**INQUIRY INTO THE CRIMES AMENDMENT (FAIRNESS FOR MINORS) BILL 2011**

**No.: 2011**

**Senator Hanson-Young**

**SUBMISSION ON BEHALF OF**

**AUSTRALIAN SOCIETY OF FORENSIC ODONTOLOGY INC**

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## Summary

An age estimation is the chronological age range of an individual determined from the analysis of dental, skeletal and other physical characteristics, compared to relevant standards developed from individuals of known age. Precise determination of age is not possible due to human variation; an age range, with confidence intervals, is the best expression of age estimation.

If age estimation is limited to an external physical examination and reliance upon circumstantial evidence derived from interviews with parents, guardians, school authorities or public documents sourced from the individual's home, there is a potential for gross error in either over or under estimating the age.

A multi-factorial approach, where examination of multiple age markers in the same individual is undertaken, will result in a more accurate age estimation than if one age marker only is assessed. It is recognised that dental development is able to provide the most reliable indicator for chronological age from birth until 15 years of age.

Observation of the number and type of teeth present in the oral cavity, by simple intra-oral and x-ray examination, can be used to estimate the age of an individual from birth until 15 years. Since this technique is non-invasive, safe, child and gender sensitive it would be a technique of choice for assessment of the age of an individual still in the process of exfoliating deciduous teeth. The age assessment is simplistic in nature, can be easily undertaken, will rapidly assist in the direction of legal proceedings and will allow for the expedient return of the child to his/her legal guardian if the individual is determined to be a child.

The analysis of third molar (wisdom tooth) development, from an OrthoPantomoGraphic (OPG) image assessment, is sufficiently correlated with chronological age to be of forensic value. The assessment of the development of the third molar provides an ideal means to discriminate between an adult and a child. Third molars develop from mid-teens to early 20s and complete closure of the apices of the third molar teeth is an indication that the living individual is over the age of 18 years and thus, by definition, an adult.

Hand/Wrist X-ray examination was designed as a tool to assess the general skeletal development and overall growth of an individual. The Greulich-Pyle Radiographic Atlas (GPRA) consists of a series of standard, skeletal hand/wrist x-rays which relate to known chronological age and it is this atlas that is used in Australia for age assessments. At no time was this atlas designed to determine chronological age; it was designed as a tool for health workers to better assess a child's skeletal development and overall growth.

Protocols and standards for age assessment examination have been agreed upon by the Australian Society of Forensic Odontology:

- Signed, written informed consent must be obtained from the client or his/her legal representative, before any examination is undertaken. The informed consent must clearly explain to the client, that the examination is primarily to assess the age of the client. However, since the examination would encompass a general health screening, any abnormal medical, hard and soft tissue pathology noted would be included in the written report.
- An intra-oral examination of the client shall be undertaken in a suitably equipped dental operatory by a fully trained and experienced forensic odontologist.

- An OPG and/or hand/wrist radiograph shall be taken of the client by a qualified and registered radiographer.
- A panel of qualified, registered and experienced practitioners, chaired by a forensic odontologist, (including anthropologists, radiographers, pediatricians, or orthodontists), shall assess all information gathered.
- A clinical report shall be written covering all aspects of the general oral condition, including hard and soft tissue anomalies that may be found.
- An age assessment of the client shall be given which will include an age range.

All States and Territories within Australia have qualified and experienced forensic odontologists within easy reach of centres where those suspected or accused of people smuggling, who claim to be children (under 18), are detained. All centres have suitable medical facilities in which oral examinations can be undertaken and many have radiographic facilities which can produce appropriate x-ray images. In some cases the individual may have to be transferred to an outside radiography facility to obtain an OPG and/or hand/wrist radiograph. It is anticipated that the time taken from an initial examination to the presentation of a final signed medico-legal report, including the age estimation would be 14 days. This clearly sits within the timeframe proposed in the *Amendments to the CRIMES AMENDMENT (FAIRNESS FOR MINORS) BILL 2011 (Senator Hanson-Young), Item 3, No 8.*

There needs to be considered debate concerning the risks and ethics associated with the use of X-rays for non-medical purposes versus the benefits of more accurate age assessments in the interests of justice.

**Introduction**

I make this submission to the Parliamentary Inquiry in my position as President of the Australian Society of Forensic Odontology.

This submission seeks to address proposed amendments to the *Crimes Act 1914* concerning issues of timeframes and setting up evidentiary procedures for the age determination and prosecution of non-citizens who are suspected or accused of people smuggling offences under the *Migration Act 1958* and who may have been a child (under 18) at the time of allegedly committing the offense.

Specifically, this submission will address:

*Item 1*

*4* *removes the possibility of taking an x-ray of a person's body part as a prescribed procedure for age determination*.

*Item 2*

*5* *inserts a new subsection that ensures that the regulations cannot be used to re-insert the possibility of taking an x-ray of a person's body part as a procedure for age determination. It also ensures that existing regulations which, at the time the Bill commences, allow for the taking of an x-ray of a person's body part to determine age will cease to have effect on and after commencement*.

*Item 3*

*8* *sets a time limit of 30 days for the investigating official to apply for an age determination hearing. The timeframe starts from when the person is taken into immigration detention (usually point of interception by Australian naval or customs authorities).*

*Item 3*

*9* *the standard of proof for the age determination as being the balance of probabilities*

*Item 3*

*10* *non-exhaustive guidelines regarding what evidence the investigating official may rely on during the age determination hearing*

**Background**

The ability to assign an accurate age to living individuals charged with people smuggling offences has become a matter of urgency following recent well-publicised cases in New South Wales, Queensland and Victoria where children have spent long periods of time incarcerated in adult correctional facilities. Many people accused of people smuggling enter Australian jurisdictions without identification papers, or with suspect identification documents. The determination of the age status of such persons has particular medico-legal significance, not only in how they will be treated by the law in criminal prosecutions, but also in immigration hearings, licensing applications and the determination of their refugee status [1]. It is therefore of the utmost importance that scientifically tested and proven techniques are undertaken if accurate age estimations are to be given. The simple expediency of a visual assessment of an individual, coupled with circumstantial evidence derived from interviews with parents, guardians, school authorities or public documents sourced from the individual's home country has

the possibility for manipulation and falsification. The evidence of untrained, inexperienced persons involved in the confinement of detainees is also totally unreliable. Age assessment must be undertaken using scientific, research supported evidence and techniques grounded in well recognised, robust, academic foundations. It must involve a multi-factorial approach where examination of multiple age markers from the same individual is undertaken [2-7].

Most authorities are agreed that data derived from the developing dentition provides the most accurate means of age estimation. This fact, coupled with the high survivability of teeth exposed to severe physical factors, makes assessment of the developing teeth the method of choice in forensic age estimation.

**Development of the human dentition**

The predictable, chronological pattern of exfoliation and eruption of the human dentition, as living individuals progress from infancy to adulthood, has long been used as a means to assess the probable age of that individual. To better understand the scientific basis for the use of this technique, there is a need to briefly understand the process of exfoliation and eruption of the teeth into the oral cavity.

