



Research paper

Development of a Reference Data Set (RDS) for dental age estimation (DAE) and testing of this with a separate Validation Set (VS) in a southern Chinese population



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ABSTRACT

Background: Many countries have recently experienced a rapid increase in the demand for forensic age estimates of unaccompanied minors. Hong Kong is a major tourist and business center where there has been an increase in the number of people intercepted with false travel documents. An accurate estimation of age is only possible when a dataset for age estimation that has been derived from the corresponding ethnic population. Thus, the aim of this study was to develop and validate a Reference Data Set (RDS) for dental age estimation for southern Chinese.

Materials and methods: A total of 2306 subjects were selected from the patient archives of a large dental hospital and the chronological age for each subject was recorded. This age was assigned to each specific stage of dental development for each tooth to create a RDS. To validate this RDS, a further 484 subjects were randomly chosen from the patient archives and their dental age was assessed based on the scores from the RDS. Dental age was estimated using meta-analysis command corresponding to random effects statistical model. Chronological age (CA) and Dental Age (DA) were compared using the paired *t*-test.

Results: The overall difference between the chronological and dental age (CA-DA) was 0.05 years (2.6 weeks) for males and 0.03 years (1.6 weeks) for females. The paired *t*-test indicated that there was no statistically significant difference between the chronological and dental age ($p > 0.05$).

Conclusion: The validated southern Chinese reference dataset based on dental maturation accurately estimated the chronological age.

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1. Introduction

In recent years, there has been a global increase in cross-border migration which has resulted in a growing number of illegal immigrants who cannot provide documentary evidence for their date of birth. Most often, these individuals genuinely do not know their date of birth, or they are suspected of giving an incorrect age. This occurs frequently in criminal proceedings, where the subject's age

is of relevance in the sentencing procedure. Many countries have experienced a rapid increase in the demand for forensic age estimates of unaccompanied minors. Consequently, this has now become an integral part of forensic practice. In addition, unaccompanied minors require an estimate of age so that foster care and education may be arranged to match the child's needs. This is usually carried out in conjunction with psychometric testing of the child's knowledge and understanding, and the assessor's perception of the child's life circumstances.¹

According to the recommendations issued by the Study Group on Forensic Age Diagnostics, for determining the age of live subjects, a forensic age estimate should combine the results of a physical examination, radiograph of the d and wrist, and a dental radiograph, usually a Dental Panoramic Tomograph (DPT). Age estimation should also take into consideration the ethnic origin and

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socio-economic status of the person under investigation.² In the United Kingdom, a recent judicial review criticised medical assessments of age because it was considered that there is insufficient evidence of its value for determining age to a reasonable level of accuracy. This resulted in the withdrawal of legal aid for conducting age estimation. The role and value of dental age was included in this judgement, although without an appropriate discussion of the large body of data available for different ethnic groups.³ It is unfortunate that Dental Age Assessment (DAA) has been excluded as several studies have shown that of all the measures of maturity namely morphological age based on height and weight, skeletal age, mental age, and dental age; it is dental age that correlates most closely with chronological age.⁴ Osteogenic and odontogenic tissues can be used to estimate the age by creating exclusive datasets⁵ or by adaptation of previously established datasets.⁶ Several studies have demonstrated accurate age estimation. The assessment based on the stages of tooth development with the data scored from the corresponding population group has been demonstrated to be the most accurate method available.^{7–9}

The number of passenger movements into and out from Hong Kong which is a popular tourist and business center in Asia has increased to 290 million in 2014, a 4.7% increase from the previous year. Due to the strong economy of Hong Kong, illegal immigrants seek entry hence thousands are intercepted by the immigration authorities every year.¹⁰ In most European countries adult penal law is applicable to individuals in the age range between 10 years and 18 years, although in some countries individuals can be held accountable for criminal offenses from as young as 7 years of age.¹¹ In this regard, the legal system in Hong Kong is similar to most other Asian countries. The Law Reform Commission of Hong Kong has proposed an increase to the minimum age of criminal responsibility from 7 to 10 years of age. It is also proposed that children between 10 and 14 years should be presumed to be incapable of committing a crime unless that presumption can be rebutted by the prosecution. This proposal is still under revision; so currently in Hong Kong, the age thresholds of 7, 14, 16 and 18 years are considered to be of legal importance.¹²

