Comparison of dental maturation in Hong Kong Chinese and United Kingdom Caucasians populations

Jayaraman J1*, Roberts GJ2.

1Dr. Jayakumar Jayaraman, BDS, MDS, DipFHID, MPaed Dent RCS, FDSRCS, PhD. Children’s Dentistry & Orthodontics, School of Dentistry, International Medical University, Kuala Lumpur 57000, Malaysia e-mail: jayakumar83@hotmail.com Phone: +601112108642
*Corresponding Author

2Prof. Graham Roberts, MDS, MPhil, BDS, FDSRCS, ILTM, DipFHID, PhD. Department of Orthodontics, King’s College London Dental Institute, 22/F Guys Tower, London SE1 9RT, United Kingdom e-mail: graham.roberts101@outlook.com

Highlights

- First ever study to provide insight on dental development through direct comparison of tooth development stages from a large sample of Caucasians and Chinese populations.
- Outcomes of this study has significance in both clinical and forensic applications, particularly in dental age estimation.

Abstract

Understanding dental maturation in ethnically distinct populations is important in forensic age estimations and the presence of population differences in dental maturation was highly debated. No such comparison had been performed between two major populations; Caucasian and Chinese. This study aims to analyse and compare the maturation of permanent teeth from a
sample of Caucasians and Chinese populations. Dental panoramic radiographs of subjects aged 2 to 24 years belonging to United Kingdom (UK) Caucasians and Hong Kong (HK) Chinese populations were obtained from a teaching hospital. The teeth were scored and reference datasets were developed separately for males and females. Statistical significance was set at p < 0.05 and independent sample t-test was conducted between the average ages at assessment for each stage of development for all the teeth in both groups. The HK Chinese were dentally advanced than the UK Caucasians by an average of 5 months, however, reverse trend was observed in third molars (p<0.05). These findings must be considered whilst utilising population specific reference dataset for dental age estimation.

**Keywords**
Dental maturation; Chinese; Caucasian; Age estimation; Reference dataset; Forensic Anthropology Population Data.

1. Introduction

1.1. Background

Dental development is a process primarily regulated by genes although several other factors including nutrition, socio-economic status, environment and secular changes have been reported to influence to an extent [1,2]. Population geneticists had emphasised the need for inclusion of racial and ethnic demographics in biomedical research since they determine the expression and prevalence of various diseases [3]. Several studies have shown ethnic specific variations in physiological maturity that includes height, weight, Body Mass Index (BMI) and
skeletal development [4]. A study comparing the growth patterns of Asian, Hispanic, African-American and White children from their hand-wrist radiograph found that Asian and Hispanic children mature earlier than the other two ethnic peers. Recently, a longitudinal study conducted in South Africa found that skeletal maturity was delayed by 7 months in blacks compared to white ethnicity; however no such changes were observed in girls [5]. In the context of Asia, a study that compared cervical vertebra and hand wrist development between Indonesian and Caucasian children found that white boys and girls were ahead of their Indonesian peers [6].

The above trend has been observed in dental development as studies had shown variations in both dental emergence and dental formation amongst different ethnic populations. Advancement in the emergence of permanent dentition was observed in black children compared to white although both belonged to similar socio-economic and environmental background [7]. This was supported by a study conducted in New Zealand that reported significant variations in the emergence of permanent teeth amongst Maori, Pacific Chinese, Indian and European children [8]. This observation was also evident in the primary dentition; a recent study that looked into the eruption pattern of primary dentition in American sub-ethnic population found that at a given age, native American children had more number of primary teeth compared to Black and White children [9]. A few studies have reported variations in dental formation. Dental development of Afro-Trinidadians was found to be delayed by approximately 8 months compared to UK Caucasians [10]. This finding was similar to a study on Maltese children who demonstrated earlier dental maturation than the Caucasians, although the results did not reach statistically significance [11]. An earlier study comparing the dental formation of permanent teeth of African Black and London children reported that the African
blacks were advanced in maturation with mandibular third molars erupting ahead of London children [12].

