Massler chart has been in largest use, but is open to criticism on the grounds that it was based on a small

group of children many of whom died of prolonged illnesses which may have affected the chronology of tooth development. Garn, Lewis and Polachek (1959) conducted a survey of the development of mandibular premolar and molar teeth in 255 children and compared the finding with the ranges indicated in the Schour and Massler chart. They concluded that the age range found in their survey for the attainment of a particular land mark was approximately three times that indicated by the Schour and Massler chart. Brauer and Bahadur (1942) in a survey of 415 children found that a third of their sample fell outside the age ranges shown in the Schour and Massler chart.

The Moorrees, Fanning and Hunt chart provides more information on the individual stages of development for each tooth, and have the advantage of providing separate charts for each sex.

On comparing the Schour and Massler, and the Moorrees et al charts, two differences can be made out. First, the average age for attaining the land marks tends to be lower in the Moorrees et al chart than in the Schour and Massler chart. Secondly, the age range for attaining a land mark is larger in case of Moorrees chart. Garn, Lewis and

Polachek(1959) and Brauer and Bahadur (1942) also found that the range of age for attaining a given land mark to be greater than that indicated by the Schour and Massler chart.

The Gustafson and Koch chart cannot be used with the precision of the other charts, because it records fewer stages of development for each tooth than the other two charts. The information provided by the Gustafson and Koch chart which is not directly obtainable from the Schour and Massler or from the Moorrees, Fanning and Hunt charts is the age range for the eruption of the teeth.

b) Age Assessment from the weight of the Developing Dentition.

Stack (1960) described this method, relying on the progressive increase in weight of the growing dental tissues. He dissected and weighted the developing teeth from jaws of known age, and constructed a regression line of weight against age. When the weight of the teeth from a specimen of unknown age is compared with the regression line an estimate of age is obtained. The method, however, is useful only in estimating the age of cadavers, only in the very early age group.

c) Age assessment of Examination of Incremental pattern of Tooth Formation:

This method involves a microscopic examination of the incremental markings found in longitudinal ground sections of the teeth, and relies on the identification of the neonatal line in teeth forming at birth. Starting from the neonatal line, the number of small incremental lines that cross the enamel prism are counted up to the edge of the forming enamel front. Each increment represents one day's addition of enamel, thus the number of increments represent the number of days of age (Boyde, 1963).

d) Age assessment by other methods of examination of teeth.

Eruption and classification of dental tissues has been used to determine the dental age. Tooth calcification is superior to tooth emergence because emergence of a tooth is a fleeting event and its precise time is very difficult to determine where as calcification is continuous process that can be assessed by permanent records such as X-ray films. For this dental formation of calcification which is a continuous developmental process should be considered a better measure of physiological maturity than dental emergence. For this dental age.

Determination from Othopantomograph using Demeirjian method is very helpful. The other methods like Kusri's triangle is helpful in age estimation of children between 6 – 12 years (Fig no. 10)

II. Age Assessment Methods applied to Adult Dentition

In the adult dentition age estimation techniques are limited to the assessment of the progression of 'Wear' and 'Tear' changes in the teeth.

Gustafson suggested the use of six of those progressive changes as a method for age estimation. They are:

1. Attrition
2. Peridontosis
3. Secondary Dentine Deposition
4. Root Resorption
5. Root Transparency
6. Cementum Apposition.

Using teeth of known age, he awarded a scale of points from 0-3 for each of the six criteria to each tooth. The more severe the age

changes, the higher the score. He constructed a regression line plotting tooth points against age.

Teeth of unknown age are allocated a points score and when the score is entered on the graph, the intercept with the regression line indicates the estimated age. The average error for this technique is plus or minus 3.6 years (Gustafson, 1950).

Johanson (1971) examined this method and reported that the 95 percent confidence limit is approximately plus or minus 14 years.

A difficulty in the use of this technique lies in the assessment of the progress of 'wear' changes, as the allocation of points is on a subjective basis and may vary from observer to observer. Also some of the criteria are not true 'age' changes, for instance, the rate of attrition of the crown may vary widely from individual to individual depending on the diet and chewing habits.

Of the six criteria used by Gustafson, the assessment of the area of root transparency has proved the single most reliable 'age' change (Miles 1963). The use of this age change has the advantage that the area of root

transparency may be directly measured by the use of a microscope thus minimizing the subjective error in the estimation. But, the use of this single change has not proved more accurate than the use of the method of assessing all six changes together.

The Gustafson method has been modified by Johanson (1971) using the same six changes. In this method the relative reliability of each of the 'age' change as an age marker is taken into account. Seven points are awarded for each 'age' change, and a computer-based multiple regression technique is used to calculate the age estimation. As a result the 95% confidence limit improved from 14 years to ± 10.3 years (Johanson 1971).

STRUCTURE OF TOOTH

The human dentition as in all mammals is characterized, by diphyodont, heterodont dentitions attached to the jaws by gomphosis. That is there are two dentitions, a deciduous and a permanent (diphyodont) and their morphology differs in different parts of the mouth, (Heterodont) and they are attached to the jaws by a fibrous ligamentous material which is embedded into the surface of the root and into the surface of the bone which envelopes the roots (gomphosis).

The tooth consists of the following component parts:

1. An **enamel** crown, which is very hard.
2. The **dentine** which forms the body of the tooth.
3. The **pulp** which contains living cells, bolld vessels, and nerves. The pulp therefore is necessary for maintaining the vitality of dentine.
4. The **cementum** which covers the roots of the teeth and which provides a means of attaching the fibres which support the tooth in the jaws.

5. The fibres of the **periodontal ligament** which are attached on one side to the bone and on the other to the root of the tooth.
6. The **alveolar bone** of the jaws which encases the root, and
7. The **epithelium** of the mouth which forms the junctional waterproof seal around the neck of the tooth.

DEVELOPMENT OF TOOTH

Each tooth develops from a tooth bud that forms from the lining of the oral cavity. A tooth bud consists of three parts:

An enamel organ, which is derived from the oral ectoderm;

1. A dental papilla, which is derived from the mesenchyme ; and
2. A dental sac, which is also derived from the mesenchyme.

The enamel organ produces the tooth enamel, the dental papilla produces the tooth pulp and the dentin, and the dental sac produces the cementum and the periodontal ligament.

Developmental stages (Fig. 2):

1. The Bud stage: The first sign of tooth development is seen during the sixth week of intra-uterine life. Certain cells in the basal layer of the oral epithelium proliferate more rapidly than the adjacent cells. An epithelial thickening arises in the region of the future dental arch and extends along the entire free margin of the jaws. This is called the Dental Lamina. From the Dental Lamina in each jaw, round swelling arises at ten different points, corresponding to

the future position of the deciduous teeth. These are called the Tooth Buds which are the primordial of enamel organs.

2. Cap Stage: As the tooth bud continues to proliferate it doesn't expand uniformly. Unequal growth in the different parts of the bud leads to formation of the cap stage, which is characterized by a shallow invagination on the deep surface of the bud.

The cells which line the convexity of the cap are called the outer enamel epithelium, and the cells which line the concavity are called the inner enamel epithelium.

The mesenchyme, partly enclosed by the invaginated portion of the inner enamel epithelium proliferates, to form the dental papilla.

The dental sac is a condensation in the mesenchyme, surrounding the enamel organ and the dental papilla.

3. Bell Stage: As the invagination of the epithelium deepens and its margins continue to grow, the enamel organ assumes a bell shape.

During this stage, the inner enamel epithelium starts to produce enamel. The dental papilla produces dentin. The dental sac produces cementum and periodontal fibers. The dental lamina, in all teeth except the permanent molars, proliferates at its deep end to give rise to the enamel organs of the permanent teeth (Sicher. H, & Bhaskar.S.N. 1972).

The deciduous dentition: Calcification of the deciduous teeth begins about the fourth month of foetal life: near the end of the sixth month all of the deciduous teeth have begun to develop.

The deciduous mandibular central incisors appear in the mouth at the age of approximately six months. They are followed a month or so later by the maxillary central incisors. About two months later, the maxillary lateral incisors appear. The mandibular lateral incisors usually emerge a little earlier than their maxillary counter parts. At the age of one year or so, the first deciduous molars erupt. The deciduous canines appear at about sixteen months. When the child is two or two and a half years of age, all of deciduous teeth are expected to be in use.

Thus the usual order of apperance of the deciduous teeth in the mouth :

1. Central incisors.
2. Lateral incisors
3. First molars
4. Canines
5. Second Molars.

However, there is considerable variance in the sequence. Sometimes, infants are born with erupted mandibular central incisors. In some cases, babies are seen displaying four mandibular incisors and no maxillary teeth at all.

Permanent Dentition :

The permanent teeth fall in two groups:

1. Succedaneous teeth:

Teeth which take the place of their deciduous predecessors. The permanent incisors, canines and premolars fall into this category.

2. Teeth which are not preceded by deciduous teeth:

These are the three molars.

The eruption of the permanent teeth closely follows the resorption of the root of the deciduous predecessor, leading to its exfoliation. The permanent tooth in its follicle attempts to force its way into the position held by its predecessor. The pressure brought to bear against the deciduous root causes resorption of root which continues until the deciduous crown has lost its anchorage, becomes loose and finally exfoliated.

The non succedaneous teeth, the molars, require for their eruption, their position being posterior to the rest of the teeth, sufficient jaw growth to allow the space.

The usual order in which the permanent teeth appear is :

1. First molars
2. Mandibular central incisors and lateral incisors
3. Maxillary central incisors
4. Maxillary lateral incisors
5. Mandibular Canines

6. First Premolars
7. Second Premolars
8. Maxillary Canines
9. Second Molars
10. Third Molars.

Kocher.R., Richardson.A (1997) in their study casts at 6 months interval from age 5 to 15 years the results showing premature loss of primary antecendents delayed the eruption of permanent successors except for the upper premolars which were acclerated. The difference relating to upper first premolar and lower canine were not statistically significant. Each lower tooth erupted before its upper counter part except for the premolars, there was no significant difference in the age for eruption between right and left sides. The most frequent orders of eruption were unique to the subject. These occurred in 22% of upper and 33% of lower arches, and the classic sequence of first molar-central incisor-lateral incisor-first premolar-canine-second premolar-second Molar (M1-I1-I2-PM1-C-PM2-M2) in the upper arch and I1-M1-I2-C-PM1-PM2-M2 in the lower arch occurred in only 16% of the upper arches and 13% of lower arches. Males adhered to the text book sequence

(20% upper, 17% lower) more than females (12% upper, 8% lower). In the upper arch of the females the order M1-I1-I2-PM1-PM2-C-M2 in 10% of subjects was almost as frequent as the classic sequence. Although the exclusive Caucasian sample made the data quite precise, the age ranges and orders of eruption found in this study are more reliable than many which are frequently quoted on account of its longitudinal nature and the fact that the effect of premature loss of primary antecedents is taken in to the account. Wedl JS, Schroder.V, Blake FA, Schmelzle R, Friedrich RE. (2002) in Turkey found in their study that the tooth eruption in the lower and upper jaw of male and female probands are symmerrical. In comparing the upper and the lower jaw of both genders, it becomes evident that there is a tendency for earlier tooth eruptions in the lower jaw. In respect to the tooth eruption sequence, a change was noted in the upper jaw. Contrary to the reports of other authors, the second premolar has changed places with the canine and erupts prior to this tooth. The computed differences of the tooth eruption as a mean value calculated over all teeth, was +/- 1 tear at maximum, compared to studies from different continents.

FACTORS INFLUENCING DENTAL DEVELOPMENT

1. Biological Variations :

1. Race: Adler (1959) observed that different races have different mineralisation and different eruption dates. Hurme (1957) suggested that the eruptive process occurs from one-half to one and half years earlier in the Negro than in the European or American white. There did not seem to be any striking difference between whites and Japanese, But the Maxillary canine is found to emerge earlier in Japanese than in White people. Hussanali J, Odhiambo JW (1980) in their cross sectional study found in African and Asian children that except for the premolars, the mandibular teeth erupted earlier than the maxillary ones in both races. The mandibular incisors and canines erupted earlier by 0.9 – 1.1 year in Africans and 0.6-0.8 year in Asians and the molar by 0.2-0.4 years in both races. The females were ahead of males in both races. In Asians the most frequent order is Mand M1, and Mand I1, or Max M1, I1 and Mand I2 between 6-8 years.

