Using Dental Age to Estimate Chronological Age in Czech Children Aged 3–18 Years

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Abstract: The Demirjian methods to determine dental age are based on analysis of orthopantograms. The dental age estimation is based on establishing the tooth development stages. The purpose of this study was to assess the accuracy of estimation of dental age by Demirjian in the use of all of his four methods. 505 Czech healthy boys and girls aged 3 to 18 years were examined radiographically at the Department of Stomatology, Second Faculty of Medicine, Charles University in Prague. It was mentioned the factors of underlying diseases influence the accuracy of the dental age estimation. For statistical evaluation, descriptive statistics was used to compare deviations of the mean values of chronological and dental age in each age group. The resulting difference between dental age and chronological age is not significant in both genders only when using both Demirjian 7-teeth methods of 1973 and 1976. Therefore these may be most appropriately used for forensic age estimation. There are shown standard deviation differences in different countries. Demirjian's original 7-teeth method from 1973 and Demirjian's revised 4-teeth method from 1976 appear to be the best methods for calculating the dental age of healthy Czech children of both genders.

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Introduction

With the global migration of whole families, it is nowadays important to determine the actual chronological age (CA) of people for various reasons, chiefly to determine the actual CA of children applying for asylum. There are various means of estimating the chronological age of children, for example skeletal (Greulich and Pyle, 1959; Serinelli et al., 2011). In the opinion of Finnish authors Jaasaari et al. (2012), dental development is less affected by environmental issues than skeletal maturation, and for this reason the determination of dental development is more accurate for the estimation of CA than of skeletal development. Therefore the dental age (DA) is preferred for the estimation of CA in children. Knowledge of dental age significantly helps in determining endocrinologic diagnoses in children and in planning of orthodontic treatments. DA can also be used to determine the CA of unidentified dead bodies (Feijóo et al., 2012b). DA determination is based on evaluation of teeth development.

There are many methods (Someda et al., 2009; Guo et al., 2012) by different authors – Mincer (Pechnikova et al., 2011), Pyle (Varkkola et al., 2011), Greulich (Santoro et al., 2012) – they differ in the evaluation criteria. Demirjian et al. (1973) methods are the most commonly used worldwide; they evaluate orthopantomograms (OPG) (Figure 1) and development of the evaluated teeth based on eight stages A–H of mineralized dental tissues and closure of the apex (Figure 2). Development is calculated based on a score given to each tooth. The dental maturity score is the sum of the individual tooth scores and is subsequently converted into dental age.

Figure 1 – Orthopantomogram – mixed dentition.

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	A	B	C	D	E	F	G	H
Molars								
Bicuspids								
Canines	x	x						
Incisors	x	x						

Figure 2 – Scheme representing the classification of 8 developmental stages (Demirjian et al., 1973; Demirjian and Goldstein, 1976).

Demirjian et al. (1973) carried out a study of somatic, mental and sexual indicators of maturity on a representative sample of the French-Canadian population at the Montreal Human Growth Research Center. They came to conclusion that development of permanent dentition appeared to be the most stable process with regard to the determination of CA (Rozkovcova et al., 2012).

If necessary, in the absence of the left tooth, according to Demirjian et al. (1973), the values of the corresponding tooth on the right can be substituted for the values of the left tooth. Separate evaluations were made for groups of girls and boys, as there is, according to Demirjian et al. (1973), a difference in tooth development. Four various methods have been developed. The first and oldest of the four variants – developed in 1973, is the original method and assesses the dental maturity of the seven lower left permanent teeth. As the degree of symmetry between teeth on the left and right side is known, Demirjian et al. (1973) decided to only use one side, the lower left side. Only when a permanent tooth is missing on the left lower side (extracted, not based) can the corresponding tooth on the other, lower right side be evaluated as a substitute. The next three variants (Demirjian and Goldstein, 1976) from 1976 were modifications of Demirjian et al. (1973). In two cases Demirjian and Goldstein (1976) use only the mature stages of four permanent teeth on the lower left: in the first case M2, M1, PM2, PM1 and in the second M2, PM2, PM1, I1. We reviewed all types of assessment by Demirjian for Czech children and selected the type of rating with the smallest difference and its standard deviation (SD), expressed by certain divergences between CA and DA.

The aim of our study is to determine these differences and SD in Czech children of Caucasian population and to find out which of the four Demirjian methods (Demirjian et al., 1973; Demirjian and Goldstein, 1976) is the most suitable.

