AGE ESTIMATION FROM TEETH AMONG BENGHAZI CHILDREN USING DEMIRJIAN'S METHOD

By

Mohamed Mustafa Kablan

Supervisor:

Prof. Mohamed S H Ingafou

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This Thesis was Successfully Defended and Approved on **3.10.2020**

Supervisor
Prof. Mohamed S H Ingafou

Signature: .....

Dr. Aisha Gabril Areibi **(Internal examiner)**

Signature: .....

Dr. Ahmed Guda Yousef **(External examiner)**

Signature: .....

(Dean of Faculty) **(Director of Graduate studies and training)**

University of Benghazi
Faculty of Dentistry
Dean

Dedication

To the soul of my father.

My Great mother, my Beloved wife

For their great support

To my Teachers

For their believe in me

I dedicate my thesis

Mohamed M.Kablan

Acknowledgement

I would like to express my deep sense of gratitude to my supervisor and mentor Professor Mohamed Ingafou for his outstanding guidance and support, which helped me in completing my thesis work. I would also like to thank Professor Abdullgafar El-Manafi, for his invaluable assistance and help in the statistical work and data analysis.

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Declaration

I confirm that this thesis is a record of research carried out by myself. Except where otherwise stated, the research design and analysis were my own work, subject to the help and advice received from those who were acknowledged. I have consulted all the references cited. This research has not previously been submitted for a high degree.

Mohamed M. Kablan

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List of abbreviations used in this thesis

BM	Biological maturation
CA	Chronological age
CBCT	Cone Beam Computed Tomography
DA	Dental Age
DMJ	Demirjian's method
DMS	Dental Maturity Score
MS	Maturity Score
OPG	Orthotopantomograph
SD	Standard Deviation

Age Estimation from Teeth among Benghazi Children Using Demirjian's Method

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Abstract

Aims: This study is aimed to evaluate the accuracy of Demirjian's method in Benghazi children estimating the chronological age of male and female children between 6 and 16 years of age from panoramic radiographs and to establish a new dental age (DA) curve if the Demirjian's method was not found to be accurate.

Materials and Methods: This retrospective cross-sectional study consisted of 250 panoramic radiographs of 127 boys and 123 girls between the ages of 6–16 years. All children were placed in the age group closest to their chronological age. The dental age was scored on all seven left mandibular teeth by calibrated examiner. Statistical analyses using the t-test and Pearson correlation were performed.

Results: There was no significant difference in both boys and girls in all the age groups between their chronological age and dental age except for age group 6, 7, 15. Even though there was a slight overestimation in boys in some age groups and slight underestimation in girls in some groups, Moreover, correlation analyses for each age group showed a significant correlation between the chronological age and the dental age, using the Demirjian

method, in most age groups ($P < 0.01$). When comparing the maturation score between boys and girls, the Student's t-test showed that there were no statistical differences between boys and girls in most age groups.

Conclusions: Benghazi boys and girls living in the east region of Libya exhibited similar pattern of dental development when compared to the Demirjian 's method. Hence, the Demirjian's method could be used as reference in children from the eastern region of Libya.

Chapter 1

Introduction

Introduction

1.1. Age estimation in forensic sciences

"*Age*" is defined as the length of time a person has lived or an object has existed. The chronological age of individual or an object is defined as the amount of time that has elapsed since the person was born, or since the object was made(Bagic et al. 2008).

Age estimation of both living and dead persons is of great importance for the identification of unknown bodies or skeletal remains of accidents and crimes as well as in disasters (Willems et al. 2002). In case of living people who have no acceptable identification documents, such as refugees, adopted children of unknown age verification of chronological age is required in order to be entitled to civil rights and social benefits (Kvaal and Haugen 2017; Yang et al. 2006). There are instances in which teeth are the only human remains and present the only means of age determination (Maples 1978) .

The determination of age has great deal of importance in many clinical situations, particularly in forensic sciences, legal medicine, pediatrics, pediatric dentistryand in orthodontics especially in determining the stage of growth and somatic development and in the area of anthropology to estimate the age of past populations from their skeletal remains. The increased influx of immigrants and mix up of population, results from globalized economy has implements legal problems of different kinds, which increased the demand for determining the chronological age (CA) of children, youths and young adults in many circumstances, and for determining the legal adult age of people without documents for judicial purposes(Willems et al. 2001).

Age estimation is considered as one of the most important sub-disciplines of forensic sciences and is of paramount importance in medico legal issues. Age estimation of children and adolescents is essential to answer a variety of legal questions. In the current scenario, most of the age estimation modalities are invasive, requiring lengthy processing times, use of expensive instruments, and the services of an experienced pathologist to deduce the age of a person(Kumar and Gopal 2011).

Age estimation can also provide valuable information when the birth date is not available, as in case of illegal immigrants. The chronological age (Calendar age) can also be helpful in case of living people is important in cases of employment and marriage, while cementum or dentine can be studied in dead bodies, the focus for the living is on the clinical situation and radiographs(Azrak et al. 2007).

Age estimation is done by morphologic, radiographic, histological and biochemical methods(Chaudhary and Doggalli 2018). Teeth prints and morphological analysis of dental structures such as size, shape, developmental anomalies, crown root width and height ratio, and inter-arch distance have been analyzed by many forensic odontologists to prove the uniqueness and its application in personal identification and criminalization (Uma Maheswari 2017).

1.2. Historical background

The first known attempts, which used teeth as an indicator of age originate from England, at the early 19th century there wasn't registrations at birth and juvenile work not allowed as social legislation provided that no child under 9 years should be employed and

the limit for criminal responsibility was 7 years of age. Up to this time the determination of age was based mostly on the calculation of height (Miles 1963; Stavrianos et al. 2008).

In 1836, Thomson, claimed that children where the first molars had not erupted certainly they had not reached the age of seven. The first scientific study was presented by Edwin Saunders, in which he pointed out that dentition is a more reliable standard than height for determination of age. In 1872, Wedl made the first observations of changes with age in the permanent dentition and described fatty degeneration, calcification, colloid deposits, netlike trophy and pigment, deposits in the pulp cavity due to continued deposits of new dentine layers (Kvaal 2006).

1.3. Significance of age estimation

Age estimation has great importance in many clinical decisions, being commonly used in pediatrics, legal medicine, forensic sciences, anthropology, odontopediatrics and orthodontics(Bagherpour et al. 2010).Increased immigration and mixing of populations, due to the globalized economy resulting from the increased migratory flow, sets legal problems of various orders, with increasing importance of determining the chronological age of children, youths and young adults. So estimating chronological age is important in assessing the legal adult age of people without documents for judicial purposes, in determining growth and somatic development, in orthodontic treatment and in the area of anthropology to estimate the age of past populations from immature skeletal remains(Birch and Dean 2014).

1.4. Definitions and assumptions

Age *as defined in Merriam-Webster Dictionary* "is the period contemporary with a person's lifetime or with his or her active life or it is the time of life at which some particular qualification, power, or capacity arises or rests".

Biological maturation(BM) is a series of gradual transformations through the time going on in the human body from conception to death as part of life cycle of the organism.

Chronological age (CA) refers to the actual amount of time a person has been alive. In other words, the number of days, months or years a person has been alive does not change, regardless of how healthy a lifestyle, even one filled with great exercise and nutrition habits they are living.

Dental Age (DA) can be defined either as a measure of how far the teeth have progressed towards maturity or as a measure of childhood dental development and it corresponds to odontogenesis, development, and emergence of teeth.

Children are defined as the human beings from birth to puberty and adolescents as from puberty to approximately age of 20 years.

Chapter 2

Literature review

Literature review

2.1. Introduction

Age estimation is an important factor in biological identification in many forensic fields, such as forensic odontology. Forensic Medicine, Forensic Anthropology, and Forensic Osteology. Age estimation can assist in narrowing the search possibilities for unidentified deceased or living individuals for legal purposes. Additionally, age estimation helps determining the age of perpetrators and their subsequent penalty for criminal liability, particularly in young people. Age assessment can be highly useful for estimating the real age of asylum seekers or in medico-legal assessments of age-disputed children charged with criminal acts. Demirjian's dental maturity score is currently a dental scoring system universally adopted for age assessment of unidentified children.

2.2. Rationale of studying dental age

(Gustafson 1950) had earlier proposed age determination can based on five of the age related changes such as attrition, secondary dentin, periodontitis, Cementum deposition and root transparency, another changes were added by later researchers such as surface roughness, color and sex (Gustafson 1950; Solheim and Kvaal 1993).

The accuracy of information obtained from determining DA is characteristically based on the fact that tooth formation have stable formation mechanisms, (Schmeling et al. 2016).Dental tissue can last for long periods of time after body decomposition. Dentition is the only structures fit for examination even in cases of cremation or other disasters. Current dental age estimation techniques are based on age related changes in teeth

such as teeth formation and growth, post formation changes in teeth, and biochemical changes in teeth (Chaudhary and Doggalli 2018).

Attempts of age estimation from teeth (especially in children, adolescents, and young adults) had been carried out through two major methods: the tooth eruption method, which is conducted by a visual assessment of the eruption of the teeth into the mouth, and the tooth development method using radiographic evaluation. The radiographic evaluation is the preferable and more precise method as the age estimation is usually carried out as the tooth eruption occurs during a relatively short period of time and is highly influenced by many factors including lack of space, feeding habits, local trauma, pathosis of deciduous teeth, and nutritional status. There are several methods that use radiographs for estimating dental age in the literature(Ardakani et al. 2007). Most of them use panoramic radiographs to perform the assessment.

The most widely used and well studied method for comparing dental ages in different population is the method of Demirjian stated that there is a strong correlation co-exists between skeletal age and chronologic age. Demirjian's research concludes that dental development has no significant relationship to maturity indicators, menarche, height growth or skeletal maturity, which predicts that the mechanisms that regulate dental growth and development are independent on common growth mechanisms and are closely related to the age of the patient(Demirjian et al. 1985).

2.3. Dental age estimation versus bone age evaluation

Age of an unknown person can be assessed by correlating the physical, skeletal, and dental maturity of an individual. Among many methods of chronological age estimation,

the evaluation of hard tissue mineralization is being the most widely used methods. Both dental and bone ages have been assessed in many studies to determine the extent of their correlation to chronological age(Gupta et al. 2013). Considering that the state of dental mineralization is much less affected by environmental(Kumar and Gopal 2011; Nolla 1960), and hormonal variations(Cardoso 2007; Jayaraman et al. 2013) than the state of bone mineralization. Dental development usually provides the most reliable indications of chronological age than bone development assessment(Demirjian and Goldstein 1976). Although cervical vertebral bone age can be utilized as an adjunct in identifying the stages of dental maturation of lower left permanent canine and second molar (Kulkarni and Dave 2019).

Dental age (DA) can be determined by certain growth features such as dental mineralization, gingival clinging, quantum cementation, or narrowing of the pulp space as well as some other degenerative changes of teeth such as attrition or periodontal changes(Odzhakov and Apostolov 2019).

In cases where the chronological age (CA) of the individual is unidentifiable, at least the age at the time of death can be estimated according to biological maturity of the body. Multiple radiological approaches (periapical radiograph, cone-beam computed tomography, or panoramic radiographs) can allow an accurate view on the whole dental system, Different methods of DA assessment were elaborated by several workers and frequently found in literature.

OPG is being the most commonly used method in dental age determination. Furthermore these dental panoramic radiograph was recommended to be made periodically during the mixed dentition and adolescence to evaluate growth and development

(Willems 2001). It has been stated that the use of reconstructed 3D images makes the evaluation of the maturation of teeth more accurate in comparison to the use of generated panoramic images (Ginzelova et al. 2019).

Hand-wrist radiograph is the most commonly used tool to indicate bone age or bone maturation of a patient. It is considered as one of the most commonly used methods among all possible means of age assessment, as it is simple, requires little irradiation exposure and inexpensive. The obtained radiograph can provide precious information on hand bones ossification, based on the shape and volume of metacarpal bones(Thompson et al. 1973), (Kumar et al. 2013).The presence of epiphyseal plates at certain age can also be helpful in determining the bone age(Björk and Helm 1967); (Fishman 1982)

However , if bone age assessment has reached a consensus to predict patient maturation, one more tool has to be considered on dental side leading to evaluate dental age (DA) of an individual.

2.4. Principles of dental age estimation

Dental biometrics refers to human identification using unique dental records such as teeth, dental radiographs, and other soft tissue oral structures such as lip prints, tongue prints, and palatal rugae prints may play an important role in future. Dental age estimation is one of the most important procedures that is widely used in forensic sciences, especially at the time of disasters or facial disfigurement or decomposed bodies(Uma Maheswari, 2017).

2.4.1. Degree of tooth formation

Tooth formation is a complex process that begins with structural reorganization anda change in the embryonic cell phenotype. Deciduous teeth begin their development during the 6^{th} to 8^{th} weeks of gestation; while permanent teeth begins about 20^{th} week of gestation. When determining the dental age, the term "tooth formation" generally refers to the mineralization of the dental rigid tissue rather than the non-mineralization stages of tooth growth. The reason behind this is probably the possibility of the mineralized tissue being examined radiologically , as well as its resistance to decomposition (Haavikko 1970; Zhao et al. 2014).

2.4.2. Speed of formation of dental crown structures

The time intervals taken for the formation of some characteristic dental crown structures can be estimated when determining the chronological age. The most commonly used examination technique is the microscopic histological evaluation such asthe number of prisms of the transverse stretch(Boyde et al. 1989).

Lines of Retizus can serve as an adjunctive tooth feature in age estimation. They can be found in the crown of the tooth enamel in occlusal direction in deciduous teeth as well as in the permanent first molar. These neonatal lines represent the borderline between pre and postnatally formed enamel (and dentin), and is often used to determine the chronological age at the time of death(Benesova et al. 2004). This feature, along with the total number of transitions, allows for the determination of the chronological age at the time of death.

Perikimata, is a small visible line on the surface of enamel, representing the appearance of the striae of Retizus along the tooth circumference their intervals were studied if they can be used to determine the chronological age .

2.4.3. Changes of the pulp-dentinal complex associated with age

Dentin, unlike the enamel, is continuously formed throughout life so an additional tissue is deposited at the pulpal side of the dentine called “secondary dentin which is formed physiologically in a slow process, expressed as cell growth in pulpal space in response to masticatory stress and temperature alterations leads to a significant reduction in pulp space and may contribute to the obliteration of the root canal. There is a little difference between primary and secondary dentin, which can be detected by coloring, micro-engraphy or polarization microscopy .Bodecker first found that the accumulation of secondary dentine was associated with chronological age, while(Gustafson 1950), was in traduced a linear measurement of secondary dentine as one of his 6 criteria for the determination of the chronological age. Pulp/tooth ratio determination in OPG or peri apical X-rays was used to determine the chronological age (Ten Cate 2013). Another research approach involves the combined analysis of labio lingual and mesial peri apical X-rays of lower and upper canine teeth of skeletal corpses (Wittwer-Backofen et al. 2004).

Dentin sclerosis (root transparency) is another indicator of the pulpo-dentine complex interactions considered as a form of protective response to caries, wiping and medication treatment was first described by Tomes in 1861 and it under went significant changes in the course of aging and it long been used by (Gustafson 1950), as one of the 6 criteria proposed by him(Boyde et al. 1989).The Lamendin’s method is based on the application of dentinal transparency for the purposes of determining the individual's chrono-

logical age. Lamendin presents a single tooth age approach using the degree of paradontosis and root transparency(Burns and Maples 1976).

2.4.4. Age-related tooth color changes

It is common knowledge that the teeth change color with the years, showing yellowish and brownish shades. Progressive staining is due to the degradation of organic constituents of dental rigid tissue, the accumulation of external substances in enamel and dentin, mineralization and related changes in the refractive index. The problem of objective assessment of the color of the teeth has not yet been resolved. In addition, the question of the discoloration of the root of the teeth and their resistance to external influences is unclear (Kvaal and Solheim 1989).

2.4.5. Changes in chemical composition of teeth with age

Nitrogen is the chemical element, which content increases with age. This widespread conception explained the accumulation of a pigment that changes the color of the older teeth (Yamamoto 2016).