2. Sex : Sexual Dimorphism refers to those differences in size, stature and appearance between male and female that can be applied to dental identification because no two mouths are alike (Keisu, 1990). Girls tend to be earlier with regard to the eruption of permanent teeth (Stones et al 1951; Sutow et al, 1954). This was Confirmed by Garn et al (1958 a) For white children of European ancestry the average sex difference in the time of eruption is 0.45 year with a maximum of 0.93 year for the mandibular teeth. The sex difference in eruption is smallest in the first permanent molars and greatest in the canines. Kaul SS, Pathank RK (1987) studied 1137 Punjabi school children aged 6-14 years in Chandigarh, India, and in that cross sectional study they found an error of about 13 to 34% of median age for males and about 11 to 35% for females. Kaul SS, Patnaik RK, Santhosh (1991) used probit analysis in 312 children aged 4 to 31 months and found female children are found to be advanced with respect to tooth emergence than their male counter parts regarding to the deciduous teeth. Sharma K, Mittal S in 2001 in Chandigarh studied in cross- sectional sample of 483 children from 6 to 13 years of age and it was found females were markedly advanced in permanent tooth emergence times over males, but no such sex differences

were observed in sequence of emergence. Differences between median emergence times of right and left side were significant for only for 4 to 28 instances (14.29%) namely central incisors, mandibular first molars in males and lateral maxillary incisors in females. In general mandibular teeth except premolars tended to emerge earlier than their maxillary counterparts. Weld JS, Schrooder V, Blake FA, Schmelzle R, Friedrich RE (2002) in Izmir, Turkey studied in 2101 subjects (1046 boys and 1055 girls) excluding the third molar and the times of tooth eruption is earlier in females than males and entire tooth eruption process of the second dentition occurs in females earlier than in males. The tooth eruption in the lower and upper jaw of male and female probands is symmetrical. In comparing the upper and lower jaw of both genders, it becomes evident that there is a tendency for earlier tooth eruption in the lower jaw. In respect to the tooth eruption sequence, a change was noted in the upper jaw.

3. Season: Even seasons are observed to exert some influence on tooth eruption. Adler (1959) found a variation in tooth eruption between summer and winter.

4. Socio-economic: Early eruption is also connected with the economic status, for the teeth in children of well-to-do families erupt earlier than those children from poor families (Rose).

5. Urban vs. Rural: Urbanization has caused an acceleration of the eruption of the permanent teeth.

6. General Physical Development: There is an intimate relationship between growth and tooth eruption. In a study made by Leslie (1951), there was a clear difference between the age distribution of the permanent teeth in New Zealand as compared with the same teeth in children from England and the U.S.A. The New Zealand children showed earlier eruption. It was found that New Zealand children were advanced in physical development, weight and stature, as compared with English children.

II. Pathological Variations :

General Factors:

1. Heredity may have certain influence on the eruption of teeth (Gustafson).

2. Nutritional Deficiency: Under- nutrition may lead to delayed teeth eruption. Specifically vitamin D deficiency is blamed to affect teeth development. Triratana T, Hemindra, Kiatiparjuk C. studied in Bangkok in 1990 for about 400 children aged between 6 to 16 years. The results from the study showed that there were significantly delay in time of eruption of permanent teeth in malnutrition group when compared to the normal group of other study, and pattern of permanent dentition in malnutrition group coincided with those normal group of other study.
3. Endocrine Disturbances : Generalised retardation of eruption may be caused by hypopituitarism or hypothyroidism where there is a retardation of somatic growth.

Local Factors :

1. Caries : In the case of high caries incidence in the deciduous dentition the loss of the diseased teeth may be earlier than normal so that the permanent teeth may also erupt prematurely.

Alternatively, the premature loss of deciduous teeth may be followed by closure of the space by a shift of the neighbouring teeth leading to retardation of the permanent tooth eruption.

2. Trauma: Severe acute trauma may result in an arrest of active tooth eruption if the periodontal ligament of the tooth has been injured. Resorption of the root may ensue ; bone is deposited in the spaces opened by resorption leading to an ankylosis by fusion of alveolar bone and root. The movement of the tooth is arrested, while the other teeth continue to erupt.

ERUPTION TIMES AS A GUIDE TO AGE ESTIMATION

Among the various techniques suggested for the estimation of age based on the land marks of tooth development, the one based on tooth emergence into oral cavity has certain advantages. The identification of the other phases of tooth development require techniques like radiographic examination, histological examination of the removed tooth which are difficult and can only be applied in select cases. An examination of the eruption or noneruption of various teeth is very easy; no special techniques injurious to the subject are needed and involves least disturbance to the person examined. The method is equally applicable to the living person as well as the dead in the given age range.

In order to utilize data on dental eruption for age assessment, certain standards have to be developed regarding the time of eruption of the various teeth. It is a question whether there can be universal standards for eruption times which can be applied to persons all over the world, belonging to all races and both sexes.

There is sufficient evidence to show that dental development is considerably influenced by race, geographic character, climate, sex, nutrition, genetic and socio-economic factors. It is obvious that there can't be uniform standards, which are applicable universally. Thus there is a need to develop specific standards for each group separately.

EARLIER WORK ON ERUPTION TIMES

Among the earlier works, only Gustafson, and Koch chart provides the age range for eruption of teeth. But the disadvantage of their work is that they used many different sources to compile their chart. They have recorded four land marks in the process of development of each tooth.

1. The commencement of Mineralization,
2. The completion of Crown Formation,
3. The completion of Tooth Eruption and
4. The termination of Root Formation.

Each land mark is represented graphically on the chart by a small triangle. The apex represents the average age of attaining the landmark, and the angles at the base indicate the earliest and the latest ages for the landmarks found in the survey.

Schour and Massler; and Moorrees et al also have provided charts. But they worked on only the radiographic signs of tooth development. So these charts are not applicable in the present context.

Logan and Kronfeld (1933) have given ranges for the various landmarks of the dental development (Fig. 3)

In India, few attempts are made at fixing the eruption times of various teeth. One of them is the work done by S.K.Nayak and S.Patel who studied the age of eruption of permanent teeth among the Tibetan Refugees. They have examined 236 males and 133 females and calculated mean eruption times for all permanent teeth for each sex. The limitations of their work are that their subjects are Tibetans, and that the size of their sample is small for such types of study.

In the state of Tamilnadu, no reliable large scale data is available to determine the age of eruption of permanent teeth. As it has been felt already that regional standards have to be developed on the age of eruption of teeth, the present study was undertaken.

INTRODUCTION

The value of tooth in estimation of age is well recognized. The various stages of development of teeth and the secondary 'wear' changes are the basis of age estimation. Tooth undergoes a series of changes from womb to tomb. Thus tooth acts as a guide to age's estimation at any phase of life from fetal life to old age. The assessment during the later years of life is less accurate than during the earlier years, when the teeth are developing.

Among the various stages of dental development, the only stage which is visible to naked eye is the emergence of tooth into oral cavity. The other stages require radiography for their demonstration. Thus to observe the eruption or non-eruption is easier and simpler than to observe the various radiological signs of tooth development.

To determine the age of an individual by noting the eruption of teeth, the standard eruption times must be known. It is an established fact that the standard eruption times cannot be universally applied and regional standards have to be developed. Such standards, at present are not

adequate. In order to meet the necessity to develop these standards, the present study was undertaken. In some of the previous studies elsewhere, the techniques for the estimation of age of eruption were based on crude graphical methods which are partly subjective in nature and that too on small sample data. The present study, attempts to over come these deficiencies.

AIM OF THE STUDY

1. The present study aims to determine the median age eruption of the permanent teeth.

2. The age of range of eruption of the above teeth will be expressed.

3. The study aims to fine whether any differences in the age of eruption can be found between the lower and upper jaws.

4. The study also aims to determine the normal ages of eruption with their ranges for each tooth among males and females and find the differences if any.

MATERIAL AND METHODS

The present study was carried out on 290 children, consisting of 200 boys and 90 girls. The age of the subjects ranges from 6 years to 16 years. The study of eruption time of 3rd molar teeth is not included in the present work. Care was taken to see that the subjects are uniformly distributed between these two ages. The subjects selected were school children from Kindergarten to 10th standard. A school in Madurai city was taken up for the study, and as many children as possible were examined. The subjects represented mostly the middle socio-economic with few from lower socio-economic group.

While examining the subjects, certain cases were exempted from the study, where there is crowding of teeth, supernumerary teeth, trauma to teeth, caries because these factors hamper the normal tooth development.

The information noted from each subject was:

1. Name of the Student :
2. Sex :
3. Marks of Identification : 1) 2)

4. Parent's Name :
5. Address :
6. Occupation of Parent :
7. Age of Student as per School Records :
8. Date & Place of Examination :
9. Consent of Parent :
10. Signature of person :

PHYSICAL EXAMINATION.

1. Height :
2. Weight :
3. Chest circumference at the level of nipples :
4. Abdominal Girth at the level of Umbilicus :
5. General, Build and Appearance :
6. Voice :
7. Onset of Puberty :

    A) Date of Menarche

    B) Regularity of Menses

7. Teeth : Permanent Tooth :

Rt.	**58 57 56 55 54 53 52 51**	**61 62 63 64 65 66 67 68**	**Upper jaws**
Lt.	**88 87 86 85 84 83 82 81**	**71 72 73 74 75 76 77 78**	**Lower Jaws**

P-Permanent

The subjects were examined in day time only. Wooden spatulae were used to open the mouth correctly so as to observe the eruption of the posterior teeth. A tooth was considered to have erupted only when a portion of the crown of the tooth, however small, had penetrated the gingival. The teeth which satisfied this requisite were registered. For registration, the modified M.D.I notation system of designation was used. In this system the teeth are divided into four quadrants dividing upper jaw from lower jaw, and right side from left side.

The quadrants were represented as :

5 = Right Upper

6 = Left Upper

7 = Left Lower

8 = Right Lower

The different categories of teeth were denoted as follows:

1) = the central incisor

2) = the lateral incisor

3) = the canine

4) = the first pre-molar

5) = the second pre-molar

6) = the first molar

7) = the second molar

8) = the third molar

The modified M.D.I. notation system was used.

Date of birth of the subjects were obtained from the institutional records. The age of each individual was calculated as on the date of examination of the subject.

The subjects were grouped into various age groups each of the magnitude of a half-year. Thus, there were 20 groups from 6 years to 16 years of age. Each age group contained an average of 10 boys and 5 girls.

STUDY DESIGN

To determine the ages at the time of eruption of various teeth conventionally the procedure would be to follow a cohort of children of age four over a period of thirteen years till all of this cohort develop the third molars. In such a cohort study, examination has to be done for each child at small periodic intervals to observe and note the age at the time of eruption of various teeth. The difficulties associated with this type of study are :

1. The prolonged duration of follow up (about 13 years) of each of the group of children under study.
2. It is very likely that most of the children will be lost for follow-up, at various ages due to change of address, or even death.
3. Repeated examinations over these 13 years follow up period, will result in a lot of problems and the results can be known only after a prolonged period of study.

Because of these practical problems, not many studies could be conducted in this regard.

In the present study attempt has been made to overcome the above problems by means of a study design using the technique of 'Probit Analysis'. This technique was in vogue especially in biological assays based on quantal responses. Broadly, the age of the subject was taken as the dose, the eruption or non-eruption of each tooth was taken as the quantal response and 'dose-response' curve has been constructed. Some workers have used this technique by visually determining the dose-response line by a graphical technique. As this method is likely to give differing results because of the subjectiveness of the observer in visualizing the response curve, in the present study the method suggested by D.J.Finney has been adopted. (Probit Analysis – D.J.Finey 1971).

Subjects have been classified into half year age groups starting form the age of 6 years to 16 years. At least 5 -10 individuals are studied in each age group. In each age group and for each tooth, tables have been prepared which give the number of the individuals for whom the specified tooth has erupted. From this information by following the standard technique of probit analysis, the various parameters, the percentile values, the median age of eruption have been worked out. In view of the vastness of the calculations involved, computer techniques have been employed.

OBSERVATIONS

THE AGE DISTRIBUTION OF ERUPTION

The age distribution of eruption of the permanent teeth is shown in tables 1 to 14, each table representing an individual tooth in either sex. These tables show the total number of subjects examined in each age group and the number and percentage of subjects showing the eruption of the particular tooth.

90 boys of the age group of 6.0 to 10.5 years were examined for the eruption of the central incisor and the proportion of the subjects in each half year age group showing the eruption in upper jaw, lower jaw and in all 4 quadrants is given in table 3. Similar data for 30 girls from 6.0 to 9.0 years of age is shown in table 4.