The development of the human dentition begins in utero at 6weeks, with the first primary (deciduous) tooth appearing in the oral cavity at around 6months of age. The primary dentition then develops in a well-documented sequence and is complete by 3 years of age. The appearance of the first permanent molar tooth at around 6 years of age signifies a period of loss of all deciduous teeth and replacement with their permanent successors. The process of eruption of the permanent teeth and associated exfoliation of primary teeth occurs in a sequential, predictable pattern and is complete at around 15 years of age. The final permanent tooth to erupt into the oral cavity is the third permanent molar, commonly referred to as the wisdom tooth. These teeth are radiographically visible at 10 years of age with development completed by early 20's. Once dental development and eruption is complete, degradation changes of the dental tissues occur as a result of occlusal attrition, restorative procedures to maintain the dentition and tooth loss [8-14].

**Categories for age assessment**

In May 2010, under the auspices of the National Institute of Forensic Science (NIFS), the Medical Sciences Scientific Advisory Group (MSSAG) convened a workshop meeting in Adelaide entitled 'A Critical Assessment of Human Age at Death Estimations'. This was attended by Australian forensic odontologists and forensic anthropologists [Appendix 1]. One of the agreed outcomes of the workshop was the defining of categories for age assessments as being:

- Foetal 8weeks – birth
- Infant 0 – <2 years
- Child 2 - <13 years
- Adolescent 13 -<18 years
- Adult >18+ years

This classification is in accord with the *Convention on the Rights of the Child (CRC)* definition of a child as being an individual under 18 years of age.

**Age assessment techniques**

Historically, non-invasive methods for age assessment of living individuals include direct intra-oral examination and the utilization of various medical imaging modalities. Conventional X-ray and CT scanning techniques capture images of the developing skeleton and dentition. The anatomical sites most commonly radiographed are the hand/wrist region for assessment of skeletal development, the maxillary and mandibular dentition for assessment of dental age and more recently the use of CT scanning techniques to capture images of both the developing clavicle and the dentition[15-17].

It is recognised that dental development, as opposed to skeletal development, is able to provide the most reliable indicator for chronological age from birth until 15 years of age. This is due to the fact that tooth formation (maturation) develops independent of somatic, skeletal and sexual maturation. Dental development is also less affected by environmental insults and systemic illness [18-24].

1. Tooth Count and Eruption Chart Comparisons:

Observation of the number and type of teeth present in the oral cavity is widely used as a means of age assessment. This technique is based on the assumption that different teeth erupt at different ages, in a relatively constant chronological order, and by referring to established scientific eruption charts or pictorial representations of the eruption patterns, one can estimate the dental age of the individual. Since this technique is non-invasive, safe, child and gender sensitive it would be a technique of choice for estimation of the age of an individual still in the process of exfoliating deciduous teeth and in the final stages of eruption of the second permanent molars – ages 10-15 years [25]. The age assessment is simplistic in nature, can be expediently undertaken, will rapidly assist in the direction of legal proceedings and will allow for the expedient return of the child to his/her legal guardian.

2. Radiographic Images and Atlas Style Comparisons:

The dental development atlas shows a diagrammatic, pictorial representation of the development of the dentition from birth to 35 years of age. The most regularly cited atlas of representation is that of Schour and Massler [Appendix II]. However more recent versions, Blenkin and Taylor [Appendix III] and Al Qahtani [Appendix IV] are also used. These charts summarise the development of the human dentition from birth to 35 years and are based on current data. The technique used for age assessment involves the comparison of the atlas diagrammatic representation of the stage of development of the human dentition with the OrthoPantomoGraph (OPG) image of maxillary and mandibular teeth. By matching the radiographic image to a specific atlas diagram the estimated age of the individual is assigned. Whilst the earlier atlas style representation (Schour/Massler; Al Qahtani) were not derived from Australian specific data, the results proved to be of sufficient accuracy and relevance that they were commonly used in dental practice for timing of interventionist treatment. The atlas of Blenkin and Taylor has been derived from contemporaneous data obtained from a cohort of Australian individuals and would be the reference of choice. Due to lack of specific data, no atlas has been compiled for an Indonesian population. However, it can be seen from the three referenced atlas' used, there is general accord between the various pictorial representations relating to a specific age. Since any age assessment derived from an atlas comparison would be reported as an age range, it allows for a determination of age based upon the 'balance of probabilities'. This gives the individual the right to the rule of the benefit of the doubt and addresses concerns rested in the *Convention of the Rights of the Child (CRC*). This would be the technique of choice for age assessment of individuals who, on intra-oral examination, show evidence of no deciduous (primary) teeth. Since this technique involves the use of x-ray images, there are ethical issues that need to be addressed.

3. OrthoPantomoGraphic (OPG) Analysis – development of the third molar (wisdom tooth)

At the time of the development of the third molars (wisdom teeth), from mid-teens to early 20s, there are few other reliable dental methods of age estimation other than to analyse the calcification and root development of the third molars [Fig 1-3]. Recent research has concentrated on the use of third molar

development in age assessment and these studies have found analysis of third molar development to be accurate and sufficiently highly correlated with chronological age to be of forensic value [26-33]. Third molar statistics are often presented as evidence of the likelihood that the individual has attained an age of 18 years (complete closure of the apex of the root), or as a percentage of the population who would be aged 18 years when the third molar has completed development. This method of age assessment, of necessity, involves the capture of radiographic images of the third molars as they lie within the mandible and maxilla and ethical issues need to be addressed before images are captured.

