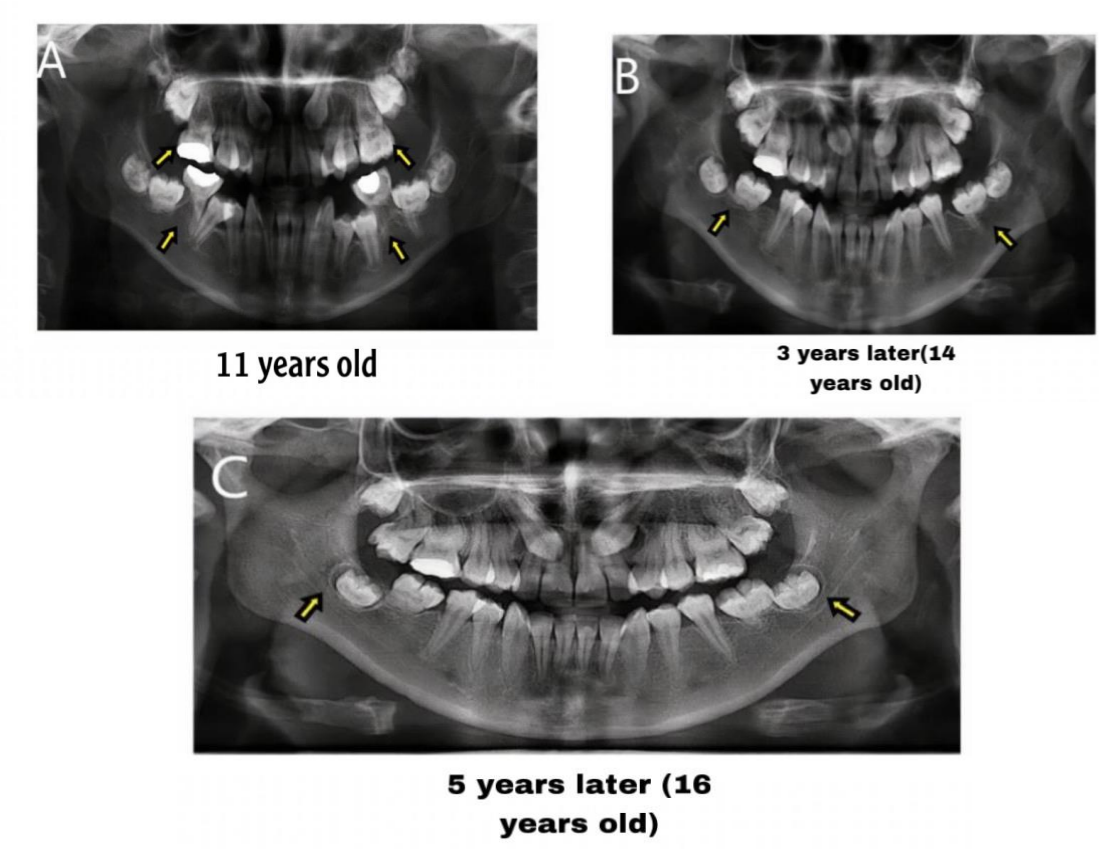
Salahaddin university

College of science

Physics department



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Abstract

Background:- age estimation is a significant role in forensic medicine, pediatric endocrinology, and also in connection between crime and accidents. In addition, chronological age is important in educational purpose, job purpose, school attendance. There are many procedures for estimating age, such as chronological age, skeletal age, mental age, facial age, and others.

Aim and objective:- aim of this study to calculate dental age which can be assessed by detecting the timing of eruption sequence and the mineralization degree of developing teeth from dental radiograph. And to compare between different radiographic methods to find dental age which is compared to chronological age.

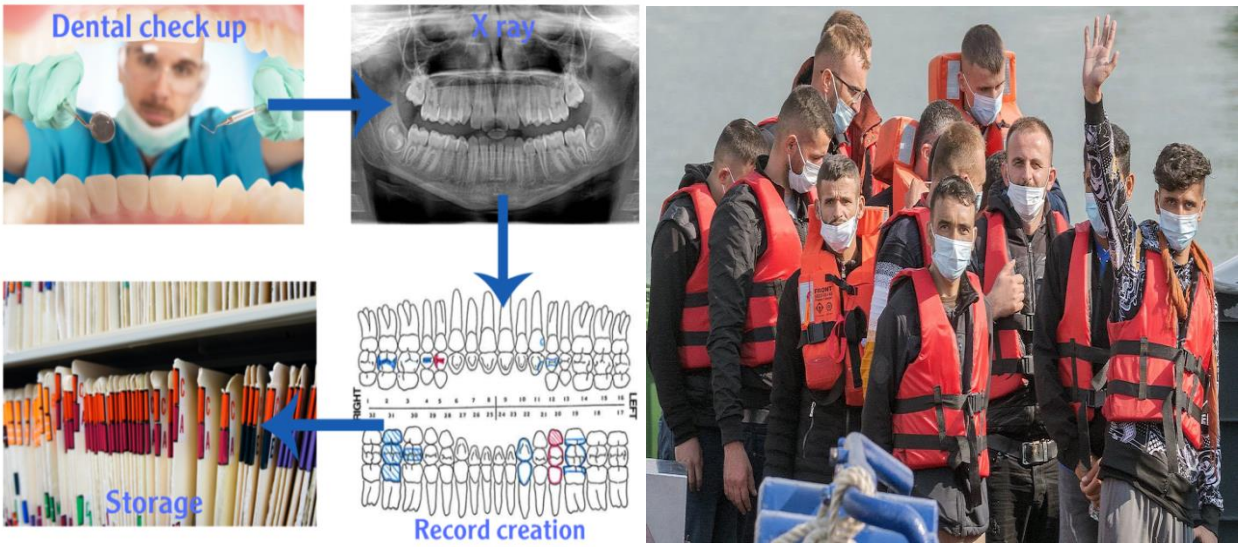
Material and method:- this study comprised of 50 subjects of age range 6-23 years. Dental age was calculated using cameriere and demirjian methods and was compared to chronological age. The recorded data of each patient included name, gender, and date of birth. All of the data were collected according to included and excluded criteria.