130 boys of the age group 6.0 to 12.5 years were examined for the eruption of lateral incisor and the proportion of the subjects in each half year age group showing eruption in upper jaw, lower jaw and in all 4 quadrants is shown in table 5. Similar data for 55 girls from 6.0 to 11.5 years is shown in table 6.

140 boys of the age 8 to 15 years were examined for the eruption of canine and proportion of subjects in each half year age group showing eruption in upper jaw, lower jaw and in all 4 quadrants is shown in table 11. Similar data for 70 girls from 7.0 to 14.0 years is shown in table 12.

130 boys of the age 7 to 13.5 years were examined for the eruption of the first pre-molar and proportion of subjects in each half year age group showing eruption in upper jaw, lower jaw and in all 4 quadrants is shown in table 7. Similarly the data for 65 girls of the age 6.0 to 12.5 years is given in table 8.

140 boys of the age 7 to 14.0 years were examined for the eruption of the second pre-molar and proportion of subjects in each half year age group showing eruption in upper jaw, lower jaw and in all 4 quadrants is shown in table 9. Similarly the data for 65 girls of the age 7.0 to 13.0 years is given in table 10.

40 boys of the age 6.0 to 8.0 years were examined for the eruption of the first molar and proportion of subjects in each half year age group showing eruption in upper jaw, lower jaw and in all 4 quadrants is shown

in table 1. Similarly the data for15 girls of the age 6.0 to 7.5 years is given in table 2.

160 boys of the age 8.0 to 16.0 years were examined for the eruption of the second molar and proportion of subjects in each half year age group showing eruption in upper jaw, lower jaw and in all 4 quadrants is shown in table 13. Similarly the data for 70 girls of the age 8.0 to 15.0 years is given in table 14.

THE PERCENTILE VALUES

The percentile values of the age of eruption for each rooth are presented in tables 15 to 21.

The percentile values were obtained for :

1) Eruption in Upper Jaw.
2) Eruption in Lower Jaw.
3) Eruption in all 4 Quadrants.

The percentile values for each tooth are shown in a separated table. Each table provides a comparison of the percentile values of males and females, as well as a comparison between upper and lower jaws.

An observation of 50^{th} percentile gives the age ranges in which 50% of the population would be expected to have the particular tooth erupted.

THE MEDIAN ERUPTION TIMES

Table 15 - 21 shows the median eruption times in males and females.

The median ages of eruption are also demonstrated in the form of bar diagrams in fig. 4,5,6.

Fig. 4 provides a comparison of the median age of eruption between upper jaw and lower jaw in males. Fig. 5 provides a similar comparison in females. Fig. 6 gives a comparison of the median eruption ages between males and females.

Central Incisor :

Males: The median age of eruption (P50) in upper jaw is 8.8 years, and for lower jaw 8.4 years. The lower jaw shows early eruption of 4 months. P50 for eruption in all 4 quadrants 9.45 years.

Females: The median age of eruption (P_{50}) in upper jaw is 7.5 years, and for lower jaw 7.3 years. The lower jaw shows early eruption of 2 months. P_{50} for eruption in all 4 quadrants 8.2 years.

Sex difference: Central incisor eruption in upper jaw is about 13 months earlier in females, whereas, in the lower jaw females have early eruption time by 9 months.

Lateral Incisor :

Males: The median age of eruption (P_{50}) in upper jaw is 8.6 years, and for lower jaw 9 years. The upper jaw shows early eruption of 4 months. P_{50} for eruption in all 4 quadrants 9.5 years.

Females: The median age of eruption (P_{50}) in upper jaw is 8.5 years, and for lower jaw 8.7 years. The upper jaw shows early eruption of 2 months. P_{50} for eruption in all 4 quadrants 9.3 years.

Sex difference: Females show earlier eruption than males in both upper (1 month) and (2 months) lower jaws.

Canines :

Males : The median age of eruption (P_{50}) in upper jaw is 11.6 years, and for lower jaw 11.9 years. The upper jaw shows early eruption of 3 months. P_{50} for eruption in all 4 quadrants 12.35 years.

Females : The median age of eruption (P_{50}) in upper jaw is 10.6 years, and for lower jaw 11.2 years. The upper jaw shows early eruption of 6 months. P_{50} for eruption in all 4 quadrants 12.45 years.

Sex difference: Canine eruption in upper jaw is earlier in females than in males by a period of 10 to 12 months whereas in lower jaw the eruption is earlier in females than in males by 7 months.

FIRST PRE – MOLAR :

Males : The median age of eruption (P_{50}) in upper jaw is 10.3 years, and for lower jaw 10.7 years. The upper jaw shows early eruption of 4 months. P_{50} for eruption in all 4 quadrants 11.4 years.

Females : The median age of eruption (P_{50}) in upper jaw is 9.6 years, and for lower jaw 10.4 years. The upper jaw shows early eruption of 8 months. P_{50} for eruption in all 4 quadrants 10.7 years.

Sex difference : Eruption of first pre-molar is earlier in females in both upper (4 to 7 months) and lower (3 months) jaws.

SECOND PRE-MOLAR :

Males : The median age of eruption (P_{50}) in upper jaw is 11.3 years, and for lower jaw 11.5 years. The upper jaw shows early eruption of 2 months. P_{50} for eruption in all 4 quadrants 11.8 years.

Females : The median age of eruption (P_{50}) in upper jaw is 10.0 years, and for lower jaw 9.6 years. The lower jaw shows early eruption of 4 months. P_{50} for eruption in all 4 quadrants 10.75 years.

Sex difference : Eruption of second premolar in upper and lower jaws is earlier in Females than in Males by a period exceeding 12 months

FIRST MOLAR :

Males : The median age of eruption (P_{50}) in upper jaw is 7.4 years, and for lower jaw 7.1 years. The lower jaw shows early eruption of 3 months. P_{50} for eruption in all 4 quadrants 7.45 years.

Females : The median age of eruption (P_{50}) in upper jaw is 6.9 years, and for lower jaw 6.6 years. The lower jaw shows early eruption of 3 months. P_{50} for eruption in all 4 quadrants 7.2 years.

Sex difference : Eruption of first molar in upper jaw is earlier in Females than in Males by 5 months whereas in the case of lower jaw, eruption is earlier in Females than in Males by 5 months.

SECOND MOLAR :

Males : The median age of eruption (P_{50}) in upper jaw is 13.2 years, and for lower jaw 12.9 years. The lower jaw shows early eruption of 3 months. P_{50} for eruption in all 4 quadrants 13.4 years.

Females : The median age of eruption (P_{50}) in upper jaw is 12.4 years, and for lower jaw 12.0 years. The lower jaw shows early eruption of 4 months. P_{50} for eruption in all 4 quadrants 13.0 years.

Sex difference : Eruption of second molar is earlier in Females than in Males in both upper (8 months) and lower (9 months) jaws.

AGE RANGE OF ERUPION (P_{50})

Central Incisor (Table 16) :

In males, 50% of the population will have the central incisor erupted in all quadrants only after 9.45 years of age.

In females, 50% of the population will have the central incisor erupted in all quadrants only after 8.2 years of age.

Lateral Incisor (Table 17) :

In males, 50% of the population will have the central incisor erupted in all quadrants only after 9.5 years of age.

In females, 50% of the population will have the central incisor erupted in all quadrants only after 9.3 years of age.

Canine (Table 20) :

In males, 50% of the population will have the central incisor erupted in all quadrants only after 12.35 years of age.

In females, 50% of the population will have the central incisor erupted in all quadrants only after 12.45 years of age.

First Pre-molar (Table 18) :

In males, 50% of the population will have the central incisor erupted in all quadrants only after 11.4 years of age.

In females, 50% of the population will have the central incisor erupted in all quadrants only after 10.7 years of age.

Second Pre-molar (Table 19) :

In males, 50% of the population will have the central incisor erupted in all quadrants only after 11.8 years of age.

In females, 50% of the population will have the central incisor erupted in all quadrants only after 10.75 years of age.

First Molar (Table 15) :

In males, 50% of the population will have the central incisor erupted in all quadrants only after 7.45 years of age.

In females, 50% of the population will have the central incisor erupted in all quadrants only after 7.2 years of age.

Second Molar (Table 21) :

In males, 50% of the population will have the central incisor erupted in all quadrants only after 13.4 years of age.

In females, 50% of the population will have the central incisor erupted in all quadrants only after 13.0 years of age.

DISCUSSION

Tooth formation is the standard choice for estimation age as it shows less variability than do other developmental features (Steward, 1963).

There are three periods in life, each differing in relation to tooth development. The first period is from in-utero to the time of eruption of the first teeth. The second phase is the age of eruption of the first teeth to about twelve years. The third phase follows from thereon, when almost all the permanent teeth are already present in the mouth.

One can estimate age with accurate results from some months in-utero upto the age of twenty. Between 12 and 20 years of age, the estimations are based only on the development of the root of the third molars. Since these are more variable in development and eruption than the other teeth of the permanent dentition, there is less reliability in assessment (Gustafson.G.,1966).

Heredity, environment, endocrine reactions, and nutrition are undoubtedly among the possible factors influencing the development of teeth (Brauer and Bahadur,1942).

In 1935 Kronfeld made histological serial section of more than thirty human jaws in the age group from birth to fifteen years. He studied the exact position, state of development, and degree of classification for each tooth in different ages.

Stack(1960) has worked out an interesting method of age assessment on developing teeth using the increase in tissue thickness, weights and volumes. He found that the weights of dry mineralized tissue gave the best expression of growth.

Kraus (1959) studied tooth development in 95 foetuses and recorded the chronology of the early stages in the formation of deciduous dentition.

Miles (1958) developed a method of age assessment during an early phase of tooth development by measuring the thickness of dentine.

Schour and Massler (1941) produced a reference chart on dental development, based on a survey of jaw sections from 30 American children carried out by Logan and Kronfeld (1933). The chart consist of a series of drawings illustrating 21 chronological stages of dental development spanning the period of four months before birth to twenty-

one years of age. This chart suffers the drawback of a small sample size, and radiographs have to be taken in order to use this chart.

Moorrees, Fanning and Hunt (1963) published charts based on a radiographic survey which gives details of the development of dentition. Their sample size is relatively larger (Radiographs of 380 American School children). Their chart shows the ages of attainment of a series of radiologic landmarks. The specimen radiographs has to be compared with this chart, in order to estimate age.

Gustafson and Koch published a chart cited by Johanson (1971) covering the development of dentition. The chart is based on pooled data collected from 19 sources published between 1909 and 1964. The landmarks of tooth development recorded in this chart are the commencement of mineralisation, the completion of crown formation, the completion of tooth eruption and termination of root formation. The advantage of this chart is that it has eruption dates. The drawback is that it is based on pooled data from various workers derived over a long period of time.

Clements, Davies – Thomas the Pickett (1953a, 1953b, 1957a, 1957b) studied the timing and sequence of eruption of the permanent

dentition in British school children. They observed the trend towards earlier eruption in children of superior socio-economic environment corresponding to the trend towards earlier development shown by over all body growth.

Nolla (1960) surveyed the development of the permanent dentition in a sample of 25 American boys and 25 American girls using serial annual radiography. She suggested that the development of the teeth should not be thought of as an isolated process, but as one which relates to other development processes.

Adler (1959) indicated some reasons for differences in the eruption times of permanent teeth. According to him there is a variation between summer and winter. In the south the eruption occurs earlier than in the north. A variation may also be found in different countries. Urbanization has caused an acceleration of the eruption. Different races have different mineralization and eruption dates. Tooth in child of well-to-do families erupt earlier than those in children from poor families (Bose 1909).

It has been mentioned that there is a marked difference in eruption time among countries situated in diverse parts of the world (Gustafson,

1966). New Zealand children were found to have earlier eruption dates than English children (Leslie, 1951).

Scott (1954) states that the third molar eruption is erratic, and absence of these teeth cannot be used as a basis for age estimation.

Stones et al (1951), and Sutow et al (1954), observed that girls tend to be earlier with regard to the eruption of permanent teeth. This was confirmed by Garn et al (1958a).

Glaiser and Hunt (1955), who studied mandibular first molar development in 25 boys and 25 girls from 18 months to 10 years of age, found that female tooth development occurs earlier than in males.

Cohen (1928) pointed that there was a clear difference in the eruption times between the upper and lower jaws. The lower permanent incisors erupt about one year earlier than do the corresponding teeth in the upper jaw. The same applies to the pre-molars and molars.