Table 1 – Compared standard deviation (SD) difference in individual countries

Method	Country	Author	Gender	Number	Dia-gnosis	Chronological age (mean)	SD	Dental age (mean)	SD	Difference (mean)	SD
Chaillet	Bosnia and Herzegovina	Galić et al. (2013)	Boys	792	healthy	10.47	1.91	10.75	2.06	0.28	0.90
			Girls	980	healthy	10.40	1.91	10.49	1.91	0.00	0.83
Demirjian 7-teeth	Spain	Feijóo et al. (2012a, b)	Boys	485	healthy	without tables		without tables		without tables	
			Girls	525	healthy	only graphs		only graphs		only graphs	
Demirjian 7-teeth	Iran	Bagherian and Sadeghi (2011)	Boys	264	healthy	8.31	2.68	8.46	2.50	0.15	0.49
			Girls	255	healthy	8.40	2.73	8.61	2.60	0.21	0.51
Demirjian	China	Jayaraman et al. (2012)	Boys	133	healthy	11.59	5.45	without tables		−0.25	1.43
			Girls	133	healthy	11.52	5.47	only graphs		0.23	1.37
Demirjian 7-teeth Chaillet	Korea	Sang-Seob et al. (2011)	Boys	754	healthy	without mean		without mean		0.31	0.87
			Girls	729	healthy	without mean		without mean		0.29	0.75
Demirjian 7-teeth Nolla	Turkey	Nur et al. (2012)	Boys	342	healthy	10.03	2.81	10.87	2.96	0.84	1.36
			Girls	331	healthy	10.37	2.90	11.26	3.02	0.89	1.15
Demirjian 7-teeth	UK	Chudasama et al. (2012)	Boys	50	healthy	12.37	1.36	12.48	1.90	−0.10	1.06
			Girls	50	healthy	13.09	1.60	13.14	1.73	−0.05	1.21
Demirjian 4-teeth	Western Australia	Flood et al. (2011)	Boys	73	healthy	are no totals	are no totals	are no totals			
			Girls	71	healthy	are no totals	are no totals	are no totals			

Method	Country	Author	Gender	Number	Dia-gnosis	Chronological age (mean)	SD	Dental age (mean)	SD	Difference (mean)	SD
Demirjian 7-teeth – original	Czech	Stanková et al. (2011)	Boys	240	healthy	10.554	not given	10.645	3.325	0.091	1.675
			Girls	265	healthy	11.645	not given	11.782	3.589	0.137	1.495
Demirjian 7-teeth – revised	Czech	Stanková et al. (2011)	Boys	240	healthy	10.554	not given	10.555	3.554	0.664	1.632
			Girls	265	healthy	11.645	not given	11.797	3.667	0.152	1.505
Demirjian 4-teeth – PM1	Czech	Stanková et al. (2011)	Boys	240	healthy	10.554	not given	10.601	3.346	0.110	1.621
			Girls	265	healthy	11.654	not given	11.970	3.616	0.325	1.530
Demirjian 4-teeth – I1	Czech	Stanková et al. (2011)	Boys	240	healthy	10.554	not given	10.662	3.390	0.171	1.860
			Girls	265	healthy	11.650	not given	12.058	3.648	0.413	1.562

The distribution of the values detected by all four Demirjian methods for age groups, number of children and dental age and chronological age was calculated in years and months; data for SD, differences in SD and paired p-tests were used. Statistically insignificant deviations were found using Demirjian original 7-teeth method from 1973 (Demirjian et al., 1973) and the Demirjian revised 7-teeth method from 1976 (Demirjian and Goldstein, 1976). Indicators monitored in different countries according to statements in literature were also compared. A comparison of the SD of children in other countries was further made according to results reported in literature (Table 1). Several systemic diseases in children, published in the literature were neurofibromatosis (Jaasaari et al., 2012), velocardiofacial syndrome (VCFS) (Heliovaara et al., 2011).

Material and Methods
505 OPGs of children (240 boys and 265 girls) aged 3–18 years were made in the years 2011 and 2012 (Table 2). All OPGs were made using the same X-ray device (Gender Orthoralix 9 200. KaVo Dental – Gendex Imaging, Italy), excluding an error in the quality of each image. Children were commonly treated at our clinic (Department of Stomatology, Second Faculty of Medicine, Charles University in Prague), rated X-rays were made for our treated patients – they were indicated for a reason of a dental disease. No X-ray was made only for the purpose of this study. Indications for X-ray examinations were diagnostics and monitoring of the treatment of pathological status. All children belonged to the Caucasian population,

Table 2 – Total number of patients at each age

Age	Boys	Girls	Total
2–3	2	2	4
4	1	4	5
5	12	7	19
6	13	11	24
7	29	23	52
8	40	18	58
9	22	29	51
10	23	21	44
11	17	25	42
12	19	23	42
13	12	23	35
14	20	21	41
15	11	23	34
16	10	21	31
17	7	9	16
18	2	5	7
Total	240	265	505

