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1 **Testing the London Atlas for age estimation in Thai population**

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1 Testing the London Atlas for age estimation in Thai population

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3 ABSTRACT

4 **Objectives:** to test the London atlas for dental age estimation in Thai population.

5 **Materials and methods:** The London atlas for age estimation was tested in 111 digital
6 panoramic radiographs from the General Police Hospital, Bangkok, Thailand. The sample was
7 composed of children (57♂ and 54 ♀) aged between 4.00 and 15.99 years. The intra- and inter-
8 examiner variations of tooth stage reliability were tested in a random-10% sample using an
9 Intraclass Correlation (ICC). The difference between chronological age (CA) and atlas for
10 dental age (ADA) were investigated using a paired subjects *t*-test. The significance of the
11 difference between CA and ADA was tested using the F-tests of the one-way ANOVA
12 ($P < 0.05$ considered statistically significant). The analysis of variance considered the effects
13 of sex, age group and the interaction between sex and age group. Other analyses included the
14 difference of ADA by age group and the comparison between CA and ADA by sex. SPSS
15 Statistics 24 was used for all analyses.

16 **Results:** ADA correlated to CA with a discrepancy of 1.3 years maximum. There was no
17 significant effect of sex ($F(1, 87) = 0.278, p = .600$), age group ($F(11, 87) = 1.032, p = .426$)
18 and sex and age group ($F(11, 87) = 1.238, p = .275$) between CA and ADA.

19 **Conclusions:** The estimates of dental ages correlate and reasonably reflect the chronological
20 ages of Thai children and adolescents for both males and females from age 4.00 to age 15.99.

21

22 **Key words:** dental age estimation, Thailand, children, London Atlas

23

24 Introduction

25 There are many aspects in which the evaluation of age in the living has become relevant but
26 the most prevalent concern issues include refugee and asylum seekers, criminals and their
27 victims, human trafficking and child pornography [1, 2]. Many techniques have been devised
28 to estimate chronological age including somatic growth measurements and dental
29 development. The somatic development is influenced by genetic, nutritional, climatic,
30 hormonal, and environmental factors but dental development is less affected [3, 4]. Age can
31 be estimated in children and adolescents by development of deciduous and permanent teeth,
32 prior to completion of the third molar [5]. After that, age can only be assessed by regressive
33 changes in teeth [6]. Methodologies for age estimation in children based on tooth development
34 may be divided into those using the atlas approach and those using scoring systems[7].The

1 London Atlas of tooth development and eruption is an example of atlas composed of designed
2 diagrams of dental age represented by median stages of dental development and alveolar
3 eruption[8]. It represents a substantial improvement on existing atlases facilitating accurate age
4 estimation from developing teeth.

5 The correlation between the dental age and the chronological age in Thai population has been
6 explored in few studies. A study on dental age estimation in Thai population aged from 6 to 15
7 years tested the accuracy of *Demirjian et al.* and *Willems et al.* methods [9] and the results
8 showed a strong correlation. Moreover, another study on third molar development in Thai
9 population aged from 9 to 20 years also presented a good correlation[10]. It is important to
10 recognize that more studies should be carried out, therefore, the main aim of this study was to
11 test the London atlas for the dental age estimation in Thai population.

12 **Materials and methods**

13 Ethical approval was granted from the Ethic Review Committee for Human research, Police
14 General Hospital, Bangkok, Thailand (COA No 94/2016). The London atlas for age estimation
15 was tested in 111 digital panoramic radiographs from the General Police Hospital, Bangkok,
16 Thailand. The sample was composed of children (57♂ and 54 ♀) aged between 4.00 and 15.99
17 years. The chronological age of each subject was calculated by subtracting the date of birth
18 from the date of radiographic examination. Inclusion criteria included good quality panoramic
19 radiographs of healthy children with no medical history of systemic diseases/disorders.
20 Children who presented hypodontia, hyperdontia, gross pathology and previous orthodontic
21 treatment or severe malocclusion were excluded. The distribution between female and male
22 was almost equal in order to avoid age mimicry as seen in table 1. The radiographs were
23 assessed by the main author using the sex-specific application software to determine the
24 developmental and eruption stages of all teeth in the left side, both upper and lower jaws,
25 according to AlQahtani *et. al.* [8]

26 **Table 1:** Number of radiographs (N) distributed by age group (years) and sex.

27 **Statistical analysis**

28 A ~~random~~-10% sample of radiographs was scored by the main author twice in an interval of
29 one week. The same radiographs were scored by the co-author. The inter- and intra-examiner
30 variations were tested using an intraclass Correlation (ICC).