Introduction

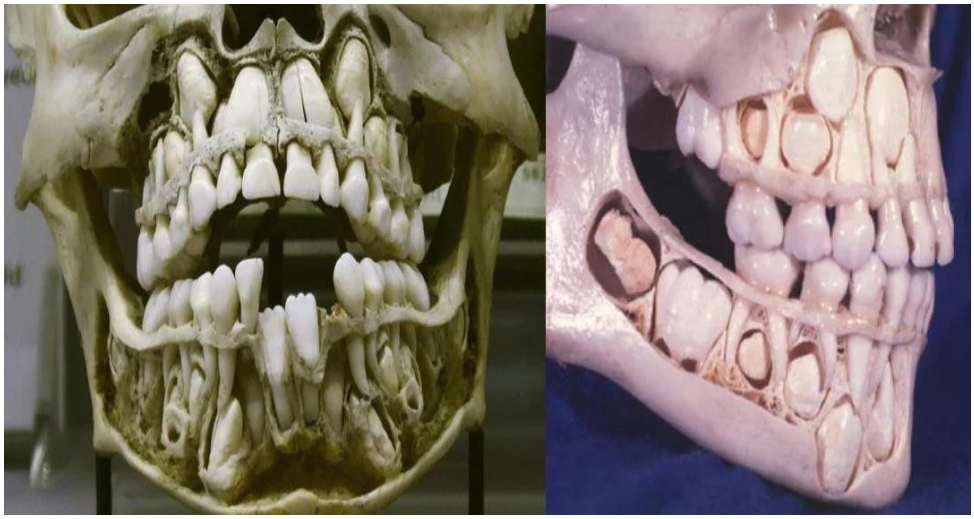
background

Estimation of dental age is a subfield of forensic dentistry that focuses on determining a person's age. The parameters used to estimate the age of teeth are tooth development, biochemical and post-formation changes(1).
Chronological age is one of the essential components of any individual’s identity. It is important on the legal, medical and medicological front. It’s very easy to calculate chronological age for people who have proper documentation of their date of birth. But it’s very difficult to estimate chronological age for people who have no documentation or faulty in documentation. It becomes very difficult to set up a personal CA that can manipulate the identity of the data subject. It is also possible for a person's identity to be lost for other reasons, such as death from a natural disaster or victim of crime. Identifying the chronological age by means other than date of birth therefore becomes an essential tool. For this reason, estimating the CA with morphological and radiological analysis of teeth has gained popularity in pediatric dentistry, orthodontics, forensic dentistry, human anthropology, bioarchaeology, psychometrics etc., [1,2]. Children’s who have the same CA may show differences in the developmental stages of different biological systems. Thus, to bridge this gap between the actual CA and the developmental ages, several indicators have been formulated, such as sexual maturity indicators, somatic maturity, skeletal age and DA [3,4]. The dental age estimation has been accepted in forensic odontology because it is less variable when compared to other Indicators and less affected by environmental factors [5]. There are many methods to measure dental development including anatomy, histology, tooth emergence dates and radiology. the most practical
and dependable of these are radiographic techniques. [6].(2)

Determining the age of a living person is important in cases where there is no birth certificate, such as when a person marries , enrolls in school, joins the military, or when a person is accused of a crime, such as rape, kidnapping, illegal immigration, prematu re birth, orthodontic malocclusion, or pediatric endocrinopathy. [2,3] (3). Age determination is crucial for identifying people at crime scenes, terrorist incidents, and natural disasters (4).



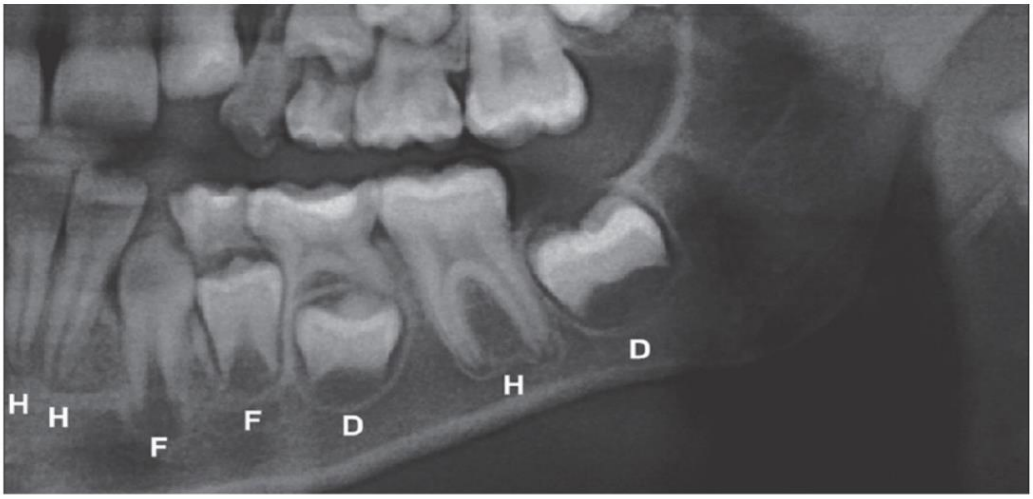
Fig(1):- in these cases panoramic dental x ray used to calculating chronological age of a person.



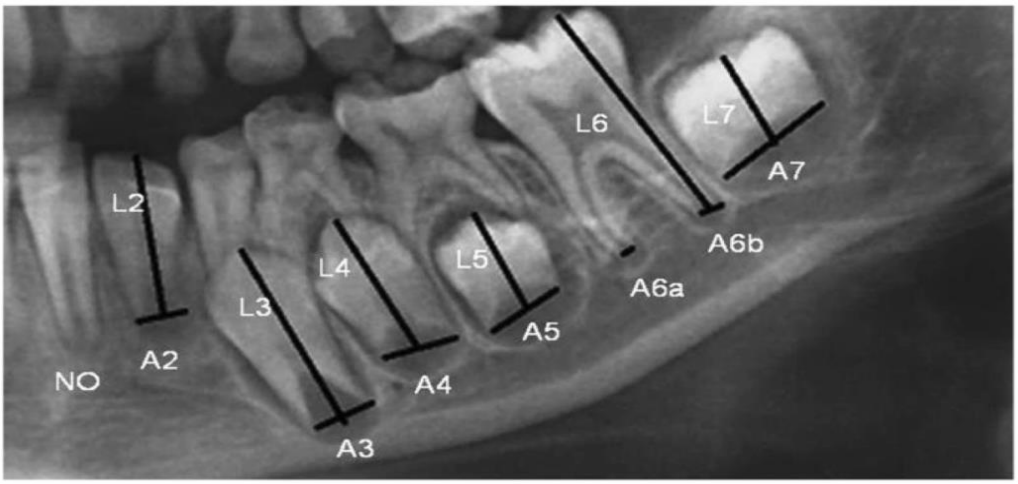
Fig(2):- child's skull before losing deciduous teeth

Radiographs can be used to estimate dental development in a number of different ways [6–9]. one frequently used method for comparing various populations is the one described by Demirjian et al. [7] in 1973. This technique is based on estimating both the extent of mineralized dental tissues and the shape of the pulp chamber of seven left permanent mandibular teeth. Recently, a new method created by cameriere has gained a significant acceptance [11-20].

