AGE ESTIMATION FROM PULP/TOOTH AREA RATIO IN RIGHT MAXILLARY TOOTH BY DIGITAL PANORAMIC RADIOGRAPHS

DISSERTATION

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MASTER OF DENTAL SURGERY

In

ORAL MEDICINE AND RADIOLOGY

By

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BABU BANARASI DAS COLLEGE OF DENTAL SCIENCES, LUCKNOW

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DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation entitled **"Age estimation from pulp/tooth area ratio in right maxillary tooth by digital panoramic radiographs"** is a bonafide and genuine research work carried out by me under the guidance of **Dr. Priya Singh**, Reader, Department of Oral Medicine and Radiology, Babu Banarasi Das College Of Dental Sciences, Babu Banarasi Das University, Lucknow, Uttar Pradesh.

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ABSTRACT

Introduction: Determination of age of a subject is one of the most important aspects of medico-legal cases and anthropological research. Teeth can serve as a splendid tool for same. Radiographic presentation of the dentition can be used to indirectly measure the rate of secondary dentine deposition which is depicted by reduction in the pulp area.

Aim & Objective: To estimate the age from pulp/tooth area ratio in right maxillary canine with objective to determine the age and compare it in different age groups by measuring the reliability and applicability in pulp/tooth ratio by digital panoramic radiographs.

Materials and Methods: In this study, 160 patients of Lucknow (U.P.) aged between 18-60 years were selected for the study. Panoramic radiographs were made and indirectly digitized. Radiographic images of maxillary canines (RIC) were processed using a computer-aided drafting program (Image J). The variables pulp/root length (p), pulp/tooth length (r), pulp/root width at enamel−cementum junction (ECJ) level (a), pulp/root width at mid−root level (c), pulp/root width at midpoint level between ECJ level and mid−root level (b) and pulp/tooth area ratio (AR) were recorded. All the morphological variables including gender were statistically analyzed to derive regression equation for estimation of age.

Results: It was observed that 2 variables 'AR' and 'b' contributed significantly to the fit and were included in the regression model, yielding the formula: Age = 87.305−480.455 (AR)+48.108(b). Statistical analysis indicated that the regression equation with selected variables explained 95% of total variance with the median of the residuals of 0.46 years which indicated that the actual age and estimated age in both age groups were closely related to each other.

Conclusion: There is significant correlation between age and morphological variables 'AR' and 'b' and the derived population specific regression equation can be potentially used for estimation of chronological age of individuals of Lucknow (U.P.) origin.

INTRODUCTION

Teeth are the hardest part of the body and are least affected by the taphonomic process, because of the effect of wear and tear, individuality and specificity; dentition and finger prints are two of the most scientifically reliable method of identification as the finger print and tooth morphology are specific for every individual and does not match to any other.[1, 2]

Uniqueness of teeth and oral structures are considered as one of the most reliable methods of identification of a person in forensic sciences. Tooth is the hardest part in the body and it cannot be easily damaged by any accident, is present for longer duration in oral cavity and change in structure either morphologically histologically and radiographically according to age. Thus it can be utilized as a tool to determine the age in an individual.[3]

On the other aspect age estimation is a continuing challenge for anthropologists and dentist. It is a specialized field under dentistry as well as forensic medicine because, an in-depth knowledge of both the fields is vital for its activity.[4, 5]

Recently minimally invasive radiographic techniques have been developed for measurements of the reduction in the dental pulp cavity associated with advancing age due to secondary dentin formation. The various review literatures also suggest that forensic science plays a major role in age estimation.[6, 7]

Forensic odontology was defined by Keiser-Neilson in 1970. It is that branch of forensic medicine which in the interest of justice deals with the proper handling and examination of dental evidence and with the proper evaluation and presentation of dental finding.[5]

Studies suggest that age estimation is a marker in solving judicial or civil problems concerning age of minors regarding questions of adoption, immutability and pedopornography. For adults, civil issues on pensionable age (50, 55, 60, 65 years, depending on the country) and other similar matters for individuals (mainly immigrants and refugees) lacking valid documents of identification or other persons who arrive in a

country without acceptable identification paper and may require a verification of age or in order to be entitled citizenship and social benefits of a country.[8]

It has also been noticed that forensic odontology is also used in analysis of maturity of a child, if the development is markedly advanced or retarded, in case of orphans to calculate exact dosage of medication for the child, and in mass disaster.[5]

Generally in children, age estimation from teeth is a relatively simple and accurate procedure and is based on the stages of development and eruption of teeth. However, in adults this procedure is a challenge to medico legal science.[9]

Chronological age assessment based on dental factors is a reliable indicator, because teeth may persist long after the, other parts of the skeleton have disintegrated. Dental maturity is more relevant as it is less affected by nutritional and endocrine status.[10]

Teeth were first used as a barometer of age in 1800. The first known attempts that used teeth as an indicator of age originated from England. **"Teeth a test of age"** to the English parliament in 1837.[5,10]

Historically age assessment using teeth was first published by Edwin Saunders in 1837, who claimed that teeth provided the most reliable guide to age compared to age estimation from height which was a standard method used during that time.[11]

A variety of methods are used for dental age estimation, e.g.; morphological, biochemical and histological methods. However these methods are invasive and require tooth extraction, which is not possible in living individuals.[1, 12, 13]

Relatively in advance ages, many changes occur in tooth structure. The enamel does not show age related changes except of loss in permeability and increase in brittleness, the remaining structure, such as dentine, cementum and dental pulp show age related physiological and pathological changes.[1]

Morphological methods are based on assessment of teeth (*ex-vivo*). Hence, these methods require extracted teeth for microscopic preparation. However, these methods may not be acceptable due to ethical, religious, cultural, or scientific reasons. Gustafson (1950), Dalitz (1962), Bang and Ramm (1970), Johanson (1971), Maples (1978), Solheim (1993) are few such morphological methods.[10]
The biochemical methods are based on the racemization of amino acids. The racemization of amino acids is a reversible first-order reaction and is relatively rapid in living tissues in which metabolism are slow. Aspartic acid has been reported to have the highest racemization rate of all amino acids and to be stored during aging. In particular, l-aspartic acids are converted to d-aspartic acids and thus the levels of d-aspartic acid in human enamel, dentine, and cementum increases with age.[14]
Some of the notable methods are: 14
1. Helfman and Bada method (1975, 1976)

2. Ritz *et al*. Method (1995)

Similarly radiography being a minimal invasive method plays a vital role in forensic dentistry to uncover the hidden facts, which cannot be seen by means of physical examination. Radiographic age estimation using teeth rely on developmental stages of teeth specially in children where as in adults the continuous deposition of secondary dentin throughout life depicted by reduction in pulp area can be employed through various radiographic images that can be used in age identification. The modalities utilized for this purpose are intraoral periapical radiographs, lateral oblique radiographs, cephalometric radiographs, panoramic radiographs, digital imaging and advanced imaging technologies.[8]
Digital panoramic are used because it is a convenient method; and both the maxillary and mandibular arches are at same line clearly seen along with all teeth and surrounding

structure; in fact total tooth area and pulp area is also appreciable in digital panoramic radiograph.
Based on the aforementioned findings the aim of my study is to estimate the age of an adult individual based on the relationship between age and measurement of pulp tooth area ratio obtainedfrom the digital panoramic radiographs.

AIM AND OBJECTIVES

Page 5

AIM

- The aim of the present study is to test the reliability and applicability of pulp/tooth area ratio (PTR) in right maxillary canine teeth as indicator of age by Digital panoramic radiographs.

OBJECTIVES

- To determine the age in different age groups by measuring of pulp/tooth ratio in upper right maxillary canines by digital panoramic radiographs.

- To determine the reliability of pulp/tooth ratio in upper right maxillary canines by digital panoramic radiographs.

- To determine the applicability of pulp/tooth ratio in upper right maxillary canines by digital panoramic radiographs.

- To compare different age groups by measurement of pulp/tooth ratio in upper right maxillary canines by digital panoramic radiographs.

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REVIEW OF LITERATURE

Page 6

3.1 History

Histories of forensic odontology frequently refer to cases such as the identification of Lollia Paulina by Agrippina using visual recognition of ‘distinctive teeth’ Charles the bold from a missing upper tooth in 1477. [15]
Dr. Amoedo can truly be said to be the **father of forensic** odontology. His seminal work ‘‘L’Artdentaire en medicinelegale”, was published by Masson at Paris in 1898.[16]

Forensic odontology was used to identify victims of a fire in the Vienna opera house in 1878.15 General Joseph warren by Paul revere via a fixed wire silver bridge in 1776 and Dr. Parkman by Nathan kept from the fit of dentures on study models in1849 as evidence of the long standing use of dentistry for identification purposes.[15]

Strom reported that the use of teeth to aid in identification in the modern understanding had been proposed by Godon in 1887, but a report by M'Grath in 1869 described the use of dental characteristics to differentiate between two incinerated females, and a paper by Reid in 1884 discussed many cases using dental science for both personal identification and age assessment, one as early as 1835.[15]

Schirnding noted that the Coroners act of 1886, the Prussian regulations of 1875 and Austrian instructions of 1855 for the holding of an inquest, all contained reference to the use of teeth to establish identity.[15]

In this modern era forensic odontology is said to have commenced with the identification of the victims of the *bazaar de la Charite fire*, which occurred on May 4, 1897 in Rue Jean-Goujon, Paris.[15]

Interest in forensic dentistry was relatively dormant until the 1960s when renewed interest was sparked by the first formal instructional program in forensic dentistry given in the United States at the Armed Forces Institute of Pathology.[15]

Rosenbluth described a murder case in the United States in 1898 where dentistry played a pivotal role.[15]

Teeth were first used as a barometer of age in 1800. The first known attempts that used teeth as an indicator of age originated from England. **"Teeth a test of age"** to the English parliament in 1837. [5, 10]

The first guide to disaster victim identification was published in 1984; historically age assessment using teeth was first published by Edwin Saunders in 1837. [17]

The FBI report having formed a disaster squad in 1940 but the identification emphasis of this group was on the use of fingerprints, although the report does mention dental charts as a 'Valuable Identification Tool'.[15]

Strom and Gustafson reported that Norway is considered to have established the first identification committee in 1945. [15]

Dr. Gerald (Gerry) Dalitz provided the early forensic odontology services in Victoria. In1961 he was awarded a doctor of dental science for a thesis entitled 'some aspects of dental science - identification of human remains' by the University of Melbourne.[15]

In the history of criminal prosecution in India, first time ever death sentence was given to the accused in which dental forensics had played a vital role in providing evidence. It was the Delhi gang rape case where the forensic odontologist linked the dentition of the two accused to the bite marks on the victim.[18]

3.2 Introduction

The most acceptable definition of forensic dentistry or forensic odontology according to brig. D. V. Taylor (1968) is "the application of dental knowledge to the elucidation of legal problems."[18]

It was further defined by Keiser–Nielson (1980) as “the branch of forensic medicine which in the interest of justice deals with the proper handling and examination of dental evidence and with the proper evaluation and presentation of the dental findings.”[18]

The identification of a person through teeth is not a new technique. The oldest example of dental finding that was used for forensic purpose in history was in 66 AD, in which Nero’s mistress, Sabina had identified the head that was brought to her as Nero’s wife only by identifying the black anterior tooth. And the first formally reported case of dental identification was that of the 8-year-old warrior John Talbot, who fell in the battle of Castillon and was identified due to a gap caused by a tooth extracted close to the time of his demise.[18]

Avon has classified forensic odontology according to major fields of activity into civil, criminal, and research. Forensic dentistry specializes in several areas that include dental records as legal document, radiographic examination, age determination, anthropological examination, mass disaster identification, bite mark evidence, and family violence.[18]

3.3 The current scenario in India

In India, forensic odontology is an upcoming branch of dentistry that has a great scope of development. It has been introduced in the syllabus for Bachelor of Dental Surgery (BDS) by the Dental Council of India. Currently, forensic odontology has not been introduced as an individual subject in the curriculum of dental council of India but this branch has been linked to two other branches accordingly, namely oral medicine and maxillofacial radiology and oral and maxillofacial pathology. In the near future, forensic odontology in India is bound to become a separate discipline of dentistry as in the western world.[18]

3.4 Significance in dentistry

Forensic odontology (dentistry) is a new and growing section of forensic medicine. The journey of forensic dentistry starts from Agrippina, the mother of roman emperor Nero, in 49 AD. Wen she recognized her rival Lollia-Paulina's discolored front teeth after her assassination.[15]

Dentistry has much to offer for law enforcement in the detection and solution of crime or in civil proceedings. Forensic dental fieldwork requires an interdisciplinary knowledge of dental science. They established the essential role which forensic dentistry plays mainly in the identification of human remains. The tooth has been used as weapons and under certain circumstances, may leave information about the identity of the biter. Dental professionals have a major role to play in keeping accurate dental records and providing all necessary information so that legal authorities may recognize mal practice, negligence, fraud or abuse, and identity of unknown individuals.[19, 20, 21]

Dental identification assumes a primary role in the identification of remains when postmortem changes, traumatic tissue injury or lack of a fingerprint record invalidate the use of visual or fingerprint methods.[22]

The identification of dental remains is of primary importance when the deceased person is skeletonized, decomposed, burned or dismembered.[22]

The principal advantage of dental evidence is that, like other hard tissues, it is often preserved after death. Even the status of a person’s teeth changes throughout life and the combination of decayed, missing and filled teeth is measurable and comparable at any fixed point in time.[23]

The dental record is a legal document owned by the dentist, and contains subjective and objective information about the patient. Results of the physical examination of the dentition and supporting oral and surrounding structures must be recorded.[24]

Comparison of ante mortem and postmortem radiographs is the most accurate and reliable method of identifying remains. Observations such as distinctive shapes of restoration, root canal treatment, buried root tips, bases under restorations, tooth and root morphology, and sinus and jawbone patterns can be identified only by examination of radiographs. In some instances a single tooth may be all that remains, and upon comparison of radiographs, a positive identification can be made.[25]

3.5 Structures utilized to identification

Human identification can be a challenging task in mass disaster situation, in crime investigation, in ethnic studies and in the identification of decomposed and disfigured bodies such as that of drowned persons, fire victims, and victims of motor vehicle accidents.[26]

The prosthetic dentistry has played a key role in assisting the forensic science to reproduce more accurate reliable and investigatory data.[26]

The various methods employed include

- • Cheiloscopy
- • Palatoscopy or Palatal Rugoscopy
- • Bite marks
- • Implants
- • Preprosthetic surgery records,
- • Prosthesis marking system,

3.5.1 Cheiloscopy

Which is the forensic investigation technique that deals with the identification of human based on lip traces. Lip prints and palatal rugae patterns are considered to be unique for an individual and hence hold the potential for identification. The presence of lip prints at

crime scene can form the basis for evidence regarding number of people involved the presence or absence of a suspect and gender of an individual.[22]

Lip prints can be obtained at the crime scene from clothing, cups, glasses, cigarettes, windows, and doors. Using lip prints for personal identification in forensic odontology is an accepted method in the criminal justice system worldwide.[22]

Lip prints have to be obtained within 24 h of the time of death to prevent erroneous data that would result from postmortem alterations of the lip.[22]

3.5.2 Rugoscopy

Palatal rugae have been considered relevant for human identification due to its stability and are equivalent to the fingerprint in that it is unique for each individual. The application of palatal rugae pattern to personal identification was first suggested by Allen in 1989.indentations of palatal rugae are often visible on the fitting surface of maxillary dentures, and these can be compared using high definition impression materials of the deceased. Another technique is using computerized recording and comparision.[26]

Palatal rugae comprises about three to seven ridges radiating out tangentially from the incisive papilla. These ridges can be classified as Curved, Straight, Wavy, and Branched. The pattern of these rugae is considered unique to an individual. In instances where postmortem dental identification is not possible, as in edentulous mouths, palatal rugae can be used as a supplement. The shortcomings in applying rugoscopy as a definitive tool in forensic odontology are many. Postmortem identification is not possible without the ante mortem records.[26]

In a situation involving fire, palatal rugae are often destroyed, and also since decomposition and skeletonization can occur in <6 weeks in summer and 4 months in winter, rugoscopy does not have application after this stipulated period.[26]

3.5.3 Bite marks

Bite mark is also a vital evidence in case of crime and abuse and can go unnoticed by untrained individuals. Knowledge of the arch alignments and specific tooth morphology of animals is also required for a forensic odontologist to distinguish human bites from nonhuman.[26]

Due to inherent alterations, the shape and clarity of bite marks found on the skin of the victims change in a relatively short duration (10–20 min) both in living and dead, and this necessitates their recording at the earliest possible time. In addition, incomplete bite marks are not conclusive and a minimum of four to five teeth has to be present for reliable bite mark analysis.[26]

3.5.4 DNA Analysis

Using DNA analysis, it is possible to establish the sample that is isolated from the biological material such as blood, semen, hair roots, tissue, teeth, bone, and saliva. The successful isolation of DNA from both saliva and salivary-stained material occurred in 1992. Saliva contains sloughed epithelial cells from the inner surface of the lips and oral mucosa; this is a potential source of DNA.The dental pulp from the given specimen of the tooth can be used for DNA analysis. Recent tooth specimen could be expected to provide good sources for the determination of blood groups.[23]

3.5.5 Fixed prosthesis and implants

Dental implants for prosthetic rehabilitation with fixed crown or mobile partial/total dentures is a very common oral treatment among the population nowadays. Component analysis of dental porcelain assists in dental identification. The fluorescence of porcelain crowns of murdered victim and several control porcelain samples were examined by fluorescent examination lamps.[26]

3.5.6 Determination of species

Recently, it has been shown that dentinal fluids contain special species information. These fluids may be compared using counter current electrophoresis with artificially antisera. This technique can determine species up to at least 12 months after death.[23]

3.5.7 Facial reconstruction and facial superimposition

This is the responsibility of forensic artists who utilize the dental profile to help the facial reconstruction. The use of ante mortem photographs to permit facial superimposition of skeletal and teeth features have been used in case of identification.[23]

3.5.8 Denture marking

The frequency of edentulousness has decreased in recent years primarily due to improvements in oral health brought about by factors such as fluoridation and increased patient awareness. The need to address the issue of denture identification still remains since it is more difficult to identify an edentulous person than a dentate one. [26]

Given that only one marked denture can reveal the identity of a deceased person when all other methods fail to do so makes the practice of denture marking worthwhile.[26]

Denture marking system includes: 26

1. Surface marking methods: identification (ID) marks are scratched, engraved, or written to the surface of denture
2. Inclusion methods: ID marks are enclosed within the denture base polymer.