31 The difference between CA and ADA were investigated using a paired subjects *t*-test. The
32 dental age estimation was defined as how closely chronological age could be predicted,
33 measured as the difference between chronological age (CA) and atlas for dental age (ADA) for

1 each subject. The chronological age was subtracted from the dental age and a positive result
 2 indicates an overestimation and a negative result indicates an underestimation. The significance
 3 of the difference between CA and ADA was tested using the F-tests of the one-way ANOVA.
 4 The analysis of variance considered the effects of sex, age group and sex & age group [lowest
 5 variance, highest variance), ($P < 0.05$ considered statistically significant)]. Other analyses
 6 included the difference of ADA by age group and the comparison between CA and ADA by
 7 sex. SPSS Statistics 24 was used for all analyses.

8 **Results**

9 The inter- and intra-examiner variations results indicated an extremely high level of reliability
 10 with a single measure ICC of 0.997 (~~95% confidence interval: 0.991,0.999~~) and 0.983 (~~95%~~
 11 ~~confidence interval: 0.937, 0.995~~) respectively. ~~The results between the chronological age and~~
 12 ~~atlas for dental age indicated an extremely high level of agreement with a single measures ICC~~
 13 ~~of 0.970 (95% confidence interval: 0.956, 0.979; $p < .001$).~~ A paired subjects t-test on the
 14 chronological age scores versus atlas for dental age scores resulted in the mean difference of
 15 0.1 (CA: 9.94; ADA: 9.84) and there was no significant difference observed.

16 There was no significant effect of sex ($F(1, 87) = 0.278, p = .600$), age group ($F(11, 87) =$
 17 $1.032, p = .426$) and the interaction between sex and age group ($F(11, 87) = 1.238, p .275$)
 18 between CA and ADA. The ~~values of the estimation of the variation for the sample pooled~~
 19 ~~difference of ADA~~ by age group can be seen in table 2. The graph (figure 1) shows that subjects
 20 whose ADA is greater than CA can be seen above the zero mark and those below presented
 21 ADA less than CA.

22 The results show an inverse correlation in the ages of 4 and 6 for both sexes. The London atlas
 23 of tooth development underestimated the ages of 7, 8 and 9 (- 0.5 years) for both females and
 24 males. At the age of 10 years old, the difference was of - 1.3 years for females whilst the
 25 difference was almost zero for males. Overestimation was noted around the age of 12 and 14
 26 within 0.5 years and underestimation at the age of 15 within 0.5 year. Overall, the results are
 27 almost identical in performance. The comparison between CA and ADA by sex can be seen in
 28 figure 2.

29 **Figure 1:** ~~Error of London Atlas as a function of sex and age in years~~ **Difference between ADA**
 30 **and CA according to sex and age group** (x=age group; y= **difference error**; female represented
 31 by dark grey color and male represented by light grey color).

32 **Figure 2:** Comparison between chronological and atlas for dental age (years) by sex.

1 **Table 2: Difference of ADA by age group**

2 **Discussion**

3 The London Atlas of tooth development and eruption has been tested in different countries
4 such as Portugal, the Netherlands, the United States, Canada, France, the United Kingdom[8],
5 New Zealand, Spain, Italian, and Saudi Arabian[11]. The results from previous studies
6 presented no statistically significant difference between estimated age and chronological age
7 and the average difference was of +/- 1 year [11, 12].

8 In this study, the age estimation produced a discrepancy of 1.3 years. Although the differences
9 in age estimation were small among males and females aged 4 to 15 years old, these differences
10 became significant only in the female at the age of 10 years old which presented an
11 underestimation. In general, the permanent dentition in females is completed earlier than in
12 males[13]; therefore, this specific age group has not followed the normal trend. Mean ages are
13 affected by the age constitution of the reference sample and a possible bias is known as age-
14 mimicry[14]; therefore, the results of age estimation methods without fully considering the
15 impact of 'age mimicry' and individual variation[15] might not reflect the real biological
16 profile. Hence, this methodology should be tested in other countries part of the Association of
17 Southeast Asian Nations (ASEAN) community. The limitation of the study was the reduced
18 number of radiographs because children do not usually take radiographs for diagnosis and
19 treatment plan. As a matter of radiation protection, the exposure to ionizing radiation must be
20 kept low in young persons, because their tissues are highly radiosensitive[16]. Further research
21 should test other age ranges using this method in Thai population.

22 **Conclusion**

23 The study indicates that the estimates of dental ages correlate and reasonably reflect the
24 chronological ages of Thai children and adolescents for both males and females from age 4.00
25 to age 15.99. Moreover, this study provided the reference data of Thai children and adolescents
26 using London Atlas of tooth development and eruption which has not been previously reported
27 in this population.

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1 Declaration of interest statement

2 The authors report no conflicts of interest.

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