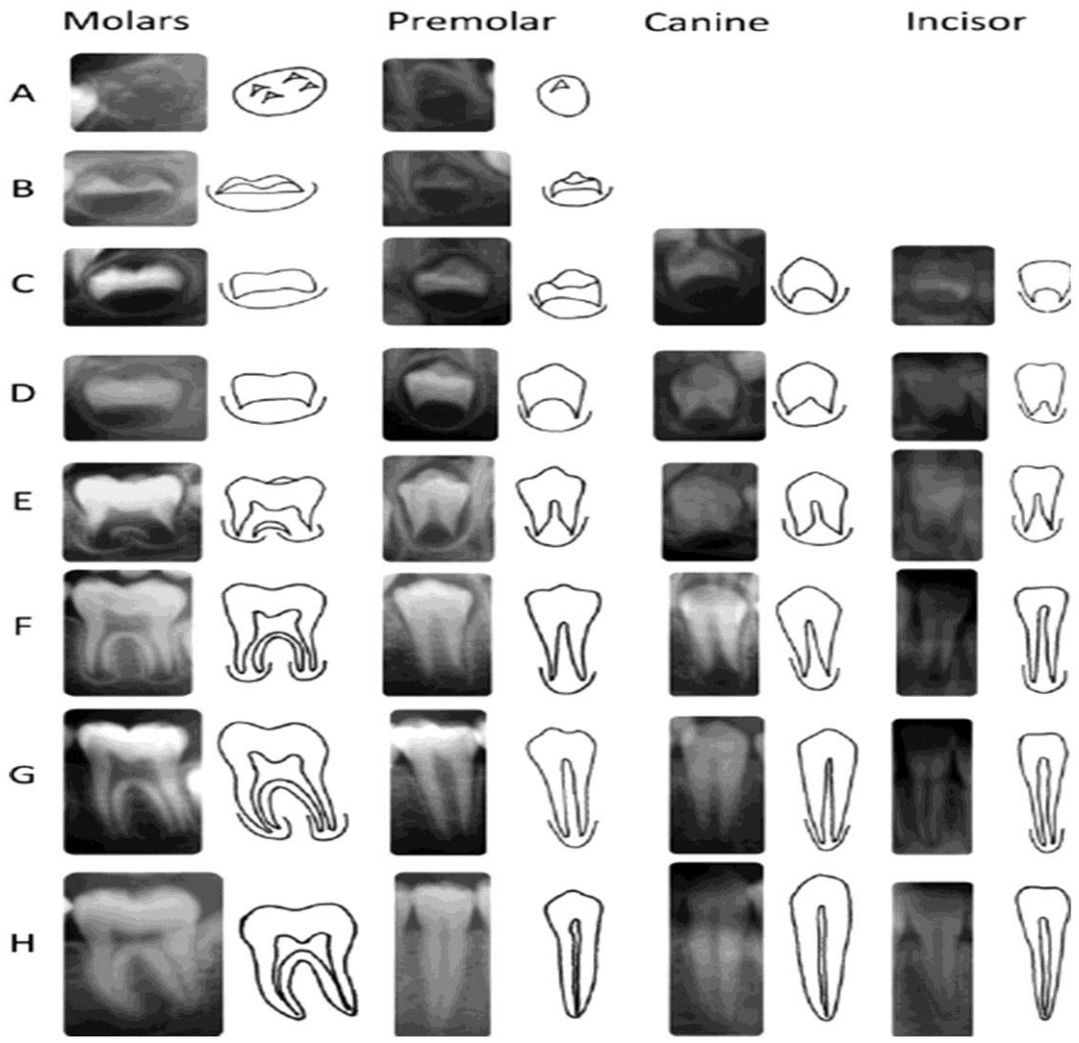
By measuring the open apices of seven permanent teeth on the l eft mandible of a panoramic radiograph, Cameriere developed a European formula [11].



Fig():- opg revealing stages of demirjian method



Fig():- an opg showing tooth measurement variables by Cameriere method.



Fig():- eight development stages(A to H) by demirjian method.

Boys

Tooth	Stage 0	A	B	C	D	E	F	G	H
M_2	0.0	2.1	3.5	5.9	10.1	12.5	13.2	13.6	15.4
M_1				0.0	8.0	9.6	12.3	17.0	19.3
PM_2	0.0	1.7	3.1	5.4	9.7	12.0	12.8	13.2	14.4
PM_1			0.0	3.4	7.0	11.0	12.3	12.7	13.5
C				0.0	3.5	7.9	10.0	11.0	11.9
I_2				0.0	3.2	5.2	7.8	11.7	13.7
I_1					0.0	1.9	4.1	8.2	11.8

Girls

Tooth	Stage 0	A	B	C	D	E	F	G	H
M_2	0.0	2.7	3.9	6.9	11.1	13.5	14.2	14.5	15.6
M_1				0.0	4.5	6.2	9.0	14.0	16.2
PM_2	0.0	1.8	3.4	6.5	10.6	12.7	13.5	13.8	14.6
PM_1			0.0	3.7	7.5	11.8	13.1	13.4	14.1
C				0.0	3.8	7.3	10.3	11.6	12.4
I_2				0.0	3.2	5.6	8.0	12.2	14.2
I_1					0.0	2.4	5.1	9.3	12.9

