I-O-F-O-S

JOURNAL of FORENSIC ODONTO-STOMATOLOGY

VOLUME 30 Number 2 December 2012

SECTION AGE ESTIMATION

Dental Age Estimation in Japanese Individuals Combining Permanent Teeth and Third molars.

Namratha Ramanan [1]. Patrick Thevissen [1]. Steffen Fieuws [2]. G.Willems [1]

[1] *1. Department of Oral Health Sciences, KU Leuven & Dentistry, University Hospitals Leuven, Belgium*

[2] *I-BioStat, Katholieke Universiteit Leuven and University Hasselt, Belgium*

Centre of Forensic Dentistry, Katholieke Universiteit Leuven, Kapucijnenvoer 7, B-3000

Corresponding author: *guy.willems@med.kuleuven.be*

The authors declare that they have no conflict of interest.

ABSTRACT

The study aim was, firstly, to verify the Willems et al. model on a Japanese reference sample. Secondly to develop a Japanese reference model based on the Willems et al. method and to verify it. Thirdly to analyze the age prediction performance adding tooth development information of third molars to permanent teeth.

Retrospectively 1877 panoramic radiographs were selected in the age range between 1 and 23 years (1248 children, 629 sub-adults). Dental development was registered applying Demirjian 's stages of the mandibular left permanent teeth in children and Köhler stages on the third molars. The children's data were, firstly, used to validate the Willems et al. model (developed a Belgian reference sample), secondly, split ino a training and a test sample. On the training sample a Japanese reference model was developed based on the Willems method. The developed model and the Willems et al; model were verified on the test sample. Regression analysis was used to detect the age prediction performance adding third molar scores to permanent tooth scores.

The validated Willems et al. model provided a mean absolute error of 0.85 and 0.75 years in females and males, respectively. The mean absolute error in the verified Willems et al. and the developed Japanese reference model was 0.85, 0.77 and 0.79, 0.75 years in females and males, respectively. On average a negligible change in root mean square error values was detected adding third molar scores to permanent teeth scores.

The Belgian sample could be used as a reference model to estimate the age of the Japanese individuals. Combining information from the third molars and permanent teeth was not providing clinically significant improvement of age predictions based on permanent teeth information alone.

KEYWORDS: *Forensic science, Forensic Odontology, Dental Age Estimation, Willems method, Third molars.*

JFOS. December 2012, Vol.30, No.2 Pag 34-39
ISSN :2219-6749

INTRODUCTION

Errors in age estimation can be calculated subtracting the predicted age from the chronological age of an individual. Dental age estimations provide the smallest errors using age related tooth developmental variables, especially in children. The main reason is that in children developmental variables can be observed in multiple tooth types and positions and that they can be combined [1]. In sub-adults only third molar(s) development can be considered [2,3]. The development of the seven lower left permanent teeth is used by diverse authors to estimate the age of children until 16 year[4, 5]. In these children the technique described by Willems et al. provides most accurate age predictions[1]. Since third molars start developing in children at the age of 7, they can be considered as an additional age predictor in children[2,6]. Another possible aspect influencing dental age prediction outcomes is discrepancies between the origin of the individuals in the used reference sample and the individual whose age has to be predicted. Verifying an age prediction model developed on a reference population similar in origin as the verification sample and a model developed on a non corresponding reference sample, can reveal possible disagreements[7,8]. Therefore the population considered in the current study was Japanese, allowing to check the performances of the Willems et al. model developed on a reference sample of 2116 Belgium children.

In Japan specific ages are of forensic interest. The national age of sexual consent is 13 years, as specified by the Japanese Penal Code Articles 176 and 177. 'Art. 177 Penal Code ' stipulates that a person who has sexual intercourse (through violence or intimidation) with a female person of not less than 13 years, commits the crime of rape and shall be punished with imprisonment at forced labor for a limited term of not less than two years. Art. 176 Penal Code states that a person who, through violence or intimidation, commits an indecent act upon a male or female person of less than 13 years shall be punished with imprisonment at forced labor for not less than six months no more than seven years. The same shall apply to a person who commits an indecent act upon a male or female person less than 13 years. The Japanese age of majority is 20 years and at the age of 18 year a license to drive can be obtained.

The aim of this study was, to verify the Willems et al. model on a Japanese sample, to construct a Japanese reference model based on the Willems et al. method, and to verify this reference model, and to analyze the age prediction performance adding tooth development information from third molars to permanent teeth.