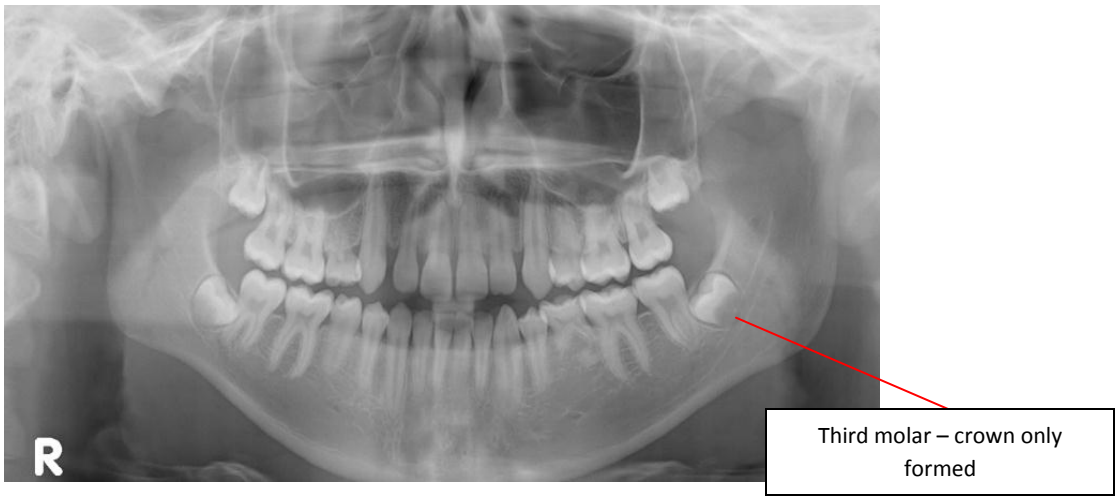



Fig 1
OrthoPantomoGraph Age 16 years – Third molar unerupted; Crown only formed

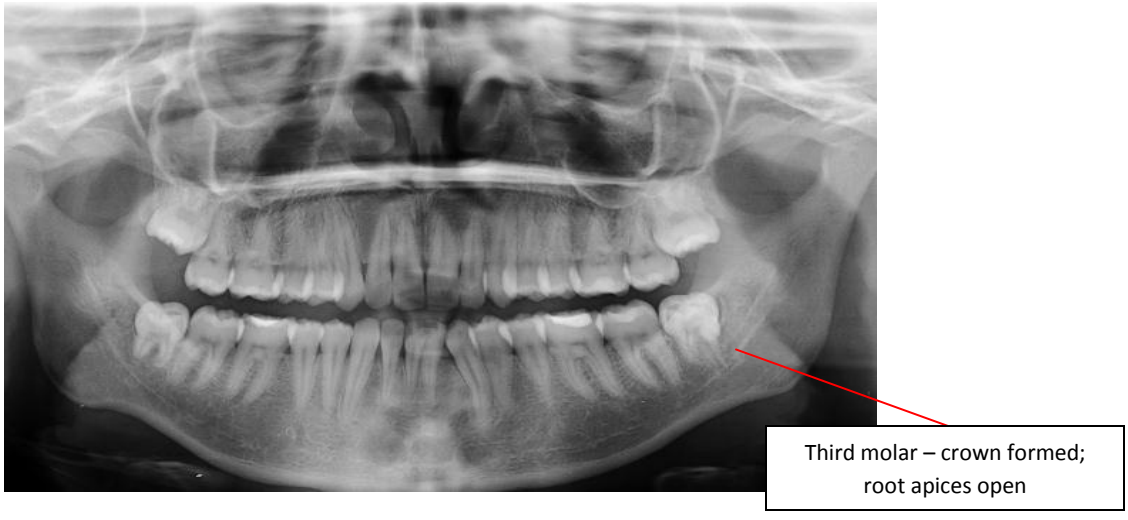



Fig 2
OrthoPantomoGraph Age 18 years – Third molar Impacted; Crown fully developed; Root apices open

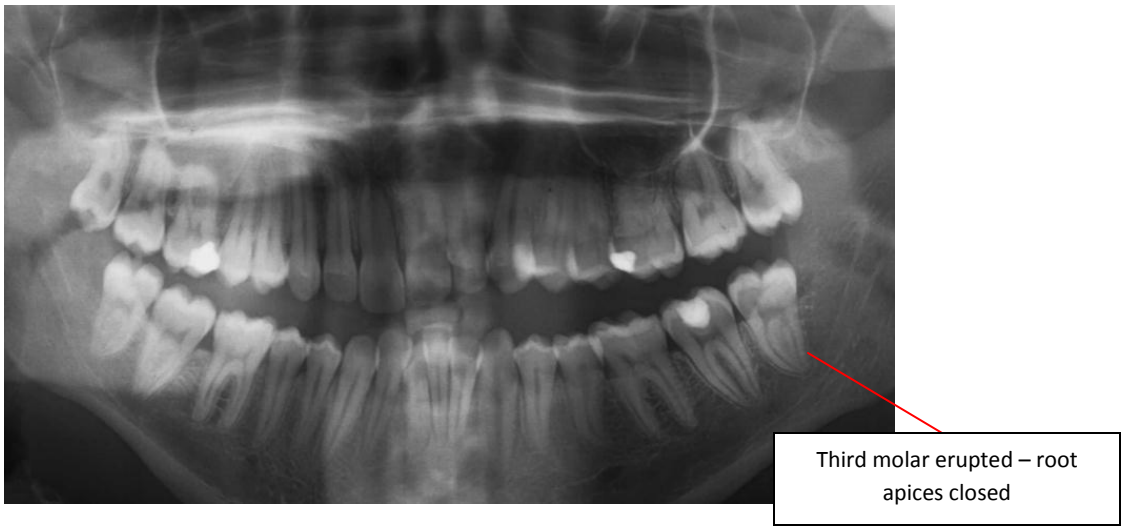



Fig 3
OrthoPantomoGraph Age 20 years – Third molars fully erupted; Apices closed

The assessment of the development of the third molar provides an ideal means to discriminate between an adult and a child. Most recent studies have shown that complete closure of the apices of the third molar teeth is an indication that the living individual is over the age of 18 years and thus, by definition, an adult [34-36].

4. Hand/Wrist Radiographic Interpretation

Hand/Wrist X-ray examination was designed as a tool to assess general skeletal development and overall growth. The reference sample used was a selection of 1000 middle-class American children who were born in the 1930's-1940's, aged from birth to nineteen years of age The data was used to develop the Greulich-Pyle Radiographic Atlas (GPRA) and consists of a series of standard, skeletal hand-wrist x-rays which relate to known chronological age [Fig 4-5]. The atlas displays skeletal development at three-month intervals during the first year of life; six-month intervals from one to five years; and one year intervals thereafter; up to 19 years. It is this atlas that is used in Australia for age estimations.

Fig 4
Skeletal Development Child aged 6 years

Fig 5
Skeletal Development Child aged 11 years

At no time was this atlas designed to determine chronological age; it was designed as a tool for health workers to better assess a child's skeletal development and overall growth. Clearly, the major drawback when using this technique is that images included in the atlas were obtained some 60 years ago from individuals who grew up on the other side of the world, under environmental conditions totally different to the detainees being assessed. Biological variation in human development means that any age assessment based on GPRA analysis of growth markers will inevitably contain a degree of error.

Recent research has focused on the development of various multi-factorial approaches to age estimation. A multi-factorial system involves using a combination of developing anatomical features in concert in order to arrive at an estimate which will offer increased accuracy and precision over an estimate which uses each development site individually [37-41]. In order to gain the most complete picture regarding an individual's developmental status it is apparent that both dental and skeletal age markers need to be examined together. Age estimation is therefore best practiced as a multi-disciplinary specialty, in that practitioners engaging in this activity should be familiar with the theory and practice of forensic anthropology, forensic odontology, medical imaging, human growth and development, and anatomy. In order to achieve this, and to obtain the most accurate age estimates, it is evident that practitioners from different disciplines need to work together on casework in order to gain the most accurate appreciation of an individual's age.