Racemization of aspartic acid is another change in the chemical composition of dental tissue that is useful in determining the age of the patient .In the living organism, the proteins are mainly composed of the L-isomer of the amino acids that polarize the light to the left. Only certain molecules are physiologically synthesized with the D-isomer of the amino acids that polarize light to the right. Changing the L- to D-isomer (racemization) of amino acids occurs both in life and after death. Racemization is influenced by environmental factors such as pH and humidity and can be detected with metabolically inactive or bradythrophic tissues such as teeth(Cameriere et al. 2007).

2.4.6. Density of teeth and its relation to the chronological age

A number of scientific studies address the issue of changing the density of human teeth and its attitude towards the chronological age. Shikano found that the incidence of density of incisors increases with age (Cameriere et al. 2007).

2.4.7. The use of dental Attrition in estimating chronological age

Attrition is the loss of dental material on incisal edges and occlusal surfaces. It is the most prominent evidence of the effect of chronological age on the human dentition. Attrition is not only a consequence of the prolonged action of masticatory forces, it is also associated with dental hygiene, bruxism and eating habits, but its applicability as the sole criterion for determining age is limited. Most methods used to quantify attrition are based on relative subjectivity, so the results show a significantly broad range of age. The optimal use of dental attrition in the process of age estimation involves evaluating other factors in order to achieve the most reliable results (Zapico 2017).

2.5. Forensic odontology in modern practice

The broadening frontiers of dentistry have taken the dentist as an expert witness in legal room proceedings and in the field of forensic sciences. However, forensic odontology for long had been a less explored area of dentistry. The assessment of age is useful in planning treatment of orthodontic and pedodontic patients, and in forensic medicine and forensic odontology. Its use is increasing in both civil and criminal matters and is also helping in the identification of age at death of a dead individual in mass disasters and natural calamities(Willems 2001). Research within the mechanisms of dental change and

the onset of various age-dependent alternations would be of great importance to the initial distinguishing forensic medical expertise (Odzhakov and Apostolov 2019). There are various radiographic methods identified by many forensic odontologists using conventional radiographs earlier, and recently, cone beam computed tomography (CBCT) is widely used to estimate the age of the individual, which is important in medicolegal cases (Uma Maheshwari 2018).

2.5.1. The concept dental age

the American Academy of Pediatric dentistry considered the work of Logan and Kronfeldas the first major attempt at developing a chronology for human dental and skeletal maturation and dispel the myth that calcification of all permanent teeth begins at the same time. Dental age estimation in the living is mostly based upon non-invasive methods, which evaluate the timing and sequence of defined growth stages of the developing dentition and the sequence or modification of traits in the mature dentition and the surrounding tissues(Chaillet et al. 2004).Human biological maturation processes and human dentition are regarded the main sources of information in the process of age estimation. While biological maturity can be measured by any of the four physiological divisions; somatic, sexual, skeletal, and dental compartment, the human dentition is considered by many authorities as a reliable source of information because of their high degree of independence from environmental factors and systemic diseases(Cunha et al. 2009). Root development, as well as the ratio between pulp and tooth or tooth and root of permanent teeth can all be measured radiologically (Maber et al. 2006).

2.5.2. Dental calcification and age estimation

Tooth eruption and dental calcification have long been suggested as potential means for determine the dental age (Hagg and Matsson 1985). However, the use of tooth calcification methods was found to be more accurate than tooth eruption because the process of calcification is continuous throughout life and can be assessed by perpetual records such as radiographs, whereas emergence of a tooth is a transitory event and it is rather difficult to record(Demirjian et al. 1973). There is now full accordance in the literature that the methods of DA estimation relying on the evaluation of the mineralization and growth stage of the teeth seem to be scarcely affected by local and systemic factors, but are dependent on the genetics of the populations as they show an ethnic variability. The estimation of age through the study of the calcification of the permanent teeth has been demonstrated to provide reliable and accurate methods and results. Determining a child's chronological age (CA) and stage of maturation is particularly important in fields such as pediatrics, orthopedics, and orthodontics, as well as in forensic and anthropological studies(Bagic et al. 2008).

2.5.3. Dental age estimation

Dental age (DA) can simply be defined as a measure of how far the teeth have progressed towards maturity (Willems 2001) or as a measure of childhood dental developmentit corresponds to odontogenesis, development, and emergence of teeth (Demirjian et al. 1973). Dental age estimation plays an essential role in forensics, anthropology and bioarchaeology(Bagic et al. 2008; Willems 2005). Dental age (DA) is of particular interest to the orthodontist in the treatment planning of different types of malocclusions in rela-

tion to maxillofacial growth (Bagic et al. 2008).While cementum, enamel or dentine can easily be studied in dead bodies, the age estimation of the living individuals is basically dependent on radiographs or certain biological changes(Azrak et al. 2007).

In 2000, an international and interdisciplinary study group on forensic age estimation in Berlin, Germany recommended that methods for age estimation in living people should consist of a physical examination, radiographic examination of the hand bones, and dental examination using panoramic radiographs. All of these methods have advantages and disadvantages. For example, a drawback of evaluating ossification of the hand bones is that the development of these bones is completed at the age of 18 years, which is earlier than tooth development (third molar teeth) that continues until the early twenties. Furthermore, skeletal indicators can present disadvantages due to variations in bone development, which can be influenced by many factors such as nutritional and environmental effects(Bolanos et al, 2000).

2.6. History of Demirjian's method

As indicated in the reference manual of the American Academy of Pediatric Dentistry, Logan and Kronfeld's work has been considered by many authorities as the first major attempt at developing a chronology for human dental and skeletal maturation and dispelling the myth that calcification of all permanent teeth begins at the same. Thereafter, Demirjian and co-associates studied dental development in 5, 437 panoramic radiographs of a genetically homogenous French-Canadian group of children aged from 2 to 19 years. The maturity of each mandibular tooth was evaluated individually, and developmental curves were

plotted for each stage of each tooth for boys and girls separately, which established a standard(Demirjian et al. 1973).

According to the recommendations of the Study Group on Forensic Age Diagnostics, the DMJ's method has the greatest predictive and practical value (Bang 1989), as third molars are the most varied teeth of their anatomical features, the agenesis and the age of eruption, determining the age for forensic practice using third-molar development studies is used in the age range 14-21 when all other teeth have completed their formation .DMJ's method was first proposed in 1973 and it is one of the widely accepted method for dental age estimation in children and adolescents of the age group of 2–20 years(Demirjian et al. 1973).

Originally, it has seven teeth method done in mandibular left side teeth from central incisor to second molar consisting eight developmental staging from A through H, that defines the mineralization of tooth development beginning at the first radiographic appearance of mineralization to complete closure of root apex. This was later modified by (Demirjian et al. 1973).

In 2004, Chaillet and Demirjian made few modifications including the third molar with a view to extend its application to a wider age group. Hence, all the eight mandibular left side permanent teeth are assessed on the radiograph, especially on OPG, and tooth development is compared to a developmental chart. It consists of ten developmental staging from 0 to 9, and each staging has its own maturity score for boys and girls separately. The final score or average sum should be 100 for all the teeth. The mandibular arch was selected due to the better quality of image as it is not superimposed by dental and cranial anatomy. It is permissible to utilize dentition on mandibular right side if the tooth is missing, malformed,

rotated, or difficult to stage for any reason on the mandibular left side. This method has the advantage that the stages of development are clearly defined, according to radiographs, diagrams and written criteria(Chaillet et al. 2004).

2.7. Methods of age estimation in adults and children

Age estimation in adults has also been studied by many investigators through a couple of accurate and reproducible techniques, using morphological, radiological or biochemical methods. All of these methods are based on degenerative processes observed in the dental structures (Valenzuela et al. 2002),(Solheim and Vonen 2006). Olze's method is good example of radiographic age estimation using 3rdmolars stages of tooth development for age estimation (Olze et al. 2007). Method of age estimation in adults includes both volume assessment of teeth using pulp/tooth ratio method by Kvaal and coronal pulp cavity index and development of third molar using Harris and Nortije's method and Van Heerden system. Volumetric analysis of the dental structures, especially pulp chambers and root canals using computed tomography and CBCT is the current research in the field of forensic odontology(Uma Maheshwari 2018). The radiographic visibility of the periodontal ligament in lower third molars is new approach (Guo et al. 2020).On the other hand tooth development and sequence of eruption have been used extensively as the preferred methods of age estimation in children and adolescent(Herschaft et al. 2007).

2.8. Common methods of dental age estimation

Several methods have been proposed for assessing dental development, which is generally referred to as dental aging. Dental aging appears in two forms: Tooth mineralization and tooth eruption patterns, both biological and developmental patterns. Eruption refers to the

emergence of the tooth through the gum rather than to the emergence from the bone or reaching the occlusal plane. This makes it impossible to use eruption for age estimation on skeletal remains in forensics. Tooth emergence may be influenced significantly by local exogenous factors such as infection, obstruction, crowding, and premature extraction of the deciduous predecessor or adjacent permanent teeth(Amariti et al. 2000), (Azrak et al. 2007).

2.8.1. Schour and Massler's method

Schour and Massler in 1941 had studied the development of deciduous and permanent teeth, describing 21 chronological steps from 4 months to 21 years of age and published the numerical development charts for them. These charts do not have separate surveys for males and females. The chart is based on histological sections, which takes into that the teeth that have erupted and the amount of resorption of roots of primary teeth and the amount of development of permanent teeth.

2.8.2. Moorrees, Fanning, and Hunt's method

(Moorrees et al. 1963)conducted a longitudinal study on children having age group from birth to 20 years. This method provides chronological age assessment information of the permanent mandibular posterior teeth and the developmental stages of the permanent maxillary and mandibular incisors. It consists of two separate development schemes, one for single rooted teeth illustrating 13 stages and the other for the mandibular molars having 14 stages of development. This technique requires the odontologist to correctly identify the tooth, to assess its proper stage of morphological development, and then to read the associated mean age and standard deviation (SD) from the gender specific graph. This method is totally radiographic study.

2.8.3. Cameriere's method

This method is based on the relationship between age and measurement of the open apices in teeth were seven permanent teeth of the right mandible are evaluated. The number of teeth with complete root development and apical ends of the roots completely closed (N0) was calculated. Teeth with incomplete root development and with open apices were considered. For teeth with one root, the distance between the inner sides of the open apex is measured. For teeth with two roots, the sum of the distances between the inner sides of the two open apices is analyzed (Wolf et al. 2016).

2.8.4. Foti's method

It is a type of radiographic age estimation method done mainly in children and young adults by counting the number of erupted 1^{st}, 2^{nd}, and 3^{rd} molar and also the tooth germs except the 3^{rd} molar. The criteria of tooth eruption are that line lying over the erupting tooth cusps have to reach over the line joining the mesial and distal cementoenamel junction of adjacent teeth. This will be applied to the regression formula (Ballal et al. 2014).

2.8.5. Willems' method

In an attempt to evaluate the accuracy of Demirjian's method of dental age estimation in children in a Belgian Caucasian population, Willems and co-associates studied 2523 OPGs of 1265 boys and 1258 girls, and noticed significant age overestimation and performed weighted ANOVA in order to adapt the scoring system for this Belgian population. The adapted scoring system resulted in new age scores expressed in years and in a higher accuracy compared to the original method in Belgian Caucasians (Willems et al. 2001).

More than one study demonstrated high correlation coefficient between both chronological and obtained dental age of Willems' method, thus confirming their potential applicability in clinical practice and forensic dentistry (Grover et al. 2012), (Mohammed et al. 2014).

2.8.6. Open apex method

This method included 455 Italian children between the ages of 5 and 15 years, their dental age was estimated by calculating the height of calcifying teeth in relation to the width of the "open" apex. The seven left permanent mandibular teeth excluding third molars were used for such a ratio calculation. To compensate for magnification and angulation errors that may have been induced during radiography. In the teeth with incomplete root development, the distance between inner sides of the open apex was measured. For the teeth with two roots, the sum of the distances between inner sides of two open apices is taken.

The dental maturity is calculated as the sum of normalized open apices (s) and the numbers of teeth with root development complete (N0): (the number of teeth with complete root development and closed apical ends) (Cameriere et al. 2006).

2.8.7. Nolla's method

It is a chronological age estimation by assessment of both maxillary and mandibular teeth. Staging is done on the evaluation of calcification of permanent teeth, and each tooth is assigned a reading and total sum of the staging of maxillary and mandibular teeth are done, which is compared with the predetermined values in the table to determine age. The development of teeth is divided into 10 stages numbered "0"–"9" Stage "0" denotes that tooth calcification is yet to begin; Stage "5" indicates crown completion, whereas stage "9" represents the completion of tooth calcification (Raj et al. 2016).

The advantages of this method are that it can be applied to an individual with or without the third molar and that; girls and boys are dealt separately. Nolla's method has been one of the least frequently used and tested across populations, despite its effectiveness. This method has already been tested in Sweden, Finland, and Andalusia, giving high correlation using limited number of teeth (teeth 21, 46 and 43 for boys and 21, 47 and 46 for girls under 10 years of age).

The study by Bolanos and co-associates has demonstrated that Nolla's method was the most reliable method for estimating chronological age, although there were variations between boys and girls (Bolanos et al. 2000). (Maber et al. 2006) found underestimation in all age groups, although more pronounced for girls and increasing particularly after 10 years old

2.8.8. Mincer's method

(Mincer et al. 1993) studied third molar development radiographically to use it as an estimator of chronological age in children and adolescents of age range 14–24 years using Demirjian's eight-grade classification. The development of maxillary third molar was found to be more foremost than mandibular third molars and root formation was earlier in males than females. It can be used for predicting whether an individual is (</>18 years) old.

2.8.9. Kohler's method

This is a modification of Gleiser and Hunt's (1955) method of grading first molar and based on the evaluation of development and maturation of all permanent third molars with ten stages of grading, (i.e., three stages of crown formation and seven stages of root formation). It has given more priority to the development of root compared to other methods as the root is completed at the age of about 23 years. This method has good accuracy in predict-

ing whether an individual is juvenile or adult using logistic regression formulas. It can also be used for age estimation in the 14–22years old individuals (Köhler et al. 1994).

2.8.10. Anderson's method

This method was principally based on (Moorrees et al. 1963) studies of mineralization of each tooth in the mandible and maxilla (including third molars) but with staging system from 1 -14 stages of development. It consists of four charts that include age assessment data on all permanent teeth, both maxillary and mandibular arches for both sexes. The order of variability in specific tooth development for both sexes was important turn up of this study. Hence, it can be noted that studying the first molar is reliable to provide the most accurate results and can be used in later childhood and early adolescence (Anderson et al. 1976).

2.8.11. AlQahtani's method

It is one of the most recent and widely accepted atlases of dental development and alveolar eruption for age estimation in children and adolescents. The chart consists of 31 diagrams depicting the median dental development observed starting at 30 weeks in utero and ending at 23.5 years of age. Eight of diagrams only describe 3rd molar development beginning at the age of 16.5 years. The chart does not differentiate between the sexes and defines tooth eruption as the emergence through the alveolar bone. This method concluded that tooth formation is least variable in childhood and most variable after the age of 16 years for the development of the third molar. This technique is available online in numerous languages (AlQahtani et al. 2010).

2.8.12. Balaraj's method

A radiological study of the closure of apical foramen of both permanent mandibular second molars for the determination of adolescents aged 14–16 years by the use of DMJ's method utilizing the description of dental formation stages of complete root formation and apical closure. The study concluded with the facts that: At 15 years, 5 months of age, 94% of boys had closed apical foramen and at 14 years, 9 months of age, 95% of girls had closed apical foramen. The dentist can determine the ages of 14 and 16 years medicolegally through a radiographical view of the closure of apical foramen of the roots (Balaraj and Nithin 2010).