Brues (1958) found that since there is an individual variation in the rate of development of the dentition, with the teeth of some children erupting earlier than normal and those of others erupting later than normal, there is a degree of inaccuracy announcing to about a year and a half by the time the age of twelve is reached.

Kocher. R., Richardson.A. (1997) found that each lower tooth erupted before its upper counterpart except for the premolars, there was no significant difference in the age for eruption between right and left sides. The most frequent orders of eruption were unique o the subject. These occurred in 22% of upper and 33% of lower arches, and the classic sequence of first molar – central incisor – lateral incisior – first premolar – canine – second premolar – second molar (M1-I1-I2-PM1-C-PM2-M2) in the upper arch and I1-M1-I2-C-PM1-PM2-M2 in the lower arch occurred in only 16% of the upper arches and 13% of the lower arches. Males adhered to the text book sequence (20% upper, 17% lower) more than females (12% upper, 8% lower). In the upper arch of the females the order M1-I1-I2-PM1-PM2-C-M2- in 10% of the subjects was almost as frequent as the classic sequence. The difference relating to upper first premolar and lower canine were not statistically significant.

Wedl JS, Schroder V, Blake FA, Schmelzle R, Friedrich RE, (2002) in Turkey found in their study that the tooth eruption in the lower and upper jaw of male and female probands are symmerrical. In comparing the upper and the lower jaw of both genders, it becomes evident that there is a tendency for earlier tooth eruptions in the lower jaw. In respect to the

tooth eruption sequence, a change was noted in the upper jaw, contrary to the reports of other authors, the second premolar has changed places with the canine and erupts prior to this tooth. The computed differences of the tooth eruption as a mean value calculated over all teeth, was +/- 1year at maximum, compared to studies from different continents.

The need to develop specific norms and standards for dental eruption for each population has been well emphasized by Gustafson. It is evident that available charts of the eruption time can be used only for a particular race and a particular country and are valid only for normal children (Gustafson, 1966).

The present study attempts to fulfill the above need for regional observations specifically coming from the state of Tamilnadu.

The present study confirms the opinion of Rose (1909) that the range of variation is least in the first permanent molars and greatest in canines and second molars.

The sequence of eruption as observed in the present study is M1 ,I1 ,I2 ,PM1 ,PM2 , C ,M2 which corresponds closely to the sequence shown in the Logen Kronfeld table (1933) and that of Nayak.SK, and Patel.S (1977), Kocher.R., Richardson.A (1997).

The mean eruption times of this study are more or less approximating the mean eruption ages of the early eruptors among the British children as mentioned by Clement et al (1957), Wedl JS, Schroder,Blake FA, Schmelzle. R, Friedrich RE.(2002).

When the sexual dimorphism is considered the present study confirms the earlier observations that in females the permanent teeth erupt earlier than the males.

The present study confirms the observation of Cohen (1928) and others that the permanent teeth erupt earlier in the lower jaw than in the upper jaw. The maximum difference in the eruption times between the upper and lower jaws is found in the case of Central Incisors. All the remaining teeth except first and second premolars and lateral incisors exhibit early eruption in lower jaw. Conspicuously, both the premolars and lateral incisors are erupting later in the lower jaw both in males and females with canines in males only.

SUMMARY

1. 290 school children were examined for the eruption of permanent dentition. There were 200 boys and 90 girls.

2. The median ages of eruption of all the permanent teeth except the third molar were determined by the method of probit analysis.

3. The fiftieth (P_{50}) percentile values of the ages of eruption were estimated for each permanent tooth.

4. Standard charts for easy reference to the ages of eruption of various teeth in males and females have been constructed.

5. It has been found that in both sexes the eruption is earlier in the lower jaw than in the upper jaw .

6. The sexual dimorphism reported in the literature has been upheld by the present study. It has been found that females have earlier eruption times than males.

7. It has been recommended that studies of similar nature have to be conducted on samples from various geographic areas and various socio-economic strata. It has also been suggested that the influence of nutrition on the development of dentition has to be investigated.

