Dental Maturity- a biologic indicator of chronological age: Digital radiographic study to assess Dental age in Romanian children

Ana Emilia Ogodescu, Alexandru Ogodescu, Kinga Szabo, Anca Tudor, Elisabeta Bratu

***Abstract*—**The assessment of dental age is useful in the planning of orthodontic treatment, in pediatric dentistry, pediatric endocrinology and forensic medicine. It also adds important knowledge of growth and development to human biology. The aim of our study was to investigate the applicability of Demirjian method for estimation of dental age in Romanian children and if the tables developed for French-Canadian population are not applicable, to develop new equation and tables for our boys and girls. Our survey was conducted on a final sample of 441 radiographs of patients aged between 5.5 and 14.5 years (218 girls and 223 boys). The sample was divided in groups, considering an age interval of one year. All dental pantomograms were scored by two examiners and intra- and inter-examiner calibration was made. We used dedicated software for scoring, dental age determination and for creating a database. A paired t-test was used to assess any difference between chronological and dental age. On average, the Romanian girls showed an overestimation of 0,36 years, meaning 132 days, p=0,129, $\alpha = 0.05$ and boys an underestimation of 0.04 years, meaning 15 days, p = 0.852, $\alpha = 0.05$. New tables were developed in order to convert dental maturity calculated according to Demirjian method into dental age of contemporary Romanian children.

***Keywords*—**Demirjian method, dental age tables, diagnostic imaging, digital tools, Romanian children sample.

I. Introduction

VARIOUS methods are used in orthodontics to evaluate the age of a patient. Chronological age is defined by birth date and skeletal age can be assessed, for example, by hand-wrist ossification [1].

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Children with the same chronological age may show differences in the developmental stages of different biological systems. Several indices have been developed to determine the developmental stage of a child for a certain biological system, namely indices for sexual maturity, somatic maturity, skeletal age, and dental age [2].

The physiological age of a person is determined by the degree of maturation of the different tissue systems. [3]. Physiological age can be used to define a child's progress towards completeness of development or maturity. Within a tissue system, the sequence of one or more irreversible events defines maturation. *Dental Age* is usually based on the maturation of the teeth [4].

There is a good correlation between dental age and chronological age in general, except some situations where two entities evaluate independent. Among all the growth indicators, dental age has the weakest correlation with general somatic development. Physical growth often deviates to the chronological age, but correlates well with skeletal age that represents relative stage of bone maturation [5].

These *correlations between dental, skeletal and chronological age* could be relevant for general dentists and orthodontists and pediatricians as well. For both dental doctors these correlations allow an overall summary of dental development and can be used as a basis for further therapeutic decisions. Such knowledge as dental and skeletal age can be useful in taking the decision about extracting primary teeth and to decide on timing of the orthodontic treatment. In patients with delayed dental maturity, orthodontic treatment may be started at a later stage, thus leading to shorter treatment duration and more stable result [6]. In case of over-retained deciduous teeth the method facilitates determination of the right time for starting treatment. The degree of calcification and the stages of the teeth give the clinician information about abnormal sequences (e.g. eruption of second molar ahead of second premolar in the mandible arch) so that the preventive measures can be taken in time [1]. Pediatricians are interested to know if the dental and skeletal maturity of a child with certain disease is delayed or advanced [7, 8, 9]. The correlation between dental and chronological age is also useful in forensic dentistry to estimate the age or to identify the child [7, 10].

Three fundamental ways exist to assess dental age; determination according to *clinical emergence of teeth* is the oldest technique [1].

Gingival emergence, which is often erroneously called eruption, represents only one stage in the continuous process of dental eruption. Emergence may be influenced by local factors: ankylosis, early or delayed extraction of the deciduous tooth, impaction and crowding of the permanent teeth [3]. Visible emergence usually occurs when root formation is about three quarters completed, but quite large departures from this rule have been observed [3]. Insufficient root development is characteristic of premature eruption (e. g. during the intraoral eruption stage root has one-third of its final length) [11]. Moreover, the method can only be used during relatively short periods because between the ages of 2.5-6, 8-10 and 13-18 years no teeth will emerge [2].

Another possibility is to estimate the position of upper and lower canine tooth buds in the panoramic radiograph, as suggested by Nawrath in 1966[1, 12].

When Schour et al. discovered in 1941 that *tooth mineralization is a constant, ongoing process*, they established a scheme of *tooth mineralization* and a third method was developed [1, 13].

Many authors have published techniques in order to assess dental maturity by tooth formation: Demirjian, Goldstein, Tanner, Glombitza, Nolla, Prahl Andersen and van der Linden. [3, 14, 15, 16].

Techniques for chronological age estimation in children based on dental maturation may be divided into those using the atlas approach and those using scoring systems whereas in adults there are the morphological and radiological techniques [17].

The atlas approach, developed by different authors uses radiographs where morphologically different stages of tooth mineralization are compared with atlas tables. [13, 15, 17, 18, 19, 20, 21]. The method sets out a typical "profile" of stages at each of the series of ages over the age range being studied. Any new set of ratings is then compared with these profiles until the best matching one is found, and the corresponding age then becomes the estimate of dental age [3]. Authors as Schour and Massler, Moorrees et al, Andreson et al, Nolla and Nicodemo developed well known and applied atlas approach techniques [22, 23].