2.9. History of Demirjian's method

On the back of much early research by several investigators age estimation from staging tooth formation appealed more reliable indicator of dental age than recording tooth emergence. Demirjian, Goldstein and Tanner had developed a method of estimating dental maturitychart based on relative and not absolute measurements of eight stages, which they described as observable during the development of the seven mandibular teeth of a French-Canadian population. They derived self-weighted maturity scores for each stage of each tooth formation, and separated the scores for males and females, and constructed centile charts that allowed the conversion of the numerical maturity score, derived by their method of assessment, to dental age(Demirjian et al. 1973). They have also proposed the staging teeth development based on estimation of growing teeth shape instead of their dimensions, using for that the lower left seven permanent teeth excluding the third molar. in their follow-

ing subsequent study on a larger sample of the same French-Canadian origin, Demirjian and Goldstein updated their originals(Demirjian and Goldstein 1976).

Demirjian distinguished between 4 stages of crown development and 4 of the roots, which are based on their species in radiological research. This method used a point system to form1 to 7 mandibular tooth. Each stage corresponds to a specific tooth result. The collection of all results reflects the Dental Maturity Score(DMS) from which it could be possible to determines the individual chronological age(Balwant and Jasdeep 2013).

2.10. Worldwide studies applying Demirjian's method

DMJ's method was formulated using French-Canadian children; and become the most widely used dental age examination method all over the world. Numerous studies have tested the applicability of this method in various population, including Australian, Brazilian, British, Chinese, Dutch, Malay, and South Indian populations, which were mainly based on the staging each tooth development of seven teeth on the mandibular left side of the panoramic radiograph.The results of application of DMJ's method on different worldwide population is variable, but it is clearly accepted method for age estimation and applicable in different parts of the world.

Combining data from several studies, Chailletand co-associates, established a database consisting of 9, 577 dental radiographs from healthy dental patients aged 2–25 years (mainly of European origin from Canada, Europe, and Australia). Derived from linear regression lines for 1-year age categories and manually smoothed, average score for age and age for score for the Chaillet database are detailed in Liversidge, who recommended their use as an international scoring system (Chaillet et al. 2004).

2.11. Limitations of methods used in age estimation

All methods used for age estimation have many drawbacks, which make them stand short of serving as all-time preferred method. For example, the main drawback of evaluating ossification of the hand bones is that the development of these bones is usually completed by the age of 18 years, which is much more earlier than tooth development (third molar teeth) that may continue until the early twenties .Furthermore, skeletal indicators can present disadvantages due to variations in bone development among individuals, and influenced by multiple factors such as nutrition and other environmental effects.

The *tooth eruption method*, conducted by visual assessment of the eruption of the teeth into the mouth is highly influenced by many factors including lack of space, feeding habits, local trauma, pathosis of deciduous teeth, and nutritional status.

All the methods applied to estimate dental age such as evaluation of tooth morphology (Mornstad et al. 1994; Someda et al. 2009), degree of ossification of skeletal structures(Schulz et al. 2008), biochemical changes in dental hard tissue and other age-dependent changes in human body(Takasaki et al. 2003) had showed different results regarding accuracy and possible means of application. It is clear that the most accurate methods of dental age estimation in children are based on the radiologically observed tooth development of the permanent teeth (Maber et al. 2006).

2.12. Motivations for applying Demirjian's method

Tooth development, is controlled more by genetics rather than by environmental and nutritional factors. Additionally, teeth are the strongest structures in the human body and are protected by the soft and hard tissues of the face, which renders the dental structures

highly resistant to external factors, such as the decomposition process and extreme temperatures (up to 1100 °C). All of these factors make the age estimation via studying dentition much more superior biological indicator for age estimation process.

In 2007, Olze published a detailed study of the ethnic differences in third molar mineralization, based on an analysis of over 3000 conventional OPGs. It has been demonstrated that Japanese, German, and South African individuals differ by up to 7 years from the rest of the studied populations, in regard to Demirjian's decimated stages. For this reason, the authors advocated that "it is imperative to use population-specific research to determine the individual chronological age for optimal reproducibility and credibility"(Bellastella et al. 1998), (Olze et al. 2007).

2.13. Research objectives of the present study

Various methods have been proposed to calculate dental age in order to estimate the chronological age through dental maturity and mineralization. DMJ's method is one of the most popular methods widely used to estimate dental age in different populations. However the results are different and it seems to be race dependent. Many investigators advised the evaluation of the accuracy of this method on population before trying to use it for age estimation for different purposes. The present study tries to shed light on the practicality of application of this method on a sample population from the Eastern part of Libya as their radiological records are available.

2.14. Studies of age estimation

Schour and Massler studied the development of deciduous and permanent teeth, describing 21 chronological steps from 4 months to 21 years of age and published the numerical

development charts for them. Gustafsongave another example of an atlas approach based on the mineralization initiation, the completed crown development, the eruption of the tooth and the completion of root development.

Gleiser and Hunt in 1955, detailed the stages of calcification of the first mandibular molar after performing radiographic and follow-up studies in this area (Andreas et al. 2004).

In the 1970s and later on a histological criteria that allow the determination of the chronological age from 7 weeks of gestation to 3 years of age has been developed (Amariti et al. 2000). These criteria included bone, salivary and dental formation characteristics (Anderson et al. 1976). (Kahl and Schwarze 1988) processed the data of Schour and Massler and proved that there is slowdown in the development of the permanent dentition among the selected cohort group used in their studies (Kahl and Schwarze 1988).

2.15. Problem statement

The accuracy of DMJ's method and its practicality of application of figures obtained from other population is questionable, so this study intended to extract data from Libyan population where the data will be assessed by compared in regard to the actual age of the individuals in the sample with the estimated age derived from DMJ's method.

Despite the fact that Age estimation by DMJ's method is universally accepted and applied in many international studies, there appears to be no data from Libya is available. The need to apply age estimation methods is increasing nowadays because of the current instability in the country and long standing armed conflict resulting in many causality and unrecognized bodies, which need to be identified. Dental age estimation is one of the most reliable methods furnishing a lot of useful information needed in this regard.

Chapter 3
Aims of the study

Aims of the study

The aims of this study are to evaluate the accuracy of DMJ's method in estimating the chronological age of male and female children between the ages of 6 and 16 years resident in Benghazi, and to establish a new DA standard for Libyan population if the DMJ's method is found to be useful in this regard. The main two goals of this study are:

1. To elaborate the use of DMJ's method of age estimation using tooth development as a guide on a Libyan sample.
2. To evaluate the accuracy of the DMJ's method in determining the chronological age of children resident in Benghazi city in Libya.

Chapter 4
Material and Methods

Material and Methods

4.1. Overview

According to DMJ's the study is based on eight stages (from A to H) of dental maturity in the seven left permanent mandibular teeth, observable through orthopantomographs (OPG). Each tooth was attributed a stage and converted in quantitative values by applying a specific table, the scores of the seven teeth are summed as a function of sex and the sum of dental maturity is obtained on a scale of 0 to100. This total is converted in dental age using a table for converting the results of dental maturity.

The original Demirjian's tables provide with a chart representing the calcification stages and separate scoring tables for boys and girls, assigning a particular score to each calcification stage, the sum of which is then compared with the tables provided for dental age estimation, separately for boys and girls. Thus, a total of three tables are required to be considered at a particular time while estimating the age of a person.

4.2. Ethical considerations

Permission to undertake this study was obtained from the designated dental faculty authorities for the use of information. Verbal implied consent was obtained from each patient's guardian for the inclusion of information in this study. A written consent is not necessary as these patients had already been asked to have an OPG by their treating doctors as per treatment needs and these OPGs were not specifically taken for this study purposes.

4.3. Study conduct

4.3.1. Research instruments

The OPGs were taken by digital panoramic x-ray system (VATECH), (AC220V+10%, 50/60Hz). Image viewer via media viewer (windows 7) was used for interpretation.

4.3.2. Research design

The study is designed to evaluate the results of application of DMJ's method of dental age estimation in a Libyan sample and to compare the actual age with the age calculated through this study using DMJ's method.

4.3.3. Type of study

This is an observational prospective study where the study subjects are chosen from the consecutive patients seeking routine dental treatments for different reasons in this faculty. The OPGs were ordered by the treating dentists solely upon dental request for treatment purposes and no patient was asked to have an OPG for sake of inclusion in this study.

4.3.4. Sampling and randomization

OPGs were taken for the consecutive patients asked by their treating doctors to have that view in the period from January to September2018 in the Oral Medicine and Radiology department of the Dental faculty of Benghazi University. The target number was set at 250 children aged 6 to 16 years, who were randomly chosen from those children attending to the Pedodontics , Orthodontics or community dentistry departments in

This faculty. Subjects were included only upon their guardian agreement for inclusion in this study (a copy of their OPG will be used).Furthermore, the quality of the OPG was carefully scrutinized prior to inclusion in case it met the inclusion criteria set for this study.

4.3.5. Blinding and quality assurance

All clinical information were collected and recorded at the scene during taking the radiograph and tagged with a unique ID, kept anonymous until it have been entered into a spreadsheet. While the information obtained from calculating the ages via DMJ's method are recorded separately and merged at data analysis stage.

To have standard OPGs, all the patients had their images taken by the same technician by the same machine at the same standing position assessed by a red laser light indicator the machine is equipped with it.

To avoid observer bias, each digital OPG of an individual was coded with a numerical identity number (001-250) to ensure that the examiner was blind to the sex, name and age of subjects.

4.3.6. Pilot study

A preliminary sample of 10 OPGs were taken at the beginning of study for purposes of calibration and to explore any concealed difficulties or any for eseeable major image errors .Assessments of chronological age were carried out by the same examiner. Furthermore, intra examiner consistency was assessed 1 month later, after the initial assessment by examining 10 randomly selected panoramic radiographs twice to achieve uniform interpretation and application of criteria.

4.4. The hypothesis

The statistical analysis was set to either accept or reject the following hypotheses:

- **Null hypothesis**: the chronological age of the individuals in this sample is not significantly different from the age estimated by the application of DMJ's method.
- **Alternate hypothesis:** The chronological age of the individuals is significantly different from the age estimated by DMJ's method.

The statistical work of this study was undertaken to either accept or reject this hypothesis.

4.5. Data quantity, quality and management

Two hundred and fifty children from North East region of Libya were included in this study provided that they met the inclusion criteria for this study. An almost equal number of patients from both gender (123 females and 127 males) were included. All the necessary clinical information, particularly the demographic data were collected prior to taking the radiograph for the individual.

Standard OPG was taken for every patient. An electronic digital copy of the OPG was used for estimating the patient's dental age blindly, then the information was collected and tabulated for analysis. A sample of radiographs are shown in figures 11-21.

4.6. Inclusion criteria

Children included in this study were selected according to the following criteria:

1. The child was born in, or permanently resident in Libya, transient immigrants and tourists are excluded.
2. Age between 6 calendar years and 16 years.
3. Healthy individuals without any chronic systemic disease.
4. Presence of a complete set of left mandibular permanent teeth (erupted or unerupted).

4.7. Exclusion criteria

1. Presence of congenital anomalies of any kind particularly the craniofacial defects or growth disorders. Those individuals taking medications affecting growth and development were also excluded.
2. If there is a radiographic evidence of hypodontia or gross pathologic problem.
3. Those individuals suffering from or had suffered serious local trauma to the region which adversely affected the primary teeth or their succedaneum teeth.
4. Unclear radiographs compromising the interpretation process, regardless of the cause of the error.

4.8. Dental age estimation

Dental age estimation was carried out in this study according to DMJ's method, which has already been discussed in previous sections. Generally, the apparent age difference is calculated by subtracting the estimated age from the chronological age, which is based on the actual date of birth. DMJ's method for age estimation is basically based on observing the stage of tooth development and given it maturity score (MS) from the tables provided by the authors and then calculate the age corresponds to the MS.

4.9. Definitions of tooth development stages according to DMJ's method

According to Demirjian et al, 1973 method.

Stage	Definition
A	"In both *uniradicular* and *multiradicular* teeth, a (sic) beginning of calcification is seen at the superior level of the crypt in the form of an inverted cone or cones. There is no fusion of these calcified points
B	Fusion of the calcified points forms one or several cusps, which unite to give a regularly outlined occlusal surface".
C	Enamel formation is complete at the occlusal surface. Its extension and convergence towards the cervical region is seen". "The beginning of a dentinal deposit is seen". "The outline of the pulp chamber has a curved shape at the occlusal border".
D	The crown formation is completed down to the cemento-enamel junction". "The superior border of the pulp chamber in the uniradicular teeth has a definite curved form, being concave towards the cervical region". "The projection of the pulp horns, if present, gives an outline shaped like an umbrella top. In molars the pulp chamber has a trapezoidal form Beginning of root formation is seen in the form of a spicule.
E	*Uniradicular teeth:* "The walls of the pulp chamber now form straight lines, whose continuity is broken by the presence of the pulp horn, which is larger than in the previous stage". "The root length is less than the crown height". *Molars:* "Initial formation of the radicular bifurcation is seen in the form of either a calcified point or a semi-lunar shape".

	"The root length is still less than the crown height".
F	*Uniradicular teeth:* "The walls of the pulp chamber now form a more or less isosceles triangle". "The apex ends in a funnel shape". "The root length is equal to or greater than the crown height". *Molars:* "The calcified region of the bifurcation has developed further down from its semi-lunar stage to give the roots a more definite and distinct outline with funnel shaped endings". "The root length is equal to or greater than the crown height".
G	The walls of the root canal are now parallel and its apical end is still partially open (Distal root on molars)".
H	The apical end of the root canal is completely closed (Distal root on molars) The periodontal membrane [ligament] has a uniform width around the root and the apex

4.9.1. Dental maturity as assessed according to DMJ's method

The left mandibular permanent teeth were rated in the following order: second molar, first molar, second and first bicuspids, canine, lateral incisor, and central incisor. All teeth were rated on a scale of A to H if there was calcification. If there was no calcification, the crypt formation was not taken into consideration and a rate of 0 was given (Figure 1).

There were no absolute measurements to be taken to compare the relative length (crown/root) in this study.

Tooth formation is divided in to eight stages and criteria of these stages for each tooth were given separately. The developmental status of a particular tooth was calculated in years on the basis of tables given by Demirjian et al, 1973.

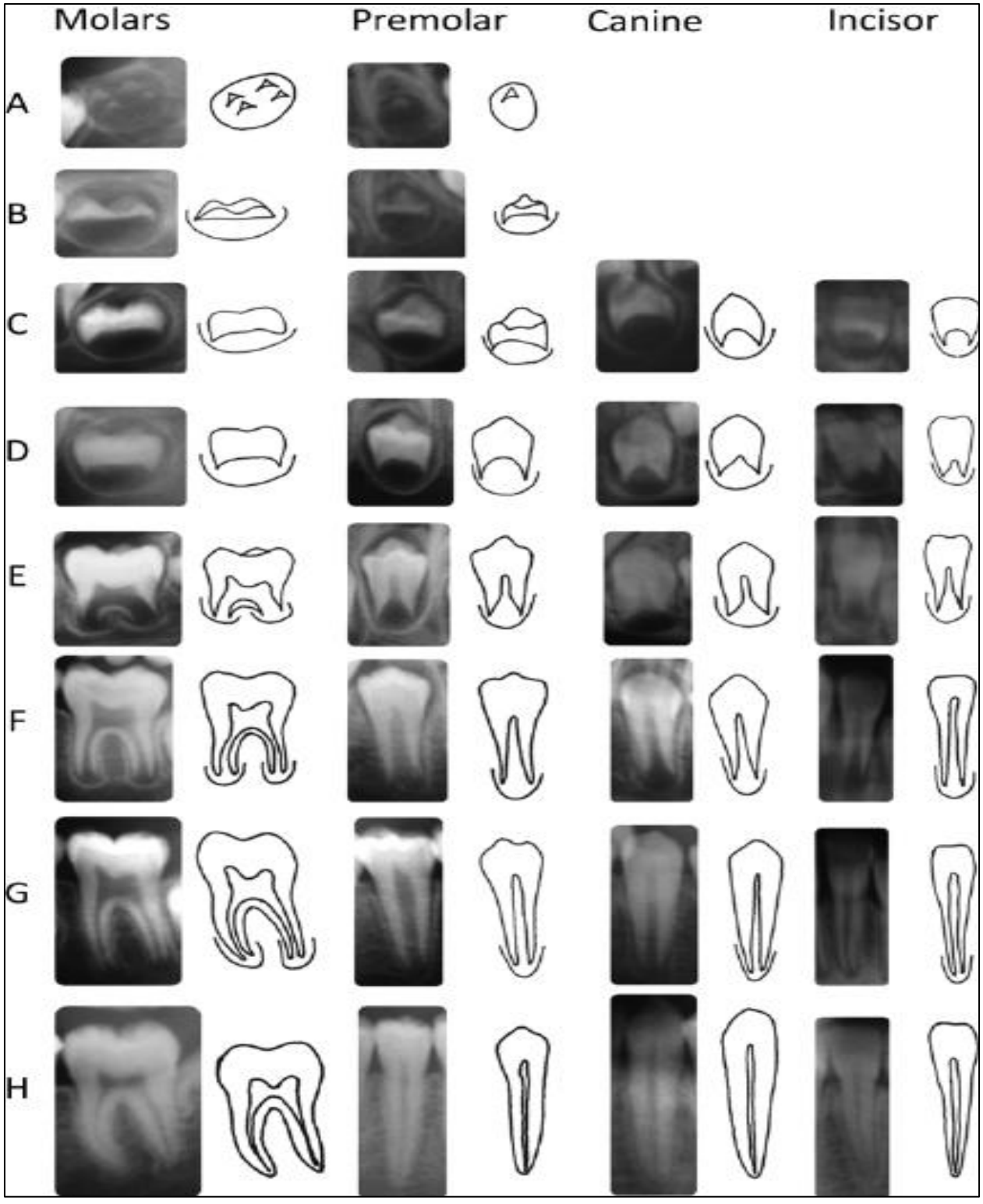

Figure 1: Pictures of tooth development stages (adapted from DMJ's method)

4.9.2. Stage description according to Demirjian's method

A- Commencement of calcification of cusps.