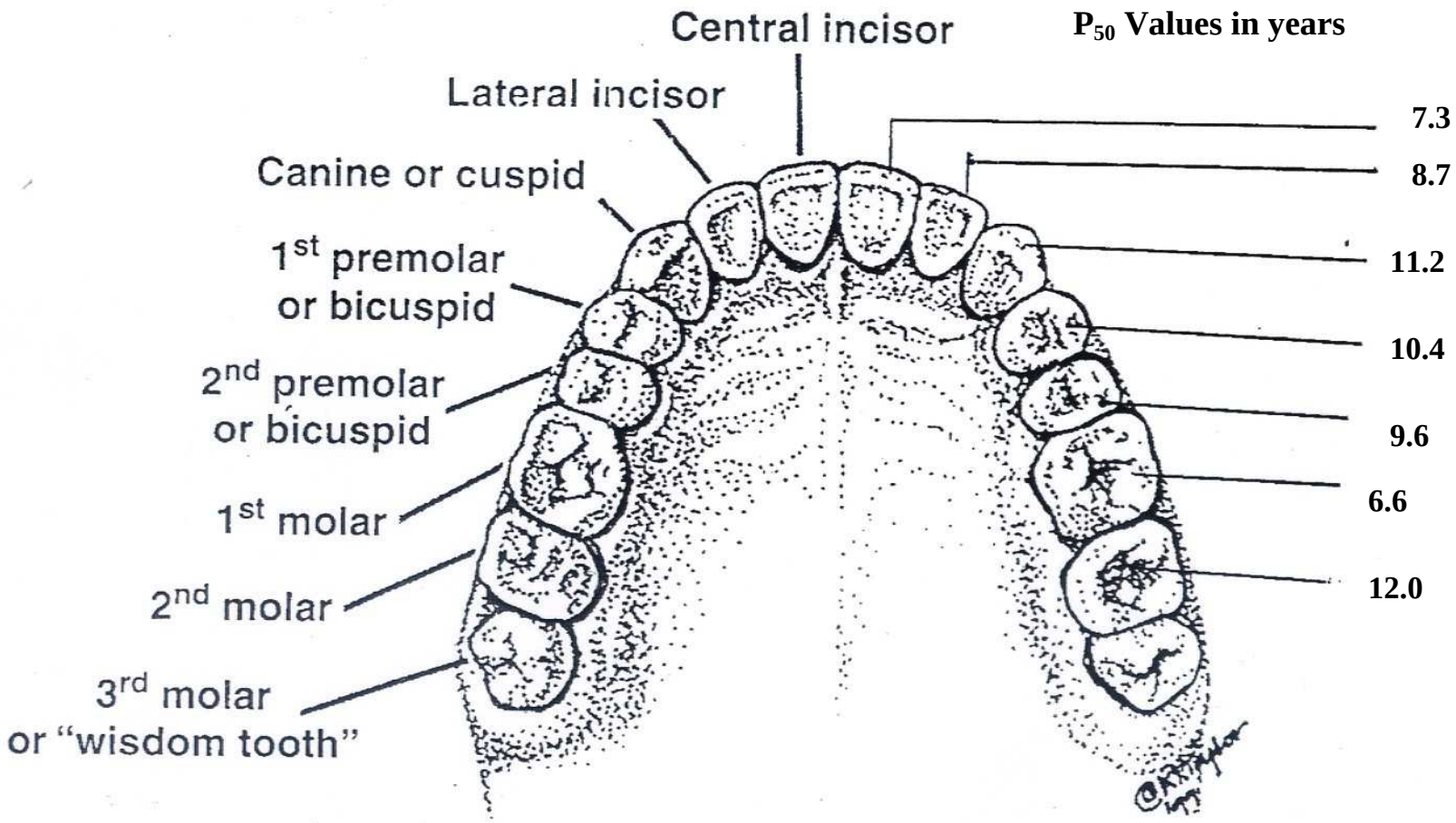


FIG.8. MEDIAN ERUPTION OF AGE OF TEETH IN LOWER JAW OF FEMALES

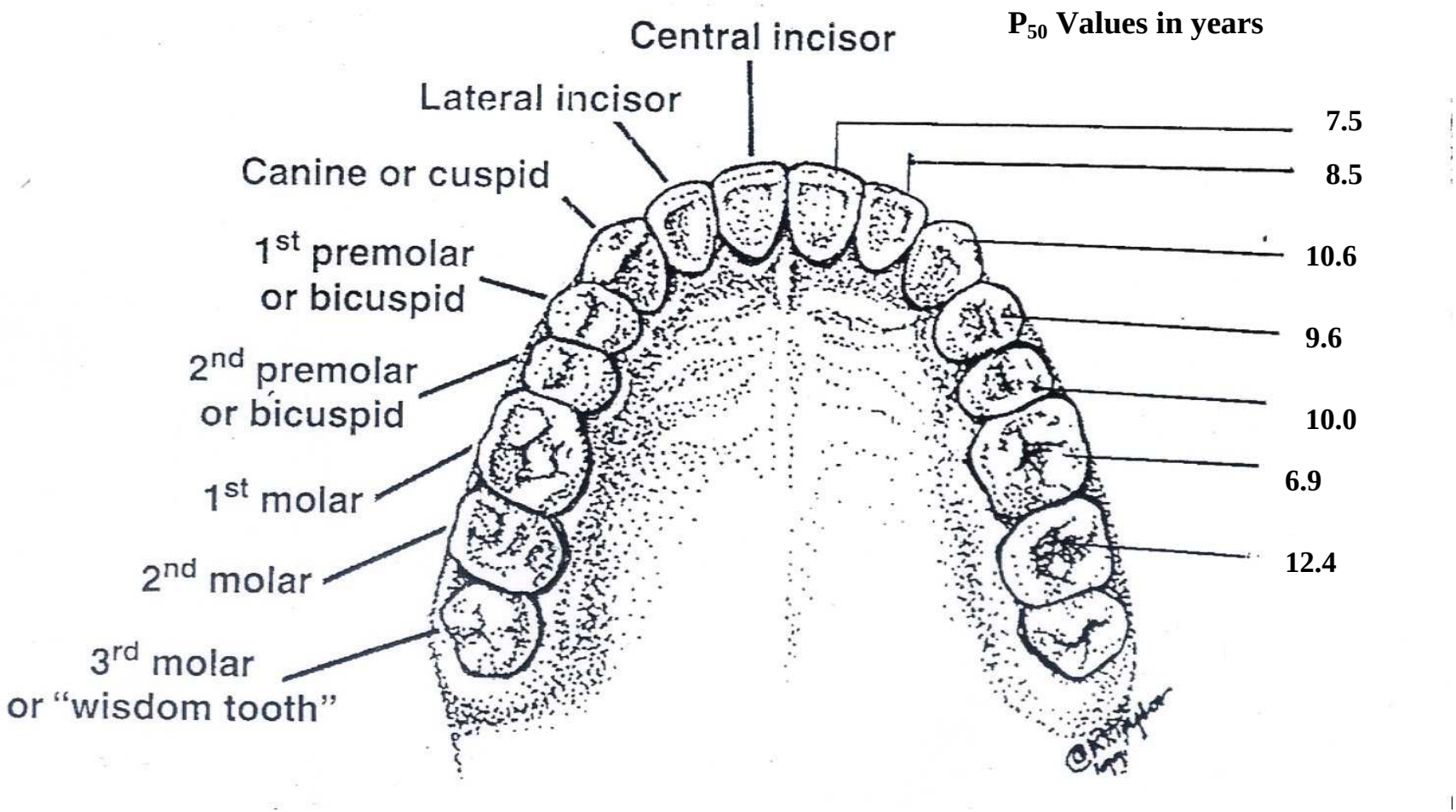


FIG.9. MEDIAN ERUPTION OF AGE OF TEETH IN UPPER JAW OF FEMALES

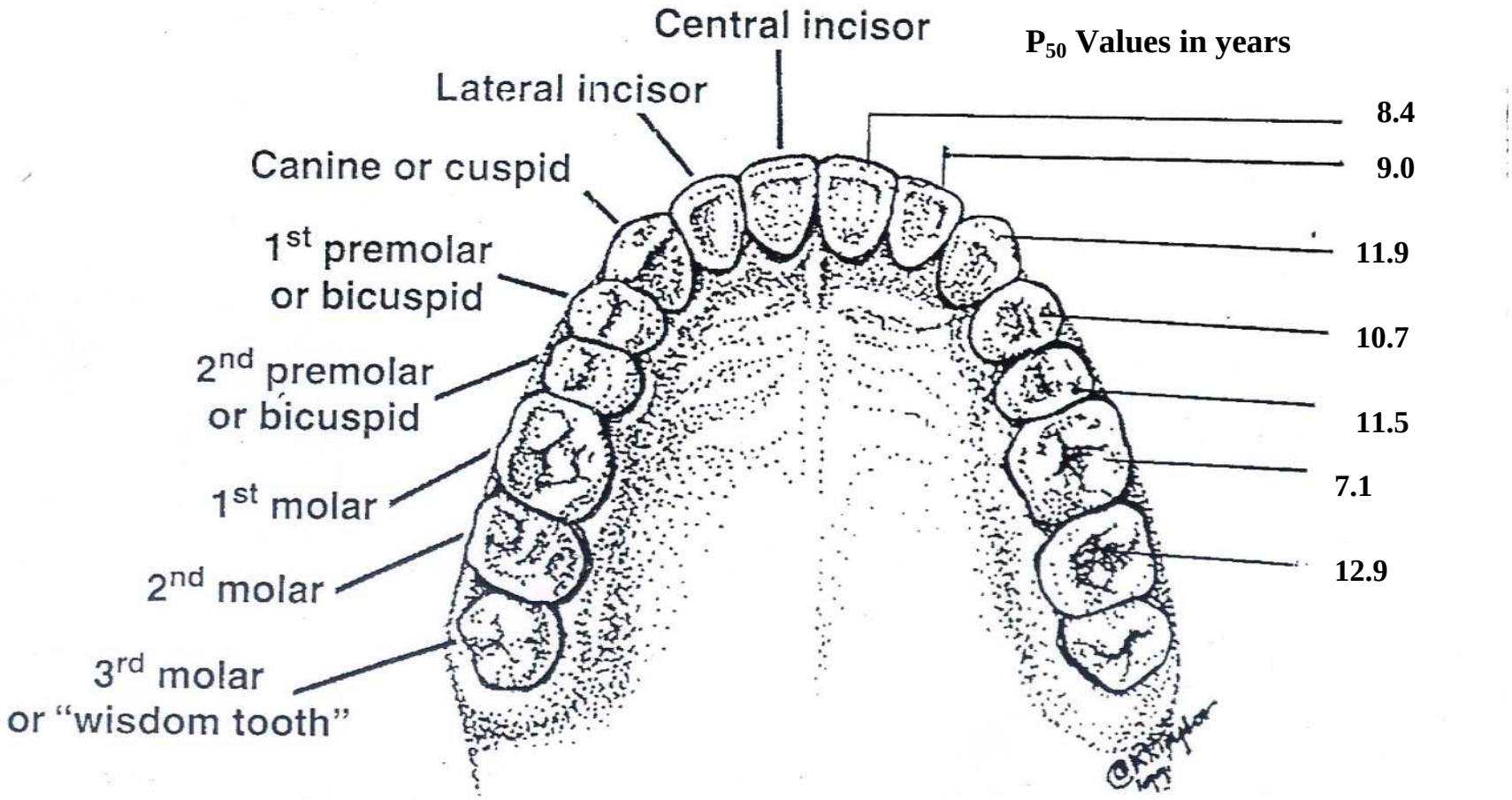


FIG.10. MEDIAN ERUPTION OF AGE OF TEETH IN LOWER JAW OF MALES

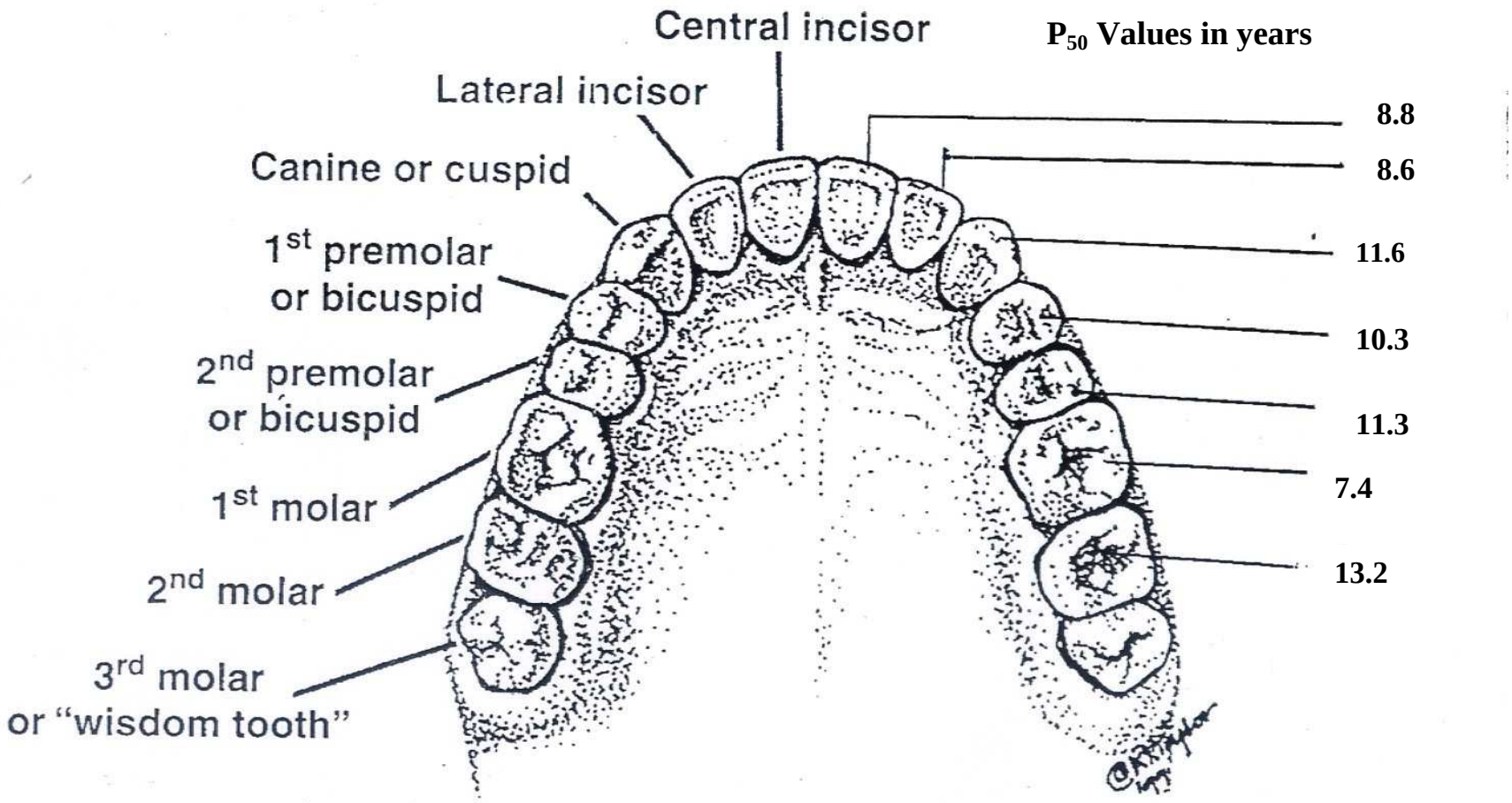


FIG.11. MEDIAN ERUPTION OF AGE OF TEETH IN UPPER JAW OF MALES

FIG.8. MEDIAN ERUPTION OF AGE OF TEETH IN LOWER JAW OF FEMALES

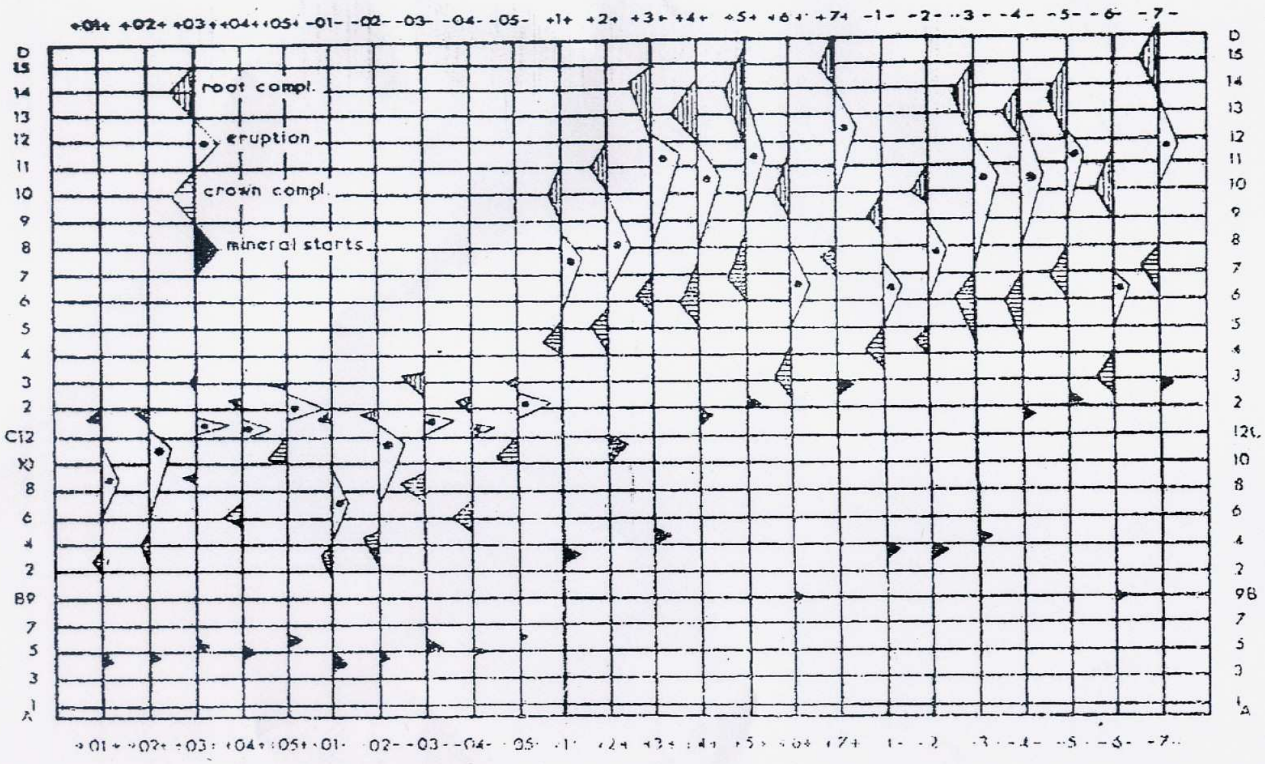


Fig.1 : Diagrammatic determination of dental development taken from Gustafson, G. and Koch, G. cited by Johanson, (1971). Each triangle represents one of four landmarks in tooth formation; commencement of miniralisation, the completion of crown formation, eruption, or the completion of tooth formation. For each land mark the apex of the triangle represents the average age, and the upper and lower angles the oldest and youngest ages encountered in the study.

Fig. 3 : Chronology of human dentition*

	Tooth		Formation of enamel matrix and dentin begin	Amount of enamel matrix formed at birth	Enamel completed	Emergence into oral cavity	Root completed
Primary dentition	Maxillary	Central incisor	4 mo. in utero	Five-sixths	1½ mo.	7½ mo.	1½ yr.
		Lateral incisor	4½ mo. in utero	Two – third	2mo.	9 mo.	2 yr.
		Canine	5 mo. in utero	One – third	9 mo.	18 mo.	3½ yr.
		First Molar	5 mo. in utero	Cusps united	6 mo.	14 mo.	2½ yr.
		Second Molar	6 mo. in utero	Cusps tips still isolated	11 mo.	24 mo.	3 yr.
	Mandibular	Central incisor	4½ mo. in utero	Three – fifths	2½ mo.	6 mo.	1½ yr.
		Lateral incisor	4½ mo. in utero	Three – fifths	3 mo.	7 mo.	1½ yr.
		Canine	5 mo. in utero	One – third	9 mo.	16 mo.	3½ yr.
		First Molar	5 mo. in utero	Cusps united	5½ mo.	12 mo.	2½ yr.
		Second Molar	6 mo. in utero	Cusps tips still isolated	10 mo.	20 mo.	3 yr.
Primary dentition	Maxillary	Central incisor	3 – 4 mo	Some times a trace	4 –5 yr.	7 – 8 yr.	10 yr
		Lateral incisor	10 – 12 mo		4 –5 yr.	8 – 9 yr.	11 yr
		Canine	4 – 5 mo		6 –7 yr.	11 – 12 yr.	13 – 15 yr
		First premolar	1½ - 1¾ yr		5 –6 yr.	10 – 11 yr.	12 – 13 yr
		Second premolar	2 – 2¼ yr		6 –7 yr.	10 – 12 yr.	12 – 14 yr
		First Molar	At birth		2½ –3 yr.	6 – 7 yr.	9 – 10 yr
		Second Molar	2½ - 3 yr		7 –8 yr.	12 – 13 yr.	14 – 16 yr
		Third Molar	7 – 9 yr		12 –16 yr.	17 – 21 yr.	18 – 25 yr
	Mandibular	Central incisor	3 – 4 mo	Some times a trace	4 –5 yr.	6 – 7 yr.	9 yr
		Lateral incisor	3 – 4 mo		4 –5 yr.	7 – 8 yr.	10 yr
		Canine	4 – 5 mo		6 –7 yr.	9 – 10 yr.	12 – 14 yr
		First premolar	1¾ – 2 yr		5 –6 yr.	10 – 12 yr.	12 – 13 yr
		Second premolar	2¼ – 2½ yr		6 –7 yr.	11 – 12 yr.	13 – 14 yr
		First Molar	At birth		2½ –3 yr.	6 – 7 yr.	9 – 10 yr
		Second Molar	2½ - 3 yr		7 –8 yr.	11 – 13 yr.	14 – 15 yr
		Third Molar	8 – 10 yr		12 –16 yr.	17 – 21 yr.	18 – 25 yr

* From Logan, W.H.,M and Kronfeld, R., J. Amer. Dent. Ass. 20:379, 1933; slightly modified by McCall and Schour.