3.5.9 Healing process

The healing process of bite marks can be useful in determining the time of the bite mark, is inflicted relative to the time of death in cases where death has occurred because of strangulation. As all healing processes cease upon death, the redness of the bite mark

relative to the redness of bruises on the neck indicate the timing of the infliction of the bite mark relative to the murder.[23]

3.6 Role in medicolegal

Forensic odontology helps the law in the administration of justice. Though in developed countries this branch of dentistry is playing a useful role but as far as India is concerned its role is definitely being recognized nowadays. An overview of the basic and recent trends of this emerging branch of dentistry is presented to make the concerned professionals aware of their role in medico legal matters.[16]

The first recorded medico-legal identification of a body using dental means is that of Dr. Joseph Warren, who was killed at the battle of Bread Hill, more often referred to as the battle of Bunker Hill in New England in 1775.[27]

Mass forensic identification by dentition was first used at Paris, in the aftermath of the fire of the bazaar de la charite that began around 16:00 h on the afternoon of May 4, 1897.[15]

Forensic odontology is a combination of art and science of dental medicine. It is the proper handling examination and evaluation of dental evidence which are presented in the interest of justice.[28]

The information so obtained is concerned primarily with: [28]

1. Establishment of identity
2. Investigation of criminal cases
3. Research purposes

But forensic dentists are responsible for the following main areas of practice.

A) Identification of human fragmentary measures

B) Identification in mass disasters
C) Assessment of bite marks, injuries
D) Assessment of abuse i.e. child, spouse and elders
E) Civil cases involving malpractice
F) Age estimation
G) Criminal liability
Identification can be further studied[28]Under two categories:
A) General or reconstructive identity is to classify unknown persons by age, sex, race, occupation and habits etc.
B) Comparative methods, in it a person's identification is indicated or excluded when the postmortem dental record is compared with the ante mortem dental record.[28]

3.7 Embryology

Acc. To Orbans et al the primitive oral cavity or stomodeum is lined by stratified squamous epithelium called the oral ectoderm. The oral ectoderm contacts the endoderm of the foregut to form the buccopharyngeal membrane .At about the twenty-seventh day of gestation this membrane ruptures and the primitive oral cavity establishes a connection with the foregut. Most of the connective tissue cells underlying the oral ectoderm are neural crest or ectomesenchyme in origin which plays a vital role in identification of individual.[29]
Teeth are unique structures that are exclusively located in the oral cavity. They consist of several cell types, including ameloblasts, odontoblasts and cementoblasts producing enamel, dentin and cementum, respectively. Teeth develop from reciprocal interactions

between epithelial and mesenchymal tissue, leading to the formation of epithelial buds and the subsequent morphogenesis and differentiation. More than 200 genes have been found to be involved in teeth development acting in conserved pathways.[30]

3.7.1 Teeth development and its molecular basis

Teeth develop from a series of reciprocal interactions between the oral epithelium and the underlying cranial neural-crest-derived ecto-mesenchyme on the oral surfaces of the mandibular, maxillary and frontonasal processes.[31]

During development of mammalian teeth pattern of the tooth region is followed by tooth induction, morphogenesis and differentiation leading to a defined identity and shape. Subsequently the cells from the stomodeal ectoderm gives rise to ameloblasts, and cranial neural-crest derived ecto-mesenchyme cells lead to the formation of odontoblasts and cementoblasts of mammalian teeth. Interestingly, the same molecules are involved during different stages of tooth development.[30]

3.7.2 Bud to cap transition

After thickening, the epithelium of the dental lamina starts to form tooth buds and induces mesenchymal cell condensations around the tooth germs (bud stage).[30]

The bud stage marks a shift of inductive potential from the tooth epithelium to the mesenchyme, accompanied by a shift of expression of signals as bmp's and fgf's from the epithelium to the mesenchyme. Budding of the tooth is followed by the cap stage, when the tip of the epithelial tooth bud bends into a cap-like structure surrounding the condensed mesenchyme, which is referred to as dental papilla.[30]

Morphological differences between tooth germs that give rise to different types of teeth become apparent during the transition from bud to cap stage.[31]

3.8 Teeth

One of the structure within the mouth that allow for biting and chewing. Teeth have different shapes, depending on their purpose. The sharp canine and incisor teeth allow for biting, and the flattened, thick molar in the back of the mouth provides grinding surface for masticating food. All teeth have essentially the same structure: a hard crown above the gum line, which is attached to two or four roots by a portion called neck. The roots are covered with a very thin layer of bone, and they keep the tooth embedded in the bone of the jaw. The exposed exterior of the tooth is covered with tough enamel. Under the enamel is a thick layer of dentine and in the center is the pulp, which contains blood vessels and nerves.[32]

3.8.1 Morphology

The maxillary and mandibular bear a close resemblance to each other, and their functions are closely related. The four canines placed at the "corners" of mouth; each one is the third tooth from the median line, right and left, in the maxilla and mandible. They are commonly referred to as the cornerstone of the dental arches.[32]

They are the longest tooth in the mouth. The shape and position of the canine contribute to the guidance of the teeth into the intercuspal position by "canine guidance". This resemblance to the prehensile teeth of the carnivores gives rise to the term canine. These teeth are perhaps the most stable teeth in the mouth. This self-cleansing quality, along with the efficient anchorage in the jaws, tends to preserve these teeth throughout life. [33]

In function, the canines support the incisors and premolars, since they are located between these groups.[32]

The outline of the labial and lingual aspect of the maxillary canine is a series of curves or arcs except for the angle made by the tip of the cusp. These cusp are the mesial incisor ridge and a distal incisor ridge. Mesial half of the crown makes contact with the lateral incisor, and distal half contacts the first premolar. Labial view, the mesial half of

the crown resembles a portion of a incisor, whereas the distal half resembles a portion of premolar.[33]

3.8.2 Dimension 32

Cervicoincisal length of crown: 10mm, length of root: 17mm
Mesiodistal diameter of crown: 7.5 mm, Labio or Buccolingual diameter of crown-8 mm, Labio or Buccolingual diameter of crown at cervix: 7 mm
Curvature of cervical line-mesial: 2.5 mm
Curvature of cervical line-distal: 1.5 mm

3.8.3 Eruption time32

First evidence of calcification: 4-5 month
Enamel completed: 6-7 year
Eruption: 11-12 year
Root completed: 13-15 year

3.8.4 Pulp

The dental pulp occupies the center of each tooth and consists of soft connective tissue. Every person normally has a total of 52 pulp organs, 32 in the permanent and 20 in the primary teeth.[29]
Each of these organs has a shape that conforms to that of a respective tooth. Each pulp organ resides in a pulp chamber surrounded by a dentin containing the peripheral extensions of the cells that formed it.[31]

The total volumes of all the permanent teeth pulp organs is 0.38 cc, and mean volume of a single adult human pulp is 0.02 cc. Molar pulp are three to four times larger than incisor pulps.[29]
Canine: It has the longest pulp with an elliptical cross section buccolingually and a distally inclined apex.[29]
Coronal pulp: It is located centrally in the crowns of the teeth and root have the ridicular pulp.[29]
Coronal pulp has the six surfaces: occlusal, mesial, distal, buccal, lingual, and the floor. Pulp horns, have extension into the cusps of each tooth. Number of these horns thus depends on the cuspal number.[31]
Radicular pulp: radicular pulp is that pulp extending from the cervical region of the crown to the root apex. Anterior teeth radicular pulps are single and in posterior ones multiple. They vary in size, shape, and number. The radicular portions of the pulp organs are continuous with the periapical connective tissue through the apical foramen or foramina.[29]
Growth proceeds, more dentin is formed, so that when the root of the tooth has matured the radicular pulp is narrower.[31]

3.9 ORTHOPANTOMOGRAM (OPG)

Panoramic imaging (also called pantomography) is a technique for producing a single topographic image of the facial structures that includes both the maxillary and mandibular arches and their supporting structures. This is a curvilinear variant of conventional tomography and is also based on the principle of the reciprocal movement of the X-ray source and an image receptor around a central point or plane, called the image layer, in which the object of interest is located. Object in front and behind the

image layer are not clearly captured because of their movement relative to the centre of rotation of the receptor and X-ray source.

White and Pharoah stated that panoramic imaging (also called pantomography) is a technique for producing a single tomographic image of the facial structures that includes both the maxillary and mandibular dental arches and their supporting structures.[34]

Hallikainen D stated that at the beginning of this century that imaging of the whole jaw was first attempted with intraoral radiation sources. Narrow beam principle was described in 1922. Experimental work and development of equipment in the 1950s resulted in commercially available manufactured panoramic machine in early 1960s. He also stated that it is an essential element in oral radiology. **Numeta and Patero** in early 1960s introduced the panoramic radiography and soon it gained popularity as a diagnostic tool.[35]

H. Devlin, et al; recommended it to be a common imaging technique in general dental practice.[36]**Gun–Sun Lee** et al. stated that it has been widely used as a diagnostic tool because it is easy to provide radiographic overview of the teeth and surrounding anatomical structures.[37]

Thiago L. Beaini. et al. stated that it is one of the complementary exams most required by dentists for diagnostic purposes.[38]where as **Fatemeh Salemi** et al. recommended it to be a simple extra oral radiographic technique. Used for both the purposes of diagnosis and treatment planning.[39]

Dental panoramic tomography has become a very popular radiographic technique in dentistry. The main reasons for this include:

Eric Whaites stated that all the teeth and their supporting structures are seen in one film, the technique is reasonably simple and the radiation dose is relatively low, particularly with modern DC units with rare-earth intensifying screens the dose is equivalent to about three to four perapical radiographs.[40]

A. Cicilia Subbulakshmi, Christoph Klingelhoffer, Mioara Decusara, et al. stated that the technique to be reasonably simple, this modality as it is with minimal distortion and overlapping of anatomic details from the contra lateral side and is findings serves as indicator of the development of medication-related osteonecrosis of the jaw.[41,42,43]

Ujwala Rohan Newadkar, Joao Cesar Guimaraes Henriques et al; further validated that the radiation dose is relatively low, particularly with modern DC units with rare-earth intensifying screens the dose is equivalent to about three to four periapical radiographs and it has low cost and technical simplicity.[44,45]

White and Pharaoh, Langland, Ongle stated that this procedure is convenient for the examination of the patient and recommended the use in patients unable to open their mouths and it requires short time to make a panoramic image, usually in the range of 3 to 4 minutes (This includes the time necessary for positioning the patient and the actual exposure cycle) and also patients readily understand panoramic films; thus they are also useful visual aid in patient education and case presentation.[34,46,47]

3.9.1 USES

Langland stated that panoramic radiography is the diagnostic radiograph used for gaining a comprehensive overview of the Dentomaxillofacial complex.[46] **Raza Sadat-Khonsari** et al. stated that it is appropriate screening tool for early temporomandibular joint (TMJ) diagnosis, TMJ disorder caused by malocclusion.[48]

Habets et al. (1988) and Kjellberg et al. (1994), proposed indices to determine condylar asymmetries by measuring vertical distance on panoramic radiograph.[48] **Mioara Decusara** stated that it is an important and complex factor in both diagnosis and prognosis. Examination of the oromaxillo-facial area in systemic diseases and syndromes.[43]

Griniatsos J, et al; proposed that it is used to determine the calcified atheromatous plaque in the carotid artery region.[49] **Farman A. G**, et al; stated that it is used as

diagnostic tool in endodontic treatment and to identify the exact cause of missing teeth.[50]
Eric Whaites proposed that it is useful for mandibular nerve paresthesia, examination of the oromaxillo-facial area in systemic disease and syndrome. He also stated that its important to evaluate vertical alveolar bone height as part of pre implant planning, for assessment of periodontal bone support where there is pocketing greater than 5mm, prior to dental surgery under general anesthesia.[40]
Sunanda Bhatnagar, et al proposed that it is an effective indicator of osseous change in post-menopausal osteoporosis.[51]**Kaviena Baskaran** stated that it is an important and complex factor in both diagnosis and prognosis, before and after the surgery in oral maxillo-facial region.[52]
Pasler F. A; proposed that it is used for facial and maxillary asymmetry, painful or asymptomatic swelling, multiple dental extraction with suspected osteomyelitis.[53]
Babutunde Olamide Bamgbose, et al; recommended that it is used for diagnosis of cystic lesion and neoplasms, congenital absence of tooth, premature loss, prolonged retention of teeth and maxillary sinus diseases. Diagnostic value of maxillary sinus includes evaluation of cystic lesion, foreign bodies, antroliths, benign soft and hard tissue lesions and antral malignancies.[54]
Fatemeh Salami, et al; proposed its use for assessment of third molars, at a time when consideration needs to be given to whether they should be removed or not.[39]
Rafael Henrique Nunes Rondon, et al; recommended the use of OPG in examination of teeth to diagnose caries, pulp origin disease, disease of facial bone, radicular cyst, tumor, post accidental fracture, sinusitis. pediatric growth and development.[55]
T. M. Graber, et al; stated that it is used to know the normal growth and development pattern, delayed tooth eruption, abnormal eruption direction and resorption, ankylosis, REVIEW OF LITERATURE

mandibular morphology and fracture, space adequacy, treatment progress and post treatment appraisal.[56]

Noriyuki Kitai, et al; stated that it is used to examine maxillary impacted canine, dental caries, periradicular diseases, impacted third molar, alveolar bone and developing teeth.[57]

G. A. Zach, et al; recommended that it used to evaluate orthodontic treatment progress and post treatment appraisal, change in condylar position during and after orthodontic treatment, effect of premature loss of deciduous teeth on permanent successors and adjacent teeth, postoperative appraisal of class III malocclusion, development and eruption of third molars.[58]

White and Pharaoh stated that it is used in fractures of all parts of the mandible except the anterior region, antral disease — particularly involving the floor, posterior and medial walls of the antra, destructive diseases of the articular surfaces of the TMJ.[34]

Karina-Morais Faria, et al; stated that it is used in identification of multiple myeloma bone lesions. According to **International Myeloma Working Group** one or more osteolytic lesion has to be visualized on skeletal radiograph for the diagnosis of multiple myeloma.[59]

3.9.2 Factor affecting the image quality

White and Pharaoh stated that the factors that affect its size are variables that influence image definition: arc path, velocity of the receptor and x-ray tube head, alignment of the x-ray beam, and collimator width. The location of the image layer can change with extensive machine use, so recalibration may be necessary if consistently suboptimal images are produced. As the position of an object is moved within the image layer, the size and shape of the resultant image changes.[34]

3.9.3 Radiographic magnification

H Devlin, et al; stated that radiographic magnification is the magnification and distortion that occurs when the patient's jaws are not positioned near the focal trough of the X-ray beam. One-third had low density and contrast due to poor patient positioning and less than 1% had excellent quality. Even when properly taken, dental panoramic radiographic images are associated with enlargement of the actual object size by about 15–25%, and distortion occurs when horizontal magnification differs from vertical magnification with poor patient positioning.[36]

Mehrdad Abdinian, et al; proposed that distortion and magnification might lead to inaccurate and unreliable measurements, horizontal magnifications varies from0.7 to 2.2 time the real dimension. Total vertical magnification mean of planeca machine was 95%, and horizontal magnification was 91%. Vertical and horizontal magnification differs in various regions of jaws, and the vertical measurement was more reliable than the horizontal.[60]

Vazquez L et al; stated that vertical measurements showed acceptable accuracy and reproducibility and digital panoramic radiography is reliable in determining the preoperative implant loadings. Magnification may also be influenced by variation in patient's jaw shape and size, and even within a particular jaw distortion and magnification are greatest in the canine and premolar regions and least in the third molar region.[61]

Devlin and Yuan, et al; recommended that in panoramic radiography there is less variation in vertical magnification value than horizontal. Two different approaches have been used historically to try to circumvent the problems associated with image magnification. The first was to develop mathematical theory of dental panoramic imaging; the second, practical approach was to use calibration objects with which to calculate magnification at some points on the image. We combined both approaches by developing a set of equations that are precise yet simple enough to be solved easily for

magnification from object position, and vice versa, for calibration ball bearings and other small round objects.[36]

3.9.4 Technique and positioning

Eric Whaites stated that the exact positioning techniques vary from one machine to another. However, there are some general requirements that are common to all machines and these can be summarized as follows: [40]

National Radiological Protection Board and Royal College of Radiologist (NRPB/RCR) Guidelines on Radiology Standards in Primary Dental 'Care (1994) positively discourages the use of lead aprons because they can interfere with the final image.[40]

White and Pharaoh stated that the patients should be placed accurately within the machines using the various head-positioning devices and light-beam marker positioning guides. (In some units the patients face is away from the equipment and towards the operator and in others the patient faces the other way round). Panoramic tomography is generally considered to be unsuitable for children under 5 years old, because of the length of the exposure and the need for the patient to keep still.[34]

Langland stated that the patients should be instructed to place their tongue into the roof of the mouth so that it is in contact with the hard palate and not to move throughout the exposure cycle (approximately 18 seconds). Appropriate exposure setting should be selected, typically in the range 70-100 kV and4-12mA.[46]

3.9.5 The importance of accurate patient positioning

Rafael Henrique Nues Rondon et al; recommended that correct patient position in the focal tough a lack of artifacts, good density, and adequate contrast are considered to be good quality image. Most common error is patient positioning and then after technical and processing are the main error that occur during panoramic radiography.[55]

H Devlin et al stated that one third of the images had low density and contrast due to poor patient positioning and less than 1% had excellent quality. When the patient teeth are placed in focal trough distortion of image is avoided.[36]