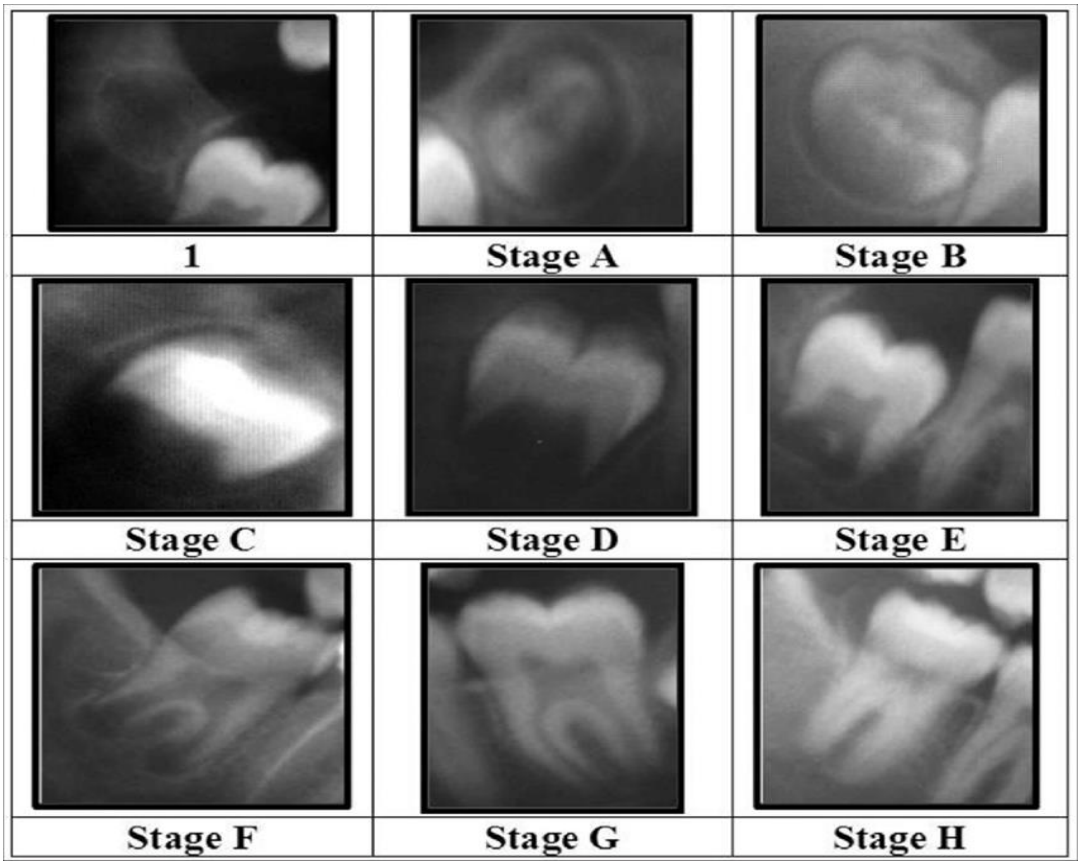
NB: Stage 0 is no calcification

Fig():- scores of left mandibular teeth stages according to demirjian et al 1973.

Third molar as an indicator of age:-

For young children, the age of the teeth can be more accurately determined. This is because many teeth develop and classify at the same time. After the teens, however, most teeth classify and erupt, with the exception of the third molars. This makes third molar development the most important option for age assessment from the late teens to early twenties. In addition, using other biological indicators such as epiphyseal fusion, pubic symphysis changes, wrist bones and fusion of cranial sutures have not been credible in recent years. Therefore, third molars are most useful when there is no valid documentation documenting age and it is necessary to determine a person's juvenile or adult status.

In this study third molar method consists of eight stages(A to H) investigated using the grading system by demirjian et Al. , with the first four corresponding to development of the crown, and the last four corresponding to development of the root.



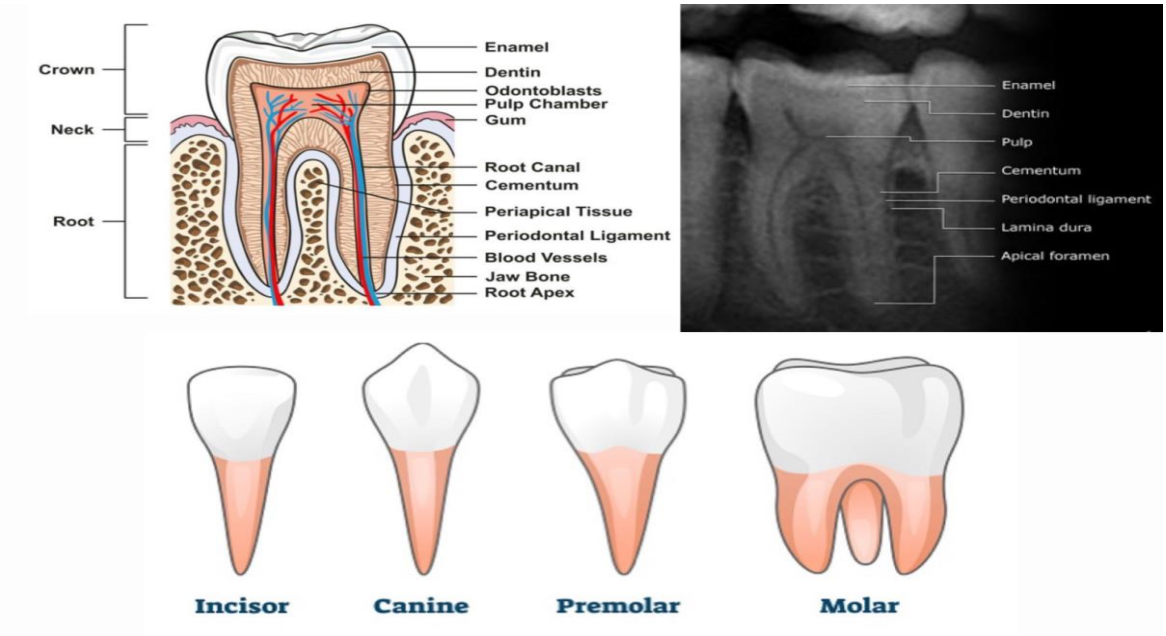
Fig():- third molar mineralization stages by demirjian method.