Table 3 – Detected values for all four Demirjian methods – boys

Age group	Number	Chronolo-gical age	1973 – 7 dental age	SD	Difference	SD	p
3–3.99	2	3.417	5.200	0.000	1.783	0.000	–
4–4.99	1	4.667	5.800	–	1.133	–	–
5–5.99	12	5.569	6.575	0.427	1.006	0.442	0.000
6–6.99	13	6.526	7.654	0.602	1.128	0.684	0.000
7–7.99	29	7.523	8.041	0.652	0.518	0.600	0.000
8–8.99	40	8.471	8.143	1.075	−0.328	1.034	0.052
9–9.99	22	9.303	9.191	0.919	−0.112	0.881	0.557
10–10.99	23	10.438	10.830	1.543	0.392	1.481	0.217
11–11.99	17	11.402	11.312	1.935	−0.090	1.768	0.836
12–12.99	19	12.412	12.316	2.447	−0.096	2.555	0.871
13–13.99	12	13.340	14.158	1.975	0.818	1.820	0.148
14–14.99	20	14.421	14.855	1.722	0.434	1.685	0.264
15–15.99	11	15.386	15.291	2.352	−0.095	2.404	0.898
16–16.99	10	16.342	15.180	2.593	−1.162	2.543	0.183
17–17.99	7	17.274	14.971	2.549	−2.302	2.444	0.047
18–18.99	2	18.167	16.000	0.000	−2.167	0.236	–
Total	240	10.554	10.645	3.325	0.091	1.657	0.394
Age group	Number	Chronological age	1976 – 7 dental age	SD	Difference	SD	p
3–3.99	2	3.417	4.900	0.000	1.483	0.000	–
4–4.99	1	4.667	5.300	–	0.633	–	–
5–5.99	12	5.569	6.217	0.473	0.647	0.508	0.001
6–6.99	13	6.526	7.523	0.763	0.997	0.812	0.001
7–7.99	29	7.523	7.997	0.796	0.474	0.715	0.001
8–8.99	40	8.471	8.145	1.114	−0.326	1.068	0.061
9–9.99	22	9.303	9.286	0.937	−0.017	0.899	0.931
10–10.99	23	10.438	10.939	1.515	0.501	1.451	0.112
11–11.99	17	11.402	11.294	1.822	−0.108	1.674	0.794
12–12.99	19	12.412	12.226	2.413	−0.186	2.532	0.753
13–13.99	12	13.340	14.267	1.942	0.926	1.798	0.102
14–14.99	20	14.421	14.525	1.852	0.104	1.830	0.802
15–15.99	11	15.386	15.255	2.088	−0.132	2.144	0.843
16–16.99	10	16.342	15.180	2.593	−1.162	2.543	0.183
17–17.99	7	17.274	15.100	2.381	−2.174	2.269	0.044
18–18.99	2	18.167	16.000	0.000	−2.167	0.236	–
Total	240	10.554	10.555	3.354	0.064	1.632	0.652

were healthy, without congenital anomalies and systemic diseases, were born on time, without significant deformity of lower left teeth, and with no significant differences in their individual social backgrounds.

Each X-ray examination is accompanied by ionizing radiation, which is dependent on the type of X-ray apparatus. Parameters of ionizing radiation are minimized

Age group	Number	Chronological age	M2, M1, PM2, PM1 dental age	SD	Difference	SD	p
3–3.99	2	3.417	4.900	0.000	1.483	0.000	–
4–4.99	1	4.667	4.900	–	0.233	–	–
5–5.99	12	5.569	6.208	0.472	0.639	0.393	0.000
6–6.99	13	6.526	7.623	0.867	1.097	0.882	0.001
7–7.99	29	7.523	8.083	1.019	0.560	0.949	0.004
8–8.99	40	8.471	8.225	1.270	−0.246	1.227	0.213
9–9.99	22	9.303	9.550	0.916	0.247	0.904	0.214
10–10.99	23	10.438	10.839	1.306	0.401	1.246	0.137
11–11.99	17	11.402	11.312	1.670	−0.090	1.526	0.811
12–12.99	19	12.412	12.068	2.646	−0.344	2.758	0.594
13–13.99	12	13.340	14.342	1.867	1.001	1.723	0.069
14–14.99	20	14.421	14.820	1.342	0.399	1.362	0.206
15–15.99	11	15.386	15.036	2.550	−0.350	2.622	0.667
16–16.99	10	16.342	15.080	2.593	−1.262	2.543	0.151
17–17.99	7	17.274	15.386	0.925	−1.888	0.912	0.002
18–18.99	2	18.167	15.900	0.000	−2.267	0.236	–
Total	240	10.554	10.601	3.346	0.110	1.621	0.343