**Protocols and Standards for Age Assessment Examination**

- Signed, written informed consent must be obtained from the client or his/her legal representative, before any examination is undertaken. The informed consent must clearly explain to the client, that the examination is primarily to assess the age of the client. However, since the examination would encompass a general health screening, any abnormal medical, hard tissue or bony pathology noted would be included in the written report.
- An intra-oral examination of the client shall be undertaken in a suitably equipped dental operatory by a fully trained and experienced forensic odontologist.
- An OPG and/or hand/wrist radiograph shall be taken of the client by a qualified and registered radiographer.
- A panel of qualified, registered and experienced practitioners, chaired by a forensic odontologist, (including anthropologists, radiographers, pediatricians, or orthodontists), shall assess all information gathered.
- A clinical report shall be written covering all aspects of the general oral condition, including hard and soft tissue anomalies that may be found.
- An age assessment report of the client shall be given which will include an age range [Appendix V].

All States and Territories within Australia have qualified and experienced forensic odontologists within easy reach of centres where those suspected or accused of people smuggling, who claim to be children (under 18), are detained. All centres have suitable medical facilities in which oral examinations can be undertaken and many have radiographic facilities which can produce appropriate x-ray images. In some cases the individual may have to be transferred to an outside radiography facility to obtain an OPG and/or hand/wrist radiograph. It is anticipated that the time taken from an initial examination to the presentation of a final signed medico-legal report, including the age estimation would be 14 days. This clearly sits within the timeframe proposed in the *Amendments to the CRIMES AMENDMENT (FAIRNESS FOR MINORS) BILL 2011 (Senator Hanson-Young), Item 3, No 8* .

**Ethical Concerns**

There are medico-ethical and legal considerations involved in conducting radiological procedures – with no defined medical need – on living people. Whilst the process of taking radiographic images of the development of the dentition or imaging hand/wrist areas for general skeletal development could be considered part of an overall health screening procedure, the ultimate reason for the radiographs being undertaken is to assess the age of the individual. In any investigation specifically focused on an age assessment, the client must be informed fully of the reasons and 'informed consent' must be obtained before any investigation is undertaken.

Comprehensive age assessment of living individuals necessarily involves the use of ionising radiation – X-rays – with unavoidable radiation exposure. While this exposure is not at a level sufficient to cause immediate harm, it does raise the total lifetime dose of radiation experienced by the individual (Appendix VI).

These issues are yet to be adequately addressed by the government.

**Conclusion**

An age estimation is the chronological age range of an individual determined from the analysis of dental, skeletal and other physical characteristics, compared to relevant standards developed from individuals of known age. Precise determination of age is not possible due to human variation; an age range, with confidence intervals, is the best expression of age estimation.

If age estimation is limited to an external physical examination and reliance upon circumstantial evidence derived from interviews with parents, guardians, school authorities or public documents sourced from the individuals home, there is a potential for gross error in either over or under estimating the age.

A multifactorial approach, where examination of multiple age markers in the same individual is undertaken, will result in a more accurate age estimation, than when only one age marker, from the same individual, is assessed. In order to gain the most complete picture regarding an individual's developmental status, both dental and skeletal age markers need to be examined together.

It is recognised that dental development, as opposed to skeletal development, is able to provide the most reliable indicator for chronological age from birth until 15 years of age.

Studies have found that analysis of third molar (wisdom tooth) development is accurate and sufficiently correlated with chronological age to be of forensic value. Third molars develop from mid-teens to early 20s and complete closure of the apices of the third molar teeth is an indication that the living individual is over the age of 18 years and thus, by definition, an adult.

A panel of trained and experienced practitioners, (forensic odontologists, anthropologists, radiographers, paediatrists, orthodontists), should assess all evidence gathered. Forensic age estimation is no longer simply a matter of specialists restricting themselves to their own traditional fields but now, especially with the increase in undocumented international migration, is a specialty that requires expertise in multiple fields of endeavour.

Age assessment will be given which includes an age range of the detainee. This will allow a Magistrate to interpret the age assessment results on the 'balance of probabilities' and gives the detainee the right to the rule of the 'benefit of the doubt'. It also addresses concerns rested in the *Convention of the Rights of the Child (CRC).*

There needs to be a considered debate about the risks and ethics associated with the use of X-rays for non-medical purposes versus the benefits of more accurate age assessments in the interests of justice.

**References**


1. Australian Human Rights Commission. Inquiry into the treatment of individuals suspected of people smuggling offences who say they are children. Discussion Paper: December 2011
2. Bedford ME, Russell KF, Lovejoy CO, Meindl RS, Simpson SW, Stuart-Macadam PL. Test of the multifactorial aging method using skeletons with known ages-at-death from the grant collection. Am J PhysAnthro. 1993;91(3):287–97.
3. Garamendi PM, Landa MI, Ballesteros J, Solano MA. Reliability of the methods applied to assess age minority in living subjects around 18 years old. A survey on a Moroccan origin population. Forensic Sci Int. 2005;154(1):3–12.
4. Bhat VJ, Kamath GP. Age estimation from root development of mandibular third molars in comparison with skeletal age of wrist-joint. Am J Forensic Med Pathol. 2007;28(3):238–41.
5. Martrille L, Ubelaker DH, Cattaneo C, Seguret F, Tremblay M,Baccino E. Comparison of four skeletal methods for the estimation of age at death on white and black adults. J Forensic Sci.2007;52(2):302–7.
6. Franklin D. Forensic age estimation in human skeletal remains Current concepts and future directions. Leg Med (Tokyo).2010;12(1):1–7.
7. Bassed RB, Briggs C, Drummer OH. Age estimation using the third molar tooth, the medial clavicular epiphysis, and the spheno-occipital synchondrosis: a multifactorial approach. ForensicSci Int. 2011; doi:10.1016/j.for-sciint.2011.06.007.
8. AlQahtani, S., Hector, M and Liversidge, H (2010). Brief communication: The London atlas of human tooth development and eruption. American Journal of Physical Anthropology, 142:481-490
9. Schour, I. and Massler, M. (1940) Studies in tooth development: The growth pattern of human teeth, Part II. *J Am Dent Assoc*, **27**, 1918-1931
10. Smith, B.H. (1991) Standards of human tooth formation and dental age assessment in dental age assessment. In: *Advances in Dental Anthropology* (eds M.A. Kelly and C.S. Larsen), Wiley-LissInc, New York, pp. 143-168.
11. Logan, W.H.G. and Kronfeld, R. (1933) Development of the human jaws and surrounding structures from birth to the age of fifteen years. *J Am Dent Assoc*, **20**, 379-427
12. Moorrees, C.F.A., Fanning, E.A, and Hunt, E.E. (1963) Age variation of formation stages for ten permanent teeth. *J Dent Res*, **42**,1490-1502
13. Demirjian A, Goldstein H, Tanner JM. A new system of dental age assessment. Hum Biol. 1973;45:211–27.
14. Mckern TW, Stewart TD. Skeletal age changes in young American males, analysed from the standpoint of identification. Headquqm res and dev command. Natick: Mass; 1957.
15. Webb PA, Suchey JM. Epiphyseal union of the anterior iliac crest and medial clavicle in a modern multiracial sample of American males and females. Am J PhysAnthropol. 1985;68(4):457–66.
16. Bassed RB, Hill AJ. The use of computed tomography (CT) to estimate age in the 2009 Victorian bushfire victims: a case report. Forensic Sci Int. 2011;205(1–3):48–51.
17. Schulz R, Muhler M, Mutze S, Schmidt S, Reisinger W,Schmeling A. Studies on the time frame for ossification of the medial epiphysis of the clavicle as revealed by CT scans. Int JLegal Med. 2005;119(3):142–5.
18. Lewis AB, Garn SM. The relationship between tooth formation and other maturational factors. Angle Orthod. 1960;30:70–7.
19. Smith BH. Standards of human tooth formation and dental age assessment. In: Kelley ML, Larsen CS, editors. Advances in dental anthropology. New York: Wiley-Liss, Inc; 1991.p. 143–68.
20. Gustafson, G. and Koch, G. (1974) Age estimation up to 16 years of age based on dental development. *Odont. Revy*, **25**, 297-306
21. Smith, B.H. (1991) Standards of human tooth formation and dental age assessment in dental age assessment. In: *Advances in Dental Anthropology* (eds M.A. Kelly and C.S. Larsen), Wiley-LissInc, New York, pp. 143-168
22. Lewis, A.B. and Garn, S.M. (1960) The relationship between tooth development and other maturational factors. *Angle Orthod*, **30**,70-77