Materials and Methods

Digitally collected panoramic radiographs of 1877 Japanese individuals (n=1877) with verified chronological age between 1 and 23 year were gender specific selected (Table1). In each age category of 1 year, starting at 5 years, around 50 male and female individuals were selected. Individuals with observed dental pathology influencing tooth development were excluded. The collected sample was divided into children (n=1051) with age between 5 and 15.99 year and sub-adults (n=826) between 16 and 23year. Care was taken that in the sub-adult group at least one third molar was present. In the children dental maturity of the lower left permanent teeth (except the third molar) was registered, using the 8 point staging technique proposed by Demirjian et al.[4]. The maturity of all present third molars was registered the 10 point staging

technique proposed by Gleiser et al.[9], modified by Kohler et al.[10]. In case different developmental stages were observed on the diverse roots of a third molar, the lowest stage was registered. The staging was facilitated using the image ameliorating tools of Adobe®Photoshop® CS2 version 9.0 photo editing software. In particular the image magnification, contrast and brightness were optimized.

The children sample was used to verify the Willems et al.[5] model.

Table1: Age and sex distribution of Japanese sample

SEX	N	MEAN	STD	MEDIAN	MIN	MAX	Q1	Q3
F+M	1877	13.9	5.0	14.2	0.5	23.8	9.7	17.7
F	974	14.2	5.2	14.5	0.5	23.8	9.9	18.2
M	903	13.6	4.8	14.0	5.0	22.9	9.4	17.3

F= female, M=male, N= number, STD= standard deviation, MIN= minimum age, Max= maximum age, Q1= first quartile, Q3= third quartile. All values (except N) are expressed in years.

Randomly, but stratified on age and gender, the children sample was split into a training (n=532) and a test (n=519) sample. On the training sample a Japanese reference model, based on the Willems et al. method, was developed. The test sample was used to verify the new developed Japanese reference model and the Willems et al. model.

The error in age predictions was calculated subtracting the estimated age from the chronological age. Calibrations of the error were obtained calculating mean error (ME), quantifying the direction of the error (positive ME= underestimation); mean absolute error (MAE), quantifying the magnitude of the error and the root mean square error (RMSE), enabling to quantify the variability in errors (giving more weight to large errors).

On all subjects with registered Demirjian stages on the mandibular left permanent teeth (PM) and Gleiser et al. stages, modified by Köhler on third molars, regression models were developed: a model with only PM, a model with only TM and a model with PM and TM as predictor(s) and age as response. The RMSE were calculated from the models to evaluate the magnitude of the error in age prediction.

All statistical analyses were done using the SAS software, version 9.2 of the SAS system for windows (SAS

Results

Verification of the Willems et al. model on the Japanese children sample provided overestimated age predictions (ME=-0.02 year, MAE= 0.80 year, RMSE= 1.10 year). Comparing the predictions from the new constructed Japanese reference model and the Willems et al. model resulted in comparable calibration measures, except for the difference in ME in females (0.14 year).(Table 2).

In the Japanese children the smallest RMSE values were obtained from the model with only PM compared to the model with only TM and the model with PM and TM combined. The RMSE values were not constant over the different age categories (Table 3)

Discussion

The differences in ME, MAE and RMSE between the prediction from the Willems et al. model and the prediction from the new constructed Japanese reference model reflect the usefulness of the Belgian population as reference. A factor

Table 2: Mean error, mean absolute error and root mean squared error in females and males verifying the Willems et al. and the Japanese reference model on the test sample**.**

	FEMALE							MALE						
Model	**n**	**ME**	**SD**	**MAE**	**SD**	**RMSE**	**95% CI**	**n**	**ME**	**SD**	**MAE**	**SD**	**RMSE**	**95% CI**
Willems et al.	257	0.08	1.10	0.85	0.70	1.10	1.01;1.20	262	-0.06	0.97	0.77	0.59	0.97	0.89;1.06
Japanese reference	257	-0.06	1.04	0.79	0.67	1.04	0.95;1.13	262	-0.09	0.95	0.75	0.58	0.95	0.87;1.03

n= number; ME= mean error; SD: standard deviation; MAE: mean absolute error; RMSE: root mean square error; CI: confidence interval

Table3: Root mean square errors from the regression model with only permanent teeth, only third molar and the combined tooth development information as predictor(s) and age as response.

	Female			Male		
Age category	**RMSE PT**	**RMSE TM**	**RMSE PT+TM**	**RMSE PT**	**RMSE TM**	**RMSE PT+TM**
<8 years	0.80 (0.67;0.94)	1.97 (1.65;2.30)	0.76 (0.63;0.88)	0.77 (0.64;0.89)	2.31 (1.91;2.68)	0.75 (0.63;0.88)
8-10 years	1.03 (0.81;1.25)	0.81 (0.64;0.98)	0.91 (0.72;1.10)	1.01 (0.80;1.22)	0.58 (0.46;0.70)	0.94 (0.75;1.14)
10-12 years	1.43 (1.11;1.75)	1.83 (1.41;2.24)	1.45 (1.13;1.78)	1.18 (0.93;1.44)	1.80 (1.41;2.20)	1.19 (0.93;1.45)
12-14 years	0.79 (0.60;0.97)	2.62 (2.00;3.24)	0.890 (0.69;1.11)	0.92 (0.71;1.13)	2.82 (2.18;3.47)	0.90 (0.70;1.11)
14-16 years	1.26 (0.98;1.54)	2.89 (2.24;3.54)	1.27 (0.98;1.56)	0.98 (0.75;1.21)	2.71 (2.06;3.36)	1.03 (0.78;1.28)
8-16 year	1.06 (0.96;1.16)	2.09 (1.90;2.29)	1.05 (0.95;1.14)	0.96 (0.87;1.05)	2.16 (1.96;2.36)	0.95 (0.86;1.04)