Age group	Number	Chronological age	M2, PM2, PM1, I1 dental age	SD	Difference	SD	p
3–3.99	2	3.417	5.700	0.000	2.283	0.000	–
4–4.99	1	4.667	6.000	–	1.333	–	–
5–5.99	12	5.569	6.242	0.547	0.672	0.503	0.001
6–6.99	13	6.526	7.762	0.985	1.236	0.951	0.001
7–7.99	29	7.523	8.121	1.215	0.598	1.151	0.009
8–8.99	40	8.471	8.305	1.290	−0.166	1.248	0.406
9–9.99	22	9.303	9.573	1.462	0.270	1.452	0.393
10–10.99	23	10.438	11.030	1.662	0.592	1.605	0.091
11–11.99	17	11.402	11.429	2.397	0.027	2.315	0.962
12–12.99	19	12.412	11.963	2.623	−0.449	2.731	0.483
13–13.99	12	13.340	13.742	2.679	0.401	2.567	0.599
14–14.99	20	14.421	14.820	1.595	0.399	1.670	0.298
15–15.99	11	15.386	15.673	0.754	0.286	0.950	0.341
16–16.99	10	16.342	14.710	3.763	−1.632	3.710	0.198
17–17.99	7	17.274	15.543	0.945	−1.731	0.847	0.002
18–18.99	2	18.167	15.900	0.000	−2.267	0.236	–
Total	240	10.554	10.662	3.390	0.171	1.860	0.220

if the device that can be calibrated for X-ray examinations of children is used. Success of an X-ray examination of small children depends on the degree of cooperation of the child as well as on the cooperation between the child and the radiologist. There are indications, when it is useful to try to make a radiograph in infants not only for forensic reasons, but also to specify the diagnosis (e.g. fractures of the jaw bones).

Table 4 – Detected values for all four Demirjian methods – girls

Age group	Number	Chronological age	1973 – 7 dental age	SD	Difference	SD	p
3–3.99	2	3.708	4.500	1.414	0.792	1.473	–
4–4.99	4	4.604	4.875	1.190	0.271	1.400	0.725
5–5.99	7	5.464	5.971	1.535	0.507	1.614	0.438
6–6.99	11	6.379	7.273	0.403	0.894	0.489	0.000
7–7.99	23	7.489	7.539	0.556	0.050	0.514	0.646
8–8.99	18	8.481	8.561	1.099	0.080	1.046	0.751
9–9.99	29	9.434	9.269	1.215	–0.165	1.149	0.446
10–10.99	21	10.282	10.157	1.304	–0.125	1.254	0.654
11–11.99	25	11.517	11.976	1.871	0.459	1.879	0.233
12–12.99	23	12.402	12.835	1.786	0.433	1.767	0.253
13–13.99	23	13.482	14.509	1.295	1.027	1.243	0.001
14–14.99	21	14.492	15.662	1.266	1.170	1.309	0.001
15–15.99	23	15.518	15.665	1.056	0.147	1.020	0.496
16–16.99	21	16.417	15.748	0.890	–0.669	0.932	0.004
17–17.99	9	17.361	14.900	2.479	–2.461	2.395	0.015
18–18.99	5	18.350	16.000	0.000	–2.350	0.341	0.000
Total	265	11.645	11.782	3.589	0.137	1.495	0.137
Age group	Number	Chronological age	1976 – 7 dental age	SD	Difference	SD	p
3–3.99	2	3.708	4.450	1.061	0.742	1.120	–
4–4.99	4	4.604	4.675	0.981	0.071	1.193	0.913
5–5.99	7	5.464	5.714	1.489	0.250	1.572	0.689
6–6.99	11	6.379	6.909	0.611	0.530	0.673	0.026
7–7.99	23	7.489	7.317	0.693	–0.172	0.636	0.209
8–8.99	18	8.481	8.539	1.207	0.057	1.151	0.835
9–9.99	29	9.434	9.300	1.220	–0.134	1.161	0.540
10–10.99	21	10.282	10.219	1.470	–0.063	1.414	0.841
11–11.99	25	11.517	12.072	1.975	0.555	1.974	0.172
12–12.99	23	12.402	13.030	1.680	0.628	1.654	0.082
13–13.99	23	13.482	14.691	1.244	1.209	1.219	0.000
14–14.99	21	14.492	15.700	1.166	1.208	1.212	0.000
15–15.99	23	15.518	15.700	1.078	0.182	1.043	0.412
16–16.99	21	16.417	15.776	0.728	–0.640	0.767	0.001
17–17.99	9	17.361	14.967	2.389	–2.394	2.300	0.014
18–18.99	5	18.350	16.000	0.000	–2.350	0.341	0.000
Total	265	11.645	11.797	3.677	0.152	1.505	0.102