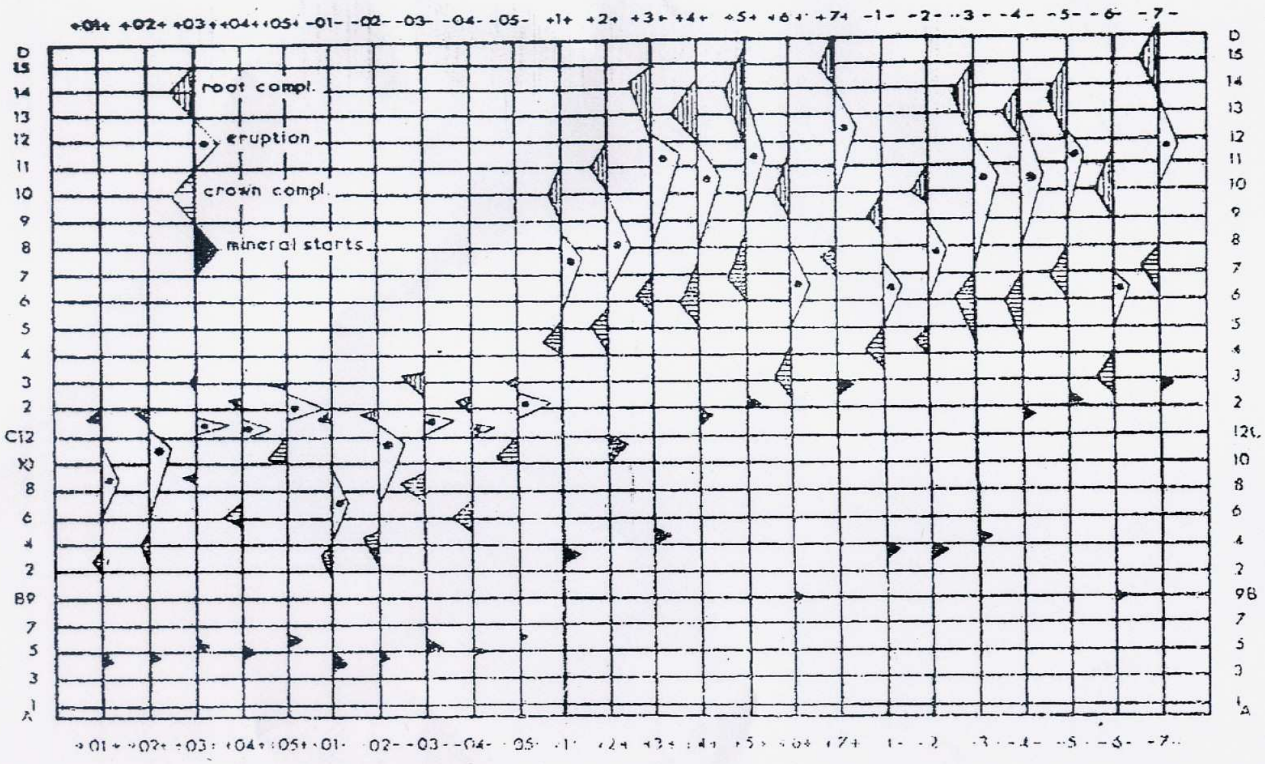


Fig.1 : Diagrammatic determination of dental development taken from Gustafson, G. and Koch, G. cited by Johanson, (1971). Each triangle represents one of four landmarks in tooth formation; commencement of miniralisation, the completion of crown formation, eruption, or the completion of tooth formation. For each land mark the apex of the triangle represents the average age, and the upper and lower angles the oldest and youngest ages encountered in the study.

KUSRI'S TRIANGLE

KEY	No	1	2	3	4	5	6	7
	Tooth	I1	I2	C	PM1	PM2	M1	M2

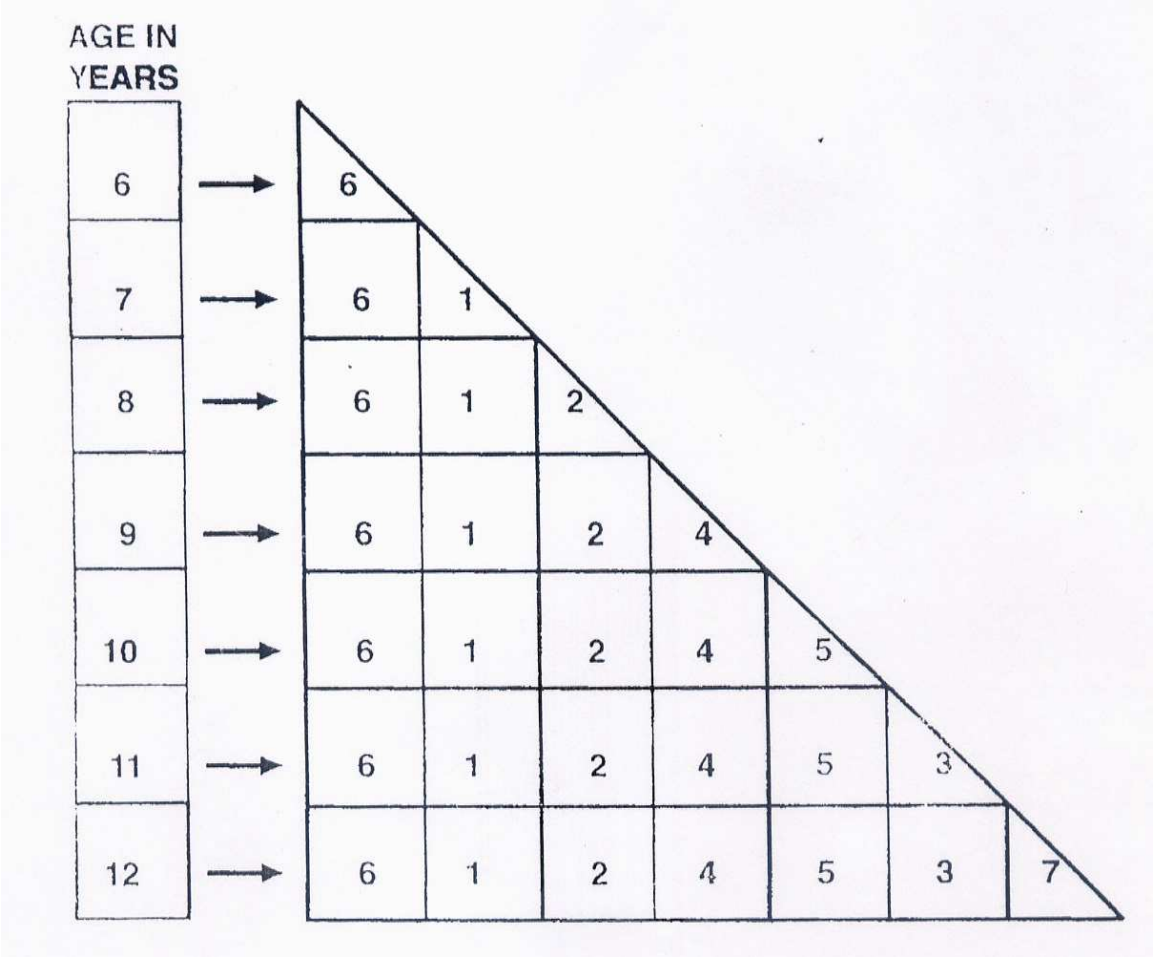


FIG.7. KUSRI'S TRIANGLE

Table No.1 Age distribution of Eruption of First Molar in Males.

Sl.No	Age group (year)	No. of Subjects	ERUPTION					
			Lower Jaw		Upper Jaw		All the 4 teeth	
			No. of subjects	Percentage	No. of subjects	Percentage	No. of subjects	Percentage
1	6.0-6.5	10	4	40	2	20	1	10
2	6.5-7.0	10	6	60	4	40	3	30
3	7.0-7.5	10	7	70	6	60	5	50
4	7.5-8.0	10	10	100	10	100	10	100

Table No.2 Age distribution of Eruption of First Molar in Females.

Sl.No	Age group (year)	No. of Subjects	ERUPTION					
			Lower Jaw		Upper Jaw		All the 4 teeth	
			No. of subjects	Percentage	No. of subjects	Percentage	No. of subjects	Percentage
1	6.0-6.5	5	3	60	2	40	2	40
2	6.5-7.0	5	4	80	3	60	2	40
3	7.0-7.5	5	5	100	5	100	5	100

Table No.3 Age distribution of Eruption of central Incisor in Males.

Sl.No	Age group (year)	No. of Subjects	ERUPTION					
			Lower Jaw		Upper Jaw		All the 4 teeth	
			No. of subjects	Percentage	No. of subjects	Percentage	No. of subjects	Percentage
1	6.0-6.5	10	2	20	2	20	1	10
2	6.5-7.0	10	2	20	2	20	2	20
3	7.0-7.5	10	6	60	4	40	3	30
4	7.5-8.0	10	7	70	6	60	4	40
5	8.0-8.5	10	7	70	6	60	4	40
6	8.5-9.0	10	8	80	6	60	5	50
7	9.0-9.5	10	8	80	7	70	8	80
8	9.5-10.0	10	9	90	8	80	8	80
9	10.0-10.5	10	10	100	10	100	10	100

Table No.4 Age distribution of Eruption of Central incisor in Females.

Sl.No	Age group (year)	No. of Subjects	ERUPTION					
			Lower Jaw		Upper Jaw		All the 4 teeth	
			No. of subjects	Percentage	No. of subjects	Percentage	No. of subjects	Percentage
1	6.0-6.5	5	2	40	2	40	1	20
2	6.5-7.0	5	2	40	2	40	2	20
3	7.0-7.5	5	3	60	2	40	3	60
4	7.5-8.0	5	3	60	3	60	3	60
5	8.0-8.5	5	4	80	3	60	4	80
6	8.5-9.0	5	5	100	4	80	4	80
7	9.0-9.5	5	5	100	5	100	5	100

Table No.5 Age distribution of Eruption of Lateral Incisor in Males.

Sl.No	Age group (year)	No. of Subjects	ERUPTION					
			Lower Jaw		Upper Jaw		All the 4 teeth	
			No. of subjects	Percentage	No. of subjects	Percentage	No. of subjects	Percentage
1	6.0-6.5	10	1	10	0	0	0	0
2	6.5-7.0	10	2	20	1	20	0	0
3	7.0-7.5	10	2	20	1	20	1	10
4	7.5-8.0	10	3	30	3	30	2	20
5	8.0-8.5	10	4	40	3	30	2	20
6	8.5-9.0	10	4	40	5	50	3	30
7	9.0-9.5	10	5	50	6	60	4	40
8	9.5-10.0	10	6	60	6	60	5	50
9	10.0-10.5	10	7	70	6	60	6	60
10	10.5-11.0	10	8	80	7	70	7	70
11	11.0-11.5	10	9	90	8	80	8	80
12	11.5-12.0	10	10	100	9	90	9	90
13	12.0-12.5	10	10	100	10	100	10	100

Table No.6 Age distribution of Eruption of Lateral Incisor in Females.