1.2. Importance of Caucasians and Chinese population groups

Dental anomalies occur more commonly in specific ethnic groups since they are highly predisposed to such disorders including cleft lip and palate, supernumerary tooth, impacted canine, hyper and hypodontia [13,14]. A study conducted to evaluate arch-length discrepancies found that southern Chinese had wider dental arch width compared to Caucasians [15]. It is unclear whether this would have profound effect on dental maturation patterns. Dental emergence and dental maturation are usually seen as two different entities. Whilst dental emergence is highly variable due to the influence of local factors including crowding, pathological conditions and early exfoliation, dental maturation is merely affected by these factors. For this reason, dental maturation was considered as a reliable tool to analyse inter-ethnic variations in dental development. Understanding such variations helps in appropriate management of population specific dental conditions. This is also useful in anthropological context to conceive the degree of variation or similarity of dental development amongst ethnically distinct populations [16]. Chinese and Caucasian ethnicities are of interest to physical anthropologists and clinicians since they represent ethnically distinct populations. Understanding dental maturation in these populations would be useful in clinical dental practice in treatment planning of several dental conditions, in forensic dentistry, in appropriate use of population specific standards for age estimation as well as an indicator of public health. Hence, this study aims to analyse the maturation of permanent teeth from a sample of United Kingdom Caucasians and Hong Kong Chinese populations.

2. Materials & Methods
2.1. Study sample

This study comprised dental panoramic radiographs of subjects aged between 2 and 24 years from UK Caucasian and Chinese population groups. All the subjects were healthy without any cranio-facial disorders that might affect the dental development. The radiographs that were taken for diagnostic purpose and were re-used for this research project. For the UK Caucasian sample, radiographs were obtained from King’s College Dental Institute, London, United Kingdom and for Chinese, the radiographs were retrieved from the archives of Prince Philip Dental Hospital, Hong Kong. The ethnicity of the subjects were identified by the ancestral details provided in the hospital information sheet. Ethics approval for this study was obtained from the West Cluster Board of the Institutional Review Board, University of Hong Kong (HKU-UW-120).

2.2. Development of Reference Dataset

The radiographs were scored based on the Demirjian’s staging criterion that classifies tooth development into 8 distinct stages identified by the letters, A to H. The designated stages start with initial crown formation and extends until closure of root apex [17]. A stage score was assigned to each Tooth Development Stages (TDSs) for all the 16 Tooth Morphology Types on the left-side of the arch. The patients’ details along with the stage scoring was then transferred to Microsoft Access® for each tooth and their corresponding stage of development. Reference data set (RDS) for Caucasian and Chinese populations were exported from the Microsoft Access® to Microsoft Excel as spreadsheets comprising of the following data for each TDS: mean Age at Attainment (Aoaa), standard deviation (sd), number of teeth (n-tds) and percentile values. The above data was obtained separately for all the 16 teeth, and separately for females and males of subjects in Caucasian and Chinese populations.
respectively. The inter- and intra-rater agreement was assessed using Cohen’s Kappa analysis [18].

2.3. Comparison of summary data between Caucasians and Chinese populations:

Using SPSS software, independent student t-test was performed between the Mean Ages at Assessment (AaA) for each TDS for all the 18 teeth. This comparison was conducted separately for males and females of Caucasian and Chinese populations. Statistical significance was set at p < 0.05.

3. Results

3.1. Reference datasets

This study comprised of a total of 4,835 dental panoramic radiographs of healthy subjects aged between 2 to 24 years. Amongst them, 2,529 (1,118 males and 1,411 females) subjects belong to Caucasian ethnicity who were residents in the UK and 2306 (1123 females and 1183 males) radiographs of southern Chinese subjects who were residents of Hong Kong Special Administrative Region of People’s Republic of China. Distribution of samples in the Caucasian and Chinese groups was presented in Table 1.

3.2. Age at assessment

The overall difference between the average age of assessment of the tooth developmental stages between the Chinese and Caucasian RDS was -0.40 years indicating that the Chinese were dentally advanced than the Caucasians by an average of 5 months. The difference was similar in both males (-0.39 years) and females (-0.41 years). The average age of attainment of most the tooth development stages were significantly different between the
Caucasian and the Chinese, in both males and females (p < 0.05). Advanced dental maturation was observed in the Chinese in 77.90% of the tooth development stages compared to the Caucasians out of which 62.70% were statistically significant (p < 0.05), excluding third molars. Amongst the sexes, Chinese females demonstrated higher advancement (81.20%) compared to Chinese males (74.70%). A reverse trend was observed in third molars where Caucasians showed earlier dental maturation in 78.1% of TDS compared to Chinese and this was observed in both maxillary and mandibular dentition and in both sexes. Statistically significant difference was observed in 70% of the TDS (p < 0.05).