CA was determined from the date of birth and the date taken from the OPG. CA was calculated in terms of years and months. There are 16 age groups between the ages of 3–18.99. The results for lower-left permanent teeth, except the third molar – from the first appearance of erupted teeth and tooth germs – were evaluated in terms of their development in eight stages, A–H, of mineralized dental tissues and the closure of the apex using Demirjian "Developmental stages of the

Age group	Number	Chronological age	M2, M1, PM2, PM1 dental age	SD	Difference	SD	p
3–3.99	2	3.708	4.900	0.141	1.192	0.200	–
4–4.99	4	4.604	4.850	1.310	0.246	1.527	0.769
5–5.99	7	5.464	6.043	1.518	0.579	1.590	0.373
6–6.99	11	6.379	7.236	0.709	0.858	0.697	0.002
7–7.99	23	7.489	7.478	0.926	−0.011	0.858	0.952
8–8.99	18	8.481	8.928	1.278	0.446	1.233	0.143
9–9.99	29	9.434	9.548	1.214	0.114	1.161	0.600
10–10.99	21	10.282	10.352	1.806	0.071	1.759	0.856
11–11.99	25	11.517	12.172	2.282	0.655	2.307	0.168
12–12.99	23	12.402	13.252	1.932	0.850	1.892	0.042
13–13.99	23	13.482	15.004	1.085	1.522	1.066	0.000
14–14.99	21	14.492	15.590	1.191	1.098	1.236	0.001
15–15.99	23	15.518	15.817	0.292	0.299	0.357	0.001
16–16.99	21	16.417	15.671	0.723	−0.745	0.751	0.000
17–17.99	9	17.361	15.556	0.720	−1.806	0.709	0.000
18–18.99	5	18.350	15.900	0.000	−2.450	0.341	0.000
Total	265	11.645	11.970	3.616	0.325	1.530	0.001

Age group	Number	Chronological age	M2, PM2, PM1, I1 dental age	SD	Difference	SD	p
3–3.99	2	3.708	5.100	0.283	1.392	0.342	–
4–4.99	4	4.604	5.350	0.742	0.746	0.856	0.180
5–5.99	7	5.464	6.171	1.230	0.707	1.335	0.211
6–6.99	11	6.379	7.073	0.714	0.694	0.735	0.011
7–7.99	23	7.489	7.500	0.915	0.011	0.844	0.951
8–8.99	18	8.481	8.872	1.383	0.391	1.340	0.233
9–9.99	29	9.434	9.807	1.346	0.373	1.270	0.125
10–10.99	21	10.282	10.548	1.926	0.266	1.859	0.520
11–11.99	25	11.517	12.232	2.178	0.715	2.199	0.117
12–12.99	23	12.402	13.091	2.399	0.689	2.347	0.173
13–13.99	23	13.482	15.117	1.152	1.636	1.138	0.000
14–14.99	21	14.492	15.676	1.255	1.184	1.299	0.000
15–15.99	23	15.518	15.909	0.303	0.391	0.364	0.000
16–16.99	21	16.417	15.867	0.432	−0.550	0.482	0.000
17–17.99	9	17.361	15.744	0.767	−1.617	0.696	0.000
18–18.99	5	18.350	16.000	0.000	−2.350	0.341	0.000
Total	265	11.645	12.058	3.648	0.413	1.562	0.000

permanent dentition" table (Figure 1) (Demirjian et al., 1973; Tanner et al., 1997). The position of the lower-left teeth was marked in the same order as in the Demirjian methods: second molar M2, first molar M1, second premolar PM2, first premolar PM1, canine C, lateral incisor I2, central incisor I1 (Demirjian et al., 1973). The M1 mandible left tooth was missing in only four children extracted due to destruction and the corresponding right mandible permanent teeth were therefore evaluated instead. Dental age was established using all four types of evaluation:

Demirjian original 7-teeth 1973 method (Demirjian et al., 1973), the revised 1976 teeth method and the two 1976 4-teeth methods (Demirjian and Goldstein, 1976). CA, DA and SD difference by age category, broken down by gender, is shown in Table 3 for boys and Table 4 for girls, all of which were evaluated using all Demirjian methods. The relationship between dental maturity score and CA is expressed and plotted in the percentile graphs (Demirjian et al., 1973) (Figure 3). The dental maturity score is the sum of individual teeth scores. Standard tables (Demirjian et al., 1973) were used to calculate dental age from the dental maturity score. All four Demirjian methods were compared and statistically evaluated for average chronological age and its relationship to dental age. Deviation from SD was evaluated using the paired p-test.