Manu Dhillon et al; stated that appropriate positioning and preparation of the patient is essential for a sharp, accurate, and undistorted image, which is not affected by ghost image. Inaccuracies in patient positioning lead to discrepancies between horizontal and vertical magnification, with consequent distortion of the image. Patients chin is too high causing a flat occlusion plane, and if chin is too low occlusion plane is smiling and cervical spine is slumped, appearing a pyramidal shaped opacity, center at lower half of the film.[62]

Eric Whaites stated that the positioning of the patient's head within this type of equipment is critical; it must be positioned accurately so that the teeth lies within the focal trough. The effects of placing the head too far forward, too far back or asymmetrically in relation to the focal trough, the parts of the jaws outside the focal trough will be out of focus. The fan-shaped X-ray beam causes patient malposition to be represented mainly as distortion in the horizontal plane, i.e. teeth appear too wide or too narrow rather than foreshortened or elongated.[40]

3.9.6 Factors Affecting Digital Image Quality

Elizabeth A. KRUPINSKI et al; stated that image quality is affected by a number of factors, beginning with the acquisition process and device and including the manner in which images are displayed. In digital systems, the functions of acquisition and display are clearly separable, so that the evaluation and optimization of image quality can take place at both ends of this imaging continuum. The analysis of image quality also depends on the particular type of imaging task.[63]

Mark B. Williams, et al; stated that there number of factors that affect the quality of the image in digital radiography. Contrast, detail, and noise are the primary factors

associated with image quality, and they play a major role in computer radiograph and digital radiograph some additional factors are the result of the digital nature of the process.[64]

3.9.7 Matrix Size and Display Size

Elizabeth A. Krupinski et al; stated that soft-copy displays should render images with sufficient pixel density to allow viewing of the whole image with sufficient spatial detail at a normal viewing distance of approximately 30 to 60 cm (with eyeglasses specifically selected for this distance when required). Matrix size should be as close to the processing image data as possible or attainable with magnification. US Food and Drug Administration recommends that only monitors that have been approved. This is true for any size image for which the detector element matrix size exceeds the display pixel matrix size.[63]

3.9.8 Luminance and Contrast

Elizabeth A. Krupinski et al; recommended that luminance of a display can affect image quality significantly, so the appropriate range of luminance should be maintained. The ratio of maximum luminance to minimum luminance of a display device for images (other than for mammography) should be at least 100. The maximum luminance of gray-scale monitors used for viewing digital conventional radiographs should be at least 200 cd/m^2. Smaller ranges could lead to inadequate levels of contrast in displayed images, and larger values could lead to poor visualization of details at the extremes of the luminance range because of the limited range of the contrast sensitivity of the human eye.[63]

3.9.9 Bit Depth

Elizabeth A. Krupinski et al; stated that it is necessary for a soft-copy display device to render image details with sufficient luminance quantification to prevent the loss of contrast details or the appearance of contour artefacts. Thus, a minimum of 8-bit

luminance resolution (bit depth) is required. Nine-bit resolution or higher is recommended for processing image data greater than 8-bit. In general, the higher the luminance ratio of the display, the larger the bit-depth resolution that is recommended.[63]

3.9.10 Display Calibration

Elizabeth A. Krupinski et al; stated that all monitors and corresponding video graphics cards used for primary diagnosis or for image adjustment and evaluation (e.g. a technologist review monitor) must provide a means to be calibrated to and conform to the current DICOM GSDF perceptual linearization methods. The intent of the DICOM GSDF is to allow images transferred using the DICOM standard to be displayed on any DICOM-compatible display device with a consistent gray-scale appearance.[63]

3.9.11 Glare and Reflections

Elizabeth A. Krupinski et al; stated that veiling glare or the spread of light within the display can reduce contrast, so the glare ratio should be greater than 400 for primary displays. Light-colored clothing and laboratory coats can increase reflections and glare. The intrinsic minimum luminance of a device should not be smaller than the ambient luminance (minimum luminance should be at least 2.5 times ambient light).[63]

3.9.12 Colour Tint and Colour Displays

Elizabeth A. Krupinski et al; recommended that the tint of the display can affect the comfort of the user. The colour tint of the display (blue, gray, yellow, etc) is based on user preference but should be uniform across the display area, and monitor pairs should be matched from the same manufacturing batch. Currently, most colour displays have lower luminance and thus lower contrast ratios than monochrome displays and are generally not recommended for viewing certain radiographic modalities (chest, bone, and mammography).[63]

3.10 Age estimation

Age estimation is a continuing challenge for anthropologists and dentist. It is a specialized field under dentistry as well as a forensic medicine because, an in-depth knowledge of both the fields is vital for its activity.[4, 5]

Chronological age assessment based on dental factors is a reliable indicator, because teeth may persist long after the, other parts of the skeleton have disintegrated. Dental maturity is more relevant as it is less affected by nutritional and endocrine status.[10]

Teeth were first used as a barometer of age in 1800.The first known attempts that used teeth as an indicator of age originated from England. **"Teeth a test of age"** to the English parliament in 1837.[5,10]

Historically age assessment using teeth was first published by Edwin Saunders in 1837, who claimed that teeth provided the most reliable guide to age compared to age estimation from height which was a standard method used during that time.[11]

Similarly radiography being a minimally invasive method plays a vital role in forensic dentistry to uncover the hidden facts, which cannot be seen by means of physical examination. Radiographic age estimation using teeth rely on developmental stages of teeth specially in children where as in adults the continuous deposition of secondary dentin throughout life depicted by reduction in pulp area can be employed.[8] The various radiographic images that can be used in age identification are intraoral periapical radiographs, lateral oblique radiographs, cephalometric radiographs, panoramic radiographs, digital imaging and advanced imaging technologies.[8]

A variety of methods are used for dental age estimation, e.g.; morphological, biochemical and histological methods. However these methods are invasive and require tooth extraction, which is not possible in living individuals.[1, 12, 13]

The first known attempts that used teeth as an indicator of age originated from England. In the early 19th century, because of economic depression due to the industrial REVIEW OF LITERATURE

revolution, juvenile workers and criminal activities were serious social problems. Edwin Saunders, a dentist, was the first to publish information regarding dental implications in age assessment by presenting a pamphlet entitled “teeth a test of age” to the English parliament in 1837.This paper reviewed various aspects of age estimation like morphological, biochemical, and radiographical methods and its scope and limitation.[10]

3.10.1 Morphological methods

Morphological methods are based on assessment of teeth (ex-vivo). Hence, these methods require extracted teeth for microscopic preparation. However, these methods may not be acceptable due to ethical, religious, cultural, or scientific reasons.[10] Gustafson (1950), Dalitz (1962), bang and Ramm (1970), Johanson (1971), maples (1978), Solheim (1993) are few morphological methods.[10]

Gustafson’s method (1950)

Gustafson (1950) and Thoma (1944) described the age changes occurring in the dental tissues and noted six changes related to age. They are: [65]

A. Attrition of the incisal or occlusal surfaces due to mastication (a)
B. Periodontitis (p)
C. Secondary dentin (s)
D. Cementum apposition (c)
E. Root resorption (r)
F. Transparency of the root (t)

Gustafson suggested the last two changes. In the method proposed, each sign was ranked and allotted 0, 1, 2, 3 points. The point values of each age-change are added according to the following formula:

An+ pn + sn + cn + rn + tn = points.
The exact equation calculated was: y = 11.43 + 4.56x, where, y = age and x = points according to the formula above. The error of estimation as calculated by Gustafson (1950) was ±3.6 years.[65]
Disadvantage: However the biggest bony it cannot be used in living person.

Dalitz method (1962)

Dalitz re-examined Gustafson's method and suggested a 5-point system from 0-4, instead of the 4-point system that was previously used. This change was proposed in order to give a slightly greater accuracy. The results showed that root resorption and secondary cementum formation could be disregarded. The other criteria, attrition (a), periodontitis (p), secondary dentine (s) deposition, and transparency of the root (t) of the12 anterior teeth, are related appreciably to age and to a similar degree. Dalitz suggested this below formula.[65]
E = 8.691 + 5.146a + 5.338p + 1.866s + 8.411t
Disadvantage: It does not take into account bicuspids and molar teeth.

Bang and Ramm method (1970)

They found that the root dentine appears to become transparent during the third decade starting at the tip of the root and advancing coronally with age.[65]
It was found that, transparency of the root dentin advances coronally from the tip of the root during the third decade. A great advantage of the method is that good results are obtained by measuring intact roots only.[65]

Johanson method (1971) Age changes were differentiated into seven different stages (a0-a3) and evaluated for the same six criteria, mentioned earlier, attrition (a), secondary dentine formation (s), periodontal attachment loss (p), cementum apposition (c), root

resorption (r), and apical translucency (t). Johanson made a more detailed study of the root transparency and stated that it is more clear when the thickness of the ground section of the tooth was 0.25 mm. The following formula was recommended: [65]

Age = 11.02 + (5.14 × a) + (2.3 × s) + (4.14 × p) + (3.71 × c) + (5.57 × r) + (8.98 × t)

Maples method (1978)

Suggested the use of only two criteria of the total six Gustafson recommended-(secondary dentine formation and root transparency), in order to make the method more simple and accurate.[65]

Solheim method (1993)

Solheim used five of the changes that Gustafson recommended (attrition, secondary dentin, periodontitis, cementum apposition, and root transparency) and added another three new changes that showed a significant correlation in different types of teeth. The three new age-related changes were surface roughness, color, and gender.[65]

3.10.2 Biochemical methods

The biochemical methods are based on the racemization of amino acids. The racemization of amino acids is a reversible first-order reaction and is relatively rapid in living tissues in which metabolism are slow. Aspartic acid has been reported to have the highest racemization rate of all amino acids and to be stored during aging. In particular, l-aspartic acids are converted to d-aspartic acids and thus the levels of d-aspartic acid in human enamel, dentine, and cementum increase with age.[65]

Some of the methods are:

1. Helfman and Bada method (1975, 1976)
2. Ritz et al. Method (1995)

Helfman and Bada method (1975, 1976)

The authors reported studies that focused on the racemization of amino acids and obtained a significant correlation between age and ratio of d/l-enantiomers in aspartic acid in enamel and coronal dentin.[65]

Ritz et al. Method (1995)

Used the racemization method in dentinal biopsy specimens in order to estimate the age of living individuals. This method emerged from the need to identify the age of living individuals without extracting teeth. [65]

3.10.3 Radiographic methods

Radiology plays an indispensable role in the human age determination. Radiological images are utilized in the process of age estimation, which is one of the essential tools in identification in forensic science. Radiographic assessment of age is a simple, non-invasive and reproducible method that can be employed both on living and unknown dead.[66]

Various radiographic images that can be used in age identification are intraoral periapical radiographs, lateral oblique radiographs, cephalometric radiographs, panoramic radiographs, digital imaging and advanced imaging technologies.[66]

The radiological age determination is based on assessment of various features as follows: [66]

- Jaw bones prenatally
- Appearance of tooth germs
- Earliest detectable trace of mineralization or beginning of mineralization
- Early mineralization in various deciduous teeth during intrauterine life
- Degree of crown completion

• Eruption of the crown into the oral cavity
• Degree of root completion of erupted or unerupted teeth.
• Degree of resorption of deciduous teeth
• Measurement of open apices in teeth
• Volume of pulp chamber and root canals/formation of physiological secondary dentine
• Tooth-to-pulp ratio
• Third molar development and topography

Age estimation is grouped into three phases:

1. Pre-natal, neonatal and post-natal
2. Children and adolescents
3. Adults

Pre-natal, neonatal and post-natal age estimation

Radio graphically, the mineralization of deciduous incisors starts at the 16th week of intrauterine life. Before the mineralization of tooth germs starts, the tooth germs may be visible as radiolucent areas on the radiograph; the subsequent radiographs of the mandible will depict the deciduous teeth in various stages of mineralization as per the pre-natal age of the fetus. One of the methods employed is: [65] **Stages by Kraus and Jordan (1965)** they studied the early mineralization in various deciduous teeth as well as the permanent first molar. The development is described in 10 stages, denoted by roman numerals from I to X the IXth stage includes three stages and the XTH stage includes five stages.[66]

3.10.4 Age estimation in children and adolescents

Dental age estimation in children and adolescents is based on the time of emergence of the tooth in the oral cavity and the tooth calcification. The radiographic analysis of developing dentition, especially when there is no clinical evidence available (2.5-6 years) as well as the clinical tooth emergence in various phases will help in age determination.[66]

Methods applied for age determination in children and adolescents

Schour and Masseler method (1941)

In 1941, Schour and Masseler 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.[66]

Nolla's method (1960)

Nolla evaluated the mineralization of permanent dentition in 10 stages. After every tooth is assigned a reading, a total is made of the maxillary and mandibular teeth and then the total is compared with the table given by Nolla.[66]

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 with separately.

Moorees, fanning and hunt method (1963) in this method, the dental development was studied in the 14 stages of mineralization for developing single and multirooted teeth. In it the permanent teeth and the mean age for the corresponding stage was determined.[66]

3.10.5 Age estimation using open apices (Cameriere method)

Various studies assessed the relationship between the age and measurement of open apices in teeth. The seven left permanent mandibular teeth were valued. The number of teeth with completion of root development with apical ends completely closed was

calculated (n0). For the teeth with incomplete root development, that is, with open apices, the distance between inner sides of the open apex was measured (a). For the teeth with two roots, the sum of the distances between inner sides of two open apices was evaluated. To nullify the magnification, the measurement of open apex or apices (if multi rooted) was divided by the tooth length (l) for each tooth and these normalized measurements of seven teeth were used for age estimation. The dental maturity was calculated as the sum of normalized open apices (s) and the numbers of teeth with root development complete (n0). The values are substituted in the following regression formula for age estimation.[66]

Age = 8.971 + 0.375 g + 1.631 × 5 + 0.674 n0 – 1.034 s – 0.176 s n0

Where g is a variable equal to 1 for boys and 0 for girls.

3.10.6 Age estimation in adults

Clinically, the development of permanent dentition completes with the eruption of the third molar at the age of 17-21 years, after which the radiographic age estimation becomes difficult. The two methods commonly followed are the assessment of the volume of teeth and the development of the third molar.[66]

1. Volume assessment of teeth

A. Pulp-to-tooth ratio method by Kvaal

B. Coronal pulp cavity index

2. Development of third molar

A. Harris and Nortje method

B. Van Heerden system

The age estimation in adults can be achieved by radiological determination of the reduction in size of the pulp cavity resulting from a secondary dentine deposition, which is proportional to the age of the individual.[66]

Pulp-to-tooth ratio method by Kvaal In this method, pulp-tooth of central and lateral incisors; maxillary second premolars; mandibular lateral incisor; mandibular canine; and the first premolar are evaluated. The age is derived by using these pulps to tooth ratios in the formula for age determination given by Kvaal et al.[66]

Age = 129.8 – (316.4 × m) (6.8 × [w-l])

The coronal pulp cavity index

This method calculates the correlation between the reduction of the coronal pulp cavity and the chronological age. Only mandibular premolars and molars were considered, as the mandibular teeth more visible than the maxillary ones. Panoramic radiography is used to measure the length (mm) of the tooth crown (coronal length, [CL]) and the length (mm) of the coronal pulp cavity (coronal pulp cavity height or length [cpch]). The tooth-coronal index (tci) is calculated for each tooth and regressed on the real age of the sample using the formula.[66]

Tcicpch 1 cl = * 00

Development of third molar

The radiographic age estimation becomes problematic after 17 years of age as eruption of permanent dentition completes by that age with the eruption of the third molar. Later, the development of the third molar may be taken as a guide to determine the age of the individual.[66]

Harris and Nortje method

They have given five stages of third molar root development with corresponding mean ages and mean length.[66]

Van Heerden system

The development of the mesial root of the third molar was assessed to determine the age using panoramic radiograph (in this system he considered five stages).[66]

Demirjian, Goldstein, and Tanner Method (1973)

In 1973, Demirjian introduced a method (demi973) which estimated chronological age based on developments of seven teeth from the left side of the mandible. This method was similar to that of Tanner, White house, and Healy, who estimated chronological age based on the maturity of hands and wrists.[67]

Demirjian, Goldstein, and Tanner used the stages which have usually been marked by recognizable tooth shapes, from the beginning of calcification through to final mature form. Useful stages must be easily recognizable, and ratio is calculated for six mandibular and maxillary teeth, such as that a tooth always passes through the same stages in every individual. Since the stages are indicators of maturity and not of the size, they cannot be defined by any absolute length measurements. In it the final scores for each tooth, previously constrained each to be 100, are allowed to vary so that only their sum (or average) over all the teeth is 100. This makes allowance for the different ages at which different teeth maturity scores for girls and boys are given.[67]

Assigning the ratings:

1. The mandibular permanent teeth are rated in the following order: 2nd molar, 1st molar, 2nd bicuspid, 1st bicuspid, canine, lateral incisor, central incisor.[67]
2. All teeth are rated on a scale a-h. The rating is assigned by following carefully the written criteria for each stage and by comparing the tooth with the diagrams and x-ray pictures given for comparison. For each stage, there are one, two or three written criteria

marked as a, b, c. If only one criterion is given, this must be met for the stage to be taken as reached; if two criteria are given, then it is sufficient if the first one of them is met for the stage to be recorded as reached; if three criteria are given, the first two of them must be met for the stage to be considered reached. At each stage, in addition to the criteria for that stage, the criteria for the previous stage must be satisfied. In borderline cases, the earlier stage is always assigned.[67]

3. There are no absolute measurements to be taken. A pair of dividers is sufficient to compare the relative length (crown/root). To determine apex closure stages, no magnifying glass is necessary. The ratings should be made with the naked eye.[67]

4. The crown height is defined as being the maximum distance between the highest tip of the cusps and the cementoenamel junction. When the buccal and lingual cusps are not at the same level, the midpoint between them is considered as the highest point.[67]

3.10.7 Dental formation stages

If there is no sign of calcification, the rating 0 is given: the crypt formation is not taken into consideration.[67]

Stage description67

A. In both uniradicular and multiradicular teeth, a 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 a) Enamel formation is complete at the occlusal surface.

b) The beginning of a dentinal deposit is seen.

c) The outline of the pulp chamber has the outline of the pulp chamber has a curved shape at the occlusal border.