B- Fusion of the calcified cusps, which gives a regular outline on the occlusal surface.

C-Completion of enamel formation at the occlusal surface with extensions and convergence toward the cervical region. Beginning of a dentinal deposit is seen.

D (a) Completion of crown formation; the superior border of the pulp is concave to the cervical.

(b)Beginning of root formation in the form of a spicule.

E- (a) The root length is less than the crown height; the pulp horn is more defined.

(b) Initial formation of the radicular bifurcation in the molar seen in the form of either a calcified point or a semi lunar shape.

F- The root length is equal to or greater than the crown height and pulp apex ends in a funnel shape.

G- The walls of the root canal are now parallel and its apical end is still partially open (distal root in molar).

H- Closure of the apical foramen; the periodontal membrane has a uniform width around the tooth.

4.9.3. Steps for dental age estimation used in this study

I. Step 1: Each tooth (teeth 31-37) was carefully assessed against the eight developmental stages (from A to H) by following the definition criteria for each stage and comparing

each tooth with drawings and radiographic images according to the Demirjian's method (Figure 1).

II. Step 2: The developmental stage of each tooth was then converted into a score (self-weighted scores) using the tables outlined by the Demirjian's method for males and females separately (Table 1).

III. Step 3: The self-weighted scores of each individual tooth (31-37) were then added together. The sum of the total self-weighted scores was expressed as the dental maturity score

IV. Step 4: The dental maturity score in each sample was converted into an estimated age by comparing them with the tables from the Demirjian's method for males and females separately (Table 2) & (Table 3).

V. Step 5: The different value for each sample was then calculated by subtracting the chronological age from the estimated age (positive and negative values indicated overestimation and underestimation, respectively).

Table 1: Self-weighted Score table for tooth developmental stages for males and females according to the DMJ's method[1]

Tooth	Stage								
	0**	A	B	C	D	E	F	G	H
Boys									
M2	0.0	2.1	3.5	5.9	10.1	12.5	13.2	13.6	15.4
M1				0.0	8.0	9.6	12.3	17.0	19.3
PM2	0.0	1.7	3.1	5.4	9.7	12.0	12.8	13.2	14.4
PM1			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
I2				0.0	3.2	5.2	7.8	11.7	13.7
I1					0.0	1.9	4.1	8.2	11.8
Girls									
M2	0.0	2.7	3.9	6.9	11.1	13.5	14.2	14.5	15.6
M1				0.0	4.5	6.2	9.0	14.0	16.2
PM2	0.0	1.8	3.4	6.5	10.6	12.7	13.5	13.8	14.6
PM1				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
I2				0.0	3.2	5.6	8.0	12.2	14.2
I1					0.0	2.4	5.1	9.3	12.9

**Stage 0 is no calcification*

[1] Adopted from Demirjian *et al.* 1973

Table 2: Conversion table from DMS to DA for *males* according to DMJ's method[2]

Age	Score	Age	Score	Age	Score	Age	Score
3.0	12.4	7.0	46.7	11.0	92.0	15.0	97.6
.1	12.9	.1	48.3	.1	92.2	.1	97.7
.2	13.5	.2	50.0	.2	92.5	.2	97.8
.3	14.0	.3	52.0	.3	92.7	.3	97.8
.4	14.5	.4	54.3	.4	92.9	.4	97.9
.5	15.0	.5	56.8	.5	93.1	.5	98.0
.6	15.6	.6	59.6	.6	93.3	.6	98.1
.7	16.2	.7	62.5	.7	93.5	.7	98.2
.8	17.0	.8	66.0	.8	93.7	.8	98.2
.9	17.6	.9	69.0	.9	93.9	.9	98.3
4.0	18.2	8.0	71.6	12.0	94.0	16.0	98.4
.1	18.9	.1	73.5	.1	94.0		
.2	19.7	.2	75.1	.2	94.4		
.3	20.4	.3	76.4	.3	94.5		
.4	21.0	.4	77.7	.4	94.6		
.5	21.7	.5	79.0	.5	94.8		
.6	22.4	.6	80.2	.6	95.0		
.7	23.1	.7	81.2	.7	95.1		
.8	23.8	.8	82.0	.8	95.2		
.9	24.6	.9	82.8	.9	95.4		
5.0	25.4	9.0	83.6	13.0	95.6		
.1	26.2	.1	84.3	.1	95.7		
.2	27.0	.2	85.0	.2	95.8		
.3	27.4	.3	85.6	.3	95.9		
.4	28.6	.4	86.2	.4	96.0		

[2] Adopted from Demirjian *et al.* 1973

.5	29.5	.5	86.7	.5	96.1	
.6	30.3	.6	87.2	.6	96.2	
.7	31.1	.7	87.7	.7	96.3	
.8	31.8	.8	88.2	.8	96.4	
.9	32.6	.9	88.6	.9	96.5	
6.0	33.6	1.0	89.0	14.0	96.6	
.1	34.7	.1	89.3	.1	96.7	
.2	35.8	.2	89.7	.2	96.8	
.3	36.9	.3	90.0	.3	96.9	
.4	38.0	.4	90.3	.4	97.0	
.5	39.2	.5	90.6	.5	97.1	
.7	42.0	.6	91.3	.6	97.3	
.8	43.6	.7	91.6	.7	97.4	
.9	45.1	.8	91.8	.8	97.5	

Table 3: Conversion table from DMS to DA for *females* according to DMJ's method[3]

Age	Score	Age	Score	Age	Score	Age	Score
3.0	13.7	7.0	51.0	11.0	94.5	15.0	99.2
.1	14.4	.1	52.9	.1	94.7	.1	99.3
.2	15.1	.2	55.5	.2	94.9	.2	99.4
.3	15.8	.3	57.8	.3	95.1	.3	99.4
.4	16.6	.4	61.0	.4	95.3	.4	99.5
.5	17.3	.5	65.0	.5	95.4	.5	99.6
.6	18.0	.6	68.0	.6	95.6	.6	99.6
.7	18.8	.7	71.0	.7	95.8	.7	99.7
.8	19.5	.8	75.0	.8	96.0	.8	99.8
.9	20.3	.9	77.0	.9	96.2	.9	99.9
4.0	21.0	8.0	78.8	12.0	96.3	16.0	100.0
.1	21.8	.1	80.2	.1	96.4		
.2	22.5	.2	81.2	.2	96.5		
.3	22.8	.3	82.2	.3	96.6		
.4	23.2	.4	83.1	.4	96.7		
.5	24.0	.5	84.8	.5	96.8		
.6	24.8	.6	84.8	.6	96.9		
.7	25.6	.7	85.3	.7	97.0		
.8	26.4	.8	86.1	.8	97.1		
.9	27.2	.9	86.7	.9	97.2		
5.0	28.0	9.0	87.2	13.0	97.3		
.1	28.9	.1	87.8	.1	97.4		
.2	29.7	.2	88.3	.2	97.5		
.3	30.5	.3	88.8	.3	97.6		
.4	31.3	.4	89.3	.4	97.7		

[3]Adopted from Demirjian *et al.* 1973

Age	Score	Age	Score	Age	Score	Age	Score
.5	32.1	.5	89.8	.5	97.8		
.6	33.0	.6	90.2	.6	98.0		
.7	34.0	.7	90.7	.7	98.1		
.8	35.1	.8	91.1	.8	98.2		
.9	36.8	.9	91.4	.9	98.3		
6.0	37.0	1.0	91.8	14.0	98.3		
.1	38.0	.1	92.1	.1	98.4		
.2	39.1	.2	92.3	.2	98.5		
.3	40.2	.3	92.6	.3	98.6		
.4	41.3	.4	92.9	.4	98.7		
.5	42.5	.5	93.2	.5	98.8		
.6	43.9	.6	93.5	.6	98.9		
.7	46.7	.7	93.7	.7	99.0		
.8	48.0	.8	94.0	.8	99.1		
.9	49.5	.9	94.2	.9	99.1		

4.10. Statistical analysis

The collected data were tabulated in Microsoft excel spreadsheet. Data were transferred to SPSS format by version 23 (Chicago, Illinois, USA). Statistical analysis of the data with different characteristics was performed with the use of descriptive analysis, correlation, frequency tables and the student paired t-test. The level of significance was set at ($p<0.05$).

The main purpose of statistical analysis is to verify whether the DMJ's method can be used to determine the actual age of the study sample. Digital copies of the radiograph were extracted and studied separately. The data obtained from these panoramic radiographs were tabulated and a comparative histogram was created. A summary statistics of the sample using descriptive statistics was first run to make a general idea about the study sample. Then a frequency table was done first for the whole sample then for both the genders separately to clarify the sort of distribution of individuals among the groups and comparison of the general characteristics of the groups.

The type of distribution of the sample was tested as well as the correlation between the two sets of data. Student t-test was used to check whether there is a statistically significant difference between the chronological and estimated age of the whole sample then within the individual age groups.

It is clear from K- S test and Shapiro-Wilk test that the sample data is not normally distributed so only the non-parametric tests can be used for comparison unless there is large sample size, because as n increases, the binomial distribution becomes very close

to normal distribution, so it is possible to analyze the data using t- test in a large number samples.

Finally, for those age groups with statistically significant difference, the estimated age was subtracted from the chronological age to check whether there's sub-estimation or over estimation of the age in such groups.

4.11. Limitations of study

Unclear x-rays were excluded as well as the radiographs those show missing teeth specially in the left side of the mandible are not useful for this study. Radiographic errors which may have resulted from any source of the common errors usually encountered during taking an OPG were excluded as well. The most common cause of such errors resulted from patient movement during exposure causing blurring or inaccurate positioning of the child during the exposure, despite the fact that the x-ray machine used in this study was equipped by a laser pointing lines, which facilitates the positioning of the patients in standard position.

Patients with multiple badly decayed teeth with crown destruction or periapical changes were also excluded as it may affect the accuracy of the radiograph interpretation. The current sample of patients may not represent the population being considered as a convenient sample (i.e. chosen from consecutive hospital patients), and only selected age group were included with a relatively small number of patients. Furthermore most of the included patients are inhabitants of the North East part of the country (as was the current sitting of this study). All of these factors make it unrepresentative for the Libyan population.

Chapter 5

Results

Results

The total number of the children included in this study was 250 (123 females and 127 males)(Figure 2), divided into 16 groups according to their age. All of them had digital panoramic radiograph taken by VATECH (digital panoramic x-ray system)in the Radiology department of the dental faculty of Benghazi University by the same machine on the same standardized position by the help of the laser pointing device this machine had equipped with (Figure 7).

Data analysis includes demography, descriptive statistics of the sample, frequency tables, correlations, test of data distribution, and comparisons of the chronological age and estimated for the whole sample and for the separate genders and individuals ages.

5.1. Demography

Almost equal number between different genders has been chosen (Figure 2).Data were analyzed for the differences between chronological age and the age obtained from DMJ's method for the whole group in each year starting for each gender and for separate age, from 6 years until the age of 16.

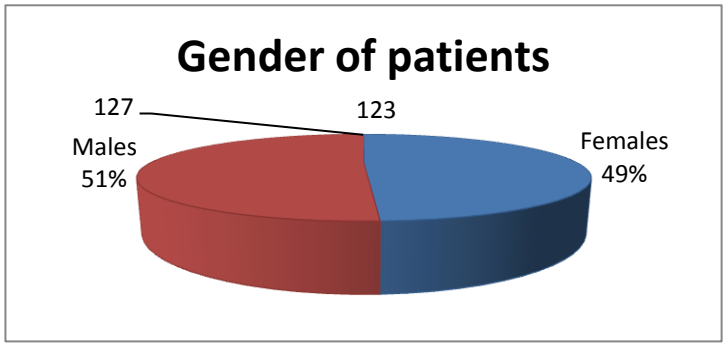

Figure 2: Number of patients according to gender

each sex was included. (127 males and 123 The number of patients according to each age group is shown in(Table 4).More than 70% of patients from the age groups 7- 11 years. Although an almost equal number from females) the number of both sexes is not equal in each age group.

Table 4: The number and percentage of children according to age

Age	No of children	Female	Male	Percentage
6	26	13	13	10.4%
7	24	14	10	9.6%
8	35	22	13	14.0%
9	29	16	13	11.6%
10	41	21	20	16.4%
11	26	10	16	10.4%
12	17	6	11	6.8%
13	21	8	13	8.4%
14	11	2	9	4.4%
15	12	4	8	4.8%
16	8	7	1	3.2%
Total	250	123	127	100%

5.2. Exploring the sample

The data analysis was done on equal number of items for both the chronological age and the estimated age as shown in. The total number of sample was 250individuals.All the non valid cases were excluded according to previously set inclusion and exclusion criteria, which were listed in the previous section. More detailed description of the sample is shown in (Table 5) revealing the mean, median, variance, SD, minimum, maximum, range, inter quartile range, skewness, and kurtosis of the sample.

Table 5: Descriptive summary

			Statistic	Std. Error
Chronological age (250 cases)	Means		10.00	.172
	95% Confidence Interval for Mean	Lower Bound	9.66	
		Upper Bound	10.34	
	5% Trimmed Mean		9.91	
	Median		10.00	
	Variance		7.422	
	Std. Deviation		2.724	
	Minimum		6	
	Maximum		16	
	Range		10	
	Interquartile Range		4	
	Skewness		.408	.154
	Kurtosis		-.656-	.307
Estimated age (250 cases)	Median		10.00	
	Variance		7.717	
	Std. Deviation		2.778	
	Minimum		6	
	Maximum		16	
	Range		10	
	Interquartile Range		4	
	Skewness		.678	.154
	Kurtosis		-.470-	.307

5.3. Frequency Table of the study sample

The Descriptive statistics of the gender is shown in (Table 6).The number of females in this sample was 123, their mean chronological age was 9.69 years, while median chronological age was 9.00 years and the mode was 8 years, the SD was 2.74 and the variance was 7.510.The mean estimated age for these 123 females was 9.89 years, the median estimated age was 9.00 years and the mode was 8 years and the SD was 2.810 and the variance was 7.899.

The number of males was 127 with mean chronological age was 10.30 years, the median age was 10.0 years and the mode was 10 years and the SD was 2.685 and the variance was 7.211. The mean estimated age was 10.33, the median age was 10.00 years and the mode was 8 years and the SD was 2.740 and the variance was 7.509.