   A comparison with deviations in various countries was made against results reported in literature (Table 1).

   All observations were carried out in accordance with the Helsinki Declaration. Ethical approval for the study was obtained from the Ethics Committee of the Second Faculty of Medicine, Charles University in Prague (Rozkovcova et al., 2012).

   DA was calculated using the score determined using tables of different systems: Demirjian 7-teeth 1973, Demirjian 7-teeth 1976, Demirjian 4-teeth M2, M1, PM2, PM1, Demirjian 4-teeth M2, PM2, PM1, I1 (Demirjian et al., 1973; Demirjian and Goldstein, 1976), converted to dental age.

   Descriptive statistics (mean, SD) were used for statistical evaluation and paired *t*-test was used to compare deviations of mean values for CA and DA in each age group.

   The evaluation was carried out with a significance level of 0.05.

   Data was processed using statistical functions of MS Excel 2013 and the Data Analysis Toolpack (MS Excel 2013) analytical add-on.

Results
Distribution of the values detected by all four Demirjian methods (Demirjian et al., 1973; Demirjian and Goldstein, 1976) for age groups, number of children and DA and CA was calculated in years and months; data for SD, differences in SD and paired p-tests are presented in Table 3 for boys and Table 4 for girls. These Tables give a comprehensive overview of the observed values. The listed values are further processed in the following Tables.

Chronological age (CA)
The mean CA for boys was 10.552 years and 11.645 years for girls.

Dental age (DA)
Estimated DA can be overestimated or underestimated (Demirjian et al., 1973; Sang-Seob et al., 2011) and the mean deviation of DA from CA varies (Table 5). DA is overestimated by all Demirjian's methods in girls, and by two methods in

Table 5 – Dental age: Number of age groups underestimated and overestimated

Demirjian methods	Total number		Difference (mean)	SD	p
	Overestimated	Underestimated			
Boys: total of 16 age groups					
7-teeth 1973	8	8	0.091	1.657	0.394
7-teeth 1976	8	8	0.064	1.632	0.652
4-teeth PM1	7	9	0.110	1.621	0.343
4-teeth I1	5	11	0.171	1.860	0.220
Girls: total of 16 age groups					
7-teeth 1973	11	5	0.137	1.495	0.137
7-teeth 1976	10	6	0.152	1.505	0.102
4-teeth PM1	12	4	0.325	1.530	0.001*
4-teeth I1	13	3	0.413	1.562	0.000*

*significant

boys – Demirjian 4-teeth PM1 and Demirjian 4-teeth I1 (Demirjian and Goldstein, 1976). Results are the same in the two residual methods. SD occurs with only two methods in girls – Demirjian 4-teeth PM1 and Demirjian 4-teeth I1 (Demirjian and Goldstein, 1976).

Difference DA-CA
Accuracy of each method is expressed by the difference between DA and CA. SD and the paired *t*-test were monitored. A comparison was made of results for boys and girls. There were varying degrees of difference for each age group (Tables 3 and 4) and varying sizes (Table 6).

Percentile chart
The percentile chart clearly shows that the relationship between dental maturity scores and children age is not linear (Figure 3). This can be more easily observed in the graph than in the tables.

Different countries
Indicators monitored in different countries according to statements in literature are compared in Table 1.

Discussion
All four Demirjian methods were used, being practical and simple. Demirjian methods were based on analysis of OPG (Demirjian et al., 1973; Demirjian and Goldstein, 1976). DA estimation was based on establishment of 8 teeth development stages; assessment is based on evaluation of the OPG. It was

Table 6 – The greatest and the least values of difference

	The greatest difference		The least difference		Total	
	Boys	Girls	Boys	Girls	Boys	Girls
Demirjian original method 1973 – 7-teeth						
Years	3–4	14–15	17–18	17–18	–	–
Difference	1.783	1.170	−2.302	−2.461	0.091	0.137
SD	–	1.309	2.444	2.395	1.657	1.495
p	–	0.001*	0.047*	0.015*	0.394	0.137
Demirjian revised method 1976 – 7-teeth						
Years	3–4	13–14	17–18	17–18	–	–
Difference	1.483	1.209	−2.174	−2.394	0.064	0.152
SD	–	1.219	2.269	2.300	1.632	1.505
p	–	0.000*	0.044*	0.014*	0.659	0.102
Demirjian method 1976 – 4-teeth (M2, M1, PM2, PM1)						
	Boys	Girls	Lesser difference	Boys	Girls	Total
Years	3–4	13–14	18–19	18–19	–	–
Difference	1.483	1.552	−2.267	−2.450	0.064	0.325
SD	0.000	1.066	0.236	0.341	1.632	1.530
p	–	0.000*	–	0.000*	0.652	0.001*
Demirjian method 1976 – 4-teeth (M2, PM2, PM1, I1)						
Years	3–4	13–14	18–19	18–19	–	–
Difference	2.283	1.636	−2.267	−2.350	0.171	0.413
SD	0.000	1.138	0.236	0.341	1.860	1.562
p	–	0.000*	–	0.000	0.220	0.000*

*significant; – = cannot be count (under age)

important to obtain reliable results that evaluated the OPG of the same persons in order to eliminate subjective deviations.