Objective

1- The purpose of this study is to find out how much the methods used are suitable with different Kurdish children aged groups.
2- In recent years, most people have been infected with various dental problems that affect oral health such as (tooth decay, periodontal disease, bad bites), so this led to aim of this study to calculate dental age which can be assessed by detecting the timing of eruption sequence and the mineralization degree of developing teeth from dental radiograph. If dental age is older or younger than chronological age, a child can be considered advanced or delayed compared to the average child. This presents a problem when chronological age is estimated from maturity because at present we cannot tell if an individual is maturing at an average rate or if a child is advanced or delayed compared to the average.
3- Another aim of this study is to calculate dental delay score, defined as dental age minus chronological age.
4- Compare accuracy of two commonly used dental age estimation methods, demirjian and cameriere.

Why teeth are more accurate than other bones for estimating the age of a person?

The medial clavicular epiphyseal cartilage, radiographic examination of the hand and wrist, and third molar development observations are possible methods of estimating chronological age in adolescents and young adults (1, 2, 3).Third molars, howe ver, are less impacted by changes in endocrine and nutritional sta tus than bone development, hand and wrist development is completed around the age of 18 while 3rd molar development continues until the early twenties when the development of almost permanent teeth may be completed, and regressive changes in teeth with increasing age may not yet be visible at that age (4,5,6) .One of the criteria of tooth morphology is tooth eruption which can be assessed through a clinical examination or by evaluation the dental radiographs to estimate the dental age(7). A variety of parameters for age estimation are provided by the teeth, which are regarded as a reliable indicator for age(8).The dentition perhaps more than other any structure in the body reflects physiological history of an individual and offers the most reliable for age assessment from approximately ten weeks of intrauterine life up to old age.



Fig():- anatomy and types of teeth

2. Chronology of tooth development

The development of the dentition is a continuous process that extends from embryonic to early adult life and it may be divided into a number of stages.

The sequence of prenatal mineralization in the deciduous teeth starts with the central incisor followed by the first molar, lateral incisor, canine and second molar. The maxillary central incisors and first molars are usually seen before those in the mandible. The lateral incisor appears first in the maxilla, but subsequent development is ahead in the mandible. Mineralization occurs in the mandibular canine before that in the maxilla, but it occurs simultaneously in the maxillary and mandibular second molars (Table 1) [12].

Table (1.1):- deciduous tooth development (classification and crown completion) by profit et al [12]

Tooth	**Calcification begins**		**Crown completed**	
	Maxillary	**Mandibular**	**Maxillary**	**Mandibular**
Central	14 wk in utero	14 wk in utero	11/2 mo	21/2 mo
Lateral	16 wk in utero	16 wk in utero	21/2 mo	3 mo
Canine	17 wk in utero	17 wk in utero	9 mo	9 mo
First molar	15 wk in utero	15 wk in utero	6 mo	51/2 mo
Second molar	19 wk in utero	18 wk in utero	11 mo	10 mo

Table (1.2):- deciduous tooth development (eruption and root completion) mentioned by profit et al.

Tooth	eruption		root completed	
	maxillary	mandibular	maxillary	mandibular
central incisor	10 mo	8 mo	11/2 yr	11/2 yr
lateral incisor	11 mo	13 mo	2 yr	11/2 yr
canine	19 mo	20 mo	31/4 yr	31/4 yr
first premolar	16 mo	16 mo	21/2 yr	21/4 yr
second premolar	29 mo	27 mo	3 yr	3 yr

At the beginning of mineralization, tooth germs may be visible as radiolucent areas on the radiograph up to 6 months. A radiograph of the fetus taken at 26 weeks of intrauterine life shows advanced mineralization in mandibular anterior teeth. The mineralized outline for the two cusps of the deciduous first molar, the one cusp outline for the deciduous second molar and the crypt of permanent first molar are seen [13, 14] . At 30 weeks of intrauterine life, mandibular anterior teeth shows 3/5 crown completion and the deciduous first molar cusps show fusion. The deciduous second molar with five cusps is seen, while no mineralization in the permanent first molar is observed. While the radiograph of the newly born fetus shows completely fused cusps for the deciduous first and second molar, for the deciduous second molar, there is no continuity across the occlusal surface [15]. At 32 weeks, the first permanent molars start to mineralize [12].

By birth, the deciduous incisors have about 60–80% of their crowns complete and canine crowns are a simple conical shape and approximately 30% fully formed [9]. The first deciduous molars have a complete occlusal cap of mineralized tissue, the maxillary tooth being more fully calcified than the other molars.
The eruption sequence of deciduous teeth in oral cavity is as follows: first, the mandibular central incisors erupt followed by other incisors. After 3–4 months, the mandibular and maxillary first molars erupt, followed, in another 3 or 4 months, by the maxillary and mandibular canines. The deciduous dentition is completed at 24–30 months as the second molars in both jaws erupt [12]. By the age of about 3 years, the deciduous dentition has emerged into the mouth and completed root formation (Table 1).
The transition from the deciduous to the permanent dentition is summarized in Table 2[12].

Table (2.1):- permanent tooth development (classification and crown completion) mentioned by profit et al.[12]

	clasification begins		**crown completed**	
Tooth	**maxillary**	**mandibular**	**maxillary**	**mandibular**
central incisor	3 mo	3 mo	4 1/2 yr	3 1/2 yr
lateral incisor	11 mo	3 mo	5 1/2 yr	4 yr
canine	4 mo	4 mo	6 yr	5 3/4 yr
first premolar	20 mo	22 mo	7 yr	6 3/4 yr
second premolar	27 mo	28 mo	7 3/4 yr	7 1/2 yr
first molar	32 wk in utero	32 wk in utero	4 1/4 yr	3 3/4 yr
second molar	27 mo	27 mo	7 3/4 yr	71/2 yr
third molar	8 yr	9 yr	14 yr	14 yr