Table 6: Descriptive statistics of the genders

Sex				**Chronological age**	**Estimated age**
F	N		Valid	123	**123**
			Missing	0	0
		Mean		9.69	9.89
		Median		9.00	9.00
		Mode		8	8
		Std. Deviation		2.740	2.810
		Variance		7.510	7.899
M	N		Valid	127	**127**
			Missing	0	0
		Mean		10.30	10.33
		Median		10.00	10.00
		Mode		10	8
		Std. Deviation		2.685	2.740
		Variance		7.211	7.509

5.4. Frequency table for age

As shown in **(Table 7**) about 70% of the patients were under 11 years of age.

Table 7: Number of patients according to chronological age and sex

Sex		Frequency	Percent
F	6	13	10.6
	7	14	11.4
	8	22	17.9
	9	16	13.0
	10	21	17.1
	11	10	8.1
	12	6	4.9
	13	8	6.5
	14	2	1.6
	15	4	3.3
	16	7	5.7
	Total	123	100.0
M	6	13	10.2
	7	10	7.9
	8	13	10.2
	9	13	10.2
	10	20	15.7
	11	16	12.6
	12	11	8.7
	13	13	10.2
	14	9	7.1
	15	8	6.3
	16	1	.8
	Total	127	100.0

Figure 3: Bar chart of the chronological age (sex = Female)

Figure 4: Bar chart of the chronological age (sex = Male)

Table 8: Number of patients according to estimated age and sex

Sex		Frequency	Percent
F	6	4	3.3
	7	20	16.3
	8	29	23.6
	9	14	11.4
	10	16	13.0
	11	8	6.5
	12	10	8.1
	13	3	2.4
	14	4	3.3
	15	8	6.5
	16	7	5.7
	Total	123	100.0
M	6	4	3.1
	7	17	13.4
	8	20	15.7
	9	10	7.9
	10	20	15.7
	11	19	15.0
	12	14	11.0
	13	4	3.1
	14	6	4.7
	15	2	1.6
	16	11	8.7
	Total	127	100.0

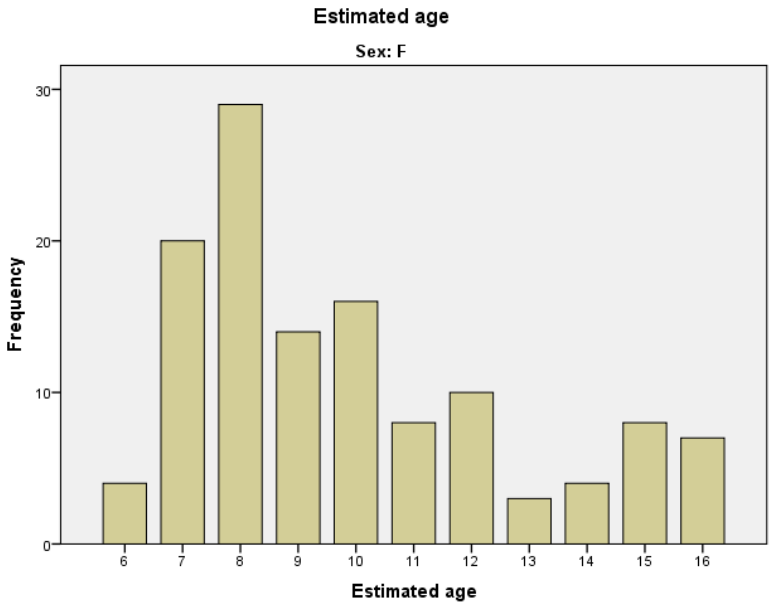

Figure 5: Bar chart of the Estimated age (sex = Female)`

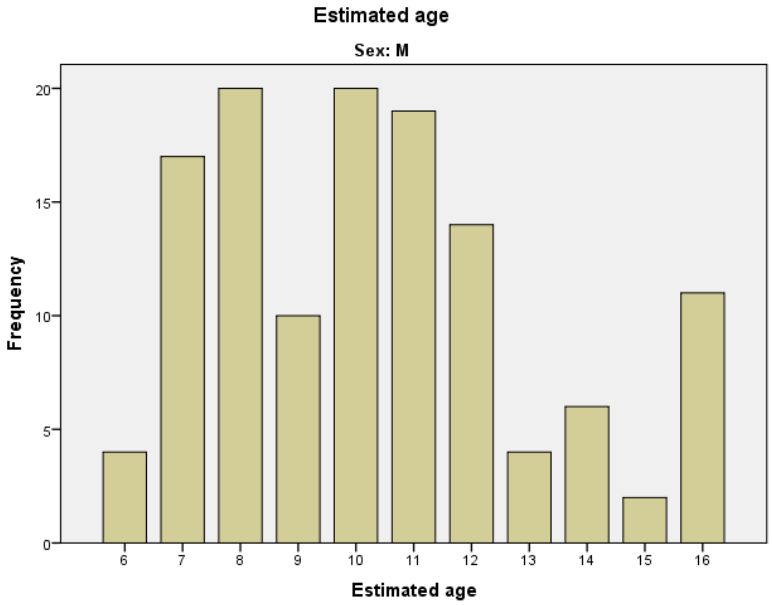

Figure 6:Bar chart of the Estimated age (sex = Male)

5.5. Tests of Normality

As testing the distribution of the sample is of great importance especially for choosing an appropriate statistical inference method, the current sample was tested for distribution of the normality. As shown in (Table 9) the Kolmogorov-Smirnova static is highly significant(0.000), as well as Shapiro-Wilkstatic is highly significant (0.000). Thus, the current sample is clearly not normally distributed. The use of the non-parametric tests such as "student t-test" for comparison can only be implemented if the sample size is of a large size. The current sample contains 250 items and the student t-test can be used for the comparison in this case.

Table 9: Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	Df	Sig.
Chronological age	.120	250	.000	.950	250	.000
Estimated age	.153	250	.000	.916	250	.000

a. Lilliefors Significance Correction

5.6. Correlation

Testing correlation of the sample data is important to explore if the two sets of data is correlated or not. It is clearly notable from that there is highly significant Correlation at the 0.01 level (2-tailed) both for parametric correlation (i.e. Pearson Correlation) (Table 10), or the nonparametric Correlation Coefficient (i.e. Spearman's rho) (

Table 11).

Table 10: Test of correlation of the samples data

		Chronological age	Estimated age
Chronological age	Pearson Correlation	1	**.928****
	Sig. (2-tailed)		.000
	N	250	250
Estimated age	Pearson Correlation	.928**	1
	Sig. (2-tailed)	.000	
	N	250	250

**. Correlation is significant at the 0.01 level (2-tailed).

Table 11: Nonparametric Correlations

			Chronological age	Estimated age
Spearman's rho	Chronological age	Correlation Coefficient	1.000	**.928****
		Sig. (2-tailed)	.	.000
		N	250	250
	Estimated age	Correlation Coefficient	.928**	1.000
		Sig. (2-tailed)	.000	.
		N	250	250

**. Correlation is significant at the 0.01 level (2-tailed).

5.7. Comparisons of differences by student T-test

5.7.1. The whole sample' means by paired student t-test

(Table 12) reveals that there is no significant differences in age estimation of all age groups except for the ages 6, 7 and 15 years (at 0.05% level of significance).

Table 12: Paired Samples Test chronological age -estimated age difference

Age (years)	Mean	Std. Dev	SE of Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
				Lower	Upper			
6	-1.038	.999	.196	-1.442-	-.635-	-5.299	25	**.000**
7	-.375	.647	.132	-.648-	-.102-	-2.840	23	**.009**
8	.029	.785	.133	-.241-	.298	.215	34	.831
9	.345	.936	.174	-.011-	.701	1.983	28	.057
10	.024	.851	.133	-.244-	.293	.183	40	.855
11	-.077	.935	.183	-.454-	.301	-.420-	25	.678
12	-.118-	1.111	.270	-.689-	.454	-.436-	16	.668
13	.476	1.662	.363	-.280-	1.233	1.313	20	.204
14	-.455	1.293	.390	-1.323-	.414	-1.166	10	.271
15	-.667	.492	.142	-.980-	-.354-	-4.690	11	**.001**
16	.250	.463	.164	-.137-	.637	1.528	7	.170

5.7.2. Estimation condition of the difference

For those ages with significant differences of age estimation, DMJ's method tends to underestimate the age if there such as in the case of 6 and 7 years old as well as in 15 years old. These age groups do not appear to be characteristically different from other age groups as illustrated in(Table 13).

Table 13: Estimation condition

Age		Estimation condition	Frequency	Percent
6.0	Valid 26	Overestimation	2	7.7
		Underestimation	**24**	92.3
		Total	26	100.0
7.0	Valid 24	Overestimation	4	16.7
		Underestimation	**20**	83.3
		Total	24	100.0
15.0	Valid 12	Overestimation	3	25.0
		Underestimation	**9**	75.0
		Total	12	100.0

5.7.3. Comparison of age according to gender

Comparison was made between the Chronological age and the estimated ages for each gender separately as shown in (Table **14**). For females (two tailed t-test =-2.136, df=122, p-value=0.035). For males (two tailed t-test= -0.344, df=126, p-value= 0.731).

Table 14: T-TestFor each gender

Paired Samples Statistics

Sex			Mean	N	Std. Deviation	Std. Error Mean
F	Pair 1	Chronological age	9.69	123	2.740	.247
		Estimated age	9.89	123	2.810	.253
M	Pair 1	Chronological age	10.30	127	2.685	.238
		Estimated age	10.33	127	2.740	.243

Paired Samples Correlations

Sex			N	Correlation	Sig.
F	Pair 1	Chronological age & Estimated age	123	.928	.000
M	Pair 1	Chronological age & Estimated age	127	.928	.000

Paired Samples Test

Sex			Paired Differences		
			Mean	Std. Deviation	Std. Error Mean
F	Pair 1	Chronological age - Estimated age	-.203-	1.056	.095
M	Pair 1	Chronological age - Estimated age	-.031-	1.031	.091

Paired Samples Test

Sex			Paired Differences		T	Df
			95% Confidence Interval of the Difference			
			Lower	Upper		
F	Pair 1	Chronological age - Estimated age	-.392-	-.015-	-2.136-	122
M	Pair 1	Chronological age - Estimated age	-.213-	.150	-.344-	126

Paired Samples Test

Sex			Sig. (2-tailed)
F	Pair 1	Chronological age - Estimated age	.035
M	Pair 1	Chronological age - Estimated age	.731

5.7.4. Chronological age 6

For comparison of the patients of chronological age = 6 with the estimated age, the number of patients was 26 (13 females and 13 males). The mean estimated age was 7.04 years. (Student t-test -5.299; df=25 and p value 0.000). (i.e. there is highly significant difference in age estimation at this age) as shown in (**Table 15**).

Table 15: Paired samples T- test for chronological age = 6 Years

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Chronological age	6.00	26	.000	.000
	Estimated age	7.04	26	.999	.196

Paired Samples Test

Chronological age - Estimated age	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		T	Df	Sig. (2-tailed)
				Lower	Upper			
	-1.038-	.999	.196	-1.442-	-.635-	-5.299	25	0.00

5.7.5. Chronological age 7

The patient with the chronological age 7 years as shown in (**Table 16**) the number of patients included at this age was 24 (14 female and 10 males. The mean estimated age was age 7.38 years. (t- test -2.840, df= 23, p value= 0.009). There is highly significant difference between the actual age and the estimated age.

Table 16:Paired samples T- test for chronological age = 7 Years

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Chronological age	7.00	24	.000	.000
	Estimated age	7.38	24	.647	.132

Paired Samples Test

Chronological age - Estimated age	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	Df	Sig. (2-tailed)
				Lower	Upper			
	-.375-	.647	.132	-.648-	-.102	2.840	23	.009

5.7.6. Chronological age 8

The patients with chronological age of 8 years were 35 (22 female and 13 males) as shown in (**Table 17**). The mean estimated age was 7.97 years. (t-test= 2.98, df= 34, p value= 0.831). There is no significant difference in age estimation at this age.

Table 17: Paired samples T- test for chronological age = 8 Years

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Chronological age	8.00	35	.000	.000
	Estimated age	7.97	35	.785	.133

Paired Samples Test

Chronological age - Estimated age	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		T	Df	Sig. (2-tailed)
				Lower	Upper			
	.029	.785	.133	-.241-	-298	.215	34	.831

5.7.7. Chronological age 9

The chronological age 9 years the number of patients included at this age was 29 (16 female and 13 males) as shown in **Table 18**. The mean estimated age was 8.66 years. (T-test = 1.983, df=28 and p value= 0.057). There is no significant difference in age estimation by these two methods at this age.

Table 18: Paired samples T- test for chronological age = 9 Years

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Chronological age	9.00	29	.000	.000
	Estimated age	8.66	29	.936	.174

Paired Samples Test

Chronological age - Estimated age	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
				Lower	Upper			
	.345	.936	.174	-.011-	-.701	1.983	28	.057

5.7.8. Chronological age 10

The total number of patients aged 10 years in this study was 41 (21 female and 20 males). Their mean estimated age was 9.98 years. (T-test =0.183, df=40 and p value= 0.855). There is no significant difference in age estimation at this age as shown in (Table 19).

Table 19: Paired samples T- test for chronological age = 10 Years

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Chronological age	10.00	41	.000	.000
	Estimated age	9.98	41	.851	.133

Paired Samples Test

Chronological age - Estimated age	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		T	df	Sig. (2-tailed)
				Lower	Upper			
	.024	.851	.133	-.244-	.293	.183	40	.855

5.7.9. Chronological age 11

The total number of patients aged 11 years was 26 (10 female and 16 males). Their mean estimated age was 11.08. (T-test = -0.420, df=25 and p value= 0.678). There is no significant difference in age estimation at this age. As shown in (Table 20).

Table 20: Paired samples T- test for chronological age = 11 Years

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Chronological age	11.00	26	.000	.000
	Estimated age	11.08	26	.935	.183

Paired Samples Test

Chronological age - Estimated age	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	Df	Sig. (2-tailed)
				Lower	Upper			
	-.077-	.935	.183	-.454-	.301-	-.420-	25	.678

5.7.10. Chronological age 12

The total number of patients aged 12 years was 17 (6 female and 11 male). Their mean estimated age was 12.12. (T-test = -0.454, df=16 and p value= 0.668). There is no significant difference in age estimation at this age. As shown in (Table 21).

Table 21: Paired samples T- test for chronological age = 12 Years

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Chronological age	12.00	17	.000	.000
	Estimated age	12.12	17	1.111	.270

Paired Samples Test

Chronological age - Estimated age	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
				Lower	Upper			
	-.118-	1.111	.270	-.689-	.454	-.436-	16	.668

5.7.11. Chronological age 13

The total number of patients aged 13 years was 21 (8 female and 13 males). Their mean estimated age was 12.52 years. (T-test = -1.313, df=20 and p value= 0.204). There is no significant difference in age estimation at this age as shown in (Table 22).

Table 22: Paired samples T- test for chronological age = 13 Years

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Chronological age	13.00	21	.000	.000
	Estimated age	12.52	21	1.662	.363

Paired Samples Test

Chronological age - Estimated age	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		T	df	Sig. (2-tailed)
				Lower	Upper			
	.476	1.662	.363	-.280-	1.233	1.313	20	.204

5.7.12. Chronological age 14

The total number of patients aged 14 years was 11 (2 female and 9 males). Their mean estimated age was 14.45 years. (T-test = -1.166, df=10 and p value= 0.271). There is no significant difference in age estimation at this age. As shown in **(**Table 23**)**

Table 23: Paired samples T- test for chronological age = 14 Years

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Chronological age	14.00	11	.000	.000
	Estimated age	14.45	11	1.293	.390

Paired Samples Test

Chronological age - Estimated age	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
				Lower	Upper			
	-.455-	1.293	.390	-1.323-	.414	-1.166	10	.271

5.7.13. Chronological age 15

The total number of patients aged 15 years was 12 (4 female and 8 males). Their mean estimated age was 15.67 years. (T-test = -4.690, df=11 and p value= 0.001). There is significant difference in age estimation at this age. As shown in (Table 24).