The mean CA was 10.552 years for boys and 11.645 years for girls. Spanish literature gives a mean age of 9.2 for both genders (Feijóo et al., 2012a).

Conversion of the dental maturity score of each subject using Demirjian standard tables for children in the two age groups from 16–18 years is not quite accurate. Demirjian evaluates children only at 16 years of age (Demirjian et al., 1973). In the Czech Republic, children are considered adolescents up to their eighteenth birthday, a fact which must be respected if the results of forensic tests are to be used. Conversion was performed according to Demirjian tables (Demirjian et al., 1973).

Nur et al. (2012) show overestimation of estimated DA against actual CA in both genders, and our results show overestimation for all Demirjian's methods (Demirjian et al., 1973; Demirjian and Goldstein, 1976) in girls, and in two methods – Demirjian 4-teeth PM1 and Demirjian 4-teeth I1 – in boys, with the same results in the two residual methods (Table 5). There was a mean paired *t*-test difference greater than 0.05 in all four Demirjian methods for boys and in two Demirjian methods for girls – Demirjian 4-teeth PM1 and Demirjian 4-teeth I1 – no group was therefore of statistical significance; however, Demirjian 4-teeth PM1 method and Demirjian 4-teeth I1 method were significant in girls (Table 5). The different values (Tables 3 and 4) in children's teeth development according to the estimation of DA based on maturity of tooth germs (Demirjian et al., 1973) are influenced by nutrition, climate and social and economic conditions (Burt et al., 2011).

Accuracy of each method is expressed as the difference between DA and CA. Variety between DA and CA is expressed by the difference between DA and CA and can have a positive or negative value (Demirjian et al., 1973) (Table 5). Accuracy of the estimated DA is expressed as the value of the SD difference. The estimated DA in our groups of children is the least accurate in the youngest and the oldest age groups; Sang-Seob et al. (2011) also indicates this. This explains the small number of 3-year-olds, and the peculiarities in the conversion of dental maturity in 16–18-year-olds.

No records at all exist of deviations from DA estimates caused by systemic diseases; children's overall health status must be taken into account.

In the event of neurofibromatosis type 1 (Jaasaari et al., 2012), dental development is more accurate for the purposes of estimating CA than skeletal development. In this case, skeletal maturation is affected, while dental development is standard. Dental maturity is never delayed in children with VCFS (Heliovaara et al., 2011).

Conclusion

Dental age estimation in children is based on the establishment of stages of tooth development. It is important to thoroughly examine, clinically and with X-ray, the real age of children from the viewpoint of pediatric dentistry and also pediatrics as a whole. Based on our results, Demirjian methods – original 7-teeth 1973 and Demirjian revised 4-teeth 1976 (Demirjian et al., 1973; Demirjian and Goldstein, 1976) – appear to be the best methods for calculating the DA of healthy Czech children of both genders. The mean of paired *t*-tests for difference between DA and CA showed no statistically significant SD in either gender.

References

Bagherian, A., Sadeghi, M. (2011) Assessment of dental maturity of children aged 3.5 to 13.5 years using the Demirjian method in an Iranian population. *J. Oral Sci.* **53**, 37–42.

Burt, N. M., Sauer, N., Fenton, T. (2011) Testing the Demirjian and the international Demirjian dental aging methods on a mixed ancestry urban American subadult sample from Detroit, MI. *J. Forensic Sci.* **56**, 1296–1301.

Chudasama, P. N., Roberts, G. J., Lucas, V. S. (2012) Dental age assessment (DAA): A study of a Caucasian population at the 13 year threshold. *J. Forensic Leg. Med.* **19**, 22–28.

Demirjian, A., Goldstein, H. (1976) New systems for dental maturity based on seven and four teeth. *Ann. Hum. Biol.* **3**, 411–421.

Demirjian, A., Goldstein, H., Tanner, J. M. (1973) A new system of dental age assessment. *Hum. Biol.* **45**, 211–227.

Feijóo, G., Barbería, E., De Nova, J., Prieto, J. L. (2012a) Permanent teeth development in a Spanish sample. Application to dental age estimation. *Forensic Sci. Int.* **214**, 213.e1–213.e6.