23. Demirjian, A., Buschang, P.H., Tanguay, R. and Kingnorth-Patterson, D. (1985) Interrelationships among measures of somatic, skeletal, dental, and sexual maturity. *Am J Orthod*, **88**, 433-438
24. Holtgrave, E.A., Kretschmer, R. and Muller, R. (1997) Acceleration in dental development: fact or fiction. *Eur J Orthod*, **19**, 703-710
25. Taylor JA, Blenkin MRB. (2010). Age Evaluation and Odontology. In Black, Aggrawal and Payne-James (eds) Age Estimation in the Living: Theory and practice for the Medico-Legal Professions. Wiley.
26. Nortjé, C.J. (1983) The permanent mandibular third molar. *J Forensic Odontostomatol*, **1**, 27-31
27. Engström, C., Engström, H. and Sagne, S. (1983) Lower third molar development in relation to skeletal maturity and chronological age. *Angle Orthod*, **53**, 97-106
28. Mincer. H.H., Harris, E.F. and Berryman, H.E. (1993) The ABFO study of third molar development and its use as an estimator of chronological age. *J Forensic Sci*, **38**,379-390
29. Mesotten, K., Gunst, K., Carbonez, A. and Willems, G. (2002) Dental age estimation and third molars: a preliminary study. *Forensic SciInt*, **26**, 110-115
30. Bhat, V.J. and Kamath, G.P. (2007) Age estimation from root development of mandibular third molars in comparison with skeletal age of wrist joint. *Am J Forensic Med Pathol*, **28**, 238-241
31. Martin-de lasHeras, S., Garcia-Fortea, P., Ortega, A., Zodocovich, S. and Valenzuela, A. (2008) Third molar development according to chronological age in populations from Spanish and Magrebian origin. *Forensic SciInt*, **174**, 47-53
32. Meinl, A., Tangl, S., Huber, C., Maurer, B. and Watzek, G. (2007a) The chronology of third molar mineralization in the Austrian population – a contribution to forensic age estimation. *Forensic SciInt*, **169**, 161-167
33. Gunst, K., Mesotten, K., Carbonez, A. and Willems, G. (2003) Third molar development in relation to chronological age: a large sample sized retrospective study. *Forensic SciInt*, **136**, 52-57
34. De Salvia, A., Calzettac C., Orrico, M. and De Leo, D. (2004) Third mandibular molar radiological development as an indicator of chronological age in a European population. *Forensic SciInt*, **146S**, S9-S12.
35. Olze, A., van Niekerk, P., Schulz, R. and Schmeling, A. (2007) Studies of the chronological course of wisdom tooth eruption in a Black African population. *J Forensic Sci*, **52**, 1161-1163.
36. Bassed, R. B., C. Briggs, et al. "Age estimation and the developing third molar tooth: an analysis of an Australian population using computed tomography." J Forensic Sci **56**(5): 1185-1191.
37. Bedford ME, Russell KF, Lovejoy CO, Meindl RS, Simpson SW,Stuart-Macadam PL. Test of the multifactorial aging method using skeletons with known ages-at-death from the grant collection .Am J PhysAnthropol. 1993;91(3):287–97.
38. Garamendi PM, Landa MI, Ballesteros J, Solano MA. Reliability of the methods applied to assess age minority in living subjects around 18 years old. A survey on a Moroccan origin population. Forensic Sci Int. 2005;154(1):3–12.
39. Bhat VJ, Kamath GP. Age estimation from root development of mandibular third molars in comparison with skeletal age of wrist-joint. Am J Forensic Med Pathol. 2007;28(3):238–41.
40. Martrille L, Ubelaker DH, Cattaneo C, Seguret F, Tremblay M,Baccino E. Comparison of four skeletal methods for the estimation of age at death on white and black adults. J Forensic Sci.2007;52(2):302–7.
41. Franklin D. Forensic age estimation in human skeletal remains: current concepts and future directions. Leg Med (Tokyo).2010;12(1):1–7.

**Appendix I**

**Medical Sciences Scientific Advisory Group Workshop**

**Title:** A Critical Assessment of Human Age at Death Estimations

**Date:** 27-28 May 2010

**Venue:** Adelaide:Forensic Science SA (21 Divett Place) & Forensic Odontology Unit (233 North Terrace)

**Duration:** 2 days

**Numbers:** 4 anthropologists and 10 odontologists

**Aims:**

- Identify similarities and differences of definitions and methods used within and between the disciplines of Forensic Odontology and anthropology
- Achieve a standardized cross-disciplinary approach to the estimation of age at death.

**Outcomes:**

- Standardized approaches to ageing
- Determine situational uses and potential clients
- Define terminology
- Determine a consensus of age ranges to be used by anthropologists and odontologists
- Discuss methods practitioners use to estimate age at death, advantages and limitations
- Discuss standard report writing and presentation of evidence
- Produce an information package, including ppt for teaching and FAQ for clients
- Discuss research protocol for combine anthropology / odontology project to be prepared for publication of results in scientific literature
- Disseminate workshop outcomes to practicing Australian odontologists and anthropologists

**Deliverables:**

- Report to Medical Science Scientific Advisory Group (MS.SAG)
- Report to Australasian Disaster Victim identification Committee (ADVIC)
- Review Australian guidelines
- FAQ Collation
- Literature Collation
- Identify Research gaps / projects
- Disseminate outcomes to odontologists / anthropologists (ANZFSS presentation)

**Age Estimation: Frequently Asked Questions**

**What is an age estimate?**

An age estimate is the chronological age range of an individual determined from the analysis of dental, skeletal and other physical characteristics and compared to relevant standards developed from individuals of known age.