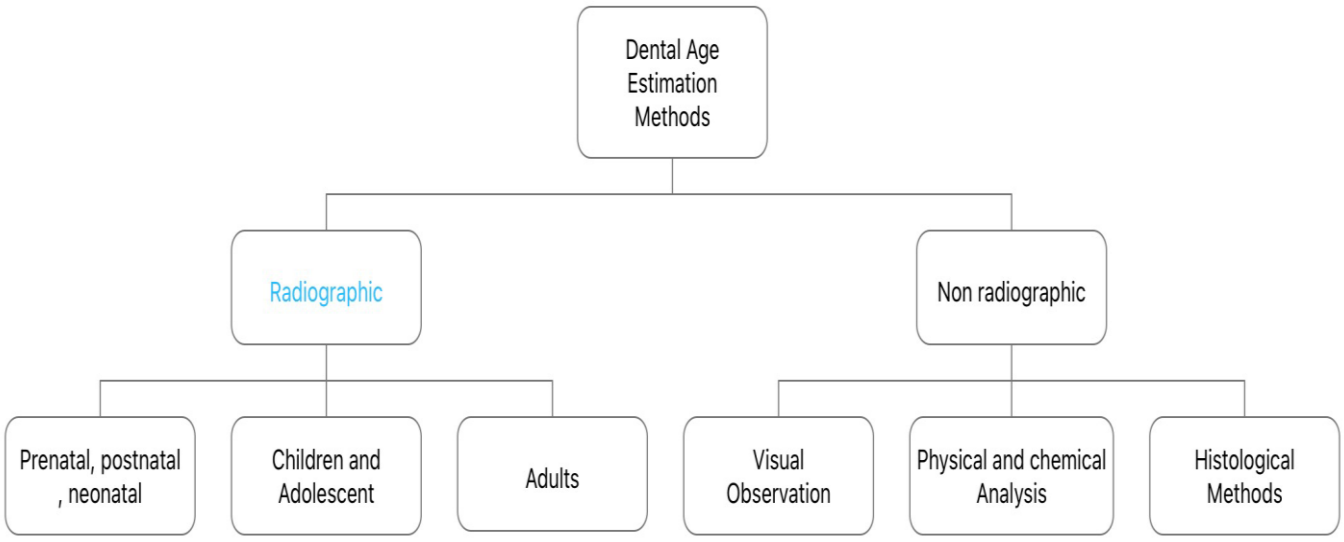
Table (2.2):- permanent tooth development (eruption and root completion) mentioned by profit et al.

	eruption		root completed	
Tooth	**maxillary**	**Mandibular**	**Maxillary**	**Mandibular**
central incisor	71/4 yr	61/4 yr	101/2 yr	91/2 yr
lateral incisor	81/4 yr	71/2 yr	11 yr	10 yr
canine	111/2 yr	101/2 yr	131/2 yr	123/4 yr
first premolar	101/4 yr	101/2 yr	131/2 yr	131/2 yr
second premolar	11 yr	111/4 yr	141/2 yr	15 yr
first molar	61/4 yr	6 yr	101/2 yr	101/2 yr
second molar	121/2 yr	12 yr	153/4 yr	16 yr
third molar	20 yr	20 yr	22 yr	22 yr

Except the third molars, all of the permanent teeth eruption takes place in two stages, between the ages of about 6 and 8 years followed by a silent period and again between 10 and 12 years. The first active stage begins at about age 6 with the eruption of the first permanent molars behind the second deciduous molar followed by the permanent incisors. The general eruption sequence is the mandibular central incisor, followed by the maxillary central and the mandibular lateral incisors about a year later, and finally the maxillary laterals. There is a silent period of 1.5–2 years before the second active stage begins. This involves the exfoliation of deciduous canines and molars and replacement by permanent canines and premolars, together with the eruption of the second permanent molars. On the other hand, the third molars appear late in development stage. They usually start mineralization between 6 and 12 years, complete their crowns in 4 years and erupt and complete development during adolescence or early adulthood [12].

Dental age estimation methods

In literature, various methods are defined for dental age assessment that can be categorized as: visual, radiological, morphological, biochemical and histological methods [1, 18, 19, 20, 21].



Fig():- flow chart of dental age estimation methods

3.1. Visual method

Visual method is based on the evaluation of the sequence of teeth eruption in oral cavity and the morphological changes on tooth structure due to functions such as attrition, changes in color that are indicators of aging.

Fully formed teeth show aging changes. Thus, examination of dentition considering the tooth wear/attrition, tooth color and stains, periodontal status, etc. can provide valuable information on an individual's development and age [1, 18, 19, 21].

3.1.1. Evaluating tooth eruption

Tooth eruption in oral cavity follows a typical chronological pattern. As it was summarized in the above section, visual examination of the maxillary and mandibular dental arch may provide the dental age estimation up to 12–13 years of age in correspondence to the second molar eruption.

3.2. Radiographic methods

Dental age may be estimated by two approaches: based on the time of emergence of the tooth in the oral cavity and the pattern of tooth development, in another word the dental maturity stages. Dental maturity is considered to be more reliable than the emergence of teeth into the oral cavity with a high heritability and low coefficient variation, and to be independent of environmental effects, nutritional and endocrine status [6, 7, 8]. The development of each tooth can be assessed over long periods of time using radiographs in a continuous pattern, using different crown and root maturity stages of tooth formation as criteria [27, 28]. Radiological methods are based on the evaluation of tooth development on the various radiographic images as intraoral periapical, panoramic radiographs, digital and advanced imaging technologies to assess the extent of tooth mineralization from the moment when radiopaque spots become visible prior to tooth calcification until the tooth apex is closed (Figure 1) [10].

Beginning from the initial mineralization of a tooth, the crown formation, root growth, eruption of the tooth into the mouth and root apex maturation are assessed. Given that this method enables continuous evaluation of tooth development from birth until the completion of third molar teeth development [24, 29], it is mainly suitable for children-adolescents. It is also simple, a noninvasive and reproducible method that can be employed both on living and unknown dead.

The age determination on radiographs is based on the estimation of various features as follows:

1. Tooth germs appearance [14, 15, 30]
2. Beginning of mineralization both in the intrauterine life and after birth [14, 15, 30]
3. Amount of crown completion [14, 30, 31]
4. Eruption into the oral cavity [13, 14, 15, 30]
5. Degree of root completion of erupted or unerupted teeth [14, 15, 30]
6. Degree of resorption of deciduous teeth [14, 15]

7. Measurement of open apices [32, 33]
8. Volume of pulp chamber and root canals/formation of physiological secondary dentine [14, 34]
9. Tooth-to-pulp ratio [34, 35]
10. Third molar maturity [14, 15, 30, 34]

Materials and method

Study design and sample:-

Panoramic radiographs of 50 patients (ranging from 6 to 23 years) were chosen from the records of several centers including khanzad, hi delux, M dental. The recorded data about each sample included the name, gender, and date of birth. All radiographs were taken with planmeca romexis, NNT viewer (Newtom). Chronological ages of a participants were calculated by subtracting (date of birth) from (date of radiograph) were stored in units of years. Orthopantomography (opg) is the most common imaging modality for routine examination in clinical practice. In this study, opg scanning was done in a standard manner using a digital panoramic scanner (planmeca proMax 2D), and with a minimum exposure time of 12s. opg images were saved as jpg format.

