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# Dental Age Estimation in Belgian Children: Demirjian's Technique Revisited*

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**ABSTRACT:** Aim: The purpose of this study was to evaluate the accuracy of Demirjian's dental age estimation (1,2) in children in a Belgian Caucasian population and to adapt the scoring system in case of a significant overestimation as frequently reported. We selected 2523 orthopantomograms of 1265 boys and 1258 girls, of which 2116 (1029 boys and 1087 girls) were used for estimating the dental age with the Demirjian's technique. The 407 other orthopantomograms were beyond the original age limit (1). A second sample of 355 orthopantomograms was used to evaluate the accuracy of the original method and the adapted method. A signed-rank test was performed to search for significant age differences between the obtained dental age and the chronological age. A weighted ANOVA was performed in order to adapt the scoring system for this Belgian population. The overestimation of the chronological age was confirmed. The adapted scoring system resulted in new age scores expressed in years and in a higher accuracy compared to the original method in Belgian Caucasians.

**KEYWORDS:** forensic science, forensic odontology, dental age estimation, Demirjian

The method of Demirjian et al. (1,2) is, among other techniques reported (3,4), useful in estimating the chronological age of children based on their dental age, i.e., of children with unknown birth data which is often true for adopted children or of children committing legal offenses. The technique may also be used to estimate the age of unidentified skeletons belonging to children. The advantage of Demirjian's technique, which is a scoring system based on the use of developmental stages of teeth, is that the predicted dental age is relatively accurate since it is not based on the eruption process of teeth. It is indeed commonly accepted that tooth eruption as an evaluation method for dental age estimation has some limitations, since tooth eruption is heavily influenced by environmental factors such as available space in the dental arch, extraction of deciduous predecessors, tipping, or impaction of teeth. Oppositely, the method for dental age estimation using developmental stages of teeth is more useful since tooth development is less influenced by environmental factors.

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The aim of the present study was to evaluate whether the dental age estimation in children according to Demirjian's method (1) would result in a significant and consistent overestimation of the chronological age—as reported in literature—when applied on a population of Belgian Caucasian origin, and, if so, to adapt the scoring system for this population.

## Materials and Methods

A first sample of the Belgian Caucasian population consisted of 2523 orthopantomograms or panoramic radiographs of 1265 boys (age ranging from 1.8 to 18.0 years) and 1258 girls (age ranging from 2.1 to 18.0 years) which were selected from patients' records of the University Hospitals of Leuven, School of Dentistry, Oral Pathology and Maxillofacial Surgery. On average, 84 orthopantomograms were selected for each age class of one year (15 age classes in total) from 3 to 18 years of age. Exclusion criteria were: age above 18.0 years at the time the orthopantomogram was taken; nonBelgian Caucasian origin; systemic diseases; premature birth; congenital anomalies; unclear orthopantomogram; aplasia of at least two corresponding teeth bilaterally in the mandible. Of this sample 2116 orthopantomograms (1029 boys and 1087 girls) could be used for estimating the dental age with the Demirjian's technique (1). The 407 other orthopantomograms were beyond the original border of this technique. A second sample of the Belgian Caucasian population consisted of 355 orthopantomograms of 195 boys (age ranging from 2.3 to 17.4 years) and 160 girls (age ranging from 2.4 to 18.0 years). The same selection criteria were applied. The second sample was used to evaluate and compare the accuracy of the original and the adapted dental age estimation method.

Dental age estimation was performed according to the method described in literature (1). Maturity scores, given according to developmental criteria of each of the seven left permanent teeth of the mandible, were summed to obtain an overall maturity score which was subsequently converted into a dental age using published conversion tables. A signed-rank test was performed to search for significant age differences between the dental age, obtained using the original method on the first sample, and the chronological age. The Bonferroni correction for multiple testing was performed.

A weighted ANOVA was performed on the data of the first sample using the General Linear Models procedure of the SAS statistical software package in order to adapt the scoring system for this Belgian Caucasian population. The ANOVA model used was an adative model with all seven teeth as covariates for boys and girls separately. No interactions were included in the model. Weighted ANOVA was used because the homoscedasticity assumption was not fulfilled.

The obtained data on dental age using the original and the adapted method on the second sample was analyzed for statistical differences with the chronological age using a signed-rank test. To compare the accuracy of both methods, the differences between the dental age of both methods was analyzed using a signed-rank test (SAS Statistical Software Package, SAS Institute, Cary, NC). The nonparametric signed rank test was preferred over the paired t-test because the normality assumption was often not satisfied.

## Results

Demirjian's method resulted in a consistent overestimation of the dental age for the first Belgian Caucasian sample, amounting to a median of 0.5 years for boys (mean: 0.4; standard deviation: 1.0) and a median of 0.6 years for girls (mean: 0.7; s.d.: 1.0). For almost each of the 13 age classes of this sample a significant difference was found between the chronological age and the estimated dental age, even after the Bonferroni correction. The most serious overestimations were found in the age class of 9 to 10 years for boys (median: 1.0; mean: 0.7; s.d.: 1.0) and 9 to 10 years for girls (median: 0.9; mean: 0.9; s.d.: 1.1) as well as 10 to 11 years for girls (median: 0.9; mean: 1.0; s.d.: 1.1).