Looking at the third molars alone, Caucasians showed advancement of 0.96 years (0.98 years for males and 0.94 years for females). Between the sexes, third molars in Caucasian males were relatively more advanced (87.50%) than females (68.75%). The summary data of tooth developmental stages for Caucasian and Chinese was presented for males (Table 2) and females (Table 3). The average age of attainment and its dispersion for each stage of development of maxillary and mandibular left third molars in Caucasian and Chinese males and females are shown in Figures 1 and 2 respectively.

3.3. Inter and intra-rater agreement

The intra-rater agreement of the investigators who assessed the southern Chinese data (JJ) and the UK Caucasian data (GR) were 0.88 and 0.84 respectively indicating that the agreement was ‘almost perfect’. The inter-rater agreement between the investigators was 0.72 showing that the agreement was ‘substantial’ [18].

4. Discussion
Ethnic difference in children and adolescents based on skeletal development has been already established [19,20]. This is the first ever study to show comparison of dental development standards by directly pairing each of tooth developmental stages from a huge sample of Chinese and Caucasian populations. The samples utilised in the study were initially used to develop and validate reference datasets for the UK Caucasian and southern Chinese respectively [21,22]. This sort of comparison has been conducted earlier in Afro-Trinidadian and Maltese populations. It has been shown that the Afro-Trinidadians develop earlier than Caucasians by around 8 months [10]. In the current study, it was found that the Chinese develop earlier than Caucasians around 5 months in both males and females. In contrast, only a slight difference was observed between the UK Caucasians and Maltese populations and a possible explanation was that the same size between those populations were not uniform [11]. In our study, the size of samples in the Caucasian and Chinese groups were similar and hence the results drawn from this study.

The influence of genetics and the presence of population differences in dental development has been long debated [1]. Investigators have shown differences in development of dentition in similar ethnic group living in different geographical areas as well as, ethnically dissimilar groups. There was a significant delay of 0.82 years in Ethnic Australian compared to UK Caucasians, aged 4 to 24 years [23]. Similarly, significant difference in dental development was observed between Saudi Arabian and Australian Caucasian children [24]. This was refuted by Liversidge & co-workers who found no difference in dental development amongst the Caucasian and Bangladeshi residents in the UK [25]. In our study, we found significant variations in most of the tooth developmental stages in UK Caucasians and HK Chinese populations. The overall difference between the age of attainment of the tooth developmental stages in Caucasian and Chinese was -0.40 years (5 months) indicating earlier dental maturity.
dentition in Chinese population. In contrast, the third molar development was advanced in Caucasians compared to Chinese on average by +0.94 years (11 months). A higher difference was observed in the root development stages (Stage E to Stage H) of third molars that was gradually progressive from 15 years to 20 years and this trend was observed in both maxillary and mandibular third molars and in both sexes. This may be attributed to post pubertal growth variations in the Caucasians and its possible influence on the dental maturity of third molars [26].

The minimum age of subjects included in the HK Chinese and UK Caucasian databases were 2.69 years and 3.65 years respectively. Despite our best efforts to cover all the tooth development stages, some earlier stages of development could not be recorded, for example UL1A, UL1B and UL1C. This was due to a small number of subjects that were available for comparison in the earlier tooth development stages. This could be possibly addressed by including more number of subjects in the younger range in the UK Caucasian group as there were sufficient number of children in the HK Chinese group. However, there is a potential challenge to this as it is difficult to obtain panoramic radiographs for younger children around 2 years as the radiographs have limited diagnostic value for this age. It is to be noted that all the radiographs employed in the study were primarily taken for diagnostic purposes and were used in treatment planning of various dental conditions. Those radiographs had been re-used in the current study.

