G18 Magnetic Resonance Imaging (MRI) of Third Molars, Clavicles, and Wrists for Age Estimation: A Combined Bayesian Approach

Jannick De Tobel, MD, Ghent University, Department of Radiology, Gent, Oost-Vlaanderen 9000, BELGIUM; Elke Hillewig, MSc, Universiteit Gent, Vakgroep Radiologie, Gent 9000, BELGIUM; Ines Phlypo, DDS, Universiteit Gent, Vakgroep Tandheelkunde, Gent 9000, BELGIUM; Michiel B. de Haas, BSc, Netherlands Forensic Institute, The Hague 2497 GB, NETHERLANDS; Mayonne Van Wijk, MSc, Netherlands Forensic Institute, The Hague 2497 GB, NETHERLANDS; Steffen Fieuws, Leuven, VB , BELGIUM; Koenraad L. Verstraete, PhD, Universiteit Gent, Vakgroep Radiologie, Gent 9000, BELGIUM; Patrick W. Thevissen, PhD, KULeuven, Leuven, Vlaams-Brabant B-3000, BELGIUM*

Learning Overview: After attending this presentation, attendees will understand how combining MRI of third molars, clavicles, and wrist for age estimation leads to a sounder age estimation.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by elaborating on the emerging field of radiation-free age estimation by means of MRI. It will be demonstrated that age estimation performance increases when combined information is used, provided that an appropriate statistical approach is applied.

Background: Currently, forensic age estimation in living adolescents and subadults is based on radiographs and Computed Tomography (CT) imaging.[1,2] These techniques imply an exposure to ionizing radiation outside a medical diagnostic or therapeutic indication. Therefore, their use is prohibited in age estimation cases in several countries. Moreover, these techniques have mostly been studied applied to one anatomical structure at a time in a retrospective design. Unfortunately, to this day, we do not know how the development of different anatomical structures correlate to each other. Consequently, we do not know how to appropriately combine results from studies focusing on one structure at a time.

To counter these drawbacks of the current approach, several research groups are studying the use of MRI of different anatomical structures for age estimation in living adolescents and subadults. So far, only one group has published results of a combined MRI approach, including third molars, both clavicles, and the left wrist.[3] Based on deep convolutional neural networks, they obtained a mean absolute error of 1.14 years (standard deviation 0.96 years). They defined the proportion of correctly identified minors as sensitivity, which equaled 88.6%. However, they did not report how the development of the different anatomical structures correlated to each other.

Purpose: (1) To introduce a Bayesian approach for age estimation based on MRI of third molars, both clavicles, and the left wrist; (2) to study its age estimation performance and its ability to discern minors from adults; and (3) to study how the development of the different anatomical structures correlates to each other.

Materials and Methods: According to the Ghent protocols, 3-Tesla MRI was conducted of all third molars, both clavicles, and the left wrist in 302 healthy Caucasian volunteers (160 females, 142 males) between 14 and 26 years of age.[4-6] Images were then assessed, applying an optimal staging technique for the development of these anatomical structures, as suggested in previous papers.[5,7,8] Several human observers assessed the images to study reproducibility. Consequently, the data were imported into the Leuven validated Bayesian ad hoc procedure for age estimation.[9] This allowed defining the correlation between the different anatomical structures' development. Moreover, the Bayesian model allowed comparing age estimation performance when different combinations of anatomical structures were included in the model. Accuracy of the models was compared by calculating the Mean Absolute Errors (MAE) and Root Mean Squared Errors (RMSE). Furthermore, the width of confidence intervals and their coverage were calculated, as was the ability to discern minors from adults by comparing diagnostic statistics (sensitivity, specificity, and discrimination slope) and calculating probabilities to have reached the 18-year threshold.

Hypothesis: Combining the MRI information of all third molars, both clavicles, and the left wrist will render a better age estimation performance than the separate approaches in living adolescents and subadults. Since this is ongoing research, there were no results available at the time this abstract was submitted to confirm or reject the hypothesis.

Reference(s):

1. Schmeling A., Dettmeyer R., Rudolf E., Vieth V., Geserick G. Forensic Age Estimation. *Deutsches Arzteblatt International*. 2016 Jan 29;113(4):44-50.
2. Thevissen P.W., Fieuws S., Willems G. Human Dental Age Estimation Using Third Molar Developmental Stages: Does a Bayesian Approach Outperform Regression Models to Discriminate Between Juveniles and Adults? *International Journal of Legal Medicine*. 2010 1/2010;124(1):35-42.
3. Štern D., Kainz P., Payer C., Urschler M. Multi-Factorial Age Estimation From Skeletal and Dental MRI Volumes. In: *International Workshop on Machine Learning in Medical Imaging*, 2017; Quebec City, Canada. Springer; 2017. p. 61-9.
4. De Tobel J., Hillewig E., Bogaert S., Deblaere K., Verstraete K. Magnetic Resonance Imaging of Third Molars: Developing a Protocol Suitable for Forensic Age Estimation. *Annals of Human Biology*. 2017 Mar; 44(2):130-9.
5. De Tobel J., Hillewig E., de Haas M.B., Van Eeckhout B., Fieuws S., Thevissen P., et al. Forensic Age Estimation Based on T1 SE and VIBE Wrist MRI: Do a One-Fits-All Staging Technique and Age Estimation Model Apply? In progress. 2018.
6. Hillewig E., De Tobel J., Cuche O., Vandemaele .P, Piette M., Verstraete K. Magnetic Resonance Imaging of the Medial Extremity of the Clavicle in Forensic Bone Age Determination: A New Four-Minute Approach. *European Radiology*. 2011 Apr;21(4):757-67.
7. De Tobel J., Hillewig E., van Wijk M., Fieuws S., Thevissen P., Verstraete K. Staging Clavicular Development on Magnetic Resonance Imaging: Pitfalls and Recommendations for Age Estimation. In progress. 2018.
8. De Tobel J., Phlypo I., Fieuws S., Politis C., Verstraete K.L., Thevissen P.W. Forensic Age Estimation Based on Development of Third Molars: A Staging Technique for Magnetic Resonance Imaging. *The Journal of Forensic Odonto-Stomatology*. 2017 Dec 1;35(2):117-40.
9. Fieuws S., Willems G., Larsen-Tangmose S., Lynnerup N., Boldsen J., Thevissen P. Obtaining Appropriate Interval Estimates for Age When Multiple Indicators Are Used: Evaluation of an Ad-Hoc Procedure. *International Journal of Legal Medicine*. 2016 Mar;130(2):489-99.

Age Estimation, Combined Dental and Skeletal, Magnetic Resonance Imaging