D. a) The crown formation is completed down to the cementoenamel junction.

b) The superior border of the pulp chamber in the uniradicular teeth has a definite curved form, being concave toward the cervical region. The projection of the pulp curved shape at the occlusal border horns if present, gives an outline shaped like an umbrella top in molars the pulp chamber has a trapezoidal form.

c) Beginning of root formation is seen in the form of a spicule.

E. Uniradicular teeth.67

- a) 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 previous stage of the crown height.
- b) The root length is less than the crown height.

• Molars: 67

- a) Initial formation of the radicular bifurcation is seen in the form of either a calcified point or a semi-lunar shape.
- b) The root length is still less than crown height.

F. Uniradicular teeth67

- a) The walls of the pulp chamber now form a more or less isosceles triangle. The apex ends in a funnel shape.
- b) The root length is equal to or greater than the crown height.

• Molars: REVIEW OF LITERATURE

- a) 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.
- b) The root length is equal to or greater than the crown.

G. The walls of the root canal are now parallel and, its apical end is still partially open.
H. The apical end of the root canal is completely closed.

- a) The periodontal membrane has a uniform width around the root and the apex.

Using the scoring system67

1. Each tooth will have a rating (a-h), assessed by the procedure described.
2. This is converted into a score using the table for boys or girls as appropriate.
3. The scores for all seven teeth are added together to give the maturity score.
4. The maturity score may be plotted on the centile charts (boys or girls as appropriate) where the age of the child is known.
5. The maturity score may be converted directly into a dental age either by reading on the horizontal Scale the age at which the 50th centile attains the maturity score value, or by using table which has been constructed by this means.

3.10.7 Other modifications of Demirjian's method

In 1976, Demirjian developed three more methods. First was based on the same seven teeth; second on four teeth, specifically the first premolar (PM-l, second premolar (PM-2), first molar (M-1), and second molar (M-2); and the third on four teeth, specifically the second incisive, first premolar (PM-1), second premolar (PM-2), and second molar (M-2). however, several authors have shown that results are less accurate if one compares another population to Demirjian's standards. Hence, for age estimation based on age, ethnicity/race we need to develop specific standards.[68] REVIEW OF LITERATURE

Further studies are required to check validity, reliability, and applicability of this method in different populations across the world. Importance of age estimation includes an assessment of minor/major status in individuals without legal documents, Demirjian method, the widely used method with appropriate modifications shall be a reliable method.[68]

Cameriere R, Ferrante L, Cingolani M. 2004[69] conducted a study with 100 sample size including 46 men 54 women age between 18 and 72 years utilized single rooted maxillary canine in the study and found that with statistical analysis that 84.9 % of variation was estimated in chronological age.

Matthew R. B. Blenkin. 2005[70] illustrated purpose of this current study was to test the applicability of one such system, the Demirjian system, to a Sydney sample population, and to develop and test age prediction models using a large sample of Sydney children (1624 girls, 1637 boys). The use of the Demirjian standards resulted in consistent overestimates of chronological age in children under the age of 14 years by as much as a mean of 0.97 years, and underestimates of chronological age in children over14 years by as much as a mean of 2.18 years in 16 year-old females. Of the alternative predictive models derived from the Sydney sample, those that provided the most accurate age estimates are applicable for the age ranges2-14 years, with a coefficient of determination value of r-square=0.94 and a95% confidence interval of ±1.8 years. The Sydney based standards provided significantly different and more accurate estimates of age for that sample when compared to the published standards of Demirjian.

Roberto Cameriere, Giuseppebrogi, Luigiferrante, Doramirtella, Claudiavultaggio, Marianocingolani et al 2006[71] conducted a study on skeletons arranged from three sites. First site included 33 skeletons, second site included 10 skeletons and third site included 9 skeletons. In all the three sites, the ages of the skeletons were estimated by evaluation of the secondary dentine of the upper canines.

Radiographs were digitized by a scanner and images were then recorded in the computer file. 20 points from each tooth and 10 points for pulp age were identified and concluded in the ptr method was not only found to be a useful technique to access the chronological age of living persons but it is also a reliable tool in determination of age at death in skeletal remains.

Ipevarghese V, **Shameena PM**, **Sudha S**, **2006**[72] purpose of this article is to familiarize about different techniques used by means of teeth. Conclusion age estimation presents a complex problem and requires considerable experience in recognizing significant changes and allowing for their variability within any particular population.

Teeth are particularly useful in age evaluation because they display a number of observable age related variables and they tend to remain intact under circumstances which might alter or obliterate the rest of the skeleton.

Roberto Cameriere, Luigiferrante, Mariagiovanna, Belcastro, Benedettabonfiglioli, Elisarastelli, and Mariano Cingolani. 2007[73] studied the accuracy of age evaluation by combined analysis of labio-lingual and mesial periapical x-rays of lower and upper canines. Total of 200 such x-rays were assembled from 57 male and 43 female skeletons of Caucasian origin, aged between 20 and 79 years. For each skeleton, dental maturity was evaluated by measuring the pulp/tooth area ratio according to labio-lingual and mesial x-rays on upper and lower canines and concluded that there were no statistically significant intra-observer differences between the paired sets of measurements carried out on the reexamined periapical radiographs.

R. Cameriere , E. Cunha , E. Sassaroli , E. Nuzzolese , L. Ferrante, 2009[74] Age estimation in adults is an important problem in both anthropological and forensic fields, and apposition of secondary dentine is often used as an indicator of age. In recent papers, cameriere et al.studied the pulp/tooth area ratio of canines for this purpose. The present study examines the application of the pulp/tooth area ratio by periapical x-ray images as an age indicator in a Portuguese identified sample.

The Portuguese sample

consisted of 126 canines of male and 132 of female from subjects 20 to 84 years old, from the osteological collection of the museum of anthropology at Coimbra University. The Italian sample consisted of 114 canines of male and 86 of female from subjects 20 to 79 years old, analyzed in cameriere et al. (2007), statistical analysis was performed in order to obtain multiple regression formulas for dental age calculation, with chronological age as dependent variable, and gender and pulp/tooth area ratio on upper (rau) and lower canines (ral) as independent variables. ANCOVA analysis showed that gender was not significant but that variables rau and ral were. The regression model for the Portuguese sample yielded the following equations: age = 101.3–556.68 rau (upper canines) and age = 92.37–492.05 ral (lower canines). Both models explained about 97% of total variance, and mean prediction errors were me = 2.37 Years and 2.55 years, respectively for the Italian sample did not reveal significant differences between the linear models, suggesting that a common regression model could be applied for both samples. The common regression model, describing age as a linear function of rau and ral, yielded the following linear regression formulas: age = 100.598–544.433 rau; age = 91.362–480.901 ral, and explained 86% and 93% of total variance, respectively. Mean prediction errors were me = 2.68 years and2.73 years, respectively.

Sasidhar Singaraju, Sharada P 2009[19] purpose of this study was to present a method for assessing the chronological age based on the relationship between age and measurement of the pulp/tooth area ratio on single-rooted teeth, using orthopantomographs and a computer-aided drafting program AutoCAD 2000. Study of 200 rotational pantomographs collected from patients orthopantomographs were digitized using astra 4000 u x-ray scanner and the images were recorded in a computer. Radiographic images of the canine were then processed using computer-aided program autocad2000.Twenty points were marked on the surface of the tooth outline and ten points were marked on the surface of the pulp outline of the right maxillary canine, to obtain the tooth surface area and the pulp surface area, respectively. To minimize inter REVIEW OF LITERATURE

observer variations, the entire sample was distributed into three different age groups. 18.30, 31.50, and 51.70 years. Similarly, the effect of gender on age estimation was also determined in this study, and found that gender had no significant influence on age.

Noorazma S, Solheim T And Ruslan S 2009[75] the Demirjian method using the seven left mandibular teeth observed from orthopanthomogram was used to study the dental maturation on the teeth of Malay children. This was then compared with the table by Demirjian et al (1973) to estimate the age of these children. The children were between 6.5 to 16 years of age. Altogether 203 girls and 131 boys were included in the study. The means for chronological age were 12.93 ± 2.4 years (2se) for the boys and 13.14 ± 1.6 years (2se) for the girls. Pearson's correlation coefficient between calculated and chronological age, r was 0.81 and 0.87 for the boys and girls respectively. Two-tailed, paired t test showed that there was no significant difference between the means of chronological age (ca) and the estimated dental age. From this study it was concluded that Demirjian's method can be used to estimate the age of the Malay mongoloid sundadont children in the population.

Deepak Pateel G. S. 2009[76] examined the possible application of pulp/tooth area ratio of canine in Intra Oral Periapical X-ray using RVG for estimation of age of an individual. 25 Individuals aged between 18 to 27years, with apparently normal canine were included in the present study. Radiovisuographic images of canine of upper and lower jaws were obtained. These images were then transformed to CAD2007 software from which area of pulp/tooth ratio will be calculated with the help of 10 points from each tooth outline and 5 points for each pulp outline. By using regressive formula the age was calculated. Results showed that the estimated age using maxillary canine (x1) showed no statistically significant difference between the estimated age and the real age (p=0.1) which means that there is little difference between real age and estimated age. So, it is feasible to estimate age using pulp to tooth area ratio of maxillary canine. REVIEW OF LITERATURE

Babshet M, Acharyaab, Naikmasur Vg 2010[77]study has assessed the usefulness of one of the formulas on an Indian sample and also examined the use of an India-specific equation in age prediction. Intraoral periapical digital radiographs of mandibular canines were obtained from 143 individuals (aged 20-70 years) using the paralleling technique; pulp and tooth areas were measured using a commercially available computer software programmed and the pulp/tooth area ratio was computed. Age was calculated using the Italian formula which revealed a mean absolute error (mae) of 11.01 years in Indians, an error recognizably greater than the 4.38 years reported in the Italian sample. The divergence may be explained on account of population differences that exist between Italians and Indians as well as variation in the pattern of secondary dentine deposition in Indians.
J. Jayaraman, N. M. King, G. J. Roberts, H. M. Wong. 2011[78] evaluated an important requisite in forensic, judicial and criminal proceedings. Total of 182 dental panoramic tomographs comprising an equal number of boys and girls with an age range from 3to 16 years were scored. Dental maturity scores were obtained from the Demirjian's dataset and dental age was calculated. There was a mean over estimation of dental age of 0.62 years for boys ($p<0.01$) and 0.36 years for girls ($p<0.01$). However it was concluded that Demirjian's dataset is not suitable for estimating the age of 3-16 years old southern Chinese children.
Jeevan MB, Kale AD, Angadi PV, Hallikerimath S 2011[79]**.** Age estimation of an individual whether living or dead is an intimidating task in forensic investigations. Since teeth are more resistant to most peri- and post-mortem changes, they are frequently used for identification and age estimation when skeletal remains are in poor condition. However, most methods are destructive and warrant extraction of teeth which is not feasible in living individuals. Cameriere's et al. put forth a radiographic method of age estimation by pulp to tooth area ratio (AR) in canines and revealed a linear regression between age and the AR. In the present study, we estimated the AR in 456 canines (upper, lower and both) in an Indian sample (114 males and 114 females) using REVIEW OF LITERATURE

radiovisiography technique. Linear regression equations were derived for upper canine, lower canine and both using the AR to estimate chronological age. Additionally, the efficacy of these equations was also evaluated in younger age group (<45 years). The mean value of residuals using these regression equations ranged from 4.28 to 6.39 years with upper canine equation generally giving a precise result. When these equations were applied for younger ages (<45 years), the regression equation derived from both canines gave a better result (mean residual 2.70 years). Overall these equations were better able to predict the age in younger ages, i.e., up to 45 years.

Manoj Kumar, S. K. Tripathi, 2013[80] concluded that estimation of age of an individual whether living or dead is a subject of great medico legal importance and is the necessity for the purpose of administration of justice. Perhaps it is the second commonest medico legal problem after trauma. Total of 610 cases were studied which were taken randomly from various schools, colleges and OPD'S of department of forensic medicine and department of radio diagnosis & imaging, institute of medical sciences, Banaras Hindu university, Varanasi. It was postulated that attrition method is the best clinical method where the attrition of molar cusps is recorded was found to be suitable for Indian population. It concluded, that above methods of age estimation can be tried in forensic cases in the identification of the individual with no birth records. Expert assessment and the combination of physical examination of the suspect, dental examination which records dental status including OPG, x-ray examination of the left hand and wrist and radiographic or CT survey of the clavicle lead to conclusions regarding the estimated age.

Ayakasakuma, Hisakosaitoh ,Yoichisuzuki ,Yohsukemakino Go Inokuchi ,Mutsumihayakawa 2013[81] Here, they evaluated whether reconstructed images of multidetector-row computed tomography (mdct) acquired before forensic autopsy are useful for estimating age at death. Images of 136 mandibular first premolars obtained from bodies of known age at death were analyzed, and the volume of the regions corresponding to pulp cavity and that of the whole tooth were determined using a voxel

counting function. The pulp cavity was clearly distinguishable from dental hard tissue on the reconstructed images when using a cut off value of 1400 Hounsfield units. Regression analysis adjusted for sex showed that estimated age correlated significantly with the pulp cavity to tooth volume ratio (r = 0.76). Mdct is gaining more widespread use in forensic medicine, and analyzing dental images to obtain parameters for age prediction is a practical approach for post-mortem identification.

Rakesh Kumar Dumpala, Venkateswara Rao Guttikonda, Geetha Kumari M, Naveen Rayapudi, 2013[82] carried out a comprehensive study to estimate the age using pulp tooth area ratio of right mandibular canine in digital orthopantamographs (OPGs) in 30 patients and estimated of age using hand wrist radiographs. Skeletal age was determined with hand wrist radiographs applying Bjork Grave and Brown method and dental age by using the pulp tooth area ratio of right mandibular canine in digital OPGs. The results showed that age estimated using pulp/tooth area ratio in digital OPGs was more accurate when compared to age estimated using hand-wrist radiographs.

Melda Misirlioglu, Rana Nalcaci, Mehmet Zahit Adisen, Selmi Yilmaz &Serap Yorubulut, 2013[83]**.** The present study was designed to test the applicability of Kvaal's method on digital orthopantomographs and to develop a new formula measuring pulp/tooth area ratio from periapical X-rays in a group of individuals living in Central Anatolia. Orthopantomographs and periapical X-rays of 114 patients aged between 17–72 years were selected. According to reported technique, three mandibular teeth were evaluated in each orthopantomogram with Kvaal's method. Additionally, the pulp/tooth area ratio was measured on periapical X-rays of maxillary canine. Correlations between real age and morphological variables were calculated for all teeth using Pearson's correlation coefficient. Kvaal's method on digital panoramic radiographs gave acceptable results (standard deviation, SD = 5.9 to 7.9 years) that were close to the original. In addition, regression equations were developed to estimate age from morphological variables and the best results were achieved using the regression equation for the maxillary canine with a pulp/tooth area ratio (standard error of estimate, SEE =

±6.75; coefficient of determination R^2 = 0.67). There was no significant difference between observed and estimated age for age groups and gender based on the established regression equations.

Mostafa M Afify1, Mohamed K Zayet, Naglaa F Mahmoud and Ahmed R Ragab In 2014[3] tested the reliability and applicability of pulp/tooth area ratio (ptr) in three mandibular teeth as an indicator of age by panoramic radiographs. The study revealed no statistically significant intra- and inter-observer differences between the paired sets of measurements carried out on the re-examined panoramic radiographs.

Manjushree Juneja, Yashoda B. K. Devi, N. Rakesh, and Saurabhjuneja. 2014[8] analysed panoramic radiographs of 200 patients of Karnataka; aged between 18 to 72 years and they concluded that there were no significant difference between the morphological variables among the males and females, indicating that gender did not influence the regression model used to estimate chronological age for both female and male groups.

Javierata-ali, Fadiata-ali. 2014[21] updated the role of odontology in human identification, based on a pubmed-Medline search of the last 5 years (1 October 2007 to 1 October 2012) and using the terms: "forensic dentistry" (n = 464 articles), "forensic odontology" (n = 141 articles) and "forensic dentistry identification" (n = 169 articles). Apart from these initial 774 articles, others article considered to be important and which were generated by a manual search and cited as references in review articles were also included. Were divided into three groups: buccodental studies in comparative identification, buccodental evaluation in re-reconstructive identification human bites as a method for identifying the aggressor, and the role of DNA in dental identification. Conclusion came that oral cavity is a rich and noninvasive source of DNA, and can be used for the identification of individuals and for providing information needed in legal processes.

REVIEW OF LITERATURE

Martinafocardi. Vilmapinchi . Federica De Luca. Gian-aristidenorelli. 2014[84] analyzed the ethical issues related to age estimation procedures based on radio-graphic methods, showing how the ethical principles of beneficence, non malevolence, justice, and autonomy may be guaranteed during the execution of the age assessment in forensic practice**.** The procedure might be conducted in accordance with international guidelines and protocols, though they need a higher homogenization and standardization. A strong collaboration between various scientific societies of professionals (forensic odontologists, forensic pathologists, forensic anthropologist, radiologists, pediatricians, and psychologists), who have been involved in age estimation for years, is needed to reach this goal. In civil criminal cases, and it is often requested by the subject or the relatives (e.g., parents of adopted children).Aim of this paper is was analyze the ethical issues related to procedures based on radiographic methods to estimate age through the evaluation of dental mineralization and bone maturational, as well as being a valid and established method on a scientific level. However it raised ethical and deontological issues and multidisciplinary debates. All the possible pros and cons were discussed and been cited in this research work.