Sl.No	Age group (year)	No. of Subjects	ERUPTION					
			Lower Jaw		Upper Jaw		All the 4 teeth	
			No. of subjects	Percentage	No. of subjects	Percentage	No. of subjects	Percentage
1	6.0-6.5	5	1	20	1	20	0	0
2	6.5-7.0	5	1	20	2	40	1	20
3	7.0-7.5	5	1	20	3	60	2	40
4	7.5-8.0	5	3	60	4	80	3	60
5	8.0-8.5	5	3	60	4	80	3	60
6	8.5-9.0	5	3	60	4	80	3	60
7	9.0-9.5	5	4	80	4	80	4	80
8	9.5-10.0	5	4	80	4	80	4	80
9	10.0-10.5	5	5	100	5	100	4	80
10	10.5-11.0	5	5	100	5	100	5	100
11	11.0-11.5	5	5	100	5	100	5	100

Table No.7 Age distribution of Eruption of First Premolar in Males.

Sl.No	Age group (year)	No. of Subjects	ERUPTION					
			Lower Jaw		Upper Jaw		All the 4 teeth	
			No. of subjects	Percentage	No. of subjects	Percentage	No. of subjects	Percentage
1	6.0-6.5	10	0	0	0	0	0	0
2	6.5-7.0	10	0	0	0	0	0	0
3	7.0-7.5	10	0	0	0	0	0	0
4	7.5-8.0	10	0	0	0	0	0	0
5	8.0-8.5	10	1	10	1	10	0	0
6	8.5-9.0	10	1	10	1	10	1	10
7	9.0-9.5	10	1	10	2	20	1	10
8	9.5-10.0	10	2	20	3	30	2	20
9	10.0-10.5	10	4	40	5	50	4	40
10	10.5-11.0	10	6	60	7	70	5	50
11	11.0-11.5	10	8	80	8	80	6	60
12	11.5-12.0	10	8	80	8	80	8	80
13	12.0-12.5	10	9	90	9	90	8	80
14	12.5-13.0	10	10	100	10	100	10	100
15	13.0-13.5	10	10	100	10	100	10	100

Table No.8 Age distribution of Eruption of First Premolar in Females.

Sl.No	Age group (year)	No. of Subjects	ERUPTION					
			Lower Jaw		Upper Jaw		All the 4 teeth	
			No. of subjects	Percentage	No. of subjects	Percentage	No. of subjects	Percentage
1	6.0-6.5	5	0	0	0	0	0	0
2	6.5-7.0	5	0	0	0	0	0	0
3	7.0-7.5	5	1	20	1	20	0	0
4	7.5-8.0	5	1	20	1	20	0	0
5	8.0-8.5	5	1	20	2	40	0	0
6	8.5-9.0	5	2	40	2	40	1	20
7	9.0-9.5	5	2	40	3	60	1	20
8	9.5-10.0	5	2	40	3	60	2	40
9	10.0-10.5	5	3	60	4	80	3	60
10	10.5-11.0	5	3	60	4	80	3	60
11	11.0-11.5	5	4	80	4	80	4	80
12	11.5-12.0	5	4	80	5	100	4	80
13	12.0-12.5	5	5	100	5	100	5	100

Table No.9 Age distribution of Eruption of Second Premolar in Males.

Sl.No	Age group (year)	No. of Subjects	ERUPTION					
			Lower Jaw		Upper Jaw		All the 4 teeth	
			No. of subjects	Percentage	No. of subjects	Percentage	No. of subjects	Percentage
1	7.0-7.5	10	0	0	0	0	0	0
2	7.5-8.0	10	0	0	1	10	0	0
3	8.0-8.5	10	1	10	1	10	0	0
4	8.5-9.0	10	2	20	2	20	0	0
5	9.0-9.5	10	2	20	3	30	1	10
6	9.5-10.0	10	3	30	4	40	2	20
7	10.0-10.5	10	4	40	4	40	3	30
8	10.5-11.0	10	4	40	5	50	5	50
9	11.0-11.5	10	5	50	6	60	5	50
10	11.5-12.0	10	5	50	7	70	6	60
11	12.0-12.5	10	7	70	8	80	7	70
12	12.5-13.0	10	8	80	8	80	8	80
13	13.0-13.5	10	8	80	9	90	9	90
14	13.5-14.0	10	10	100	10	100	10	100

Table No.10 Age distribution of Eruption of Second Premolar in Females.

Sl.No	Age group (year)	No. of Subjects	ERUPTION					
			Lower Jaw		Upper Jaw		All the 4 teeth	
			No. of subjects	Percentage	No. of subjects	Percentage	No. of subjects	Percentage
1	7.0-7.5	5	1	20	1	20	0	0
2	7.5-8.0	5	1	20	1	20	0	0
3	8.0-8.5	5	1	20	2	40	0	0
4	8.5-9.0	5	2	40	2	40	1	20
5	9.0-9.5	5	3	60	2	40	2	40
6	9.5-10.0	5	3	60	3	60	2	40
7	10.0-10.5	5	4	80	3	60	2	40
8	10.5-11.0	5	4	80	4	80	3	60
9	11.0-11.5	5	4	80	4	80	3	60
10	11.5-12.0	5	4	80	5	100	4	80
11	12.0-12.5	5	5	100	5	100	5	100
12	12.5-13.0	5	5	100	5	100	5	100

Table No.11 Age distribution of Eruption of Canine in Males.

Sl.No	Age group (year)	No. of Subjects	ERUPTION					
			Lower Jaw		Upper Jaw		All the 4 teeth	
			No. of subjects	Percentage	No. of subjects	Percentage	No. of subjects	Percentage
1	7.0-7.5	10	0	0	0	0	0	0
2	7.5-8.0	10	0	0	0	0	0	0
3	8.0-8.5	10	0	0	0	0	0	0
4	8.5-9.0	10	1	10	1	10	0	0
5	9.0-9.5	10	2	20	1	10	0	0
6	9.5-10.0	10	2	20	2	20	1	10
7	10.0-10.5	10	3	30	3	30	2	20
8	10.5-11.0	10	4	40	3	30	3	30
9	11.0-11.5	10	4	40	5	50	4	40
10	11.5-12.0	10	5	50	5	50	5	50
11	12.0-12.5	10	7	70	6	60	6	60
12	12.5-13.0	10	8	80	7	70	7	70
13	13.0-13.5	10	9	90	8	80	7	70
14	13.5-14.0	10	9	90	9	90	8	80
15	14.0-14.5	10	9	90	9	90	9	90
16	14.5-15.0	10	10	100	10	100	10	100

Table No.12 Age distribution of Eruption of Canine in Females.

Sl.No	Age group (year)	No. of Subjects	ERUPTION					
			Lower Jaw		Upper Jaw		All the 4 teeth	
			No. of subjects	Percentage	No. of subjects	Percentage	No. of subjects	Percentage
1	7.0-7.5	5	0	0	0	0	0	0
2	7.5-8.0	5	0	0	0	0	0	0
3	8.0-8.5	5	1	20	1	20	0	0
4	8.5-9.0	5	1	20	2	40	0	0
5	9.0-9.5	5	2	40	2	40	1	20
6	9.5-10.0	5	2	40	2	40	1	20
7	10.0-10.5	5	2	40	3	60	2	40
8	10.5-11.0	5	3	60	2	40	2	40
9	11.0-11.5	5	3	60	3	60	3	60
10	11.5-12.0	5	3	60	4	80	3	60
11	12.0-12.5	5	4	80	3	60	3	60
12	12.5-13.0	5	4	80	4	80	4	80
13	13.0-13.5	5	5	100	5	100	4	80
14	13.5-14.0	5	5	100	5	100	5	100

Table No.13 Age distribution of Eruption of Second Molar in Males.

Sl.No	Age group (year)	No. of Subjects	ERUPTION					
			Lower Jaw		Upper Jaw		All the 4 teeth	
			No. of subjects	Percentage	No. of subjects	Percentage	No. of subjects	Percentage
1	8.0-8.5	10	0	0	0	0	0	0
2	8.5-9.0	10	0	0	0	0	0	0
3	9.0-9.5	10	0	0	0	0	0	0
4	9.5-10.0	10	1	10	1	10	0	0
5	10.0-10.5	10	1	10	2	20	0	0
6	10.5-11.0	10	1	10	2	20	1	10
7	11.0-11.5	10	2	20	3	30	1	10
8	11.5-12.0	10	3	30	4	40	2	20
9	12.0-12.5	10	4	40	4	40	3	30
10	12.5-13.0	10	5	50	5	50	4	40
11	13.0-13.5	10	6	60	5	50	5	50
12	13.5-14.0	10	7	70	6	60	6	60
13	14.0-14.5	10	8	80	7	70	7	70
14	14.5-15.0	10	9	90	9	90	8	80
15	15.0-15.5	10	10	100	10	100	9	90
16	15.5-16.0	10	10	100	10	100	10	100

Table No.14 Age distribution of Eruption of Second Molar in Females.

Sl.No	Age group (year)	No. of Subjects	ERUPTION					
			Lower Jaw		Upper Jaw		All the 4 teeth	
			No. of subjects	Percentage	No. of subjects	Percentage	No. of subjects	Percentage
1	8.0-8.5	5	0	0	0	0	0	0
2	8.5-9.0	5	0	0	0	0	0	0
3	9.0-9.5	5	0	0	1	20	0	0
4	9.5-10.0	5	1	20	1	20	0	0
5	10.0-10.5	5	1	20	1	20	1	20
6	10.5-11.0	5	1	20	2	40	1	20
7	11.0-11.5	5	2	40	2	40	2	40
8	11.5-12.0	5	2	40	3	60	2	40
9	12.0-12.5	5	3	60	3	60	3	60
10	12.5-13.0	5	3	60	3	60	3	60
11	13.0-13.5	5	4	80	3	60	4	80
12	13.5-14.0	5	4	80	4	80	4	80
13	14.0-14.5	5	5	100	5	100	4	80
14	14.5-15.0	5	5	100	5	100	5	100

Table No. 15 Median Eruption Times (P 50) in years – First Molar.

Sl.No.	Percentage	Males			Females		
		Lower	Upper	All the 4 teeth	Lower	Upper	All the 4 teeth
1	P_{50}	7.10	7.40	7.45	6.60	6.90	7.20

Table No. 16 Median Eruption Times (P 50) in years - Central Incisor.

Sl.No.	Percentage	Males			Females		
		Lower	Upper	All the 4 teeth	Lower	Upper	All the 4 teeth
1	P_{50}	8.40	8.80	9.45	7.30	7.50	8.20

Table No. 17 Median Eruption Times (P 50) in years - Lateral Incisor.

Sl.No.	Percentage	Males			Females		
		Lower	Upper	All the 4 teeth	Lower	Upper	All the 4 teeth
1	P_{50}	9.00	8.60	9.50	8.70	8.50	9.30

Table No. 18 Median Eruption Times (P 50) in years - First Premolar.

Sl.No.	Percentage	Males			Females		
		Lower	Upper	All the 4 teeth	Lower	Upper	All the 4 teeth
1	P_{50}	10.70	10.30	11.40	10.40	9.60	10.70

Table No. 19 Median Eruption Times (P 50) in years - Second Premolar.

Sl.No.	Percentage	Males			Females		
		Lower	Upper	All the 4 teeth	Lower	Upper	All the 4 teeth
1	P_{50}	11.50	11.30	11.80	9.60	10.00	10.75

Table No. 20 Median Eruption Times (P 50) in years - Canine.

Sl.No.	Percentage	Males			Females		
		Lower	Upper	All the 4 teeth	Lower	Upper	All the 4 teeth
1	P_{50}	11.90	11.60	12.35	11.20	10.60	12.45

Table No. 21 Median Eruption Times (P 50) in years - Second Molar.