It is to be noted that the data presented in this study had been censored to exclude the outlier values thus enabling comparison between the UK Caucasian and HK Chinese tooth development stages. The data distributed beyond 3 standard deviations of the mean was considered as outlier and thus excluded. This outlier values might have arisen due to manual
error in data entry process or extreme variations in dental development of individuals included in the study. The above criteria was applied to all tooth development stages except Stage H since it is unlimited in its upper border. Hence, for Stage H, the upper age limit was determined using percentile values rather than ± 3SD. The management of data for tooth development stages including third molars had been presented in our earlier paper [27]. Both UK Caucasians and HK Chinese reference datasets used in the current had been validated and the have shown to accurately estimate the age of subjects in respective populations [21,22]. The use of population specific reference dataset for dental age estimation has been emphasized in a recent study that showed accurate estimation of age of southern Chinese subjects when utilizing population specific dataset compared to non-population specific datasets [28].

Dental maturation is a sequential process and there are several staging system to capture this development. This ranges from 4 to 32 different stages [29,30]. The Anglo-Canadian classification system was employed in this study since this 8-stage method has relatively higher reliability [17]. This was reflected in “almost perfect’ and “substantial” inter- and intra-examiner reliability scores respectively [18]. Using this staging system, stage to stage comparison of tooth development for all the maxillary and mandibular teeth in Caucasian and Chinese populations was conducted. This included number, mean age at assessment and its standard deviation for each tooth developmental stage. This comparison method was employed in earlier in Afro-Trinidadians and Maltese populations [10,11]. Development and validation of reference data in other identifiable human groups can shed more light on the population differences in dental development, a topic that has been still debated amongst the investigators.

5. Conclusions
This study strongly suggest the presence of variations in dental development amongst the Caucasian and Chinese population groups. Overall, the HK Chinese were dentally advanced than the UK Caucasians by an average of 5 months, however, reverse trend was observed in third molars in which UK Caucasians were advanced than HK Chinese by 11 months. These findings must be considered whilst utilising population specific reference dataset for dental age estimation.

Acknowledgements
The authors would like to thank Professor Nigel King, University of Western Australia and Dr Hai Ming Wong, University of Hong Kong for their help in the preparation of Hong Kong Chinese dental reference dataset.
References


Figures

Figure 1. Dental maturation of maxillary and mandibular left third molars in United Kingdom Caucasian and Hong Kong Chinese males.
**Figure 2.** Dental maturation of maxillary and mandibular left third molars in United Kingdom Caucasian and Hong Kong Chinese females.
Legends

Tables

Table 1. Distribution of samples in the United Kingdom (UK) Caucasians and Hong Kong (HK) Chinese populations.

<table>
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<th>Age</th>
<th>UK Caucasian</th>
<th>HK Chinese</th>
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Table 2. Summary data of tooth development stages in Hong Kong (HK) Chinese and United Kingdom (UK) Caucasians males.

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<td>88 5.74 0.67 -0.39 0.160</td>
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</tr>
<tr>
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</tr>
<tr>
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<td>67 9.89 1.21 -1.23 0.000*</td>
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</tr>
<tr>
<td>UL1Em</td>
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<td>336 13.33 1.92  &lt;</td>
</tr>
<tr>
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<td>44 2.97 0.51 -2.45 0.000*</td>
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</tr>
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* British Dental Journal Classification system, TDS – tooth development stages, n-tds - number of tooth development stages, x-tds – average age of attainment of tooth development stages, sd-tds – standard deviation of tooth development stages, m – males, f – females, * independent sample t-test, *significance p < 0.05, < Chinese advanced than Caucasians, > Caucasians advanced than Chinese.
Table 3. Summary data of tooth development stages in Hong Kong (HK) Chinese and United Kingdom (UK) Caucasians females.

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| UL7cf | 69 | 5.63 | 0.58 | -0.54 | 0.168 | 12 | 6.17 | 1.25 | <  |
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| UL7Gf | 92 | 13.27 | 1.47 | 0.21 | 0.271 | 151 | 13.07 | 1.37 | >  |
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| UL8ff | 47 | 18.31 | 2.00 | 2.09 | 0.000* | 193 | 16.22 | 1.30 | >  |
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| UL8Hf | 117 | 22.35 | 1.88 | 3.45 | 0.000* | 88 | 18.89 | 1.23 | >  |

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* British Dental Journal Classification system, TDS – tooth development stages, n-tds - number of tooth development stages, x-tds – average age of attainment of tooth development stages, sd-tds – standard deviation of tooth development stages, m – males, f – females, ^ independent sample t-test, *significance p < 0.05, < Chinese advanced than Caucasians, > Caucasians advanced than Chinese.