Table 24: Paired samples T- test for chronological age = 15 Years

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Chronological age	15.00	12	.000	.000
	Estimated age	15.67	12	.492	.142

Paired Samples Test

Chronological age - Estimated age	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
				Lower	Upper			
	-.667-	.492	.142	-.980-	-.354-	-4.690	11	.001

5.7.14. Chronological age 16

The total number of patients aged 16 years was 8 (7 female and 1 male). Their mean estimated age was 15.75 years. (T-test = -1.528, df=7 and p value= 0.170). There is no significant difference in age estimation at this age. As shown in (Table 25).

Table 25: Paired samples T- test for chronological age = 16 Years

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Chronological age	16.00	8	.000	.000
	Estimated age	15.75	8	.463	.164

Paired Samples Test

Chronological age - Estimated age	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
				Lower	Upper			
	.250	.463	.164	-.137-	.637	1.528	7	.170

Chapter 6

Discussion

Discussion

Age is an important factor for all human beings, whether they are living or dead. It is useful for day to-day life works such as educational purposes, governmental affairs, job relationships, medical sciences and clinical practices and more importantly, crime investigation, court of law research, and for reconstructive identification purpose in case of dead individuals.

Children are defined as the human beings from birth to puberty, while adolescents as from puberty to approximately the age of 20 years (Chaudhary and Doggalli 2018). Age estimation in children and adolescents is of paramount importance for a variety of legal procedures such as child labor, employment, status of majority, rape, adoption, eligibility for marriage, and when the birth certificate is not available (Acharya 2011), (Chaudhary and Doggalli 2018).

Age assessment is frequently required for medical and forensic purposes as well as for dental reasons such as prediction of the optimal time for various treatments (e.g. in orthodontics). Therefore, the estimated age should be as accurate as possible to gain the most benefit of it(Marroquin et al. 2017)(Moness Ali et al. 2019).The most widely proven scientific method for body identification in the forensic practice is DNA analysis, although dental age estimation methods are widely used (Odzhakov and Apostolov 2019). The developing dentition is used to assess maturity and to estimate age in many disciplines including anthropology, archeology, forensic science, pediatric dentistry, and orthodontics.

Of many procedures for age estimation such as chronological age, bone age, mental age, and others, the dental ages considered as one of the most valuable means of age identification and considered to be one of the most accurate procedures. It is basically based on tooth development stages (as tooth development shows less inconstancy than other developmental features in the human body), moreover, teeth are the most tough and resilient part of the skeleton (Leinonen et al. 1972).Furthermore, the time periods of dental development are inherited, but it is also population-specific. Clearly staggered stages differ in their manifestations for different nationalities (Schmeling et al. 2016).

Another important factor encouraging the consideration of teeth for age estimation is that there is high survivability of teeth exposed to severe physical factors, such as fire and water immersion, which makes the assessment of developing teeth as the best method of choice in forensic age estimation. In many cases, facial recognition of the deceased body is impossible, given the stage of decomposition or the circumstances in which the body has been retrieved (fire, water, acid, etc.). In such cases, it is necessary to apply scientific methods in order to obtain the most precise and accurate information about the case under investigation(Jayaraman et al. 2018).

Dental age, which is determined by hard dental tissue, is more closely related to the individual chronological age (Schmeling et al, 2016). There is a correlation existing between the individual's chronological age, dental age and skeletal age. In general, the condition of the skeleton helps to determine the individual physiological age (Mollabashi et al. 2019). Correlation also exists in the twin pairs of the same zygosity (Gupta et al. 2013).

Dental age (DA) estimation through studying dental formation is much more superior to studying tooth eruption method. Eruption of tooth is more applicable for deciduous dentition whose eruption is under genetic control but not for permanent dentition whereas, calcification of tooth is applicable for both deciduous and permanent dentition for dental age estimation (Chaudhary and Doggalli 2018). Eruption is only a brief occurrence, whereas formation may be related at different chronologic age levels. In interceptive orthodontic, knowing the time of each stage of tooth development may give general ideas to dental clinicians in proposing proper treatment plans, e.g. the prediction of emergence time of permanent teeth based on root developmental stage can help in planning for serial extraction. furthermore, tooth formation is affected much less by malnutrition, endocrinopathies, and other pathological conditions than any other tissue in the human body, while bone age is influenced by nutrition factors.

Age estimation has long been done using teeth, which can be divided into three categories of age groups: prenatal, neonatal, and early postnatal period; children and adolescents; and adults. It is well known that the most accurate methods of dental age estimation in children are those which based on the radiologically observed tooth development of the permanent teeth(Maber et al. 2006).

The development of each tooth can be divided into a series of maturity events—crown and roots stages. These biological age indicators are compared with a reference sample and from this, we infer chronological age.

During the last fifty years, numerous dental maturity studies have been reported and many are used to estimate maturity and age. Measures of performance and the terminology used to express accuracy of age estimation are varied and confusing. Some early stud-

ies report correlation between dental and chronological age, but this gives little information of the magnitude or direction of difference between dental age and real, (Bagherpour et al. 2010).

The difference between dental age and known age can be expressed in other way considerably under-aged older children. The method that performed best was the dental maturity scale of Willems (Willems 2001). Most of the methods of age estimation are based on comparisons between the radiographic developmental stages of a tooth and standard charts compiled from a large population in a well-defined geographic region. (Jayaraman et al. 2013), so it is important to carry out such methods on the intended population and the standard charts of one population may not suit another population.

Recent decades show upsurge use of modern technology in dental practice, noteworthy in the field of radiology. Radiographic methods of age estimation are noninvasive, and hence, they gained more attention compared with other methods of age estimation such as morphological, histological, and biochemical methods, which are time consuming and expensive. There are various radiographic methods identified by many forensic odontologists using conventional radiographs earlier, and recently, Cone Beam Computed Tomography (CBCT) is widely used to estimate the age of the individual, which is important in medicolegal cases(Uma Maheshwari 2018), (Asif et al. 2018).

Accuracy refers to how close dental age is to chronological age. An age estimating method might consistently under- or over-estimate age and this is known as bias. An accurate method has no bias, (i.e. the mean difference between dental age and known age will be zero or close to zero). The SD of the mean difference between dental age and real age, also known as the standard error of the estimate, which refers to the precision or reli-

ability of estimated age. An age estimating method with high precision/reliability has a small SD, but could have substantial bias. A valid age estimating method is both accurate and precise, i.e. no bias and small SD. The terms precision and reliability are also used in the context of intra- and inter-observer reproducibility (Camerieri et al. 2008).

Of different methods for age estimation, DMJ's method and AlQahtani's method are widely and commonly accepted methods for children and adolescents. As the scoring system in DMJ's method is based on the use of developmental stages of teeth and not based on the teeth eruption process it makes it more accurate in prediction of dental age (Willems et al. 2001). Age estimation from human teeth is well established field in clinical practice. Different techniques in numerous studies have been published for age estimation; each one has its own accuracy, precision, and reliability. In all cases reproducible and reliable estimation results are possible when the appropriate methods for each case are properly applied and used with a possibility of error in every approach.

The DMJ's method which was first described in 1973 is one of the most frequently used in estimating chronological age due to its simplicity, intra-examiner agreement, ease of standardization and ability to be reproduced, having been used and tested across a wide range of populations;(Demirjian et al. 1985), (Bagherpour et al. 2010) and has the greatest predictive and practical value (Bang 1989), but its applicability to all races is debatable, (Gungor et al. 2015), (Jayaraman and Roberts 2016), (Macha et al. 2017), .Many studies in the literature have found that there is a real difference in population parameters throughout the world and there should be population based studies to determine the accuracy of DMJ's method in estimating the dental age for different population, (Balgi et al. 2020).

Interestingly, (Hegde and Sood 2002) found that the method of Demirjian has overestimated the age of children from Belgaum (India), by 0.14 years for boys and 0.04 years for girls. Likewise, dental age was studied by in a sample of 261 Norwegian children (boys and 133 girls) and found the children were advanced in dental maturity by 1.5 to 4 months in boys and 4.5 to 7.5 in girls. Generally, 95% of the individual estimated ages were within ±2 years of the true age (Nykanen et al. 1998).

Davidson and Rodd 2001in a cross-sectional study comparing estimated age with dental age in 162 Somali and white Caucasian children residing in Sheffield-UK. The mean difference between dental age and chronological age was 1.01 years for Somali boys, 0.19 for Caucasian boys, 1.22 years for Somali girls, and 0.52 years for Caucasian girls. Somali children are significantly more dentally advanced than their Caucasian peers (Davidson and Rodd 2001). The outcomes of that study highlighted the need for population specific dental development standards for accurate assessment of DA .

In another European study, (Rozylo-Kalinowska et al. 2008) compared the dental age of 994 healthy Polish children from 6 to 16 years old with the development patterns proposed by Demirjian, finding that the method overestimated chronological age, with overestimation being more evident in 11-12-year-old girls and 13-year-old boys.

Jayaraman et al. concluded that DMJ's method underestimated age by 0.24 years in a sample of 266 Chinese sample (Jayaraman et al. 2013). Chen et al., found DMJ's method suitable for Chinese children (Chen et al. 2010). Sarkar et al, analyzed the effectiveness of the method with a sample of 100 Indians between 5 and 24 years old, it had underestimation of age by 1.63 years in boys and 1.54 years in girls (Sarkar et al. 2013).

Another study estimating the dental age in a Saudi children from Riyadh aged 8.5 to 17 years it has been found that the age of these Saudi children were overestimated by 0.3 years for boys and by 0.4 years for girls (Al-Emran 2008). Similar results were reported by study on Kuwaiti children aged 3 to 14 yrs, but the overestimations were 0.71 years for boys and 0.67 years for girls.(Qudeimat and Behbehani 2009) had tested the method in 509 healthy Kuwaiti children, and found that DMJ's method had underestimated the age of children.

The DMJ's method was tested on an Iranian sample composed of 114 boys and 170 girls and found that it had generally overestimated their age in the boys by 0.34 years and 0.25 years in the girls, despite its appropriateness for age estimation in the 9 to 13-year-olds(Bagherpour et al. 2010).

In an attempt to compare the efficacy of different methods of age estimation, Djukic et al. in 2013 had assessed the accuracy of the Demirjian and Willem's methods with 686 Serbian children between 4 and 15 years old, finding that both methods showed a discrepancy in relation to chronological age, although the DMJ's method was less accurate than that of Willem's(Djukic et al. 2013).

In a study of 905 panoramic radiographs of healthy Malay children between 6 and 16 years of age the DMJ's method tended to be less accurate in estimating the chronological age in Malay children (Abu Asab et al. 2011).DMJ's method was found suitable for estimating the age of boys and girls of 6–14 years in a German population. Furthermore it was much more superior to Cameriere's method for dental age estimation of 6–14 years old children in a German population (Wolf et al. 2016).

In a more recent study from Egypt DMJ's method was unsuitable for dental age assessment in 160 Egyptian children aged 3-10 years, as their age was overestimated for almost all

of the studied subjects with an accuracy range from 0.18 to 1.19 years for males and from 0.08 to 0.87 years for females. Alternatively they suggested a development of a predication equation and the introduction of adaptable conversion tables to transform the maturity score into a dental age for Egyptian children (Moness Ali et al. 2019).Yang et al, 2019 analyzed (1249 OPGs), 603 girls and 646 boys form Chinese Han population aged 8-16 years and found that DMJ's method was more accurate than Willem's method in estimating their dental age and they highly recommend it for estimating dental age in the Chinese Han population (Yang et al. 2019).

DMJ's method for estimation of dental age for southern Turkish children from the results of a study of the panoramic radiographs of 535 patients (276 females, 259 males aged from 10 to 18 years) found that the mean difference between the chronologic and dental ages was ranged from 0.02 to 0.79 years in females and 0.04 to 0.85 years in males (Gungor et al. 2015).By and large, it has been found from several studies conducted in many countries that the dental age of their children were different from that of the French–Canadian standards reported by Demirjian et al, in 1973, whereas others reported that the DMJ's method could give variations when applied to different populations.

Contrasting the findings of previous studies with the current study findings by stating the similarity and differences between the previous findings that had already mentioned in literature review and the current finding. Although observer agreement is usually reported when using DMJ's method, there is an evident tendency towards overestimation of a subject's age (Jayaraman et al. 2013), which may be a result of ethnic differences between populations (Koshy and Tandon 1998). Likely an underestimation was reported in some ages

(Wolf et al. 2016), but DMJ's method has superior accuracy in comparison with some other methods(Alassiry et al. 2019).

According to the findings of many previous worldwide studies, which advocated the need for population specific dental development standards based on ethnicity or regional population to improve the accuracy of dental age assessment specifically designed to that region this study is carried out in this region of Libya to close the gap in knowledge about this issue .Dental radiographs have widely been used in dental age estimation in children and adolescents and rarely in adults (Kvaal and Solheim 1994) and with the readily available and widely used advanced radiographic techniques this study based on interpretation of a digital OPGs. In this study, radiographic evaluation of tooth stages was used to estimate the dental age of this sample of children from Libya and found to be useful in estimation of the dental age of these children by DMJ's method.

As there is no previous reported data regarding Libyan population this study was carried to test the eligibility of DMJ's method on a Libyan sample and its accuracy to determine the dental age. On comparison of the obtained results with the previous studies it is clear that this preliminary results can be used a larger scale studies involving other parts of the country with a bigger population sample for this purpose. The results of this study supports the need for regionally and ethnically specific validated data as the reference base for age estimation techniques.

6.1. CONCLUSIONS

The results of the present study proves that DMJ's method can be used generally for age estimation of the children resident in the North east part of Libya despite the significant difference in age estimation in children of less than 8 years old and those of 15 years. Such significant differences cannot be attributed to any obvious factor such as sex or body built of the patient, because of the small study sample. Further studies are needed in this regard.

Similar to several authors who developed new specific population dental maturation tables and curves to their populations, we should develop new age prediction models and maturation scores for Libyan population based on DMJ's method as a first step towards establishing nationwide database in this regard.

Summary

Study Summary

Age estimation of children and adolescents is essential to answer a variety of legal situations such as employment and marriage, especially in the view of increased immigration and mixing of populations, due to the globalized economy resulting from the increased migratory flow. Age estimation is usually done by morphologic, radiographic, histological and biochemical methods. OPG is being the most commonly used tool in dental age determination because it gives wide area for examination of multiple teeth in one view and it is widely used in dental practice for different purposes.

The accuracy of information obtained from determining dental age is characteristically based on the fact that tooth formation have stable and dental tissue can last for long periods of time after body decomposition beside the fact that the state of dental mineralization is much less affected by environmental and hormonal variations. Attempts of age estimation from teeth (especially in children, adolescents and young adults) had been carried out through a number of methods, most of them are reliable and give good prediction of age under study.

The most widely used and well studied method for comparing dental ages in different populations in the world is the method of Demirjian who stated that there is a strong correlation co-exists between skeletal age and chronologic age. This method is universally accepted and applied in many international studies, with variable outcomes, but none was done on a Libyan population so far to the best of our knowledge.

According to the findings of many previous worldwide studies, which advocated the need for population specific dental development standards based on ethnicity or regional

population to improve the accuracy of dental age assessment specifically designed to that region, this is one of the earliest attempts to use dentition development of group of Libyan sample for actual age estimation. This cross sectional study was designed to evaluate the suitability of the use of DMJ's method for dental age estimation in a group of patients resident in the North east part of Libya. Descriptive summary of the sample reveals that the sample consisted of a total of 250 children (aged 6-16 years), 123 females and 127 males with a mean, median and mod of chronological age of 10 years and Std. Deviation of 2.724. The mean estimated age was 10 years also with Std. Deviation of 2.778. The Lowest number of patients was in the age group of 16 (8 children) and the highest number was in the age group 10 years (41 children).

Although the data were not normally distributed (according to the Kolmogorov-Smirnova static and Shapiro-Wilk, mode=10), but the sample size was larger than 50, so student t- test was used for comparison of means for whole sample, both the genders and each age group. There is strong correlation between chronological and estimated age groups, apparent from the highly significant Pearson Correlation for chronological age = 0.925; likewise, for the nonparametric Correlation coefficient by Spearman's rho test shows very highly significant correlation (0.928)between the chronological age and estimated age.