Shruti B Nayak. Renjithgeorge, **Amarnathshenoy, B. Shivapathasundaram 2014**[85] assessed that dental maturity has played an important role in Estimating the chronological age of individuals because of the low variability of dental indicators. Various methods have been constructed and tested to estimate the age of young individuals. Among them are the physical examinations using anthropometric measurements, skeletal maturation, dental age estimation, a combination of dental development and anthropometric measurements and a combination of skeletal and tooth eruption. The stages of tooth development can be considered as one of the most dependable indicators in assessing the age of the victim. Even after the complete development of dentition and craniofacial skeleton attained certain physical, chemical and biological changes takes place which aids in the age estimation. Various methods

are utilized for determination of age from dentition. Age assessment methods may be classified as:
A. According to the state of development of the dentition:

- • Methods applied to the forming dentition
- • METHODS FOR THE ADULT FULLY FORMED DENTITION.

B. According to the technique of investigation:

- • Clinical or visual
- • Radiographic
- • Histological
- • Physical and chemical analysis

As with dental identification, one must bear in mind that the report of age estimation is addressed to law enforcement agencies. Therefore, it is very important that the wordings in the report reveal the underlying concepts of age estimation, the materials that were obtained for age estimation (such as radiographs or skeletal samples), as well as the methods used. In addition, it is important to address the applicability of the methods to the population on which it was used.

Uday Ginjupally, Ramaswamy Pachigolla, Sudhakar Sankaran, Smitha Balla, Sreenivasulu Pattipati, Sai Kiran Chennoju. 2014[86] The aim of this study was to estimate the age of the patients belonging to the age group of 15 – 55 years, based on the radiographic evaluation of the pulp cavity width of the maxillary central incisors. The study group comprised of 120 subjects and intraoral periapical radiographs of the maxillary central incisors were taken for all subjects, using the conventional paralleling angle technique and the pulp cavity width was measured at the cervical and middle third using a digital vernier caliper. The data obtained was subjected to correlation and regression analysis. The study concluded the reliability of the derived formula and that the width of the pulp cavity of maxillary central incisors is reliable for estimation of age. REVIEW OF LITERATURE

A. P. Indira, R. Shashikala, Tejavathinagaraj, H.N. Santosh in 2015[5] conducted a study consisting of 100 subjects including both genders aged between 16 to 50 years. The tooth selected was maxillary left central incisor. Intraoral periapical radiographs were taken by paralleling cone technique. Total pulp length and cervical pulp width of the root canal were measured. They confirmed that there is horizontal and vertical reduction in pulp size with an increase in age due to secondary dentine formation. This radiographic morphometric gradual reduction in pulp size was observed with respect total pulp length and cervical pulp width with an increase in age and this showed a significant correlation with the chronological age.

Shirinsakhdari, Sandramehralizadeh, Maryamzolfaghari, Majidmadadi. 2015[87] in there diagnostic study assessed, digital panoramic radiographs of 120 cases. The chronological age was calculated by subtracting the date of birth from the date of radiographs and there was calculated with "AutoCAD" software. Using the regression model, the age was estimated. In this study, the role of sex was also assessed. The mean difference between the chronological and the estimated age was 0.11 years in male group. The correlation coefficient was -0.180 and the correlation between age and AR was not statistically significant conclusion cannot be used for age estimation alone; but it can be used in combination with other indices for this purpose.

Alana de Cássia Silva Azevedo, Nathalia Zanini Alves, Edgard Michel-Crosato, Marcos Rocha, Roberto Cameriere, Maria Gabriela Haye Biazevic. **2015**[88] this study were to develop a specific formula to estimate age in a Brazilian adult population and to compare the original formula from Cameriere to Brazilian formula. The sample comprised 1,772 periapical radiographs from 443 subjects (219 men, 224 women) that were organized into 12 groups according to sex (men or women) and age (20-29, 30-39, 40-49, 50-59, 60-69, and 70 years and older). The films were analyzed using the criteria described by Cameriere *et al.* (2004) and Adobe Photoshop. We obtained a mean error of 8.56 (SD = 5.80) years for tooth 13, 7.99 (SD = 5.78) years for tooth 23, 8.38 (SD = REVIEW OF LITERATURE

6.26) years for tooth 33, and 8.20 (SD = 6.54) years for tooth 43. When teeth were combined in the analysis, we observed lower mean errors. The Brazilian formula developed from this sample group was more accurate than Cameriere's formula. However, other factors must be considered to improve age estimates in adults.

Seema Basoya, Vinod V C, Priyankanath , Ashwin D Bhogte 2016[89] this paper brought across a radiological methodology to estimate the age of an individual via 3 computer aided software's on maxillary central incisor. 30 periapical radiographs of individual aged ≥ 12 to ≤ 30 years were taken using radiovisiography (RVG). Radiographic images were processed using the software; data was statistically analyzed
to compare the age. There was no statistical significant difference in age calculated by adobe Photoshop and auto cad, adobe Photoshop p=0.432 and auto cad p=0.004; though there was significant statistical difference in age calculated by image j, p<0.001. It was concluded that pulp/tooth area ratios of maxillary central incisor are reliable for estimation of age and AutoCAD gave the most accurate results.

Sargam D Kotecha. 2016[90] stated that forensic odontology is playing a very important role in the identification of an individual's age. Dental age is considered to be vital as tooth development shows less variability than other developmental features and also low variability in relation to chronological age. Formation of deciduous teeth begins in utero at about 4 months and permanent teeth complete formation at approximately 25 years of age.

Andréluizbérgamo, Cristhianeleão de queiroz, Hiromieduardosakamoto and Ricardohenriquealves Da Silva 2016[91] concluded that age estimation is essential not only in human identification, but also in civil and pension lawsuits.

Purpose of this literature review was to present the main methods in age estimation that have been currently used. Database searched was pubmed and the terms used were "dental age estimation methods" and "forensic dentistry". Just papers about dental age REVIEW OF LITERATURE

estimation methods written in English between 2012 and 2015 were selected. Results of 67 papers were retrieved through electronic searching, but nine studies were excluded. Conclusion was that the most dental age estimation methods were based on developmental stages of the teeth through radiographs and they were applied in children and sub-adults in countries of the different continents.
Nusratnazir, Altafhussainchalkoo. 2017[92] carried out a study to determine age by pulp/tooth area ratio (ptr) using three mandibular teeth by panoramic radiographs. A total of 225 panoramic radiographs of Kashmir subjects (108 males and 117 females), aged between 15 and 70 years were analyzed. According to Cameriere et al measurements of the pulp and tooth areas were done. The morphological variables i.e. pulp area, tooth area, pulp tooth ratio, age and the subject's gender were entered in a Microsoft excel spreadsheet for use as predictive variables for age estimation. Chronological age of an individual was calculated by subtracting the birth date from the date on which the radiographs were exposed for that particular individual. Results found that the 2nd premolar was the most closely correlated with age(r=-0.951) followed closely by canine (r=-0.931) and see of 3.65 years. The 1st premolar revealed the lowest correlation (r=-0.899) and see of 4.72 years. The researchers Concluded that the use of Cameriere's age-related variables in lower premolars and canine and the application of the new regression formulae on data obtained from orthopantomographs lead to accurate age estimatimation.
Urvashi a Shetty, Kumudharao, D'cruzaudrey m, Pushparajashetty, Srikalabhandary. 2017[93] aimed to study a method for assessing the chronological age of an individual by correlating the relationship between age and pulp /tooth length ratio in mandibular canine. Study included 60 extracted permanent mandibular canines from individuals with known age (between the age group of 15-70 yrs) and sex. The samples were subdivided into 6 groups based on the age of the individual with 10 samples in each group. The measurement was done by unsectioned method to measure the

tooth length ratio. Maximum tooth length was measured with a pair of digital vernier caliper and maximum pulp length by endodontic k-file. There was no significant difference in the study variables between the genders. A gradual reduction in pulp size was observed with respect to total pulp length and cervical pulp width with an increase in age and this showed a significant correlation with the chronological age. Conclusion was drawn that assessment of pulp/tooth length ratio on mandibular canine using odontometric procedure manually without any sophisticated instruments can be used as an alternative method to estimate the nearest chronological age with reasonable accuracy when radiographs are not available.

S. Venu Gopal, K. Krishnamurthy, C. Pritam Chaudhari, P. Anupama, E. Elampavai. 2017[94] The purpose of this study was to assess the validity and reliability of the various width and length variables in Kvaal's and Cameriere's methods of age estimation in a specific population of Central India origin. A total of 110 patients aged between 15 and 75 years were selected, and the variables *P* = complete pulp length/root length (from enamel−cementum junction [ECJ] to root apex), r = complete pulp length/complete tooth length, a = complete pulp length/root width at ECJ level, b = pulp/root width at midpoint level between ECJ level and mid−root level, and c = pulp/root width at mid−root level, and pulp/tooth AR were recorded as devised in Kvaal's and Cameriere's methods of age estimation, respectively.

Chandramani B. More, Ruchita Peter and Pranay T. Patel, 2017[95]**.** To assess the chronological age from the morphological parameters of all the permanent canines using digital panoramic radiographs and to evaluate the applicability of Kvaal's method. A cross-sectional study was undertaken on 300 digital panoramic radiographs where in the images of all the four permanent canines were analyzed by the investigators jointly using Adobe Acrobat professional 8.0 and Adobe Photoshop 7.0.1 software. The measurements of each canine were estimated by using Kvaal's method, and were subjected to statical analysis using Pearson's correlation and linear regression model.

The age of participants ranged from 18 to 64 years, with mean of 28.54 ± 8.39 years. The difference in morphological variables between males and females was not significant. The Pearson's correlation coefficient in maxillary canine showed that except variable A', all the other variables had correlation with age Similarly, in mandibular canines the variables 'T', 'B' and 'W-L' correlated significantly with age. The stepwise linear regression analysis was performed to correlate the variables with chronological age and a linear regression formula was obtained for Maxillary and Mandibular canine. The regression equation with the variable in Maxillary canine explained 3.5%of total variance (R2 = 0.035) with the standard error of estimate of 8.63 years and median of residuals of 2.36 years. The regression equation with the variable in Mandibular canine explained 1.9 % of total variance (R2 = 0.019) with standard error of estimate of 8.7 years and median of residuals of 1.8 years. The p value <0.05 is for both, constant and W-L, which signifies, significant relationship between the parameter and age.

T.Y. Marroquin, S. Karkhani, S.I. Kvaal, S. Vasudavan, E. Kruger, M. Tennant. 2017[96] summarized the results of some of the most recently cited methods for dental age estimation in adults, based on odontometric dental imaging analysis, to establish which methodology is more accurate, accessible, and simple. A literature search from several databases was conducted from January 1995 to July 2016 with previously defined inclusion criteria. Based on the findings of this review, it could be possible to suggest pulp/tooth area ratio calculation from first, upper canines and other single rooted teeth (lower premolars, upper central incisors), and a specific statistical analysis that considers the non-linear production of secondary dentine with age, as a reliable, easy, faster, and predictable method for dental age estimation in adults. The second recommended method is the pulp/tooth width–length ratio calculation. The use of specific population formulae is recommended, but to include data of individuals from different groups of population in the same analysis is not discouraged. A minimum sample size of at least 120 participants is recommended to obtain more reliable results. Methods based on volume calculation are time consuming and still needs improvement.

Maneesha Das, Abhishek Singh Nayyar, Neetu Punhani1, Harsha Puri1, Rakesh Rohilla, Chalapathi KV, Anand Babu B. 2017[97] The purpose of the study was to assess the validity of Kvaal's and Cameriere's methods of age estimation.A total number of 110 patients aged between 15 and 75 years were selected and the variables *P* = complete pulp length/root length (from enamel−cementum junction [ECJ]−root apex), *r* = complete pulp length/complete tooth length, a = complete pulp length/root width at ECJ level, b = pulp/root width at midpoint level between ECJ level and mid−root level, and c = pulp/root width at mid−root level; and pulp/tooth AR were recorded as devised in Kvaal's and Cameriere's methods of age estimation, respectively. Results Of all the morphological variables, i.e. *P*, *r*, mean (M), length (L), and pulp/tooth AR of Kvaal's and Cameriere's methods correlated significantly with age; with variable *P* correlating the best among them.

MATERIALS AND METHODS

4.1 INTRODUCTION

This study was conducted in Department of Oral Medicine and Radiology of BabuBanarasi Das College of Dental Sciences, Lucknow (U.P). Ethical clearance for the study was obtained from the institutional ethical committee.

The study population was drawn from the patients attending the outpatient Department of Oral Medicine and Radiology. Study was conducted on minimum of one hundred sixty (160) patients who were clinically diagnosed to haveno anomalies or pathologicfinding in respect to the right permanent maxillary canine.

4.2 ARMAMENTARIUM

1. Dental chair with illuminating facility

2. A pair of sterile disposable gloves and mouth mask.

3. Stainless steel kidney tray, mouth mirror, straight probe, tweezers and explorer.

4. Sterile gauze piece and cotton swab.

4.3 PATIENT EXAMINATION

The study subjects were made to sit comfortably on the dental chair. Patients were examined under artificial illumination using sterile gloves. Clinical examination was carried out following the method described by **Kerr, Ash and Millard**[98]**,** and relevant data were entered into proforma.

4.4 SELECTION OF THE PATIENT

Eligibility criteria set for the patient were following:-

4.4.1 Inclusion criteria

- • Patient aged b/w 18 to 60 years.

- • The selected tooth on the panoramic radiograph is the right maxillary canine, which had fully erupted into the oral cavity.

- • THE ROOT OF CANINE IS FULLY FORMED.

4.4.2 Exclusion criteria

- • Canine with any pathology, such as, caries, periodontitis or periapical lesions.
- • Malaligned canines or rotated canines, canine with any prosthetic fittings and orthodontic appliances.
- • FRACTURED CANINES.
- • Severely attrited canine secondary to para-functional habit and canines with any developmental anomalies.
- • Impacted, teeth with RCT, restoration.
- • TOOTH WITH LARGE AREA OF ENAMEL OVERLAP BETWEEN NEIGHBORING TEETH.
- • MISSING ONE OF THE STUDIED TEETH.
- • UNCLEAR RADIOGRAPH.

4.5 SAMPLING METHOD MATERIALS AND METHODS

a. Group I (18-39 years)
b. Group II (40-60 years)
1. The subjects will be selected according to the above-mentioned inclusion and exclusion criterion.
2. A detailed case history was recorded in a Case History Proforma.
3. Following establishment of the diagnosis, each patient will be informed about the protocol and will be given appropriate instructions after obtaining a written consent.
4. The study sample consisted of **160 patients** attending the Department of Oral Medicine and Radiology, referred for digital panoramic radiographs for various investigative purposes.
5. The collected data will be tabulated on spreadsheets and subjected to statistical analysis.

The study group will consist of randomly selected sample of 160 patients with the age group of 18-60 years. The study subjects were divided into two groups on the basis of age.

Materials and equipment's used in the study with specifications and company.

- ♋♓♑♓♦♋● ■♋■□❒♋❍♓♍ ❒♋♎♓□♑❒♋■♒♦

[PlanmecaProline XC, SN: XC430638, 180-240V, 50 Hz]
Installed in AERB (Atomic Energy Radiation Board) certified quality assurance facility.

- AutoCAD software 2009

4.6 METHODOLOGY MATERIALS AND METHODS

In the present study, all the subjects fulfilling the above criteria were enrolled after obtaining the informed consent.

- • All the enrolled subjects will be then subjected for digital panoramic radiographs.
- • Digital panoramic radiographs will be made.
- • Radiographic image of maxillary canines (RIC) will be processed using a computer-aided drafting program (image J).
- • The variables pulp/root length(p), pulp/tooth length(r), pulp/root width at cementum enamel junction(CEJ) level(a), pulp/root width at mid-root level(c), pulp/root width at mid point level b/w CEJ level and mid root level(b), pulp/tooth area ratio (AR) will be recorded.
- • All the morphological variables including gender will be statistically analyzed to derive regression equation for estimation of age.

Measurements

- • Measurements of the pulp and the tooth areas will be done under AUTOCAD2009 software program.
- • Radiographs will be saved as high resolution jpeg file on a computer and imported to AUTOCAD 2009 software program. Where in the long axis will be aligned vertically using the measurement tool.
- • THE WORKING AREA WILL BE ZOOMED IN AND SOFTWARE APPLICATION WILL BE APPLIED.

AUTOCAD MATERIALS AND METHODS

- A minimum of 20 points from each tooth outline and 10 points from each pulp outline has been identified and connected with the line tool on AUTOCAD'S drawing toolbox.
- The pulp and tooth areas will be measured using the point and line tools on the draw toolbox and the pulp/tooth area ratio (ptr) calculated.
- All measurement will be carried out by the same observer.
- In the present study tooth (canine) will be chosen from right side maxillary arch.

4.7 STATISTICAL ANALYSIS

The results are presented in mean, SD and percentage. The chi-square test is used to compare dichotomous/categorical variables. The unpaired t-test is used to compare two continuous variables. A two tailed p-value <0.05 is being considered as statistically significant. All the analysis is carried out by using GraphPad Prism version 5.0

4.7.1 The Arithmetic Mean

The most widely used measure of the central tendency is the arithmetic mean, usually referred to simply as the mean. The sample mean is the average and is compared as the sum of all the observed outcome from the sample divided by the total number of events. We use x as the symbol for the sample mean. It is calculated as:

WHERE "N" IS SAMPLE SIZE AND THE "X" CORRESPONDS TO THE OBSERVED VALUED.

We define the **variance** to be:-

4.7.2 The standard deviation

The standard deviation (SD) is the positive square root of the variance, calculated as-

Where n = number of observations

The **standard error is** the difference between the two means and is calculated as:

4.7.3 Chi-square test of homogeneity: the test is applied to a single categorical variable from two or more different populations. It is used to determine whether frequency counts are distributed identically across the different populations.

O=observed frequency;E=expected frequency

4.7.4 Level of significance:**"p"**In statistical hypothesis testing, the p-value or probability value or asymptotic significance is the probability for a given statistical model THAT, WHEN THE null hypothesis IS TRUE, THE statistical summary (such as the sample means difference between two compared groups) would be the same as or of greater magnitude than the actual observed results. The use of *p*-values in statistical hypothesis testing is common in many fields of research. The smaller the *p*-value, the higher the significance.