**In what circumstances may age estimates be useful?**

Living

- Refugees and immigrants
- Individual Identification
- Adoption
- Identity theft
- Fraud
- Missing persons
- Amnesia

Deceased

- Individual Identification
- Disaster Victim Identification
- Biological profiling
- Missing persons
- Differentiation of siblings

**What are the broad categories for age?**

| | |
|---|---|
| FOETAL | 8 wks - Birth |
| INFANT | 0 - <2 yrs |
| CHILD | 2 - <13 yrs |
| ADOLESCENT | 13 - <18 yrs |
| ADULT | 18+ yrs |

**Why have I been given an age range?**

Biological variability. For example, in a classroom of children many will be different heights but will be the same chronological age. The level of biological development of an individual (their biological age) can be affected by many factors including sex, nutrition, ancestry, disease, medical treatment, socio-economic background and other lifestyle factors. This variability increases with age, so the range of an estimate will be narrower in the young and much wider in adults.

**Are there growth differences between males and females?**

Yes. Males and females exhibit different rates of growth and development. This difference becomes more obvious as the child gets older.

**Are there differences between races and countries?**

Yes. Ancestry, or genetic heritage, plays a significant role in an individual's rate of growth and development.

**Are there recommended guidelines for the process of age estimation?**

There is a range of techniques available to the practitioner. The choice of the most appropriate technique will depend on the specific circumstances of the case.

**What are the limitations of scientific age estimates?**

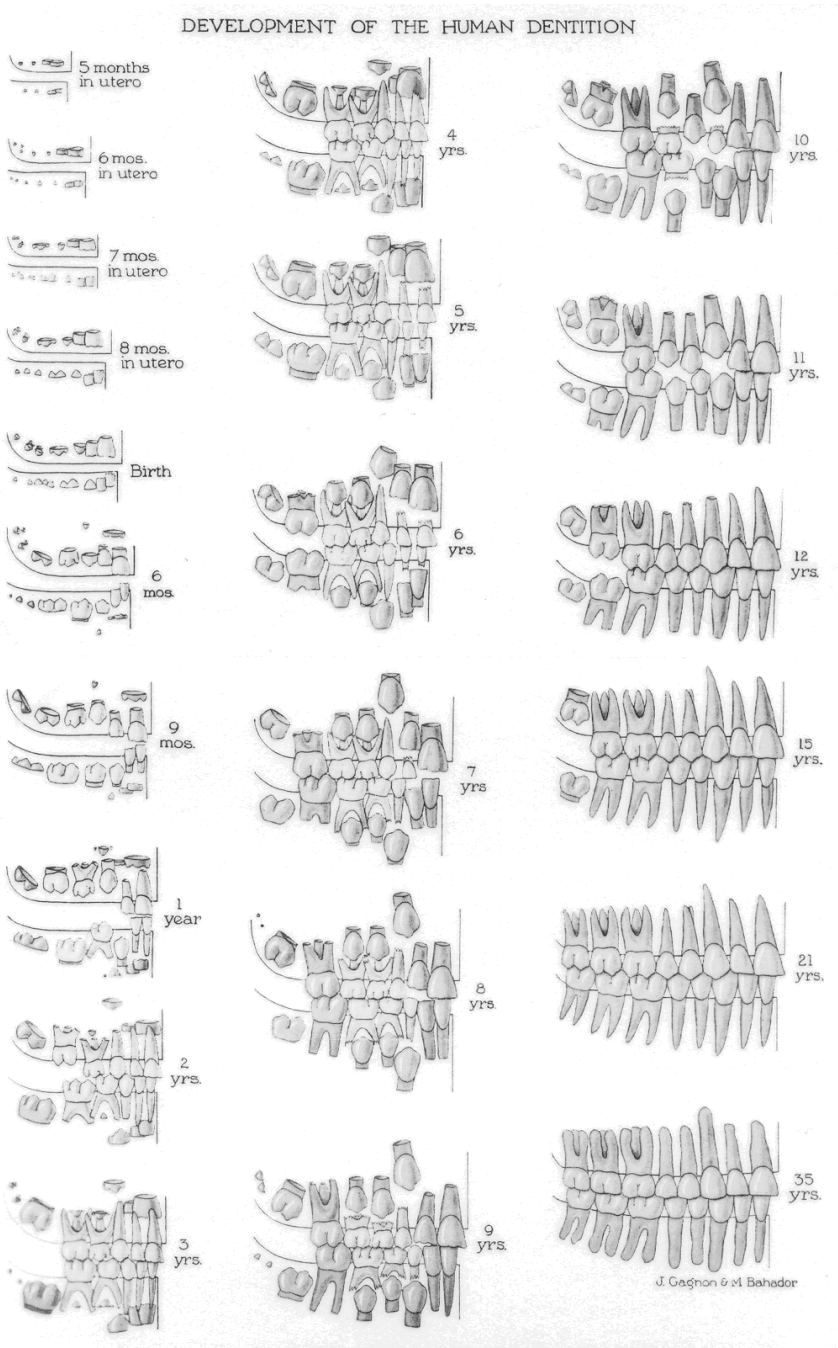
- A small proportion of people will fall outside the estimated range (about 5%);
- Congenital medical conditions can affect the rate of growth of the teeth and bones and can affect the accuracy of an age estimate;
- Nutrition and lifestyle factors may affect the rates of growth and development and can, in some cases, affect the accuracy of an age estimate;
- Estimates are less accurate in adults and more accurate in children;
- We need the appropriate bones and/or teeth to provide an age estimation. The accuracy of age estimations are affected by the completeness and preservation of the remains;
- There is not always the relevant dataset for a particular population, which means a similar (or 'next best') dataset will be used resulting in a less accurate estimate.

**Can you estimate age of an individual from another country?**

Yes. Ideally a relevant comparative dataset from the country of origin of the individual will be used for an estimation. If such a dataset does not exist the next most relevant dataset will be used. However, this will result in an estimate with a larger age range allowing for the variation between countries and ancestries.