Sl.No.	Percentage	Males			Females		
		Lower	Upper	All the 4 teeth	Lower	Upper	All the 4 teeth
1	P_{50}	12.90	13.20	13.40	12.00	12.40	13.00

Fig.4. Median Age of Eruption in Males

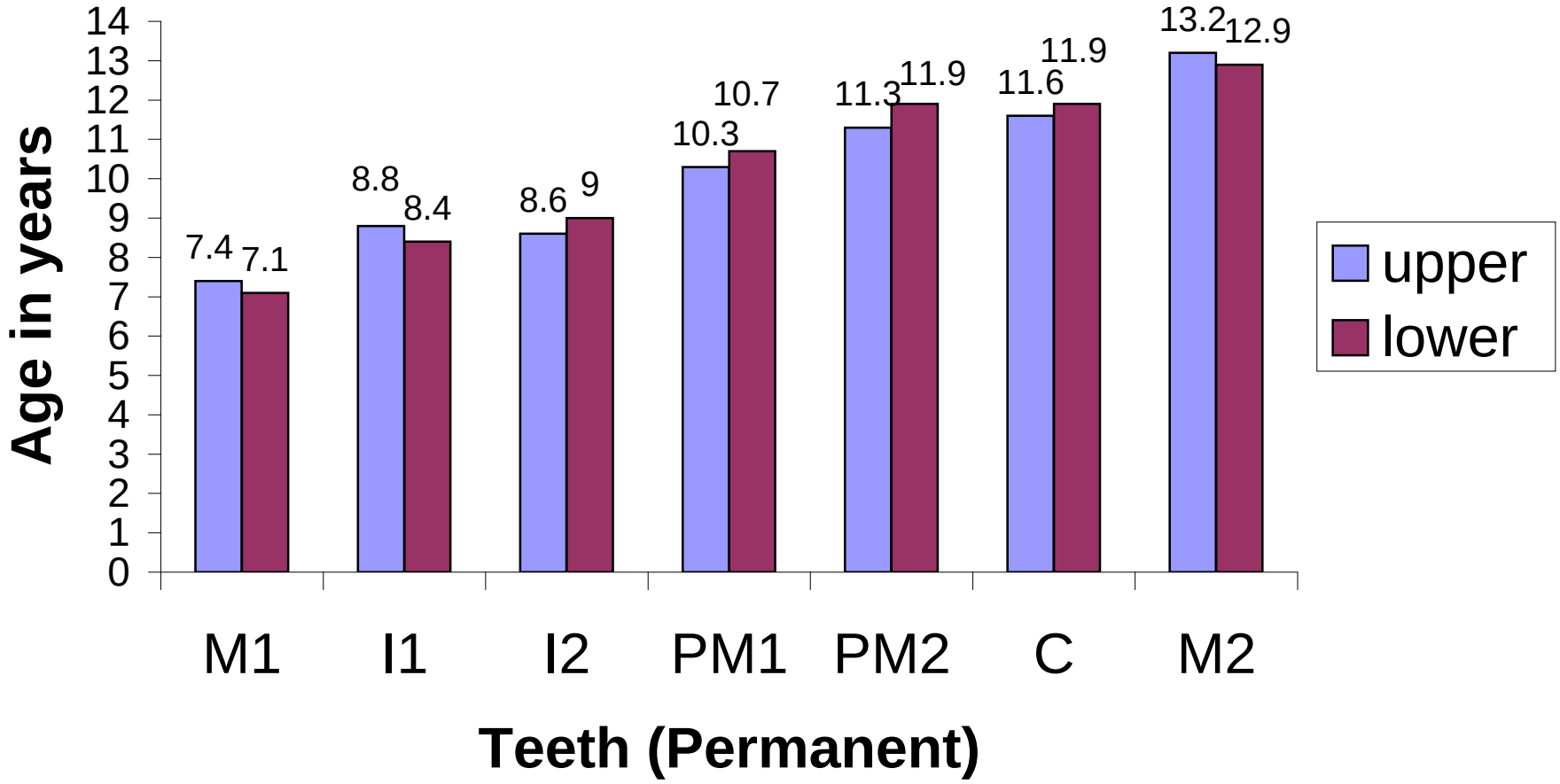


Fig.5.Median Age of Eruption in Females

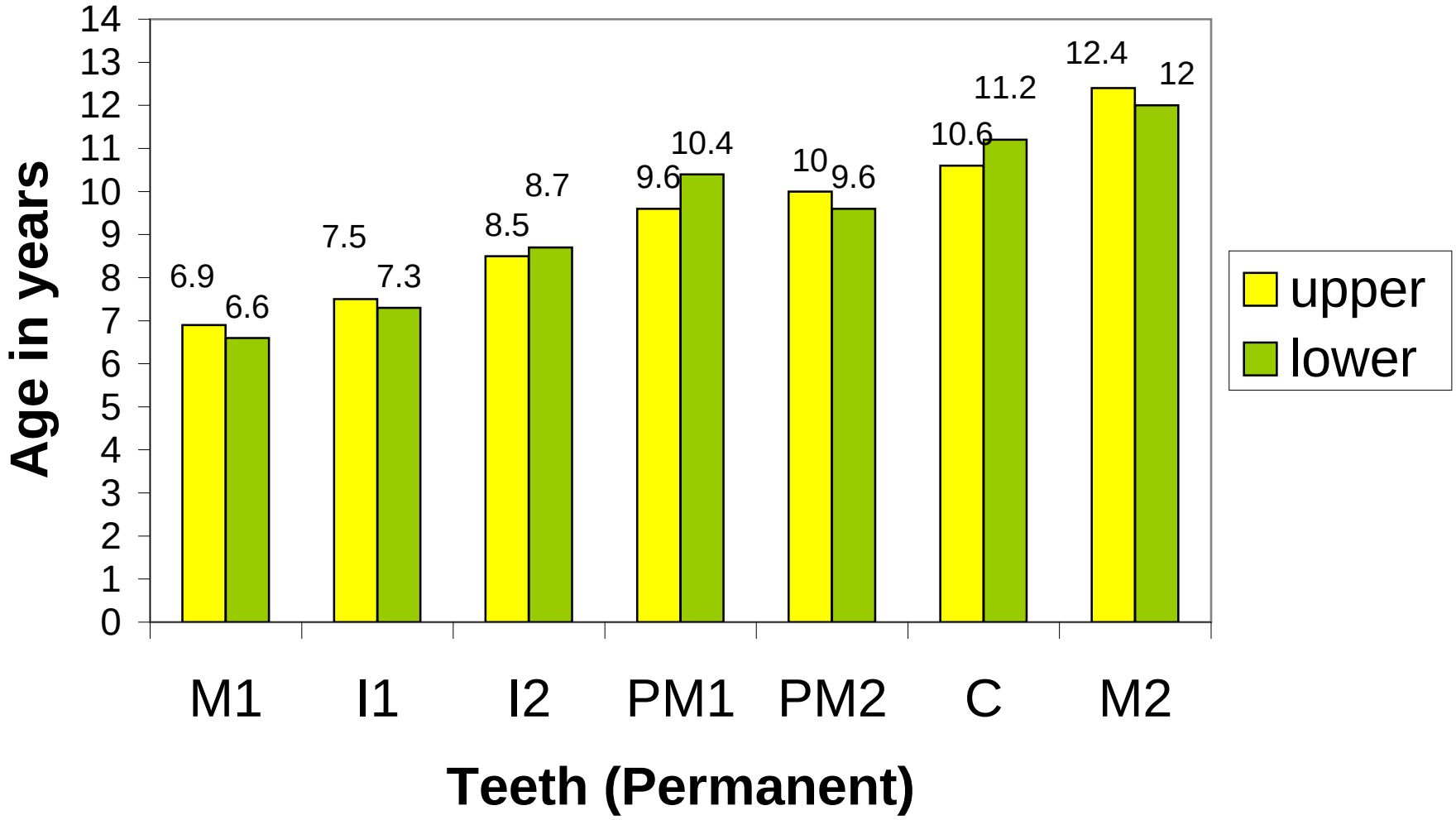
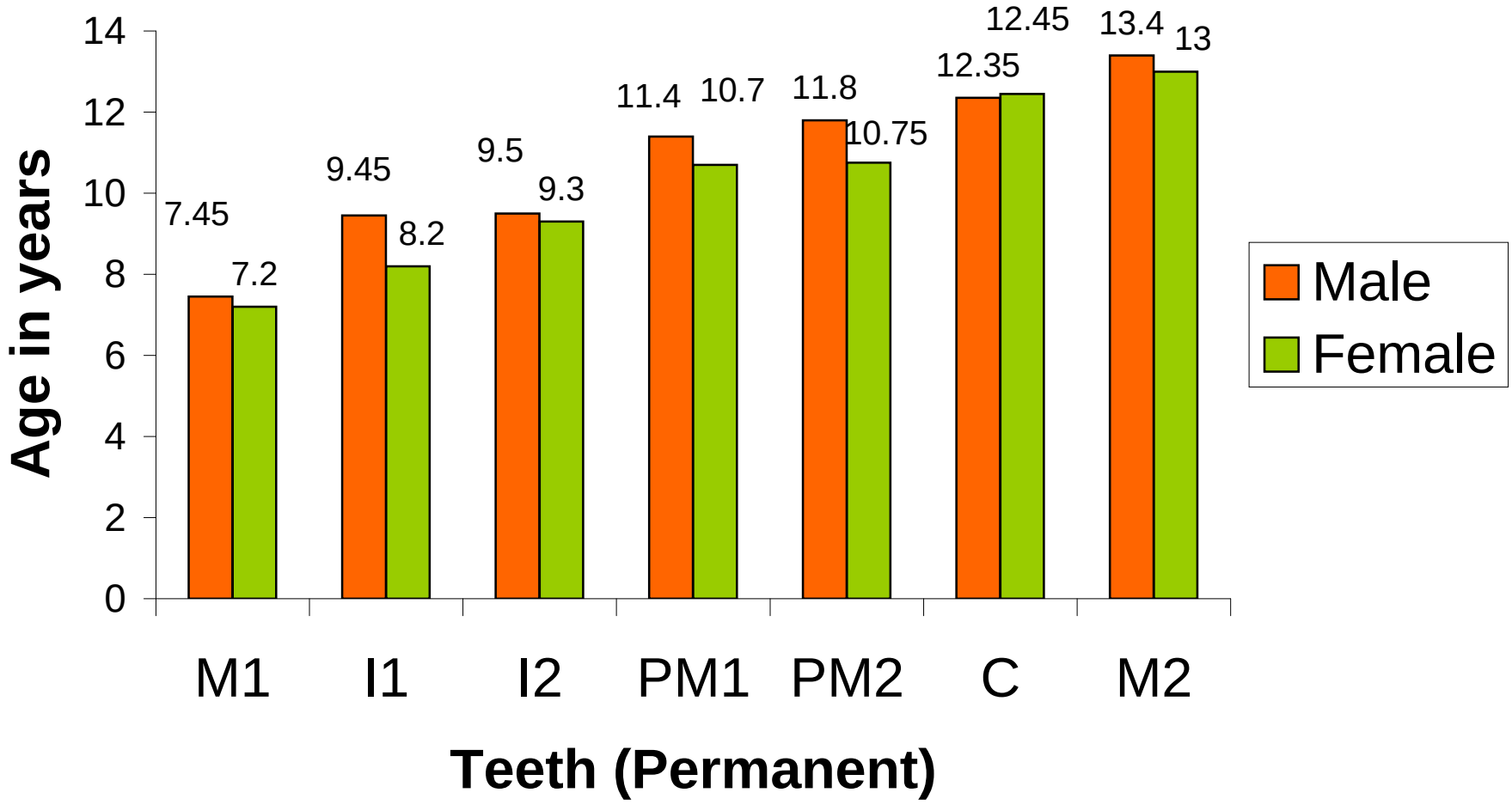


Fig.6.Median Age of Eruption in Males & Females



APPENDIX

THE TECHNIQUE OF PROBIT ANALYSIS

Problems of quantification in biomedical research concerning the relation between a stimulus (a drug, an etiological factor, a mode of therapy etc.) and a response (change in a patient's parameter, occurrence or non-occurrence of a disease, alteration in the prognosis of a patient etc.,). The problem gets complicated when the response is not exactly determined by knowledge of the stimulus and repetitions of experiments or observations for the fixed dose of the stimulus do not all give the same magnitude of response. Quantitative measurement of a response is almost always to be preferred when practicable. However, certain types of responses do not permit quantification and can only be expressed as 'occurring' or 'not occurring' of a particular event, which is called quantal response. The use of the statistical technique of 'probit analysis' of biological data began about 1935, and has been mainly used in drug assays.

The present problem can be viewed as a biological assay where the response is quantal in nature. In the 'stimulus – response' (or Dose-

Response) terminology mentioned above, the problem can be reduced to finding the relation between the age of the subject (age is the stimulus at different doses namely different age groups) and the eruption of the various teeth (the response is taken as the eruption or non-eruption, a quantal response).

In such studies the choice of the dose spectrum (or range) is very important. The general principle is to start with the dose that produces the least or no response and to study up-to-the dose that produces the maximum or 100% response. Accordingly, from the collected data, suitable tables have been constructed for each tooth with the appropriate age range, which obviously differs from tooth to tooth and from male to female.

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