Comparison of the general characteristics of the chronological and estimated ages of the whole groupand for the two genders is comparable and no significant differences were noticed .Descriptive statistics of the samples according gender shows that in females the mean chronological age was 9.69 ± 2.740 and the mean estimated age was 9.89± 2.810.

For males the mean chronological age was 10.30±2.685 and estimated age groups was 10.33±2.740.

The Paired samples T- test for chronological age = 6 years showed that there is significant difference between the estimated and chronological age in this group (p= 0.000), likewise for the 7 years old (p=0.009) and the 15 years old children(p= 0.001).Comparison of the chronological and estimated ages by the paired samples T-test for the rest of age groups has non-significant p value. So the estimated age driven from DMJ's method can be used to determine the dental age for Libyan children.

For those ages where there is a significant difference in the readings of age there is a tendency for underestimation of the age. So the use of DMJ's method for age estimation for Libyan children under the age of 8 years to be used cautiously until it can be reevaluated again by larger number of children and covering wider area of the country.

Finally, the results of this study supports the need for regionally and ethnically specific validated data as the reference base for age estimation techniques.

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Appendix

Figure 7: Digital Panoramic x-ray system used to take the OPG

Figure 8: Desktop computer part of OPG sytem used to recieve OPG

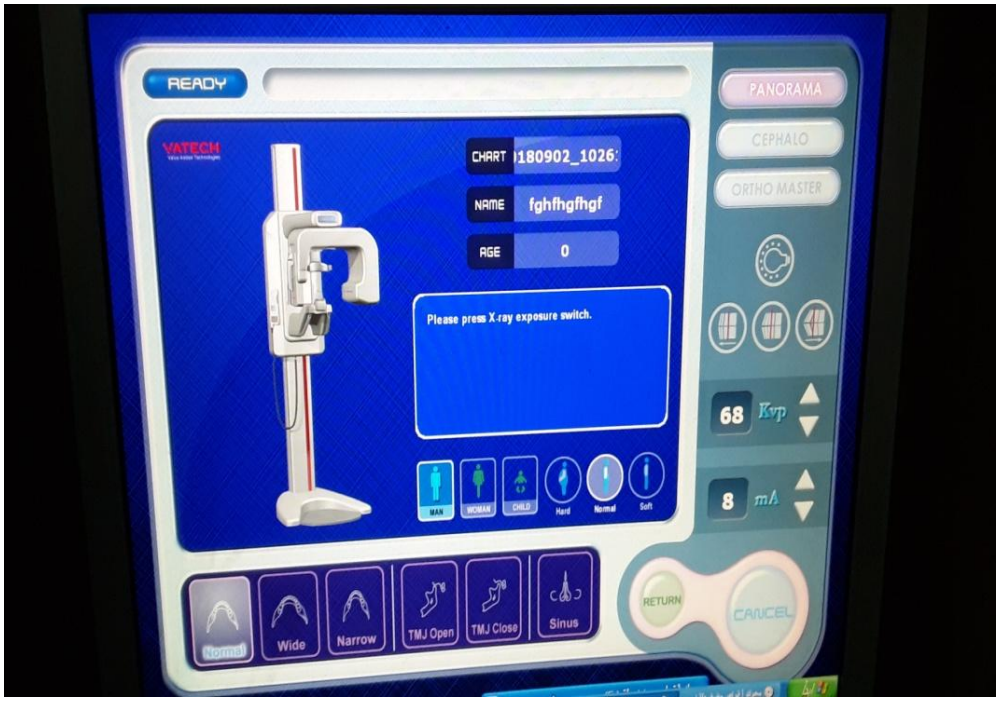

Figure 9: Digital control panel used to standardize the OPGs

Figure 10: Back and side views of an eight years old during taking and OPG

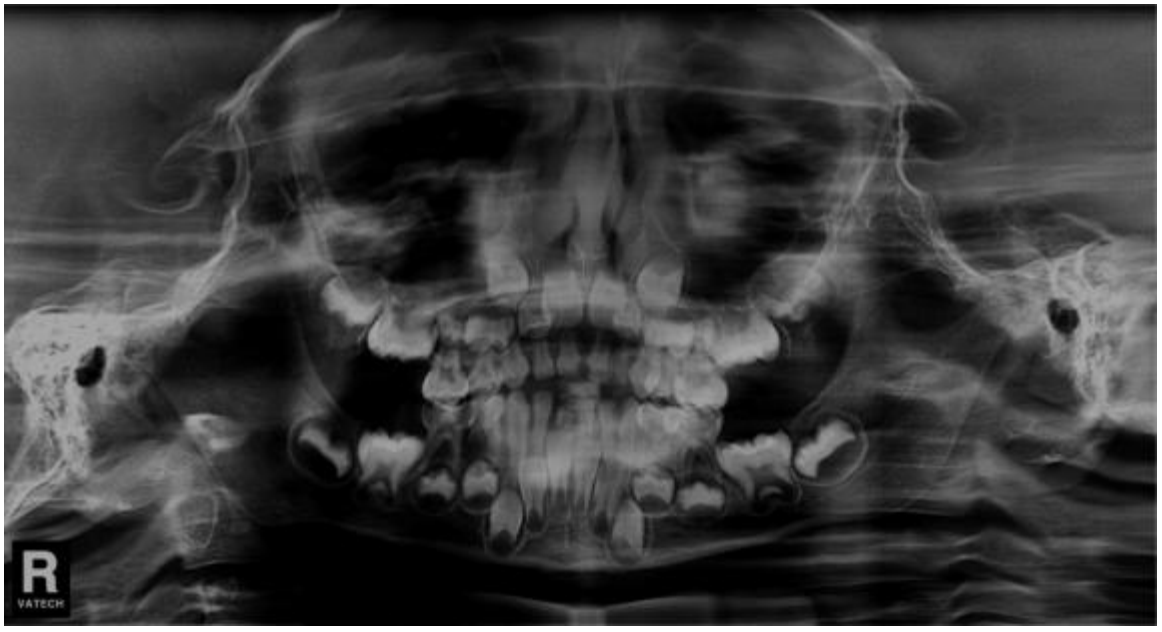

Figure 11: An OPG of 6 years old child

Figure 12: An OPG of 7 years old child

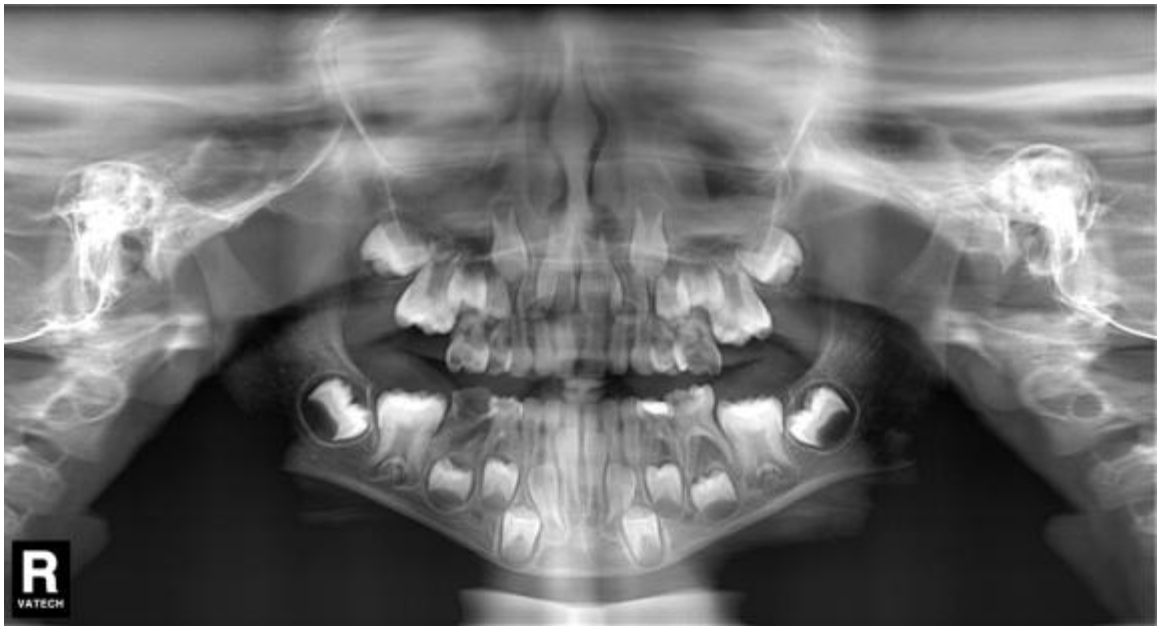

Figure 13: An OPG of 8 years old child

Figure 14: An OPG of 9 years old child

Figure 15: An OPG of 10 years old child

Figure 16: An OPG of 11 years old child

Figure 17: An OPG of 12 years old child

Figure 18: An OPG of 13 years old child

Figure 19: An OPG of 14 years old child

Figure 20: An OPG of 15 years old child

Figure 21: An OPG of 16 years old child

Protocol of study

AGE ESTIMATION FROM THE TEETH AMONG BENGHAZI CHILDREN USING DEMIRJIAN METHOD

Protocol of a thesis for Master degree

ORAL BIOLOGY

By

Mohamed Mustafa Kablan

Supervisor: Prof. Mohamed S H Ingafou

Dental faulty – Benghazi University

(2017)

CONTENTS

1- Introduction :

Age estimation is an important factor in biological identification in many forensic fields, such as forensic odontology, Forensic Medicine, Forensic Anthropology, and Forensic Osteology. Age estimation can assist in narrowing the search possibilities for unidentified deceased or living individuals for legal purposes. Additionally, age estimation helps determining the age of perpetrators and their subsequent penalty for criminal liability, particularly in young people. age assessment can be highly useful for estimating the real age of asylum seekers or in medico-legal assessments of age-disputed children charged with criminal acts. Demirjian's dental maturity score is currently a dental scoring system universally adopted for age assessment of unidentified children

In 2000, an international and interdisciplinary study group on forensic age estimation in Berlin, Germany recommended that methods for age estimation in living people should consist of a physical examination, radiographic examination of the hand bones, and dental examination using panoramic radiographs .All of these methods have advantages and disadvantages. For example a drawback of evaluating ossification of the hand bones is that the development of these bones is completed at the age of 18 years, which is earlier than tooth development (third molar teeth) that continues until the early twenties. Further more, skeletal indicators can present disadvantages due to variations in bone development, which can be influenced by many factors such as nutritional and environmental effects.

Tooth development, on the other hand, is controlled more by genetics rather than by environmental and nutritional factors. Additionally, teeth are the strongest structures in the human body and are protected by the soft and hard tissues of the face, which renders

the dental structures highly resistant to external factors, such as the decomposition process and extreme temperatures (up to 1100 °C).All of these factors make the age estimation via studying dentition much more superior biological indicator for age estimation process.

Attempts of age estimation from teeth (especially in children, adolescents and young adults) had been carried out through two major methods: the *tooth eruption methods*, which is conducted by a visual assessment of the eruption of the teeth into the mouth, and the *tooth development methods* using radiographic evaluation.

The radiographic evaluation is the preferable and more precise method as the age estimation is usually carried out as the tooth eruption occurs during a relatively short period of time and is highly influenced by many factors including lack of space, feeding habits, local trauma, pathosis of deciduous teeth, and nutritional status.

2- Aim and Objectives :

1- Elaborate on the Demirjian's method of age estimation using tooth development as a guide.

2- To assess the accuracy of the Demirjian's method of age estimation in a sample of Benghazi children.

3- Material and Methods :

A total of 250 cases will be studied, children from the age of 6-16 only included

Study subjects:

A total of 250 individuals will be included in this study. A digital panoramic radiograph will be taken for every individual included in this study by the same machine (digital OPG) by the same operator. The patients included will be selected from consecutive patients attending to dental faculty, Benghazi University for different reasons. Those patients with systemic disease, craniofacial malformation, maxillofacial trauma or hormonal problems will be excluded.

Method:

The development of seven mandibular teeth on the left side is divided into eight stage each. These are named 'A' to 'H'. As shown in Table 2 according to Demirjian's method of age estimation.

Table 2. Definition of tooth development stages according to the Demirjian's method

Stage	Definition
A	"In both *uniradicular* and *multiradicular* teeth, a (sic) beginning of calcification is seen at the superior level of the crypt in the form of an inverted cone or cones. There is no fusion of these calcified points
B	Fusion of the calcified points forms one or several cusps, which unite to give a regularly outlined occlusal surface."
C	Enamel formation is complete at the occlusal surface. Its extension and convergence towards the cervical region is seen." "The beginning of a dentinal deposit is seen." "The outline of the pulp chamber has a curved shape at the occlusal border."
D	The crown formation is completed down to the cemento-enamel junction." "The superior border of the pulp chamber in the uniradicular teeth has a definite curved form, being concave towards the cervical region."

	"The projection of the pulp horns, if present, gives an outline shaped like an umbrella top. In molars the pulp chamber has a trapezoidal form Beginning of root formation is seen in the form of a spicule
E	*Uniradicular teeth*: "The walls of the pulp chamber now form straight lines, whose continuity is broken by the presence of the pulp horn, which is larger than in the previous stage." "The root length is less than the crown height." *Molars:* "Initial formation of the radicular bifurcation is seen in the form of either a calcified point or a semi-lunar shape." "The root length is still less than the crown height."
F	*Uniradicular teeth:* "The walls of the pulp chamber form a more or less isosceles triangle." "The apex ends in a funnel shape." "The root length is equal to or greater than the crown height." *Molars:* "The calcified region of the bifurcation has developed further down from its semi-lunar stage to give the roots a more definite and distinct outline with funnel shaped endings." "The root length is equal to or greater than the crown height."
G	"The walls of the root canal are now parallel and its apical end is still partially open (Distal root on molars)."