- p > 0.05 :: Not significant
- p < 0.05 :: Significant
- p < 0.01 :: Highly significant
- p < 0.001 :: Very highly significant

4.7.5 Unpaired t-test

The unpaired t method tests the null hypothesis that the population means related to two in dependent, random samples from an approximately normal distribution are equal.

$t=x_1-x_2/ (sqrt(1/n_1+1/n_2)$

$s= [sum(x_1-x_2)_2+sum(x_1-x_2)_2]/ (n_1+n_2-2)$

Where x_1 and x_2 are sample means, s_2 is pooled sample variance, n_1 and n_2 are the sample sizes and t is a student t quintile with $n_1 + n_2 – 2$ degrees of freedom.

4.7.6 Pearson correlation coefficient

Correlation between sets of data is a measure of how well they are related. The most common measure of correlation in stats is the Pearson Correlation (r). The full name is the Pearson product moment correlation or PPMC. It shows the linear relationship between two sets of data.

MATERIALS AND METHODS

Page 65

Predictive values were calculated using the following calculations.	**Diseased**	**Not diseased**	**Total**
Screening test results			
Positive	a (true positive)	b(false positive)	a + b
Negative	c (false negative)	d(true negative)	c + d
Total	a +c	b + d	a+b+c+d

RESULTS

Page 70

The present study was conducted in the Department Of Oral Medicine And Radiology, Babu Banarasi Das College of Dental Sciences, Lucknow, with the aim to estimate age from pulp/tooth area ratio in right maxillary canine by panoramic radiographs and with objective to determine the age

and compareit in different age groups by measuring the reliability and applicability in pulp/tooth ratio; by digital panoramic radiographs. We have included 160 patients,who were divided into two groups, Group I (18-39 year) and Group II (40-60 year).

Table -1: Distribution of patients according to Age Groups

Patient Groups

No. of patients(n=160)

Percentage

(%)

Chi sq

p-value

Group-I(18-39)

69

43.12

7.85

>0.05

Group-II(40-60)

91

56.88

6.17

>0.05

Total

160

100.0

Graph 1: Age distribution of patient

0

10

20

30

40

50

60

Group-I(18-39)Group-I(18-39) Group-I(18-39)Group-I(18-39)Group-I(18-39)Group-I(18-39) Group-I(18-39)

Group-II(40-60)Group-II(40-60) Group-II(40-60)Group-II(40-60)Group-II(40-60)Group-II(40-60) Group-II(40-60)

Percentage(%) Percentage(%) Percentage(%)Percentage(%) Percentage(%) Percentage(%) Percentage(%)

43.1243.1243.12

56.8856.8856.88

Percentage of patients (%)Percentage of patients (%)Percentage of patients (%)Percentage of patients (%)Percentage of patients (%)Percentage of patients (%)Percentage of patients (%)Percentage of patients (%)Percentage of patients (%)Percentage of patients (%)

RESULTS

Table-1&graph-1 shows distribution of patients according to age group in table-1, among the 160 patients, 69(43.12%) patients were from 18-39 age groups and were included in Group-I and 91(56.88%) patients of 40-60 age groups were included in Group-II.

Graph -2: Distribution of Patients on the basis of Age in Group-I (18-39)

Graph-2shows the age distribution of patient ranging from 18-39 years. Maximum presentation was of patient in 30 year i.e. 9 patients and minimum presentation was in 27 year i.e.no patient.

0

2

4

6

8

10

18

19

20

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23

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29

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32

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34

35

36

37

38

39

1

1

3

2

3

3

2

1

2

0

4

5

9

2

5

6

1

7

1

7

2

2

Age (18 Age (18Age (18Age (18Age (18Age (18-39)

No. of patientsNo. of patientsNo. of patientsNo. of patientsNo. of patientsNo. of patientsNo. of patientsNo. of patientsNo. of patientsNo. of patients

RESULTS

Graph-3 Distribution of Patients on the basis of Age in Group II (40-60)

Graph-3shows distribution of patient in group II from 40 to 60 years. Maximum patient presented in 45 and 60 year about 11 patients each and minimum in 57 year i.e. no patient.

Table: 2 Gender Distributions of Patients

Groups

I

II

Total (Group I&II)

Age(years)

18-39

40-60

160

Male

38

65

103

%

55.07

71.43

64.38

Female

31

26

57

%

44.93

28.57

35.62

Total

69

91

100

Table-2shows the male to female ratio of study group was 2:1.In group I 55.07% was male while 44.93% were female thus male to female ratio of study group I was 1.2:1.In

0

2

4

6

8

10

12

40

41

42

43

44

45

46

47

48

49

50

51

52

53

54

55

56

57

58

59

60

7

4

3

3

1

11

4

3

7

1

4

4

3

2

2

8

1

0

8

4

11

Age (40 Age (40Age (40Age (40Age (40Age (40-60)

No. of patientsNo. of patientsNo. of patientsNo. of patientsNo. of patientsNo. of patientsNo. of patientsNo. of patientsNo. of patientsNo. of patients

RESULTS

group II; 71.43% were male while 28.57% were female thus male to female ratio was 2.5:1. The measurement of pulp/tooth area ratio of the tested teeth did not reveal any significant differences between male and female, and consequently gender was not included in the statistical models.

Graph: 4 Gender Distributions of Patients

Graph-4 shows the gender distribution of patients. About 64.38% were male while 35.62% were female.

FORMULA

Age = 87.305−480.455 (AR) +48.108(b)

(i) Correlation between age and pulp tooth area ratio (AR): We analyze in the graph 5&6 correlation between pulp tooth area ratio and age and foundthe significant negative correlation in group I (r=-0.689, $p<0.05$) and in group II (r=-0.830 and $p<0.05$).

Male Male Male Male

64.38

Female Female Female Female

35.62

RESULTS

r= -0.689, $p<0.05$

0 10 20 30 40 50

0.00

0.05

0.10

0.15

0.20

AR(Pulp tooth area ratio)

AGE (Group I)

AR

Graph 5:Correlation between age and Pulp tooth area ratio (AR)

r= -0.830, p<0.05

35 40 45 50 55 60 65

0.00

0.05

0.10

0.15

AR(Pulp tooth area ratio)

AGE (Group II)

AR

Graph 6:Correlation between age and Pulp tooth area ratio (AR)

Table 3: Mean value of pulp tooth area ratio in different groups

Age N Mean SD r R2 p-value

RESULTS

Group-I

69

0.125

0.016

-0.689

0.475

<0.05

Group-II

91

0.078

0.018

-0.830

0.696

<0.05

Table-3 shows the means of pulp tooth area ratio in different groups. The mean of total pulp area ratio was found to be highest in Group-I being 0.125±0.016 and gradually reduced to 0.078±0.018 in Group-II. It suggested the negative correlation between the age and pulp tooth area ratio which proved that with increase in age, the reduction in pulp tooth area ratio was observed.

Graph 7: Mean value of pulp tooth area ratio in different groups

Graph-7 shows the means of pulp tooth area ratio in different groups. The mean of total pulp area ratio was found to be highest in Group-I being 0.125 and gradually reduced to 0.078 in Group-II.

(ii)Correlation between age and pulp/root width at midpoint level b/w ECJ level & mid-root level(b): We analyzed in the graph 8 & 9 correlation between b and age and

0

0.02 0.02

0.04 0.04

0.06 0.06

0.08 0.08

0.1

0.12 0.12

0.14 0.14

Group-1(18-39)Group-1(18-39) Group-1(18-39)Group-1(18-39)Group-1(18-39)Group-1(18-39) Group-1(18-39)Group-1(18-39)Group-1(18-39) Group-1(18-39)

Group-2(40-60)Group-2(40-60) Group-2(40-60)Group-2(40-60)Group-2(40-60)Group-2(40-60) Group-2(40-60)Group-2(40-60)Group-2(40-60) Group-2(40-60)

Mean value of AR Mean value of AR Mean value of AR Mean value of AR Mean value of ARMean value of AR Mean value of ARMean value of AR

RESULTS

Page 76

we found the significant negative correlation in group I ($r = -0.442$, $p<0.05$) and in group

II ($r = -0.540$ and $p<0.05$).

$r = -0.442$, $p<0.05$

0 10 20 30 40 50

0.00

0.05

0.10

0.15

0.20

b(PULP/ROOT WIDTH AT MIDPOINT LEVEL B/W

ECJ LEVEL&MID-ROOT LEVEL

AGE (Group I)

b

Graph 8: Correlation between age and pulp/root width at midpoint level

b/w ECJ level & mid-root level in group I

$r = -0.540$, $p<0.05$

35 40 45 50 55 60 65

0.00

0.05

0.10

0.15

b(PULP/ROOT WIDTH AT MIDPOINT LEVEL B/W

ECJ LEVEL&MID-ROOT LEVEL

AGE (Group II)

b

Graph 9: Correlation between age and pulp/root width at midpoint level

b/w ECJ level & mid-root level in group II

Table 4: Mean value of pulp/root width at midpoint level b/w ECJ level &

mid-root level(b):

RESULTS

Age

N

Mean

SD

r

R2

P value

Group-I(18-39)

91

0.078

0.021

-0.442

0.195

<0.05

Group-II(40-60)

91

0.058

0.016

-0.540

0.292

<0.05

Table-4shows the means of pulp/root width at midpoint level b/w ECJ level & mid-root levelin different groups. The mean of pulp/root width at midpoint level b/w ECJ level & mid-root level was found to be highest in Group-I being 0.077±0.021 and gradually reduced to 0.058±0.018 in Group-II. It suggested the negative correlation between the age andpulp/root width at midpoint level b/w ECJ level & mid-root level which proved that with increase in age, the reduction in pulp/root width at midpoint level b/w ECJ level & mid-root level was observed.

Graph 10:Mean value of pulp/root width at midpoint level b/w ECJ level & mid-root level (b):

Graph-10 shows the means of pulp/root width at midpoint level b/w ECJ level & mid-root level in different groups. The mean of pulp/root width at midpoint level b/w ECJ

0

0.01 0.01

0.02 0.02

0.03 0.03

0.04 0.04

0.05 0.05

0.06 0.06

0.07 0.07

0.08 0.08

Group-1(18-39)Group-1(18-39) Group-1(18-39)Group-1(18-39)Group-1(18-39)Group-1(18-39) Group-1(18-39)Group-1(18-39)Group-1(18-39) Group-1(18-39)

Group-2(40-60)Group-2(40-60) Group-2(40-60)Group-2(40-60)Group-2(40-60)Group-2(40-60) Group-2(40-60)Group-2(40-60)Group-2(40-60) Group-2(40-60)

Mean value of b Mean value of b Mean value of b Mean value of b Mean value of bMean value of b Mean value of bMean value of b

RESULTS

level & mid-root level was found to be highest in Group-I being 0.077 and gradually reduced to 0.058 in Group-II.

Table 5: Comparison of actual and estimated age of all the patients

Age	Sample size	Mean age(years)	Degree of freedom	Chi square	p value
Actual	160	42.47±12.29	159	14.029	>0.05
Estimated	160	41.58±11.83			

Table: 5 show Comparative analysis between actual age and estimated age of all the patient revealed that the mean of actual age is 42.47±12.29 and the mean of calculated estimated age is 41.58±11.83and X2 = 14.029 is not at 0.05 level (p>0.05). Therefore our estimated values are close to the actual age of the patients/study subjects.

Comparison of age in actual and estimated age:

Comparative analysis between the actual age and estimated age in both groups revealed that the mean of actual age is 30.06±0.67 and the mean of calculated estimated age is 30.67±0.72 in group I ($p>0.05$) and in group-II the actual age mean is 50.31±0.70 and calculated estimated age mean is 51.47±0.74 ($p>0.05$). Non parametric t test does not show significant difference therefore our estimated values are close to the actual age of patients.

Table 6:Comparison of age in actual and estimated age in subjects grouped according to age.

RESULTS

Age (years)

N

Mean age

SD

Min. age

Max. age

‘t’ value

d,f

‘p’value

18-39

Actual

69

30.06

0.67

18

39

0.619

136

0.537

Estimated

69

30.67

0.72

17.25

40.89

40-60

Actual

91

50.31

0.70

40

60

1.132

180

0.259

Estimated

91

51.47

0.74

38.97

62.94

Graph 11:Comparison of Age in Actual and Estimated Age in subject grouped into two

Table 6: Correlation between actual age and estimated age.

Groups

N

Actual age

Estimated

r

P value

RESULTS

(mean) age(mean)

Group-I 69 30.06±0.67 30.67±0.72 0.955 <0.05

Group-II 91 50.31±0.70 51.47±0.74 0.978 <0.05

Table-6& graphs-12, 13 shows the entire sample was distributed into two different age groups – group-I (18-39year) and group-II (40-60year) - to observe the effect of this method on different age groups. The observed correlation coefficients ‘r’ of group-I is 0.955 and group-II is 0.978, respectively, which indicated that the actual age and estimated age in both age groups were closely related to each other.

r= 0.955, p<0.05

0

10

20

30

40

50

0

10

20

30

40

50

Actual AGE (Group I)

Estimated age

Graph 12:Correlation between actual age and estimated age in group I

RESULTS

r= 0.978, p<0.05

35

40

45

50

55

60

65

30

40

50

60

70

Actual AGE (Group II)

Estimated age

Graph 13:Correlation between actual age and estimated age in group II

Pearson's correlation analysis was conducted to evaluate the association between pulpal size and age. Linear correlation suggested that there was a negative correlation between the age and pulp size which proved that with an increase in age, the reduction in pulp size was observed. The observed correlation between the actual and dental age showed

that with increase in age there is decrease in pulp size.

DISCUSSION

The most acceptable definition of forensic dentistry or forensic odontology according to brig. D. V. Taylor (1968) is “the application of dental knowledge to the elucidation of legal problems.”[18]
It was further defined by Keiser–Nielson (1980) as “the branch of forensic medicine which in the interest of justice deals with the proper handling and examination of dental evidence and with the proper evaluation and presentation of the dental findings.”[18]
The identification of a person through teeth is not a new technique. The oldest example of dental finding that was used for forensic purpose in history was in 66 AD, in which Nero’s mistress, Sabina had identified the head that was brought to her as Nero’s wife only by identifying the black anterior tooth. And the first formally reported case of dental identification was that of the 8-year-old warrior John Talbot, who fell in the battle of Castillon and was identified due to a gap caused by a tooth extracted close to the time of his demise.[18]
Avon has classified forensic odontology according to major fields of activity into civil, criminal, and research. Forensic dentistry specializes in several areas that include dental records as legal document, radiographic examination, age determination, anthropological examination, mass disaster identification, bite mark evidence, and family violence.[18]
Uniqueness of teeth and oral structures are considered as one of the most reliable methods of identification of a person in forensic sciences. Tooth is the hardest part in the body and it cannot be easily damaged by any accident; is present for longer duration in oral cavity and change in structure either morphologically histologically andradiographicallyrarely manifested with age. Can be utilized as a tool to determine the age in an individual.[3] DISCUSSION

Studies suggest that age estimation is a marker in solving judicial or civil problems concerning age of minors regarding questions of adoption, immutability and pedopornography. For adults, civil issues on pensionable age (50, 55, 60, 65 years, depending on the country) and other similar matters for individuals (mainly immigrants and refugees) lacking valid documents of identification or other persons who arrive in a country without acceptable identification paper and may require a verification of age or in order to be entitled citizenship and social benefits of a country.[8]
It has also been noticed that forensic odontology is also used in analysis of maturity of a child, if the development is markedly advanced or retarded, in case of orphans to calculate exact dosage of medication for the child, and in mass disaster.[10]
Chronological age assessment based on dental factors is a reliable indicator, because teeth may persist long after the, other parts of the skeleton have disintegrated. Dental maturity is more relevant as it is less affected by nutritional and endocrine status.[10]Teeth were first used as a barometer of age in 1800. The first known attempts that used teeth as an indicator of age originated from England. **"Teeth a test of age"** to the English parliament in 1837.[5,10]
In the present study the agedistribution of patients according to age group (Table 1), among the 160 patients, 69(43.12%) patients were from 18-39 age groups and were included in Group-I, maximum presentation was of patient in 30 year i.e. 9 patients and minimum presentation was in 27 year i.e. 0 patient. and 91(56.88%) patients of 40-60 age groups were included in Group-II,Maximum patient presented in 45 and 60 year about 11 patients each and minimum in 57 year i.e. no patient.
In the present study thegender distribution of patients (Table 2) included 64.38% male while 35.62% female with male to female ratio being 2:1. In group I; 55.07% were male while 44.93% were female with male to female ratio of study group I was 1.2:1 and group II 71.43% were male while 28.57% were female with male to female ratio of DISCUSSION

study group II was 2.5:1. The measurement of pulp/tooth area ratio of the tested teeth did not reveal any significant differences between male and female, and consequently gender was not included in the statistical models.

Similar results was observed by ***Manjushree Juneja et al. (2014)***that there were no significant difference between themorphological variables among the males and females, 'r' value 0.946 and 0.882indicating that gender did not influence the regression modelused to estimate chronological age for both female andmale groups.[8]

Similar results was observed by ***Mostafa M Afify et al. (2014)***;they also found that the measurements of the pulp/tooth area ratio ofthe tested teeth did not reveal any significant differences between maleand female, ($p>0.05$) and consequently gender was not included in the statisticalmodels.[3]Similar results was also observed by***SasidharSingarajuShradha P et al.(2009)*** p value to be 0.86(>0.05) and r value 0.99 (2009),R.Cameriere et al.(2009),R_2 =0.971,Dr. ***Chandramani B. More et al. (2017)***.They found that the gender had no significant influence on age.[3,19, 74, 95]

Chandramani B. More et al. (2017) have also elaborated thatthe age of participants ranging from 18 to 64 years, with mean age of 28.54 ± 8.39 years ($p<0.001$) had shown that the difference in morphological variables between males and females was insignificant.[95]

T.Y. Marroquina et al. (2017),(SD=5.6, r = -0.95), ***Mohammad Arif Dar et al.(2016)***, ***Maneesha Das,et al (2017)*** and***S. VenuGopal,et al.(2017)***.Alsofound from their respective studiesthat the gender does not affect the estimated age models($p= -0.920$).[25, 94, 96, 97]

Rezwana Begum Mohamamed et al. (2014) demonstrated the distribution of estimation dental age in comparison with chronological age in males and females respectively. They showed that

underestimation of age was more common than overestimationin both **DISCUSSION**

thesexes. The mean difference between dental age and chronological age according to the Willem method was 0.39 years and is statistically significant (p<0.001).[99]

Manjushree Juneja, Yashoda B. K. Devi, N. Rakesh, SaurabhJuneja. (2014) observed that 2 variables 'AR' and 'b' contributed significantly to the fit and included in the regression model, yielding the formula: Age = 87.305-480.455(AR)+48.108(b). Similar resultwasanalyzed in our study (Table 3) where we found that correlation between pulp tooth area ratio and age and found the significant negative correlation in group I (r=-0.689, *p*<0.05) and in group II (r=-0.830 and p<0.05).The mean of total pulp area ratio was found to be highest in Group-I being 0.125±0.016 and gradually reduced to 0.078±0.018 in Group-II. It suggested that negative correlation exists between the age and pulp tooth area ratio which proved that with increase in age, the reduction in pulp tooth area ratio was observed.