RMSE: root mean square error; PT permanent teeth; TM: third molars

influencing these comparable results was the difference in size of the current Japanese training set (n= 539) and the set of subjects used by Willems et al. to develop their prediction model (n= 2116). In the Willems et al. model no linearity assumption was made with respect to the

Demirjian scores. Therefore, the same approach was being used in the current analysis. Allowing non-linearity by using the score as a categorical predictor in the regression model, increases the risk of overfitting. This phenomenon will be stronger, the smaller the training data set

and is therefore another factor possibly influencing the study results. The fact that the results of the verification of the Willems et al. model on the Japanese children sample, provided similar or better age prediction results than the verified new

developed Japanese reference model, additionally justifies the use of the Willems et al.[5] model for age estimations in Japanese children.

Liversidge et al.[11] concluded that significant differences in Demirjian's dental maturity method in different groups are incorrectly interpreted as population differences. This conclusion is confirmed in the current study. Indeed the used Willems et al. model was derived from the Demirjian's dental maturity method and the obtained results of the verified new developed Japanese reference model and the Willems et al. Belgium reference model did reveal similar results in age predictions. The fact that the test sample used for this verification was from Japanese origin had no influence on the error in age prediction.

In the Japanese children an overall decrease in RMSE values (age range 8-16 year) was detected adding TM information to PM information. This decrease was not big enough to provide better RMSE values than obtained with PM information alone. Moreover added TM information to PM information decrease the RMSE values obtained from PM information alone. These finding proofs that only the combined age related information of the mandibular left 7 permanent teeth (PM) should be considered for optimal age predictions in (Japanese) children.

An age of forensic interest in Japan is the age of 13 years because the punishment of a crime committed to on a child above or under this age will be different. It was found that in this age category adding third molar development information to the permanent teeth development information was not decreasing the obtained RMSE values. Therefore in a Japanese population the ages in this particular age category are at best estimated based on the permanent teeth information alone.

Conclusion

The Belgian population used as a reference sample to develop the Willems et al. age prediction model was proven useful in Japanese children. In Japanese children age related information collected from third molars and permanent teeth provided no or clinically insignificant improvement in age prediction accuracy.

.

REFERENCES

1. [1] M. Maber, H.M. Liversidge, M.P. Hector. Accuracy of age estimation of radiographic methods using developing teeth, Forensic Sci. Int. 2006 159 S68–S73.
2. [2] H. M. Liversidge,.Timing of human mandibular third molar formation, Annals of Human Biology, 2008 35:3 ,294S.
3. [3] P.W.Thevissen, S Fieuws, G. Willems, Human dental age estimation using third molar developmental stages: does a Bayesian approach outperform regression models to discriminate between juveniles and adults? Int J Legal Med. 2010 124(1):35-42.
4. [4] A. Demirjian, H. Goldstein, J.M. Tanner, A new system of dental age assessment, Hum. Biol.1973 45 211–227.
5. [5] G.Willems, A. Van Olmen, B. Spiessens, C Carels. Dental age estimation in Belgian children: Demirjian's technique revisited, J Forensic Sci.2001 46(4):893-5.
6. [6] P.W.Thevissen, S.Fieuws, G.Willems, Third molar development: measurements versus scores as age predictor.Arch Oral Biol. 2011 56(10):1035-40.
7. [7] P.W.Thevissen, A. Alqerban, J. Asaumi, F. Kahveci, J. Kaur,Y.K. Kim, P.Pittayapat, M.Van Vlierberghe, Y. Zhang, S. Fieuws, G. Willems, Human dental age estimation using third molar developmental stages: Accuracy of age predictions not using country specific information, Forensic Sci Int. 2010, 201(1-3):106-11.
8. [8] P.W.Thevissen, S. Fieuws, G. Willems, Human third molars development: Comparison of 9 country specific populations, Forensic Sci Int. 2010, 201(1-3):102-5.
9. [9] I. Gleiser, E. Hunt, The permanent first molar: its calcification, Am. J. Phys. Anthropol. 13 (1955) 253–284.
10. [10] S. Kohler, R. Schmelzle, C Loitz, K. Puschel, Development of wisdom teeth as a criterion of age determination, Ann. Anat. 1994 176:339–345.

11. [11] H.M. Liversidge, Interpreting group differences using Demirjian's dental maturity method, Forensic Sci Int. 2010 Sep 10;201(1-3):95-101.

*****