Legal systems differ between countries and miscreants are dealt with based on legislation determined by the local legal system. Because of the need to establish an accurate method of age assessment, a study was conducted in Hong Kong in 1994 which demonstrated a consistent over estimation of dental age compared to French-Canadian children. Thus it was concluded that the dataset which was based on French-Canadian subjects, was inaccurate for age estimation of 5–7 years old southern Chinese children.¹³ In addition, more recent studies have also demonstrated that both the Demirjian French-Canadian¹⁴ and the United Kingdom datasets¹⁵ are inappropriate for the age estimation of southern Chinese children. These poor results indicate the need for a population specific Reference Data Set (RDS) for southern Chinese subjects. Similarly, it has been shown that there is a need for a specific Afro-Trinidadian RDS.⁹ An accurate estimation of age is only possible when the dataset has been derived from the corresponding ethnic population. To date, there are no specific dental age estimation datasets for southern Chinese people. Around 94% of Hong Kong's population belong to the southern Chinese ethnic group. Thus, the aims of this study were twofold:

Firstly, to establish a reference data set (RDS) for southern Chinese population. This will be based on the Tooth Development Stage (TDS) developed by the Anglo-Canadian research team at the Institute of Child Health in London.¹⁶ They are similar in concept to the Bone Stages developed for hand wrist radiographs developed in the same institution.¹⁷ Secondly, to validate the established RDS with a randomly selected sample of the southern Chinese ethnic population separate from the RDS.

2. Materials and methods

Ethical approval for this study was obtained from the Institutional Review Board of the University of Hong Kong - West cluster Hospital authority (IRB No. UW 12-280).

2.1. Sample population for Reference Data Set (RDS)

The archives of the department of Paediatric Dentistry & Orthodontics, Prince Philip Dental Hospital, Hong Kong provided the source for retrieval of suitable dental panoramic radiographs. For the reference dataset (RDS), samples were obtained from the list of patients attending the hospital from 1985 to 2008. The subjects were segregated based on gender and approximately 50 subjects per gender per age band was conveniently selected from the patient list. This sample was used to construct the reference dataset by calculating the Age at Attainment (AaA) for each of stages of development of all the teeth on the left side of the upper and lower jaws.

2.2. Sample population for Validation Set (VS)

For the Validation Set (VS), the DPTs of subjects who had attended the hospital in the year 2011 and 2012 were used. Based on computer-generated numbers, approximately ten subjects per age per gender for each age band were chosen randomly. The radiographs used in both the construction and validation phases of this study had been taken for diagnostic purposes and were re-used for this study.

2.3. Data processing

All of the dental panoramic radiographs were digitized using a scanner (Canon, Canon Inc, Japan). The patient details were masked and stored in an independent secure digital memory device. Two trained and calibrated examiners (JJ and HMW) scored the radiographs. The examiners are Paediatric Dentists and had been involved in age estimation projects for more than 8 years. Forty eight DPTs were re-evaluated to assess the intra- and inter-examiner reliabilities.

The radiographs were scanned at a resolution of 600 dpi used a flatbed scanner (Epson Expression 10000 XL, Seiko Epson Corp, Japan). The scanned images were viewed on a widescreen monitor (Samsung P2770HD, Samsung Corp, South Korea) under standard magnification of 160% without use of any image editing program. Each DPT was scored and the findings were marked on a scoring card using the eight-stage system of Tooth Development Stages (A to H) (Fig. 1). In addition, the written descriptions of the TDS were used when it was difficult to choose between stages based on the schematic drawings alone. This scoring was performed by assigning a stage from A to H for Tooth Development Stages (TDSs) of the 16 individual Tooth Morphology Types (TMTs) that included all of the teeth on the left-side and the third molars on the right-side making a total of 18 teeth. It is to be noted that staging system reported by Demirjian and co-workers alone was employed in the study and the weighting system employed by them was not used.¹⁶ The British Dental Journal's system of tooth nomenclature was used (e.g. UL1 for upper left central incisor). Ten percent of the subjects in the validation samples were randomly selected, and the TDSs were re-evaluated 2 weeks later to test the inter-examiner and intra-examiner reliabilities.

2.4. Construction of southern Chinese Reference Data Set (RDS)

Patients' details including hospital number, date of birth, date of

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