Similar results were observed by***A.P. Indira et al. (2015).*** They also found the negative linear correlation. The correlation between total pulp length and age was negative, and the r value was -0.241 at p=0.016.[5] ***ShirinSakhdari et al. (2014)*** also found that the mean AR was calculated to be 0.143±0.023 in 60 female subjects. The correlation coefficient was found to be -0.336 and this correlation was statically significant (p=0.004). The negative correlation coefficient showed that AR decreased with aging.[87]

Roberto Camerier et al (2004) also found all correlation coefficient (r=0.945) between age and morphological variables were significant and negative. The only variables AR and c contributed significantly to the fit. [69]

Similar results was observed by***Urvashi A Shetty et al. (2017);*** they also found that the Pearson's correlation value of r= -0.663; showed a statistically significant correlation between age and pulp tooth length ratio (p<0.01), which was highly significant.[93] ***Mohammad Arif Dar et al. (2016)*** also found that the Pearson's correlation coefficients between age and morphological variables AR correlated significantly with age variable DISCUSSION

p. Complete pulp length/root length (from ECJ-root apex) correlated best among them with correlation coefficient r= -0.951 and -0.896 respectively.[25]

S. VenuGopal, K. Krishnamurthy et al. (2017)also found that theKarl Pearson's correlation coefficients (R_2 = 47.90, SEE 9.990) between age and morphological variablesshowed that the variables p = complete pulp length/root length (from ECJ to root apex), r = complete pulp length/ complete tooth length, mean (M), length (L), and pulp/tooth AR correlated significantly with age with variable p = complete pulp length/root length (from ECJ to root apex) correlating the best among them.[94]

Similar results were observed by***Chandramani B. More et al. (2017).*** In the study the age of participants ranged from 18 to 64 years, with a mean age of 28.54 ± 8.39 years. The Pearson's correlation coefficient between the age and the morphological parameters in maxillary canines showed thatexcept variable 'A', all the other variables showed weak correlation with age. The probability 'p' value was significant ($p < 0.001$).[95]

Maneesha Das et al. (2017) also found that the Karl Pearson's correlation coefficients between age and morphological variables showed that the variables P, r, mean (M), length (L), and pulp/tooth AR correlated significantly with age with variable P correlating the best among them.[97]

ArezouTorkian et al. (2015)in their study found that the mean AR was calculated to be 0.143±0.023. In 60 female subjects, the regression formula for age estimation in each individual was calculated as follows: Age=- 144× AR+55 and the correlation coefficient was found to be -0.336 and this correlation was statistically significant (p=0.004); the negative correlation coefficient showed that AR decreased with aging.[100] ***ShirinSakhdari et al. (2014)*** evaluated that the minimum and maximum difference between the actual age and the estimated age in males was0.07 and 33.28 years, respectively. The mean AR was calculated to be 0.144±0.044. In 60 male subjects, the regression formula for age estimation in each individual was calculated as follows: DISCUSSION

Age=24×AR+37.7 the correlation coefficient was found to be -0.180; statistically, the correlation between AR and age was insignificant (p=0.169).[87]

ArezouTorkian et al. (2015) also had the similar result stating thatthe mean AR was calculated tobe 0.144±0.044. In the study; in 60 male subjects, theregression formula for age estimation was calculated as follows:Age=24×AR+37.7 the correlationcoefficient was found to be -0.180; statistically, the correlation between AR and age was not significant (p=0.169).[100]

In thepresent study we found that (Table 4) correlation exists betweenpulp/root width at midpoint level b/w ECJ level & mid-root level(b) and age and had significant negative correlation in group I (r= -0.442, $p<0.05$) and in group II (r= -0.540 and p<0.05. This means that pulp/root width at midpoint level b/w ECJ level & mid-root level was found to be highest in Group-I being 0.077±0.021 and gradually reduced to 0.058±0.018 in Group-II. It suggested negative correlation between age andpulp/root width at midpoint level b/w ECJ level & mid-root level which proved that with increase in age, the reduction in pulp/root width at midpoint level b/w ECJ level & mid-root level was observed.

Similar results were observed by***Roberto Camerier et al (2004);*** they found all correlation coefficient r = 0.945 between age and morphological variables were significant and negative. The only variables AR and c contributed significantly to the fit. The regression model utilizing AR and c, yielded the following linear regression formula.[69]

A.P.Indira et al. (2015); also found correlation between cervical pulp width and age and the negative correlation and r value -0.392 at P was<0.0001.[5]

UdayGinjupally, RamaswamyPachigolla et al. also conducted similar study in year (2014). The Pearson correlation was performed between the width of the cervical and

middle third of the pulp cavityand age and a negative linear relationship was obtained between the age and pulp cavity width (cervical third= - 0.459 and middle third, r = - 0.704) and was suggestive of the fact that as age increases, the pulp cavity width decreases.[86]

Chandramani B. More et al. (2017); also observed similar results as ours. In their study the age of participants ranged from 18 to 64 years, with a mean age of 28.54 ± 8.39 years, the study had only male participants. The Pearson's correlation coefficient between the age and the morphological parameters in maxillary canines showed thatexcept variable 'A', all the other variables showed correlation with age but no strong correlation. The probability 'p' value was significant ($p < 0.001$).[96] However there have been few studies where the final observation was not similaras ours.***S. VenuGopal, K. Krishnamurthy et al. in (2017)*** found thatthe ratios between width measurements (a = complete pulp length/root width at ECJ level, b = pulp/root width at midpoint level between ECJ level and mid−root level, and c = pulp/root width at mid−root level) correlated least with age and were not found to be statistically significant(p= -0.920).[94]

Maneesha Das et al. (2017); too statedthe ratios between width measurements (a, b, and c) correlated the least with age and were not found to be statistically significant and therefore were excluded from further statistical analysis variable p had the highest p value of -0.920 for central incisor and -0.951 for lateral incisor .[97]

Similar results was also not observed by ***Mohammad Arif Dar et al. (2016)***the ratios between width measurements (a = complete pulp length/root width at ECJ level, b = pulp/root width at midpoint level between ECJ level and mid−root level, and c = pulp/root width at mid−root level) correlated least with age and were not found to be statistically significant (p= -0.920).[25] **DISCUSSION**

In the present study comparative analysis was done between actual age and estimated age (Table 5) of all patients whichrevealed that the mean of actual age is 42.47±12.29 and the mean of calculated estimated age is 41.58±11.83and $X_2 = 14.029$ is not at 0.05 level ($p>0.05$). Therefore our estimated values are close to the actual age of the patients/study subjects.

Similar results was observed by ***Manjushree Juneja et al. (2014)*** they also found there is no significant difference between chronological and estimated age groups (p value >0.05) thus signifying that the derived formula is appropriate for all the selected age groups.[8]***Mostafa M Afify et al. (2014)*** also found that the paired t-test to evaluate potential observer error revealed no statistically significant intra- and inter observer difference between the paired sets of measurements carried out to re-examine the panoramic radiograph ($p>0.05$).[3]

Similar result was observed by ***Rakesh Kumar Dumpala et al. (2013);***the chronological age was compared to the dental age estimated using Student's t-test and a p-value of 0.6515 was obtained. Since $p>0.05$, it was concluded that there is no significant difference between dental age estimated and the chronological age.[82]

UdayGinjupally, RamaswamyPachigolla. (2014); also found that the mean real age obtained in the study was 36.16 years. The mean estimated age obtained in the study using the regression formula was 36.17 years. Student's t-test revealed no significant difference ($P = 0.998$) between the estimated age and real age.[84]Similar results was observed by ***S. VenuGopal, K. Krishnamurthy et al. (2017);*** they also found that the comparison of the readings of the 2 observers($p= -0.920$&-0.951) did not reveal any statistical significant difference.[94]

MeldaMisirlioglu et al. (2013) found correlations between real age and morphological variables and were calculated for all teeth using Pearson's correlation coefficient. Kvaal's method on digital panoramic radiographs gave acceptable results (standard DISCUSSION

deviation, SD = 5.9 to 7.9 years) that were close to the original. In addition, regression equations were developed to estimate age from morphological variables and the best results were achieved using the regression equation for the maxillary canine with a pulp/tooth area ratio (standard error of estimate, SEE = ±6.75; coefficient of determination R_2 = 0.67). There was no significant difference between observed and estimated age for different age groups and gender based on the established regression equations.[84]Similar results was observed by ***Deepak Pateel et al. (2009);*** also found that the estimated age using maxillary canine (x1) showed no statistically significant difference between the estimated age and the real age (p=0.1) which means that there is little difference between real age and estimated age. So, it is feasible to estimate age using pulp to tooth area ratio of maxillary canine.[76]

Jeevan M B et al. (2010) also found similar results. The mean value of residuals using the regression equations ranged from 4.28 to 6.39 years with upper canine equation generally giving a precise result. When these equations were applied for younger ages (<45 years), the regression equation derived from both canines gave a better result (mean residual 2.70 years). Overall these equations were better able to predict the age in younger ages, i.e., upto 45 years.[77]***SasidharSingarajuShradha P et al.(2009)*** also found the analyzed results to show that the P value was >0.05, which meant that there is no significant difference between estimated age and chronological age.[19]

Noorazma S, Solheim T et al. (2009) also foundthat the two-tailed, paired T-test of the chronological and estimated dental age for the boys showed no significant difference (r= 0.81). T test for the girls also showed no significant difference (r= 0.87) between the chronological and estimated dental age. The intra-observer r was 0.99 for both the genders.[77]Similarresults was observed by***SeemaBasoya et al. (2016).*** This study also found that the predicted age calculated by the 3 software's was in accordance to the chronological age. There was statistical significant difference in age calculated by Image J, p<0.001and there was no statistical significant difference in age calculated by adobe

DISCUSSION

Photoshop and Auto CAD (p=0.432 and p=0.004). On comparison of the 3 software's the predicted age was best measured by AutoCAD followed by Adobe Photoshop and the Image J.[89]
Rezwana Begum Mohammed,et al.(2014) also found that the mean age difference between dental age determined using the Willems method (from the Belgian Caucasian population) and the chronological age of this Andhra population was 0.69 years for male and 0.08 years for females and independent t-test showed that these differences were statistically not significant (P>0.05).[99]
Roberto Cameriere et al (2004) also found there was no statistically significant intra-observer differences between the paired sets of measurements carried out on the RIC (p=0.64).[69]***R.Cameriere et al. (2009)***further found there were no statistically significant intra-observer difference between the paired sets of measurements carried out on the re-examined peri-apical X-rays.[74]
However similar results was not observed by ***NusratNazir et al. (2017);***they found that the chronological and estimated age difference was statistically significant (p<0.05).[92] ***J.Jayaraman et al. (2011);*** also found that the overall mean difference between the estimated dental age and chronological age for boys was 0.62 (±1.09) year (p<0.01) while for girls, it was 0.36 (±0.95) years (<0.01).[78]
In present study the entire sample was distributed into two different age groups (Table 6), group-I (18-39year) and group-II (40-60year) - to observe the effect of this method on different age groups. The observed correlation coefficients 'r' of the two groups were; group-I 0.955 and group-II 0.978, respectively, which indicated that the actual age and estimated age in both age groups were closely related to each other.
Similar results were observed by***SasidharSingarajuShradha P et al. (2009).*** In theirstudy the entire sample was distributed into three different age groups, 18-30, 31-

50, and 51-70 years, toobserve the effect of this method on different age groups. The observed correlation coefficients r were 0.89, 0.97, and0.96, respectively, which indicated that the chronologicalage and the estimated age in all the three age groups wereclosely related to each other.[19]

J. Jayaraman et al. (2011) also found that the variation between the estimated dental age and chronological age ($p>0.01$) had minimal difference.[78]***Noorazma S, Solheim T et al. (2009)***in their study also found that the Pearson's correlation coefficient (r) was 0.99 for both gender.[75]

The results of the study are promising; however, it cannot begeneralized to other populations. The study was limited tothe maxillary canines because it is the long lasting tooth andis easiest to analyze due to largest pulp area among all thesinglerooted teeth.

SUMMARY & CONCLUSION

It's fair to say that personal computer has become the most empowering tool we've ever created. They are tools of communication, they're tools of creativity, and they can be shaped by their user"

The chronological age estimation is now a day is of great importance in forensic sciences, mainly in the criminal law field.

The establishment of international guidelines and quality assurance in living individuals is done through the methodology of general physical examination. Dental age prediction is useful in routine and mass fatalities as teeth can be preserved for long time.Teeth are particularly useful inage evaluation because they display anumber of observable age related variablesand they tend to remain intact undercircumstances which might alter or obliteratethe rest of the skeleton.

In a mixed population, age estimated usingpulp tooth area ratio is a more accuratemethod of age estimation when compared tohand-wrist radiographs, clinical dental observation complete with orthopantomogram, give more reliable result to criminal law application.

From the results of this study, it may be concluded that the use of age-related variables in upper canine and the application of the new regression formulae on data obtained from orthopantomographs and AutoCAD software lead to accurate age estimates, if at least the selection criteria are respected and good quality orthopantomographs with clear radiological images are used. The key observation of this research was that the size of the pulp chamber reduces in both vertical and horizontal dimension with increasing age. Besides, it also highlights that each individual in the groups had different pulpal measurements. Another major outcome of this study was that this method proved to be a non-invasive technique to assess the chronological age of an adult using the dental pulp.

Thus, it can be concluded that the radiographic reduction in pulp size with increase in age can be used to assess the age of the adults. The radiographic morphometric procedure is easier, feasible, of low cast, simple and. There is significant correlation between age and morphological variable 'AR' and 'b', and based on these variables SUMMARY & CONCLUSION

chronological age can be determined with an accuracy of 95% in Lucknow population. The derived population specific regression equation can be potentially used for estimation of chronological age of individuals of Lucknow origin.

BIBLIOGRAPHY

1. Ohtani S, Yamamoto K. Age Estimation Using the Racemization of Amino Acid in Human Dentin. J Forensic Sci. 1991; 36: 792-800.
2. Ketaki Kinikar, Prakash Sandeep, Gupta Ashok Kumar, Dhingra Deepti. Estimation of Age based on tooth: pulp area ratio of maxillary central incisor assessed in Indian sample- An intraoral periapical radiographic study, International journal of preventive and clinical dental research, April-Jun 2016;3(2):102-109.
3. Mostafa M Afify, Zayet Mohamed K, Naglaa F Mahmoud and Ahmed R Ragab. Age Estimation from Pulp/Tooth Area Ratio in Three Mandibular Teeth by Panoramic Radiographs: Study of an Egyptian Sample.J Forensic Res 2014, 5:3
4. Cameriere Roberto, Brogi Giuseppe, Ferrante Luigi, Mirtella Dora, Vultaggio Claudia, Cingolani Mariano, and Fornaciari Gino,. Reliability in Age Determination by Pulp/Tooth Ratio in Upper Canines in Skeletal Remains J Forensic Sci, July 2006; 51(4):861-863.
5. Indira A. P., R.,Nagaraj Shashikala, Tejavathi, Santosh H. N. Age Estimation Of Adults Using Dental Pulp: A Cross-Sectional Radiographic Study Journal Of Advanced Clinical &Research Insights (2015), 2, 131–134.
6. Kvaal SI, Kolltveit KM, Thomsen IO, Solheim T. Age estimation of adults from dental radiographs. Forensic Sci Int (1995), 74: 175-185.
7. Drusini AG, Toso O, Ranzato C The coronal pulp cavity index: a biomarker for age determination in human adults. Am J Phys Anthropol (1997),103: 353-363.
8. Juneja Manjushree,Yashoda B. K. Devi,N. Juneja Rakesh,Saurabh. Age estimation using pulp/tooth area ratio in maxillary canines−A digital image analysis Journal of Forensic Dental Sciences / September-December 2014; 6(3):165-170.
9. Ubelaker DH, Parra RC. Application of three dental methods of adult age estimation from intact single rooted teeth to a Peruvian sample. J Forensic Sci 2008; 53:608-11.
10. Priyadarshini C, Puranik Manjunath P, Uma S R.Dental Age Estimation Methods: A Review. International Journal of Advanced Health Sciences.April 2015; 1(12):19-25.