Data collection:-

Data were collected according to:-

Inclusion criteria:-

- CAs of the patients aged between 6 and 23 years.
- Both date of birth and date of radiograph (exposure) were obtained.
- Only Kurdish people were included in the study.

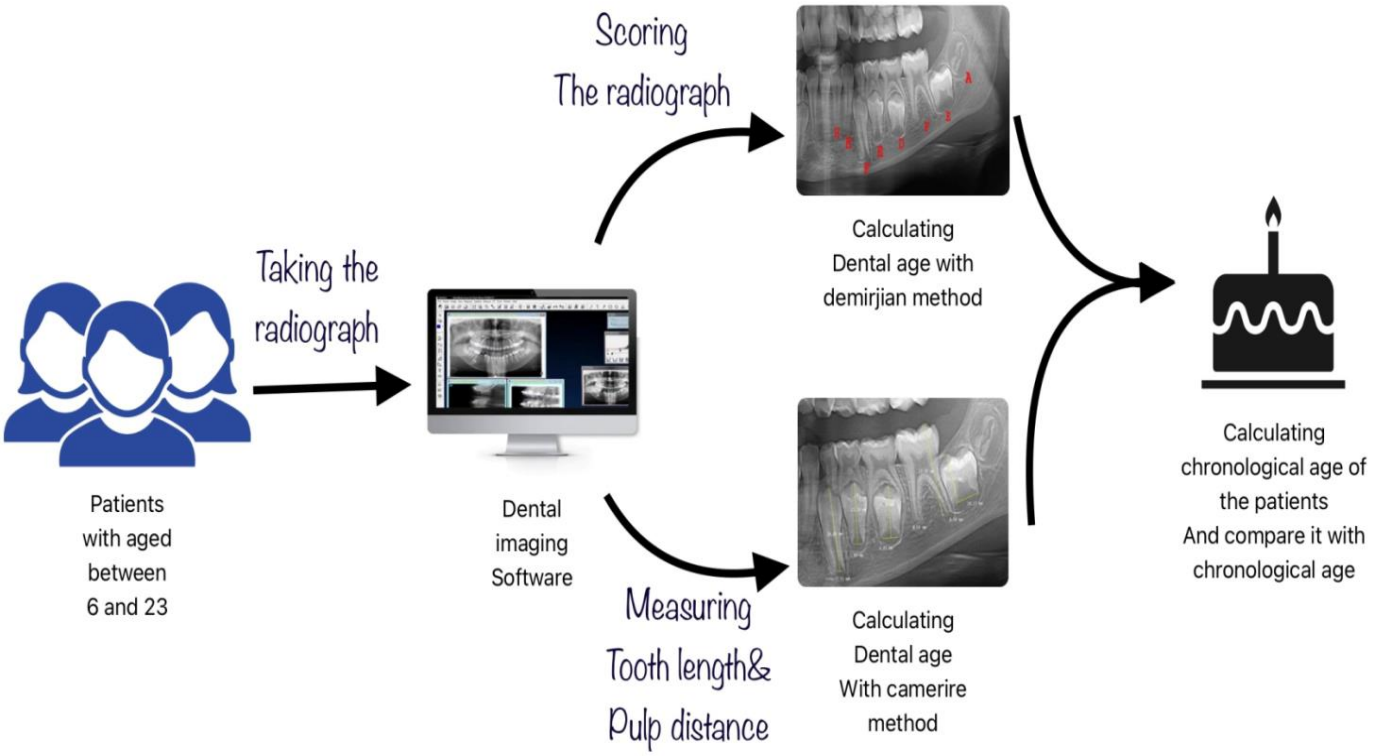
Exclusion criteria:-

- Genetic disorders that would affect dental growth.

- Unclear orthopantomographs affecting mandibular permanent tooth visualization.
- Poor quality radiograph in which one or more teeth can't be scored.
- Present or history of orthodonotic treatment
- History of surgical removal of third, second and, fist molar.
- Agenesis of teeth

Fig():- digital panoramic x ray positioned

for a Kurdish young adult.



Fig():- Graphical abstract for measuring dental age

Age calculation methods:-

In this study we use methods only for living people.

For age estimation by Demirjian’s method [5], 7 permanent left mandibular teeth were evaluated. 'e developmental stage of each tooth was determined according to Demirjian’s method'e process followed for age estimation are as follows:
1- Permanent left mandibular teeth were ranked as follows: second molar, first molar, second premolar, first premolar, canine, lateral incisor, and central incisor.

2- teeth were coded A to H as shown in(Figure 1)using the available instructions. In the instructions, each dental stage had A , B, or C characteristics. If a stage had only one defining characteristic, the tooth should meet the respective characteristic in order to be assigned to a respective stage. If a stage had two characteristics, only the presence of the first characteristic would suffice. If a stage has 3 characteristics, the first two characteristics should be met in order for a tooth to be assigned to the respective stage. Teeth assigned to a particular stage should meet all the characteristics of the previous stage(s) as well. For borderline cases, the lower (earlier) stage was considered for the respective tooth.

3- A magnifier was not used for the assessment of apex closure, and staging was performed by the naked eye.

4-Crown length was defined as the maximum distance between the highest cusp tip to the cementoenamel junction. In cases where the buccal and lingual cusp tips were not at the same level, their midpoint was considered the highest point.

The developmental stages observed are as follows:

Stage 0:- tooth not yet been calcified

Stage A:- In both single-rooted and double-rooted teeth, the onset of calcification was seen at the peak of the tooth bud in the form of a cone or an inverted cone. the calcified points were not connected.

Stage B:- Connection of calcified points led to the development of cusp(s) such that the occlusal surface of the tooth was outlined.

Stage C:- 1- Enamel formation of the occlusal surface was completed, and it extended towards the cervical region; 2- dentin formation was initiated; and 3- the outline of the pulp chamber was seen in the form of a curve at the occlusal border.