In order to try and avoid this overestimation Demirjian's maturity scores were adapted using a weighted ANOVA on the data of the Belgian Caucasian sample. This resulted in new tables for boys and girls with age scores directly expressed in years (Tables 1,2). Calculating the overall maturity score by summing the adapted scores for the seven mandibular teeth directly results in the estimated dental age.

The accuracy of the adapted scores was tested on the second sample and compared to the accuracy of the original method when applied to the same sample. The adapted scoring system for dental age estimation resulted in more accurate predictions in the Belgian Caucasian sample. The original method resulted in an overestimation for boys (median: 0.4; mean: 0.5; s.d.: 1.0) and girls (median: 0.8; mean: 0.9; s.d.: 1.2) The new adapted method resulted in a smaller overestimation for boys (median: 0.1; mean: 0.0; s.d.: 0.9) and girls (median: 0.2; mean: 0.2; s.d.: 1.3) and was found to be more accurate in this Belgian Caucasian population. Actually the overestimation with the new adapted method for both boys and girls was found to be not statistically different from zero.

TABLE 1—*Developmental tooth stages according to Demirjian's technique (1) with corresponding age scores expressed directly in years for each of the seven left mandibular teeth in boys.*

| Tooth | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| Central incisor | . . . | . . . | 1.68 | 1.49 | 1.5 | 1.86 | 2.07 | 2.19 |
| Lateral incisor | . . . | . . . | 0.55 | 0.63 | 0.74 | 1.08 | 1.32 | 1.64 |
| Canine | . . . | . . . | . . . | 0.04 | 0.31 | 0.47 | 1.09 | 1.9 |
| First bicuspid | 0.15 | 0.56 | 0.75 | 1.11 | 1.48 | 2.03 | 2.43 | 2.83 |
| Second bicuspid | 0.08 | 0.05 | 0.12 | 0.27 | 0.33 | 0.45 | 0.4 | 1.15 |
| First molar | . . . | . . . | . . . | 0.69 | 1.14 | 1.6 | 1.95 | 2.15 |
| Second molar | 0.18 | 0.48 | 0.71 | 0.8 | 1.31 | 2 | 2.48 | 4.17 |

TABLE 2—*Developmental tooth stages according to Demirjian's technique (1) with corresponding age scores expressed directly in years for each of the seven left mandibular teeth in girls.*

| Tooth | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| Central incisor | . . . | . . . | 1.83 | 2.19 | 2.34 | 2.82 | 3.19 | 3.14 |
| Lateral incisor | . . . | . . . | . . . | 0.29 | 0.32 | 0.49 | 0.79 | 0.7 |
| Canine | . . . | . . . | 0.6 | 0.54 | 0.62 | 1.08 | 1.72 | 2 |
| First bicuspid | −0.95 | −0.15 | 0.16 | 0.41 | 0.6 | 1.27 | 1.58 | 2.19 |
| Second bicuspid | −0.19 | 0.01 | 0.27 | 0.17 | 0.35 | 0.35 | 0.55 | 1.51 |
| First molar | . . . | . . . | . . . | 0.62 | 0.9 | 1.56 | 1.82 | 2.21 |
| Second molar | 0.14 | 0.11 | 0.21 | 0.32 | 0.66 | 1.28 | 2.09 | 4.04 |

## Discussion

As expected from literature (5–8) an overestimation of chronological age when using the method reported by Demirjian was mostly found. In their original work they also reported that the possibility that the standards they obtained from a large sample of French-Canadian origin may not be valid in other populations and that perhaps adaptations should be made for other samples (1). Although, some authors, especially for a Swedish population, seem to confirm the validity of the original technique in view of the biological individual variation in dental maturity (9–11). When searching for applications of Demirjian's technique in literature this mainly results in a summation of reports mentioning an overestimation of chronological age or reports on inter- and intraexaminer variations when applying this technique (12,13). Only few reports were found showing adaptations made to the original technique based on dental age estimations in other populations such as South Indian (5) and Finnish samples (14). Therefore the maturity scores obtained from the total Belgian Caucasian sample were analyzed with a weighted ANOVA in order to create an adapted method for dental age estimation in Belgian Caucasians.

Different authors reported that dental maturation demonstrates few pubertal changes and thus is a poor indicator for the pubertal growth spurt (15). Therefore, overall dental maturity scores giving dental age scores after conversion from published tables were omitted by constructing new tables with maturity scores directly expressed in years (Tables 1,2). The sum of the values from these tables corresponding to the observed developmental stages of the seven left mandibular teeth directly results in the estimated dental age. In doing so it was stressed that dental maturation is rather independent from overall maturation in contrast to other maturational processes like skeletal or secondary sex character maturation, both of which are reported to be strongly correlated (16–18). In Table 2 some negative values were found as a consequence of performing a weighted ANOVA. They are caused by the phenomenon of multicolinearity. The obtained values are not to be considered separately, but are only meaningful in the total formula summing the maturity scores of all seven left mandibular teeth.

## Conclusion

As expected from literature, this study confirmed significant overestimation of the dental age in Belgian Caucasians using the original methods developed by Demirjian and coworkers (1). This is basically due to different rates of dental development in different populations.

The obtained data were used to create an adapted method for dental age estimation in a Belgian Caucasian population. The adapted method was validated and resulted in more accurate dental age estimations in this population, but may not be valid in other populations.

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