BIBLIOGRAPHY

11. Shah A F, Batra M, Baba I A, Gupta V, Meher J, Rai R. Age Estimation: Dental Perspective. International Journal of Maxillofacial Research2015;1(1):19-27.
12. Takasaki T, Tsuji A, Ikeda N, Ohishi M. Age estimation in dental pulp DNA based on human telomere shortening. Int J Legal Med (2003), 117: 232-234.
13. Meinl A, Tangl S, Pernicka E, Fenes C, Watzek G. On the applicability of secondary dentin formation to radiological age estimation in young adults. J Forensic Sci (2007), 52: 438-441.
14. Panchbhai AS. Dental radiographic indicators, a key to age estimation. Dentomaxillofacial Radiol 2011; 40:199-212.
15. Taylor J. A Brief History of Forensic Odontology and Disaster Victim Identification Practices In Australia. J Forensic Odontostomatol 2009; 27:2:64-74.
16. Bruce-Chwatt Robert Michael. A brief history of Forensic odontology since 1775. Journal of Forensic and Legal Medicine 17 (2010) 127–130.
17. Shamim T, Ipe Varghese VShameena PM, Sudha S, Age Estimation: A Dental Approach. JPAFMAT, 2006; 6:14-16.
18. Singh Arora Karandeep and Kau Prabhpreetr .Role of forensic odontology in the Indian Armed Forces: An unexplored arena.J Forensic Dent Sci. 2016 Sep-Dec; 8(3): 173.
19. Singaraju Sasidhar,Sharada P. Age estimation using pulp/tooth area ratio:A digital image analysis. Journal of Forensic Dental Sciences. January-June 2009;1(1):37-41.
20. Bhateja Sumit, Arora Geetika,Katote Ruchita. Evaluation of adult dental patterns on orthopantomograms and its implication for personal identification: A retrospective observational study. Journal of Forensic Dental Sciences . January-April 2015; 7(1):14-17.
21. Ata-Ali Javier, Ata-Ali Fadi. Forensic dentistry in human identification: A review of the literature. J Clin Exp Dent. 2014; 6(2):162-7.
22. Jeddy Nadeem,Ravi Shivani, Radhika T.. Current trends in forensic odontology. Journal of Forensic Dental Sciences September-December 2017; 9 (3):115-119.

BIBLIOGRAPHY

23. Verma K. Anoop, Kumar Sachil, Rathore Shiuli, Pandey Abhishek. Role of dental expert in forensic Odontology. National Journal of Maxillofacial SurgeryJan-Jun 2014; 5(1):2.-5.

24. Hariz Raihan, Sabarad Pallavi,Abdulla Riaz, Dhar Sneha, Prabhu Vishnudas. Review of cases involving forensic odontology and its relevance in world statistics: an original study. IOSR Journal of Dental and Medical Sciences (IOSR-JDMS).September. 2017;16(9):99-102.

25. Dar Mohammad Arif, Singh Nayyar Abhishek. A Comparative Analysis between Various Teeth in Kvaal's and Cameriere's Methods of Age Estimation in a Specific Populace of Andhra Pradesh: An Original Study. Int J Forensic Odontol 2016; 1:26-35.

26. Vinutha Y. Josna, Priya V. Krishna, Shilpa G., Vasanti D. Forensic Dentistry: A Pedodontist's Prespective. Journal of Medicine , Radiology, Pathology and Surgery. Mar-Apr 2015; 1(2):8-14.

27. B Shiva Kumar, Tonse Rahul Ganesh. Forensic Odontology: The Investigative Branch of Dentistry - A Review. International Journal of Oral Health Dentistry. January – March 2016; 2(1):29-34.

28. Kaur Gurjot, Chanana Shivangi, Forensic Odontology And Its Indian Perspectives. JPAFMAT 2009; 9(1):21-23.

29. Orban's. oral histology and embryology. 10th ed.pg; 135-174.

30. Georg C. Schwabe, Charlotte Opitz, Sigrid Tinschert, Stefan Mundlos,Paul T. Sharpe. Molecular Mechanisms of Tooth Development and Malformations. Oral Biosciences & Medicine. 2004; 1(2):77-91.

31. Ten Cate's Oral Histology development, structure, and function. 6th ed. Elsevier; pg: 79-110.

32. Wheeler's. Dental Anatomy, Physiology, and Occlusion. 9th ed. Elsevier; pg: 125-131.

33. Wheeler's. Dental Anatomy, Physiology, and Occlusion. 8th ed. Elsevier; pg: 191-203.

BIBLIOGRAPHY

34. White SC, Pharoah MJ. Oral Radiology. Principles and Interpretation. Sixth Edition. Mosby, St. Louis, 2012.

35. Hallikainen D. History of panoramic radiography. ActaRadiol. May 1996; 37(3,2): 441-445.

36. Devlin H, Yuan J. Object position and image magnification in dental panoramic radiography: a theoretical analysis. Dentomaxillofacial Radiology; (2013) 42, 1-7.

37. Lee Gun- Sun, KimJin-Soo,Seo Yo-Seob, Kim Jae-Duk. Effective dose from direct and indirect digital panoramic units. Imaging Science in Dentistry 2013; 43: 77-84.

38. Thiago L. Beaini, Paulo Eduardo Miamoto Dias, Rodolfo F. H. Melani. Exposure Standard for Digital and Analogue Dry Skull Orthopantomography. J Rorensic Res 2011; 2(1):1-6.

39. Fatemeh Salemi, Abbas Shokri, Sepideh Falah-Kooshki. Common Errors on Conventional and Digital Panoramic Radiographs. Avicenna J Dent Res. 2014 June; 6(1): 1-4.

40. Whaites E. Essentials of dental radiography and radiology. Fourth edition, Churchill Livingstone Elsevier 2007.

41. Subbulakshmi A. Cicillia, N, Thiruneervannan Mohan, Naveen R., S.,Gokulraj Sabitha . Positioning errors in digital panoramic radiographs: A study J Orofac sci 2016; 8:22-6.

42. Klingelhoffer Christoph, Klingelhoffer Manja, Muller Steffen et al. Can dental panoramic radiographic findings serve as indicators for the development of medication- related osteonecrosis of the jaws. Dentomaxillofacial Radiology (2016); 45:1-7.

43. Decusara Mioara. Use Of Orthopantomogram In Dental Practice- A Statistical Study. International Journal of Medical Dentistry. December 2011; 1(4):389-392.

44. Newadkar Ujwala Rohan, Chaudhari Lalit, Khalekar Yogita K. Common errors on panoramic radiograph: A time to reflect and review and not to sweep them under the carpet. SRM Journal of Research in Dental Sciences; 2016; 7(3):146-149.

BIBLIOGRAPHY

45. Henriques Joao Cesar Guimaraes, Kreich Eliane Maria, Baldani Maracia Helena, Mariely Luciano, Julio Cezar de Melo Castilho and Luiz-Cesar de Moraes. Panoramic Radiography in the Diagnosis of Carotid Artery Atheromas and the Associated Risk Factors. The Open Dentistry Journal, 2011; 5:79-83.

46. Langland Olaf E., Langlais Robert P., John W. Preece. Principle of dental imaging. 2th Edition. Lippincott Williams and Wilkins.2002; 201-219.

47. Ongle Ravikiran, Praveen B N, textbook of oral medicine oral diagnosis and oral radiology, 2nd edition Elsevier 2014, 724-797.

48. Sadat-Khonsari Reza, Fenske Christian, Behfar Leyli, Oskar Bauss. Panoramic radiography: effects of head alignment on the vertical dimension on the mandibular ramus and condyle region. European Journal of Orthodontics; 34 (2012): 164-169.

49. Griniatsos J, Damaskos S. Correlation of calcified carotid plaque detected by panoramic radiograph with risk factors for stroke development. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009, 13.

50. Farman A.G. Panoramic radiology Seminars on Maxillo-facial Imaging and Interpretation, Ed. Springer, 2007

51. Bhatnagar Sunanda, Krishnamurthy Vasavi, Pagare Sandeep S. Diagnostic Efficacy of panoramic Radiography in Detection of Osteoporosis in post-menopausal women with low bone mineral density. Journal of Clinical Imaging Science. 2013 Apr-Jun; 3(2): 1-7.

52. Baskaran Kaviena. Comparison of the image quality of intraoral radiograph (IOPA) and orthopentomograms (OPG). International Journal Of science and Research. 2017 May; 6(5): 67-71.

53. Pasler F.A. Color Atlas of Dental Medicine Radiology, Ed. Thieme, 1993.

54. Bamgbose BO, Ismail A, Yahaya AI, Oginni FO. Diagnostic anatomy of the maxillofacial region on orthopantomograph..Niger J Basic Clin Sci 2017;14:1-7.

55. Henrique Rafael,Rondon Nunes. et al. Common positioning errors in panoramic radiography: A review. Imaging Science in Dentistry 2014; 44:1-6.

56. Graber T.M. Panoramic Radiography. The Angle Orthodontist 1966; 36: 293-311.

57. Kitai Noriyuki, Mukai Yousuke, Murabayashi Manabu et al. Measurement accuracy with a new dental panoramic radiographic technique based on tomosynthesis. Angle Orthodontist 2013; 83(1):117-126.

58. Zach G. A., LanglandO. E.,Sippy F. H. The Use of the Orthopantomograph in Longitudinal Studies. Department of Oral Diagnosis, University of Iowa. Jan 1969;39(1): 42-50.

59. Faria Karina-Morais, Brandao Thais-Bianca, Silva Wagner-Gomes et al. Panoramic and skull imaging may aid in the identification of multiple myeloma lesions. Oral Medicine and Pathology Jan 2018; 1: 23(1):38-43.

60. Abdinian Mehrdad, Fatemeh Soheilipour, Rehman Nazeri et al. Investigations of the magnification of digital panoramic radiographs in different regions of the jaws. SRM Journal of Research in Dental Sciences 2016; 7(1):10-16.

61. Vazquez L, Saulacic N, Belser U, Bernard JP. Efficacy of panoramic radiographs in the preoperative planning of posterior mandibular implants: A prospective clinical study of 1527 consecutively treated patients. Clin Oral Implants Res 2008; 19:81-5.

62. Dhillon Manu, Srinivasa M Raju, Verma Sankalp. et al. Positioning errors and quality assessment in panoramic radiography. Imaging Science in Dentistry 2012; 42: 207-12.

63. Elizabeth A. Krupinski, Williams Mark B., Katherine Andriole et al. Digital Radiography Image Quality: Image Processing and Display. J Am Coll Radiol 2007; 4: 389-400.

64. William Mark B., Elizabeth A. Krupinski, Keith J. Strauss et al. Digital radiography Image Quality: Image acquisition. J Am Coll Radiol 2007; 4: 371- 388.

65. Stavrianos C, Mastagas D, Stavrianou I, Karaiskou O. Dental age estimation of adults: A review of methods and principles. Res J Med Sci 2008;2:258-68.

66. Panchbhai AS. Dental radiographic indicators, a key to age estimation. Dentomaxillofac Radiol 2011; 40:199-212.

67. Demirjian A, Goldstein H, Tanner JM. A new system of dental age assessment. Hum Biol 1973; 45:211-27.

BIBLIOGRAPHY

68. Ambarkova V, Galic I, Vodanovic M, Biocina-Lukenda D, Brkic H. Dental age estimation using Demirjian and Willems methods: Cross sectional study on children from the Former Yugoslav Republic of Macedonia. Forensic Sci Int 2014; 234(187):1-7.

69. Cameriere R, Ferrante L, Cingolani M. Variations In Pulp/Tooth Area Ratio As An Indicator Of Age: A Preliminary Study. J Forensic Sci2004; 49: 317-319.

70. Matthew R.B.Blenkin. forensic dentistry and its application in age estimation from the teeth using a modified demirjian system 2005.

71. Cameriere R, Brogi G, Ferrante L, Mirtella D, Vultaggio C, Et Al. Reliability In Age Determination By Pulp/Tooth Ratio In Upper Canines In Skeletal Remains. J Forensic Sci2006; 51: 861-864.

72. Ipevarghese V, Shameena Pm, Sudha S, age estimation a dental approach.JPAFMAT,2006;6:14-16.

73. Cameriere R, Ferrante L, Belcastro MG, Bonfiglioli B, Rastelli E, Et Al. Age Estimation By Pulp/Tooth Ratio In Canines By Mesial And Vestibular Peri-Apical X-Rays. J Forensic Sci. 2007; 52(5):1151–1155.

74. Cameriere R, Cunha E, Sassaroli E, Nuzzolese E, Ferrante L. Age Estimation By Pulp/Tooth Ratio In Canines: Study of a Portuguese sample to test Cameriere's method. J Forensic Sci. international 193(2009) 128.e1-128.e6.

75. Noorazma S, Solheim T, and Ruslan S.Dental age estimation using the Demirjian method in malay children of Malaysian population in the district of kajang. Mal J for path sci 2009; 4(1): 21-25.

76. Pateel Deepak G. S. Efficacy of Pulp/Tooth Area Ratio in Age Estimation by Using Radiographs of Permanent Canine - A Preliminary Study. Indian Journal of Forensic Odontology January - March 2009; 2(1):21-24.

77. Babshet M, Acharyaab, VG. Age estimation in Indians from pulp/tooth area ratio of mandibular canine.forensic sci Int.Apr 2010 15; 197(1-3):125.e1-4.

BIBLIOGRAPHY

78. Jayaraman J, King N.M, Roberts G.J,Wong H.M. Dental Age Assessment: Are Demirjian's Standards Appropriate For Southern Chinene Children. J Forensic Odontostomatol 2011; 29(2):22-28.

79. Jeevan MB, Kale AD, Angadi PV, Hallikerimath S. Age estimation by pulp/tooth area ratio in canines: Cameriere's method assessed in an Indian sample using radiovisiography.Forensic Sci Int. Jan 2011 30; 204(1-3):209.e1-5.

80. Kumar Manoj, Tripathi S. K. medicolegal study of age by dental radiograph.IJSR june 2015; 4(6):813-818.

81. sakuma Ayaka, saitoh Hisako ,suzuki Yoichi,makino Yohsuke.Inokuchi Go, Hayakawa Mutsumi. Age estimation based on pulp cavity to tooth volume ratio using post-mortem computed tomography image.JFR 23 July 2013.

82. Dumpala Rakesh Kumar, Guttikonda Venkateswara Rao, Kumari Geetha M, RayapudNaveen i. Age estimation using pulp/tooth area ratio and hand wrist radiographs : A comparative study. Health Sciences 2013; 4(2).

83. Misirlioglu Melda,Nalcaci Rana,Adisen Mehmet Zahit ,Yilmaz Selmi &YORUBULUT Serap .Age estimation using maxillary canine pulp/tooth area ratio, with an application of Kvaal's methods on digital orthopantomographs in a Turkish sample.JFS: 11 Apr 2013; 27-38.

84. Focardi Martina &Pinchi Vilma & Federica De Luca &Norelli Gian-Aristide. Age estimation for forensic purposes in Italy: ethical issues.Int J Legal Med (2014) 128:515–522.

85. nayak Shruti D, George Renjith, Shenoy Amarnath, Pathasundaram B.Shiva. Age estimation in forensic dentistry –A review.IJSR. April 2014; 3(4).

86. Ginjupally Uday, Pachigolla Ramaswamy, Sankaran Sudhakar, Balla Smitha, Pattipati Sreenivasulu, Chennoju Sai Kiran. Assessment of age based on the pulp cavity width of the maxillary central incisors.Journal of Indian Academy of Oral Medicine & Radiology Jan-Mar 2014 26(1).

BIBLIOGRAPHY

87. sakhdari Shirin, Mehralizadeh Sandra, zolfaghariMaryam, Madadi Majid. Age estimation from pulp/tooth area ratio usingdigital panoramic radiography.Winter 2015; 27(1).

88. Silva Azevedo Alana de Cássia, Alves Nathalia Zanini, Michel-Crosato Edgard, Marcos Rocha, Roberto Cameriere, Maria Gabriela Haye Biazevic. Dental age estimation in a Brazilian adultpopulation using Cameriere's method. Braz Oral Res .2015; 29(1):1-9.

89. Basoya Seema, VC Vinod, Nath Priyanka, Ashwin D Bhogte.Estimation of age by pulp-tooth area ratio using three computer aided software's.quality in primary care 2016; 24(4):161-166.

90. Kotecha Sargam D. Dental age estimation in children: A Review. Forensic research and Criminology international journal 2016; 3(1).

91. Bérgamo André Luiz, Queiroz Cristhiane Leao de, Sakamoto Hiromi Eduardoand Silva Ricardo Henrique Alves da. Dental age estimation methods in forensic dentistry: literature review.peertechz j forensic sci technol 1: 017-022.

92. Nazir Nusrat, Chalkoo Altaf Hussain. Age estimation from pulp/tooth area ratio by panoramic radiographs: In Kashmiri population. IP International Journal of Maxillofacial Imaging, October-December,2017;3(4):115-119

93. Shetty Urvashi A, Rao Kumudha, Cruzaudrey D M, Shetty Pushpa Raja, Bhandary Srikala. Assessment of pulp tooth length ratio in forensic age estimation.International journal of Dentistry Reasurch 2017; 2(2):44-48.

94. Gopal S. Venu, Krishnamurthy K., Chaudhari C. Pritam, Anupama P., Elampavai E. Assessment of Reliability of Width and Length Variables in Kvaal's and Cameriere's Methods of Age Estimation.J Interdiscip Dentistry 2017; 7:91-100.

95. More Chandramani B., Peter Ruchita and Patel Pranay T., Age Estimation Using Tooth/ Pulp area ratio in permanent maxillary and mandibular canines By Kvaal's method on digital panoramic radiograph. International Journal of Current Research: May, 2017; 9(5):51475-51478.

BIBLIOGRAPHY

96. Marroquin T.Y.,Karkhani S.,Kvaal S.I., Vasudavan S, Kruger.E, Tennant M.. Age estimation in adults by dental imaging assessment systematic review. Forensic Science International 275 (2017) 203–211.

97. Das Maneesha, Singh Nayyar Abhishek, Punhani Neetu, Puri Harsha, Rohilla Rakesh, Chalapathi KV, Anand Babu B. Validation of Kvaal's and Cameriere's Methods of Age Estimation in People of Marathwada Origin.CHRISMED J Health Res 2017; 4:238-47.

98. Kerr DA, Ash M, Millard HD. Oral Diagnosis. 4th ed.Saint Louis Mosby; 1974: 160-162.

99. Mohammed Rezwana Begum, Krishnamraju P . V., Prasanth P. S., Sanghvi Praveen, Reddy M. Asha Lata, Jyotsna S. Dental age estimation using willems method: A digital orthopantomographic study. Contempclin Dent. 2014 Jul-Sep; 5(3): 371-376.

100. Torkian Arezou, Age estimation using digital panoramic radiography. IJBPAS, September, 2015, 4(9):124-129