Stage D:- 1- Formation of the crown was completed to the level of the cement-enamel junction; 2- the superior border of the pulp chamber in single-rooted teeth was seen in the form of a curve, which was concave towards the cervical region. Pulp horns, if present, were seen in the form of an umbrella tip. In molars, the pulp chamber had a trapezoidal form, and 3- the initiation of the root formation was seen in the form of a spicule.

Stage E:- Single-rooted teeth: 1- pulp chamber walls formed straight lines, which were interrupted by the pulp horns, and had become larger compared with the previous stage; 2- the root length was shorter than the crown length. Molars: 1- primary formation of root bifurcation was noted in the form of a calcified or semilunar shape; 2- the root length was shorter than the crown length.

Stage F:- Single rooted teeth:- 1- pulp chamber walls formed separate triangles; 2- the root length was equal to or longer than

the crown length. Molars:- 1- the calcified bifurcation area had grown downward, conferring a more distinct shape to the roots with a funnel-shaped apical region; (b) root length was equal to or longer than the crown length.

Stage G:- Root canal walls were parallel, and part of the apex was still open (the distal root of molar teeth)

Stage H:- 1- the apex of the root canal was completely closed

(the distal root of molars) ; 2- the periodontal membrane had a uniform width around the root and apex.

Cameriere's method:-

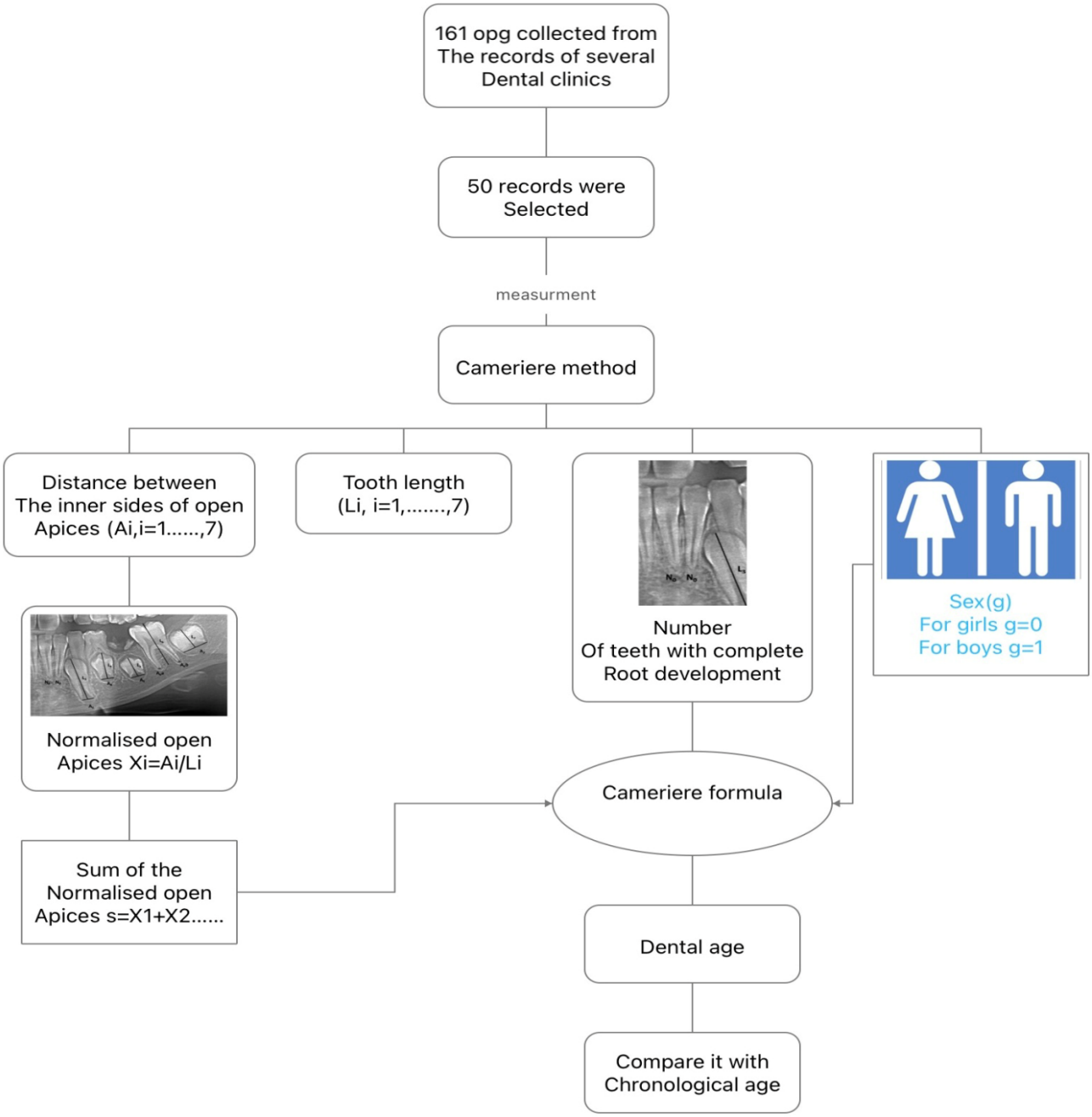
For age estimation using Cameriere's method, 7 permanent mandibular left teeth were used [17]. For this purpose, the number of teeth with complete root development and closed apices was recorded (N0). Teeth with inadequate root development and open-apex teeth were also identified. For single-rooted teeth, the distance between the internal surfaces of the open apices (Ai, i = 1–5) and in double-rooted teeth, (Ai, i = 6.7) the total distance between the internal surfaces of the two open apices was calculated (Figure)

In order to control the possible difference in image magnifications and angles on radiographs, the sizes were normalized by dividing them by the tooth length (Li, i: 1–7)

(Xi = Ai/Li, i = 1–7). Finally, dental maturation was calculated by using the normalized values for the 7 permanent left mandibular teeth. The sum of these values (S) and the number of teeth with complete root development (N0) were calculated. All calculations were performed by one operator, and Cameriere formula was calculated as

Dental age= 9.402 – 0.879c+0.663No – 0.711s-0.106sNo

where (g) is the variable equal to 1 in boys and 0 in girls. N0 is the number of teeth with closed apex and developed root, and S is the sum of the maturity scores of all open-apex teeth.



Discussion:-

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