Feijóo, G., Barbería, E., De Nova, J., Prieto, J. L. (2012b) Dental age estimation in Spanish children. *Forensic Sci. Int.* **223**, 371.e1–371.e5.

Flood, S. J., Mitchell, W. J., Oxnard, Ch. E., Turlach, B. A., McGeachie, J. (2011) To evaluate the utility of smaller sample sizes when assessing dental maturity curves for forensic age estimation. *J. Forensic Sci.* **56**, 1604–1609.

Galić, I., Vodanović, M., Janković, S., Mihanović, F., Nakać, E., Prohić, S., Galić, E., Brkić, H. (2013) Dental age estimation on Bosnian-Herzegovinian children aged 6–14 years: Evaluation of Chaillet's international maturity standards. *J. Forensic Leg. Med.* **20**, 40–45.

Greulich, W. W., Pyle, S. I. (1959) *Radiographic Atlas of Skeletal Development of the Hand and Wrist.* Stanford University Press, Stanford.

Guo, L., Jiayin, R., Shuping, Z., Yuanyuan, L., Na, L., Wanhong, W., Shanshan, H. W. (2012) Dental age estimation from the developmental stage of the third molars in western Chinese population. *Forensic Sci. Int.* **219**, 158–164.

Heliovaara, A., Rantanen, I., Arte, S. (2011) Dental development and tooth agenesis in children with velocardiofacial syndrome. *Int. J. Paediatr. Dent.* **21**, 446–450.

Jaasaari, P., Visnapuu, V., Nystrom, M., Peltonen, S., Peltonen, J., Happonen, R. P. (2012) Dental age in patients with neurofibromatosis 1. *Eur. J. Oral Sci.* **120**, 549–552.

Jayaraman, J., Roberts, G. J., King, N. M., Wong, H. M. (2012) Dental age assessment of southern Chinese using the United Kingdom Caucasian reference dataset. *Forensic Sci. Int.* **216**, 68–72.

Nur, B., Kusgoz, A., Bayram, M., Celikoglu, M., Nur, M., Kayipmaz, S., Yildirim, S. (2012) Validity of Demirjian and Nolla methods for dental age estimation for northeastern Turkish children aged 5–16 years old. *Med. Oral Patol. Oral Cir. Bucal* **17**, e871–e877.

Pechnikova, M., Gibelli, D., De Angelis, D., De Santis, F., Cattaneo, C. (2011) The blind age assessment: Applicability of Greulich and Pyle, Demirjian and Mincer aging methods to a population of unknown ethnic origin. *Radiol. Med.* **116**, 1105–1114.

Rozkovcova, E., Dostalova, T., Markova, M., Broukal, Z. (2012) The third molar as an age marker in adolescents: new approach to age evaluation. *J. Forensic Sci.* **57**, 1323–1328.

Sang-Seob, L., Dongjae, K., Saebomi, L., U-Young, L., Joong, S. S., Yong, W. A., Seung-Ho, H. (2011) Validity of Demirjian's and modified Demirjian's methods in age estimation for Korean juveniles and adolescents. *Forensic Sci. Int.* **211**, 41–46.

Santoro, V., Roca, R., De Donno, A., Fiandaca, Ch., Pinto, G., Tafuri, S., Introna, F. (2012) Applicability of Greulich and Pyle and Demirjian aging methods to a sample of Italian population. *Forensic Sci. Int.* **221**, 153.e1–153.e5.

Serinelli, S., Panetta, V., Pasqualetti, P., Marchetti, D. (2011) Accuracy of three age determination X-ray methods on the left hand-wrist: A systematic review and meta-analysis. *Leg. Med. (Tokyo)* **13**, 120–133.

Someda, H., Saka, H., Matsunaga, S., Ide, Y., Nakahara, K., Hirata, S., Hashimoto, M. (2009) Age estimation based on three-dimensional measurement of mandibular central incisors in Japanese. *Forensic Sci. Int.* **185**, 110–114.

Stanková, M., Buček, A., Dostálová, T., Ginzelová, K., Pacáková, Z., Seydlová, M. (2011) Patients with special needs within treatment under general anesthesia – Meta-analysis. *Prague Med. Rep.* **112**, 216–225.

Tanner, J., Oshman, D., Bahhage, F., Healy, M. (1997) Tanner-Whitehouse bone age reference values for North American children. *J. Pediatr.* **131**, 34–40.

Varkkola, O., Ranta, H., Metsaniitty, M., Sajantila, A. (2011) Age assessment by the Greulich and Pyle method compared to other skeletal X-ray and dental methods in data from Finnish child victims of the Southeast Asian Tsunami. *Forensic Sci. Med. Pathol.* **7**, 311–316.