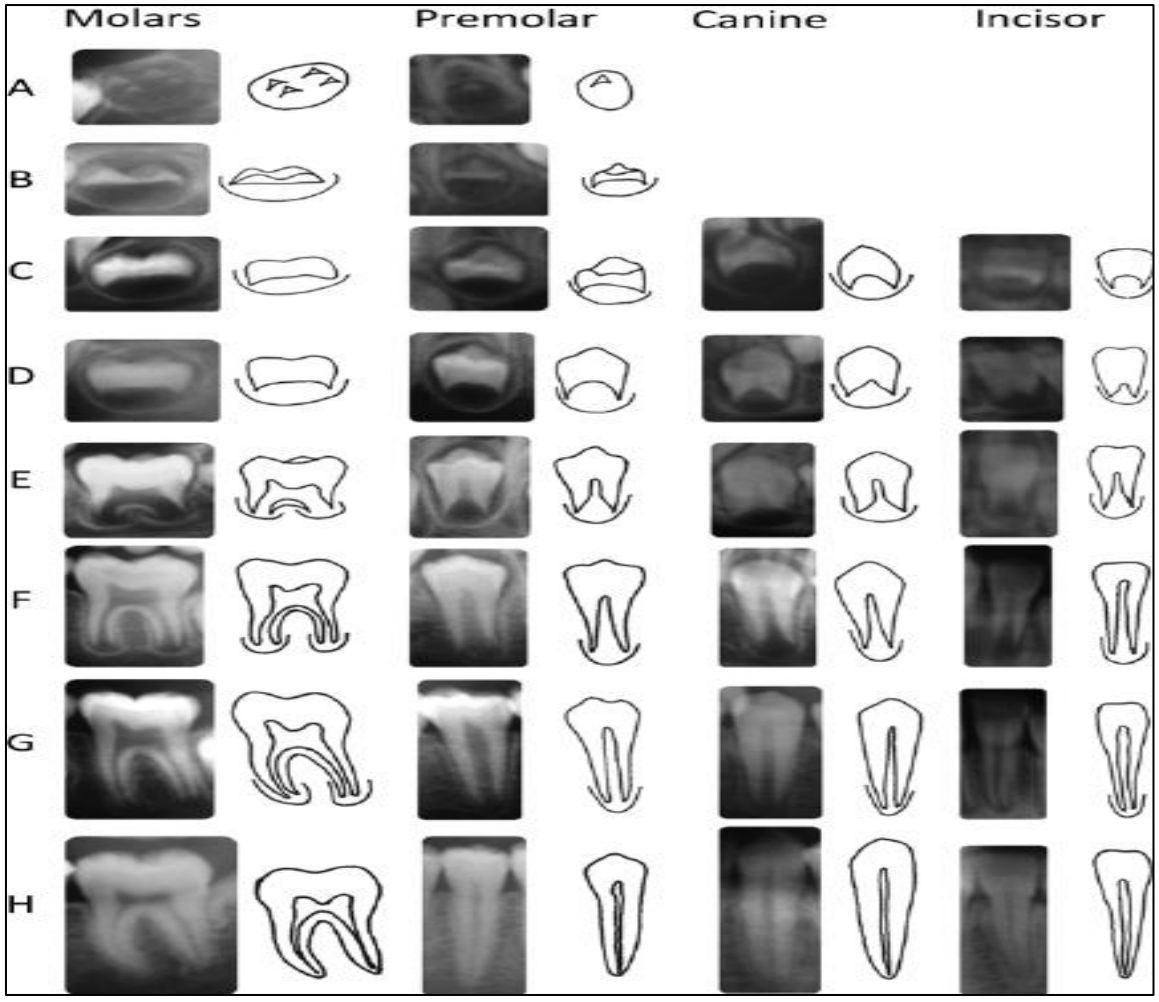

Figure 1. Pictures of tooth development stages (adapted from Demirjian's method

Table 3: Self-Weighted Score table for tooth developmental stages for males and females according to the Demirjian's method

Tooth	Stage								
	0	A	B	C	D	E	F	G	H
Boys									
M2	0.0	2.1	3.5	5.9	10.1	12.5	13.2	13.6	15.4
M1				0.0	8.0	9.6	12.3	17.0	19.3
PM2	0.0	1.7	3.1	5.4	9.7	12.0	12.8	13.2	14.4
PM1			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
I2				0.0	3.2	5.2	7.8	11.7	13.7
I1					0.0	1.9	4.1	8.2	11.8
Girls									
M2	0.0	2.7	3.9	6.9	11.1	13.5	14.2	14.5	15.6
M1				0.0	4.5	6.2	9.0	14.0	16.2
PM2	0.0	1.8	3.4	6.5	10.6	12.7	13.5	13.8	14.6
PM1			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
I2				0.0	3.2	5.6	8.0	12.2	14.2
I1					0.0	2.4	5.1	9.3	12.9

Stage 0 is no calcification.

Table 4. Conversion table from Dental Maturity Score to Dental Age for males according to the Demirjian's method

Age	Score	Age	Score	Age	Score	Age	Score
3.0	12.4	7.0	46.7	11.0	92.0	15.0	97.6
.1	12.9	.1	48.3	.1	92.2	.1	97.7
.2	13.5	.2	50.0	.2	92.5	.2	97.8
.3	14.0	.3	52.0	.3	92.7	.3	97.8
.4	14.5	.4	54.3	.4	92.9	.4	97.9
.5	15.0	.5	56.8	.5	93.1	.5	98.0
.6	15.6	.6	59.6	.6	93.3	.6	98.1
.7	16.2	.7	62.5	.7	93.5	.7	98.2
.8	17.0	.8	66.0	.8	93.7	.8	98.2
.9	17.6	.9	69.0	.9	93.9	.9	98.3
4.0	18.2	8.0	71.6	12.0	94.0	16.0	98.4
.1	18.9	.1	73.5	.1	94.0		
.2	19.7	.2	75.1	.2	94.4		
.3	20.4	.3	76.4	.3	94.5		
.4	21.0	.4	77.7	.4	94.6		
.5	21.7	.5	79.0	.5	94.8		
.6	22.4	.6	80.2	.6	95.0		
.7	23.1	.7	81.2	.7	95.1		
.8	23.8	.8	82.0	.8	95.2		
.9	24.6	.9	82.8	.9	95.4		
5.0	25.4	9.0	83.6	13.0	95.6		
.1	26.2	.1	84.3	.1	95.7		
.2	27.0	.2	85.0	.2	95.8		
.3	27 F	.3	85.6	.3	95.9		
.4	28.6	.4	86.2	.4	96.0		
.5	29.5	.5	86.7	.5	96.1		
.6	30.3	.6	87.2	.6	96.2		
.7	31.1	.7	87.7	.7	96.3		
.8	31.8	.8	88.2	.8	96.4		
.9	32.6	.9	98.6	.9	96.5		
6.0	33.6	10.0	89.0	14.0	96.6		
.1	34.7	.1	89.3	.1	96.7		
.2	35.8	.2	89.7	.2	96.8		
.3	36.9	.3	90.0	.3	96.9		
.4	38.0	.4	90.3	.4	97.0		
.5	39.2	.5	90.6	.5	97.1		
.7	42.0	.6	91.3	.6	97.3		
.8	43.6	.7	91.6	.7	97.4		
.9	45.1	.8	91.8	.8	97.5		

Table 5. Conversion table from Dental Maturity Score to Dental Age for females according to the Demirjian's method13

Age	Score	Age	Score	Age	Score	Age	Score
3.0	13.7	7.0	51.0	11.0	94.5	15.0	99.2
.1	14.4	.1	52.9	.1	94.7	.1	99.3
.2	15.1	.2	55.5	.2	94.9	.2	99.4
.3	15.8	.3	57.8	.3	95.1	.3	99.4
.4	16.6	.4	61.0	.4	95.3	.4	99.5
.5	17.3	.5	65.0	.5	95.4	.5	99.6
.6	18.0	.6	68.0	.6	95.6	.6	99.6
.7	18.8	.7	71.0	.7	95.8	.7	99.7
.8	19.5	.8	75.0	.8	96.0	.8	99.8
.9	20.3	.9	77.0	.9	96.2	.9	99.9
4.0	21.0	8.0	78.8	12.0	96.3	16.0	100.0
.1	21.8	.1	80.2	.1	96.4		
.2	22.8	.2	81.2	.2	96.5		
.3	22.5	.3	82.2	.3	96.6		
.4	23.2	.4	83.1	.4	96.7		
.5	24.0	.5	84.8	.5	96.8		
.6	24.8	.6	84.8	.6	96.9		
.7	25.6	.7	85.3	.7	97.0		
.8	26.4	.8	86.1	.8	97.1		
.9	27.2	.9	86.7	.9	97.2		
5.0	28.0	9.0	87.2	13.0	97.3		
.1	28.9	.1	87.8	.1	97.4		
.2	29.7	.2	88.3	.2	97.5		
.3	30.5	.3	88.8	.3	97.6		
.4	31.3	.4	89.3	.4	97.7		
.5	32.1	.5	89.8	.5	97.8		
.6	33.0	.6	90.2	.6	98.0		
.7	34.0	.7	90.7	.7	98.1		
.8	35.1	.8	91.1	.8	98.2		
.9	36.8	.9	91.4	.9	98.3		
6.0	37.0	10.0	91.8	14.0	98.3		
.1	38.0	.1	92.1	.1	98.4		
.2	39.1	.2	92.3	.2	98.5		
.3	40.2	.3	92.6	.3	98.6		
.4	41.3	.4	92.9	.4	98.7		
.5	42.5	.5	93.2	.5	98.8		
.6	43.9	.6	93.5	.6	98.9		
.7	46.7	.7	93.7	.7	99.0		
.8	48.0	.8	94.0	.8	99.1		
.9	49.5	.9	94.2	.9	99.1		

Table 6: Steps For Dental Age Estimation Using the Demirjian's Method

Step 1: Each tooth (teeth 31-37) was carefully assessed against the eight developmental stages (from A to H) by following the definition criteria for each stage and comparing each tooth with drawings and radiographic images according to the Demirjian's method (Table 2 and Figure 1).
Step 2: The developmental stage of each tooth was then converted into a score (self-weighted scores) using the tables outlined by the Demirjian's method for males and females separately (Tables 3).
Step 3: The self-weighted scores of each individual tooth (31-37) were then added together. The sum of the total self-weighted scores was expressed as the dental maturity score.
Step 4: The dental maturity score in each sample was converted into a dental age by comparing them with the tables from the Demirjian's method for males and females separately (Tables 4 and 5).
Step 5: The different value for each sample was then calculated by subtracting the chronological age from the dental age (positive and negative values indicated overestimation and underestimation, respectively).
Example of dental age estimation using the Demirjian's method.

4- Analysis of the results

- All the recorded data will be tabulated using spreadsheet in an excel format and checked for validity and accuracy then will be exported to SPSS statistical analysis program
- Statistical analysis would involve an appropriate parametric analysis of the data comparison at predetermined level of significance.
- Data presentation will involve different illustrative charts and graphs as it would be appropriate.
- The results will be subjected to critical analysis and contrast against the findings of previous studies.

5- Discussion

- The main points for discussion will be evolve around the validity of Demirjian's method in age estimation.
- Comparison of the obtained results of the age estimation radiographically with the actual age.
- Comparison of the obtained results with the previous studies.
- Discussion of the usefulness of Demirijan's method for age estimation in Libyan population.
- Conclusions and advice will be presented.

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تقــدير العمر بين أطفال بنغازي باستخدام طريقة ديمرجان

قدمت من قبل :

محمد مصطفى كبلان

تحت إشراف :

أ.د محمد انجافو

الملخص

يعد تقدير عمر الأطفال والمراهقين أمرًا ضروريًا للإجابة عن مجموعة متنوعة من المواقف القانونية مثل التوظيف والزواج، خاصةً في ضوء تزايد الهجرة والاختلاط بين السكان،وبسبب الاقتصاد المعولم الناتج عن تزايد تدفق الهجرة. عــادة ما يتم تقدير العمر بالطرق المورفولوجية والإشعاعية والنسيجية والكيميائية الحيوية.وتظل الصورة البانورامية (OPG) هي الأداة الأكثر استخدامًا في تحديد عمر الأسنان لأنها تغطي مساحة واسعة لفحص أسنان متعددة في نفس الوقت ونفس الصورة ناهيك عن إنها تستخدم على نطاق واسع في مجال طب الأسنان لأغراض مختلفة.

إن دقة المعلومات التي يتم الحصول عليها من تحديد عمر الأسنان تعتمد على حقيقة أن تشكيل الأسنان يحتوي على أنسجة مستقرة يمكنها أن تستمر كذلك لفترات طويلة من الزمن بعد تحلل الجسم، إلى جانب حقيقة أن حالة تمعدن الأسنان هي الأقل تأثرًا بالتغيرات البيئية والهرمونية.

لقد جرت محاولات عديدة لتقدير العمر من الأسنان (خاصة عند الأطفال والمراهقين والشباب) من خلال عدد من الطرق، معظمها موثوق به وتعطي تنبؤًا جيدًا عن العمر قيد الدراسة.ولكن الطريقة الأكثر استخدامًا ودراسةًبصورةٍ جيدة لمقارنة أعمار الأسنان في مجموعات مختلفة من السكان في العالم هي طريقة **داميرجيان** الذي ذكر أن هناك علاقة ارتباط قوية بين عمر الهيكل العظمي والعمر الزمني.

وهذه الطريقة مقبولة عالميًا ويتم تطبيقها في العديد من الدراسات العالمية، مع نتائج متباينة ولكن لم يتم تنفيذ أي منها على السكان الليبيين حتى الآن على حد علمنا.

ووفقًا لنتائج العديد من الدراسات العالمية السابقة التي نوهت إلى الحاجة إلى إيجاد معايير محددة لتطور الأسنان مبنية على أساس العرق والسكان الإقليميين لتحسين دقة تقييم عمر الأسنان المصمم خصيصًا لتلك المنطقة، تعد هذه الدراسة إحدى أولى المحاولات المبكرة لاستعمال طريقة تقييم تطور الأسنان لتقدير العمر الحقيقي لدى مجموعة من الأطفال الليبيين. صممت هذه الدراسة المقطعية لاختبار مدى مناسبة طريقة ***"داميرجيان"*** لتقدير عمر الأسنان على مجموعة من الليبيين القاطنين في شمال شرق ليبيا.

المعلومات الوصفية لهذه العينة أظهرت أن هذه العينة اشتملت على ما مجموعه 250 طفلا (أعمارهم من 6 إلى 16 سنة), 123 من الإناث و 127 من الذكور بمتوسط حسابي ووسيط ومنوال عمري يبلغ 10 سنوات و انحراف معياري قدره 2.724.هذا وقد بلغ متوسط العمر المقدر بهذه الطريقة أيضاً 10 سنوات بانحراف معياري 2.778 وكان أصغر عدد للمرضى في المجموعة السنية هو لدى المجموعة السنية 16 سنة (8 أطفال)و أعلى عدد منهم في المجموعة السنية 10 سنوات (41 طفلاً).

على الرغم من أن البيانات لم تكن موزعة على النمط الطبيعي (بناءاً على متطلبات العامل الإحصائي لكل من كلموغروف-اسميروف و كذلكشيبارو-ويلك), إلا أن حجم العينة أكبر من50, فلذلك أمكن استخدام (اختبار الطالب-تي) في عملية مقارنة الوسط الحسابي لمجموع العينة و كذلك لكلا الجنسين. تبين منه وجود علاقة قوية بين العمر الحقيقي و العمر المقدر بطريقة **داميرجيان** و ذلك واضح من خلال القراءة العالية الأهمية لمعدل بيــرسون للارتباط و التي تساوي 0.925 و بالمثل فأن معامل ارتباط (سبيرمانآراتش) كان عالي الأهمية (0.928)كذلك بين العمر الحقيقي و العمر المقدر.

مقارنة الخصائص العامة للعمرين الحقيقي و المقدر لكل العينة و لكلا الجنسين كانت متقاربة و لا توجد اختلافات ذات أهمية تذكر. أما الإحصاءات الوصفية للعينات بناءاً على نوع الجنس أظهرت أن متوسط العمر الحقيقي للإناث كان 9.69 ± 2.740سنة, و أما متوسط العمر المقدر للإناث كان 9.89 ± 2.810. أما بالنسبة للذكور فإن متوسط العمر الحقيقي فقد بلغ 10.30 ± 2.685 سنة وأما متوسط العمر المقدرللذكور فقد بلغ 10.33 ± 2.740.

اختبار (الطالب-تي المزدوج) للعينة للمجموعة العمرية 6 سنوات أظهر وجود فارق مهم بين قراءتي العمر الحقيقي و العمر المقدر لهذه المجموعة (p= 0.000), و بالمثل للمجموعة العمرية 7 سنوات (p= 0.009) و المجموعة العمرية 15 سنة (p= 0.001) . بينما أكدت كل نتائج المقارنات لباقي المجموعات عدم وجود فوارق ذات أهمية إحصائية بين قراءتي العمرين. فلذلك يمكن القول ان العمر المقدر بطريقة **داميرجيان** يمكن استعماله لتحديد عمر الأسنان للأطفال الليبيين.أما بالنسبة للأعمار التي يوجد بها فروقات مهمة بين قرائتي متوسط العمرين (أي 6 و7 و15 سنة) فإنه لوحظ وجود ميول لهذه الطريقة نحو التقليل من العمر المقدر فلذلك يجب أن يتم استخدامها بحذر عند تقييم أعمار من هم دون الثامنة من العمرلحين القيام بدراسة اشمل لعدد اكبر من الأشخاص تغطي مناطق أوسع من البلاد.

وفي النهاية تؤيد نتائج هذه الدراسة الدعوات المنادية بالحاجة لوجود بيانات مختصة محليا و مدققة سريريا" و أخلاقيا لتكوّن قاعدة بيانات لأساليب تحديد العمر.

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قدمت من قبل :

محمد مصطفى كبلان

تحت إشراف :

أ.د محمد انجافو

قدمت هذه الرسالة استكمالا لمتطلبات الحصول على درجة الماجستير في بيولوجيا الفم

جامعة بنغازي

كلية طب وجراحة الفم والأسنان

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