**Appendix II**

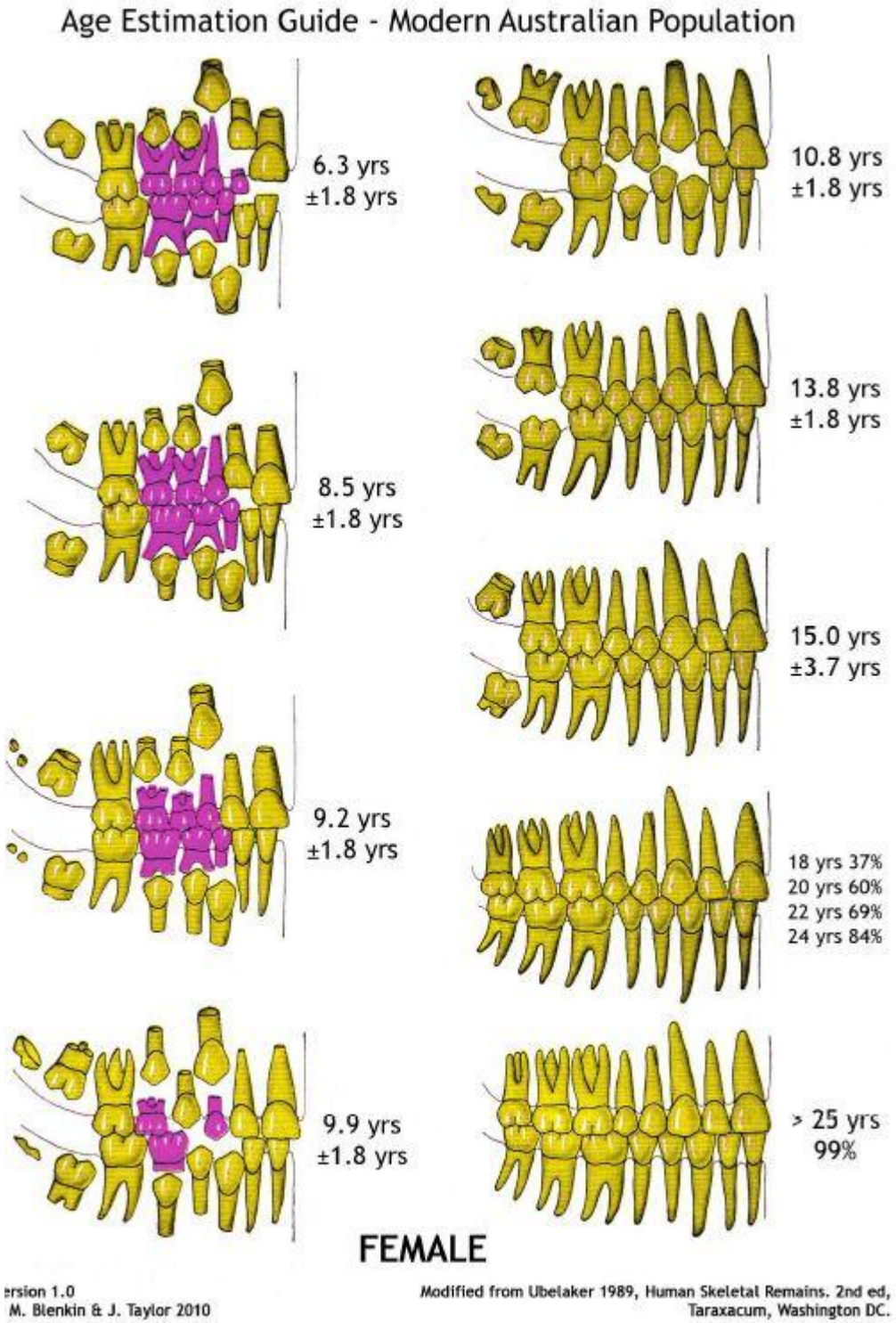
**Schour and Massler Dental Development Atlas**



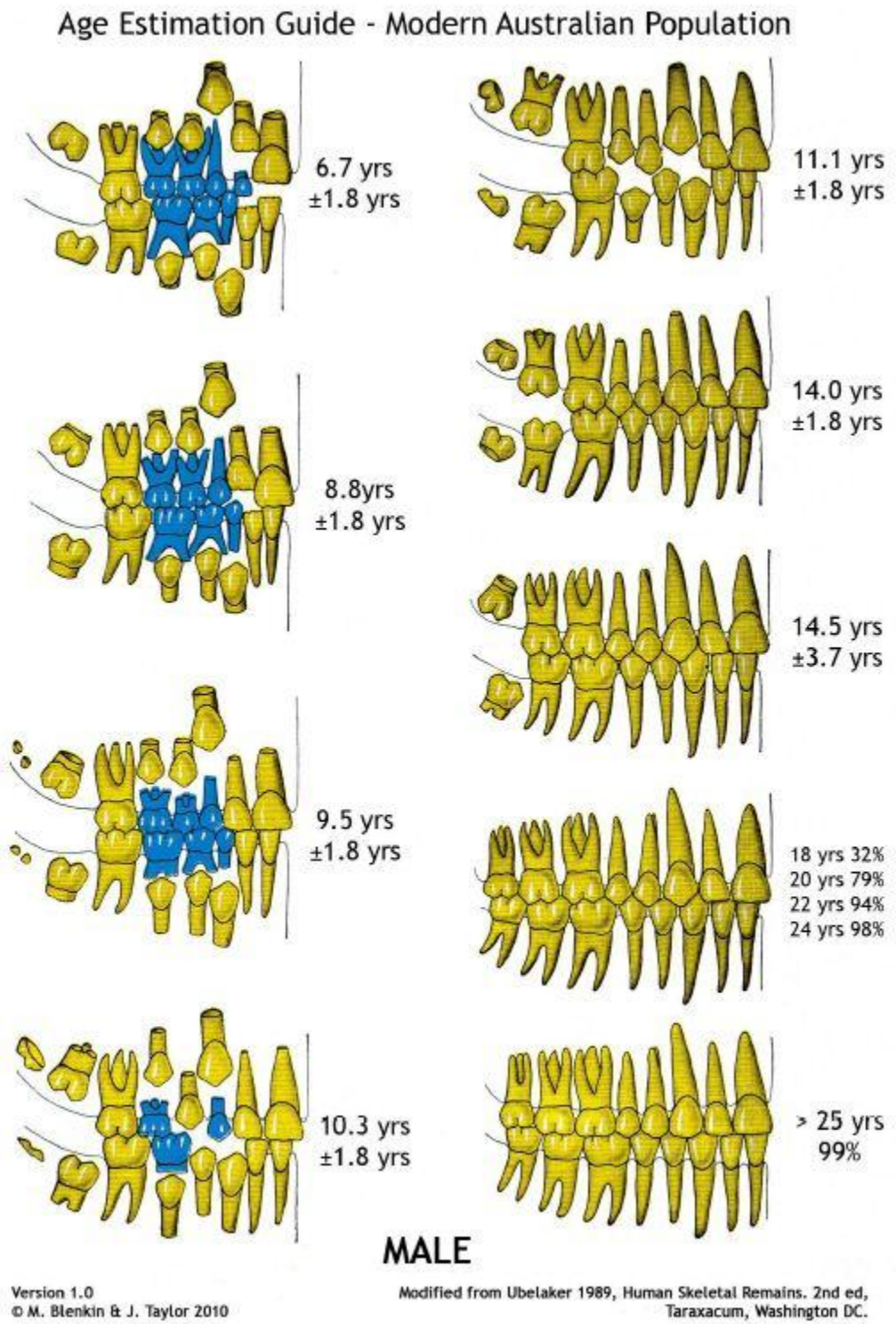

Atlas style age estimation charts developed by Schour and Massler. (Schour I, Massler M. The development of the human dentition. JADA 1941; 28: 1154. Copyright © 1941 American Dental Association. All rights reserved. Reprinted by permission)

**Appendix III**

**Blenkin and Taylor Dental Development Atlas for Australian Population**

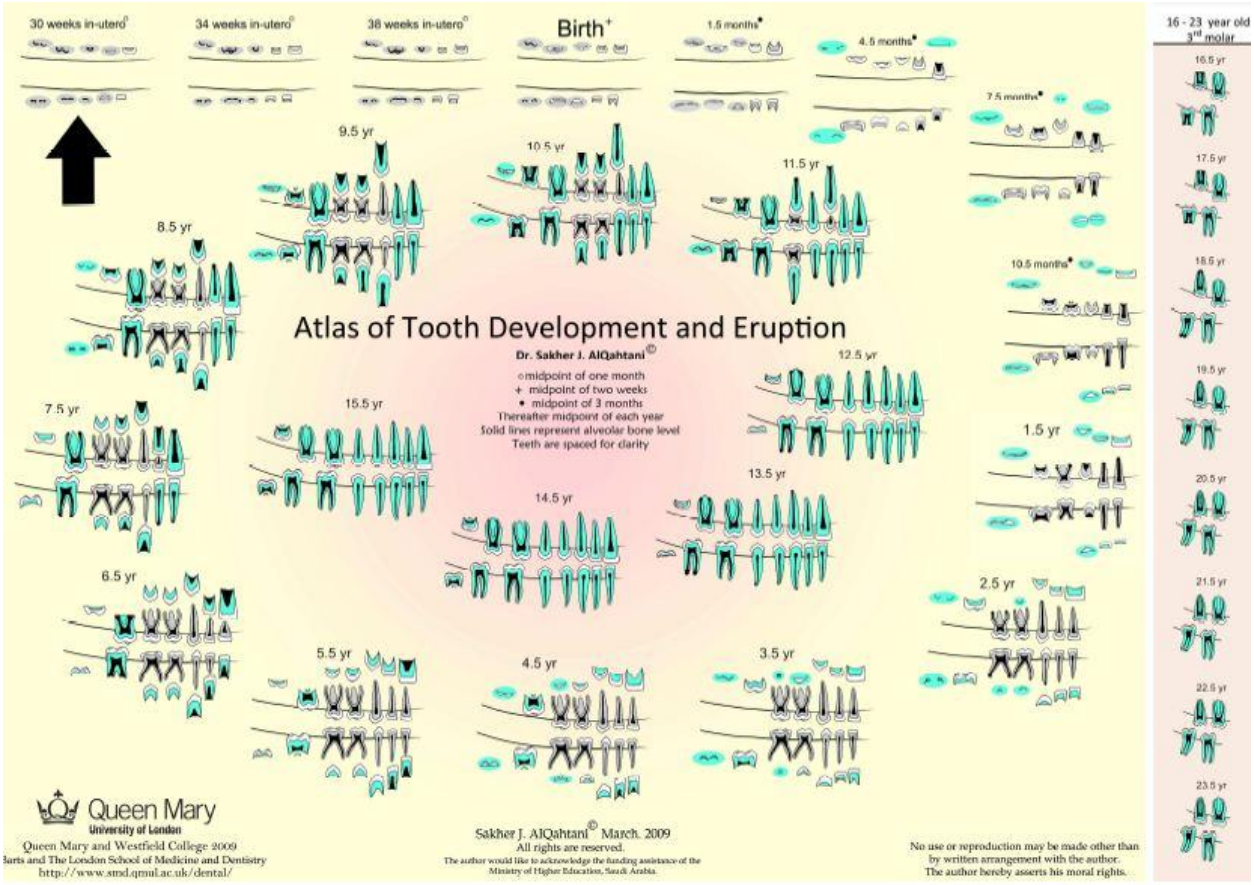


**Blenkin and Taylor Dental Development Atlas for Australian Population**



**Appendix IV**

**Sakher J Al Qahtani Dental Development Atlas**



**Appendix V**

**Draft Age Assessment Report**

Date:……..

Re: … *Client Name…*

*…Address*

Dear Sir,

At the request of …….*Name……,*from …….*Organisation……*., and with written consent from ……..*Name……..*and his legal representative, I arranged a referral for ……*Name*…… to have an OrthoPantomoGraph (OPG) and/or Hand/Wrist radiograph taken at ……..*Radiography Department*…..…… on…..*Date*……

The radiographic images taken were forwarded to my office on the ……*Date*……

As background information, the human dentition develops from a process of calcification of embryonic membranous tissue, commonly called 'tooth germs'. Calcification of the tissue commences prior to birth and is complete in early adult life with the calcification of the root apex of the third permanent (adult) molar tooth - (wisdom tooth).

The OPG radiograph is viewed to:

- evaluate the dental health status of the dentition; a complete clinical oral examination is required to confirm the status of the oral health of the client
- assess the age of the client

The chronological age assessment is determined by comparing the stages of calcification of all teeth and 'tooth germs' present on the OPG image with relevant published data from individuals of known age (list attached). The chronological age assessment is expressed as an age range, with confidence intervals.

I forwarded the images to Specialist Forensic…… *insert name of specialist……* who reviewed the images for their assessment and comment.

An analysis of the teeth and bone as viewed in the radiographs showed… *Unremarkable/Revealed anomalies* …….

*Note: All abnormal findings are to be reported and recommendations for further investigation must be made. Any follow-up treatment would be the responsibility of the client who had the OPG taken to arrange.*

Evaluating the status of the teeth present with published data on age assessment (as per the list attached) we assess the age of ……*Name*…… at the date the radiographs were taken to be …… with a range of …+/-…… months.

If additional information is required please contact myself on the above address or by phone

Yours sincerely,

Dr ……*Name*……..

……*Title*……

……Position

Attached:

Reference list

Reviewers' Addresses

**Appendix VI**

**Radiation dosage table**

| For this procedure: | approximate effective radiation dose is: | Comparable to natural background radiation for: | Additional lifetime risk of fatal cancer from examination: |
|---|---|---|---|
| **ABDOMINAL REGION:** | | | |
| Computed Tomography (CT) Abdomen and Pelvis | 15 mSv | 5 years | Low |
| Computed Tomography (CT) Abdomen and Pelvis, repeated with and without contrast material | 30 mSv | 10 years | Moderate |
| Radiography (X-ray) Upper GI Tract | 6 mSv | 2 years | Low |
| **BONE:** | | | |
| Radiography (X-ray) Spine | 1.5 mSv | 6 months | Very Low |
| Radiography (X-ray) Extremity | 0.001 mSv | 3 hours | Negligible |
| **CENTRAL NERVOUS SYSTEM:** | | | |
| Computed Tomography (CT) Head | 2 mSv | 8 months | Very Low |
| Computed Tomography (CT) Head, repeated with and without contrast material | 4 mSv | 16 months | Low |
| **CHEST:** | | | |
| Computed Tomography (CT) Chest | 7 mSv | 2 years | Low |
| Computed Tomography (CT) Chest Low Dose | 1.5 mSv | 6 months | Very Low |
| Radiography Chest | 0.1 mSv | 10 days | Minimal |
| **DENTAL:** | | | |
| Intraoral X-ray | 0.005 mSv | 1 day | Negligible |
| OPG | 0.02mSv | 3 days | Negligible |
| Cone beam OPG | 0.07-0.2mSv | 9-24 days | Minimal |