The techniques that are using *the scoring system* tried to simplify chronological age estimation and restricted the number of teeth studied to *7* (developed by Demirjian, Goldstein, Tanner in 1973 and used in many studies) [3] or *4* (first studied by Demirjian et al. in a group of teeth and then developed by Haavikko in 1974, in other group of teeth) [7, 24]. The method of Haavikko is based on the evaluation of 12 radiographic stages for each tooth. These stages are transformed into dental age with the use of tables. Chronological age is then calculated as the mean of all the estimates [7, 25]. The investigation of Demirjian in 1973 resulted in the creation of a dental maturity scaling system valid for universal use [3, 4]. This method has been found the most easy to use, the most accurate and that is confirmed by the use in so many studies in the whole world.

The method developed in Zurich, taking in account usually one tooth is not the most accurate, but provides a quick and easy age assessment. Between 3 and 12 years, we can best estimate dental age considering the stages of dental development and mineralization of *first lower premolar* (the beginning of mineralization at about 2 years and a half, crown development that lasts approximately 4 years and root development that last about 5-6 years). The estimated age could be proved, applying similar method when taking in consideration other permanent teeth [26, 27].

Other methods using measurements on radiographs as a basis for determination of dental development use the length of the tooth, crown or root as an indicator of dental age. [2, 6, 28, 29]. This methods were again not completely reliable as estimating that the root is half formed is difficult if the final length of the root is not correctly foreseen [2, 6]. When applying the Kvaal dental age calculation technique on panoramic radiographs of adult patients, the following measurements were carried out for all six types of teeth: the maximum tooth length, the pulp length, the root length on the mesial surface from the ECJ to the root apex, the root and pulp width at three different levels [30, 31].

The future is promising. Although it was limited to a pilot study, the developed technique showed results for dental age estimation in a non-invasive manner using cone-beam CT images in living individuals [32]. It can be used in children, giving more precise information about the tooth stages or in adults where pulp/tooth volume can be calculated, using 3D images in both situations [32, 33].

The new Galileo's cone beam technology (Sirona Dental Systems, Inc.) has a perfect combination of hardware and software (Galaxis 3D imaging software), 3D volume reconstruction and 3D diagnostics [33, 34, 56].

II. Problem Formulation

Dental age assessment is important in medicine and biology and has a lot of applications in these fields. Many authors have reported different standards of dental maturation, using different methods, assessed at different populations: Indian[23, 35,36], Chinese(Chengdu)[37], Senegalese[38], Australian[4], South African[22], Saudi[39], Pakistani[6], Brazilian[20, 21] and also Europeans. Among the last group are : German from south-western Germany[1], Finnish [40,41], Norwegian[42], Swedish[43], British[4, 44, 45],Hungarian from south-western Hungary[46], Dutch[2], Danish[25], Italian[7], Turkish[47], Polish from Central Poland[48], French from South France[49]. In the majority of studies the comparisons have been made between the determined values of studied populations and French-Canadian standards reported by Demirjian and.

After determining their own standards many of these studies compare the results with data of populations other than French-Canadian that have determined the dental age standards before. Sexual differences in dental development were always studied for each age group and prediction of emergence were sometimes made [3, 50].

Our clinical day by day observations proved that there are differences between chronological age and dental age calculated according to Demirjian standards, at Romanian children.

The *objectives of this study* were: dental maturity assessment from orthopantomograms using Demirjian method and creation of a database for Romanian children; to evaluate the applicability of dental age assessment tables developed for French-Canadian children for our population[55]; to develop new standards for Romanian children; to compare the results with those of other European countries; to assess the sexual differences in dental development; to compare dental age determination on digital against conventional radiographs, focusing on the advantages conferred by the modern digital imaging technologies [51, 52, 53]

III. Problem Solution

A. Material and Methods

In order to investigate the regional characteristics of the dental eruption in actual Romanian population we conducted a cross-sectional study on a sample of 467 panoramic radiographs of patients aged 3.5 to 16 years, from which 230 females and 237 males. The radiographs were collected from five different private dental offices and from the Clinic of Paedodontics-Orthodontics from Timisoara. These were selected after applying the inclusion and exclusion criteria.

The *inclusion criteria* were: children of Romanian origin (Romanian parents); pretreatment radiographs of all the paedodontic and orthodontic patients (it is not possible to conduct a radiographic survey on perfect dentitions from bioethical reasons, although the results would be the most accurate for determining normal standards); healthy children; free from any disorder affecting growth; good radiographic quality; the presence of all seven left or right mandibular permanent teeth (erupted or not).

The *exclusion criteria* were: general health problems; endocrine or nutritional disorder because this may affect child's development; genetic problems; craniofacial syndromes; extractions, agenesis and pathological processes in the apical bone of the same permanent teeth on both sides of the mandible; the same missing teeth on both mandibular sides, except third molars; prior orthodontic treatment history.

We used panoramic radiographs and not intraoral radiographs (as in almost all the studies) because of the advantages confirmed in former studies: easier to make especially in young children, the mandibular region is little distorted [3], in the cases with unilateral hypodontia or first molar extraction we can evaluate the same teeth but from the opposite side and data management is better.

At the end, a number of 26 assessed radiographs (12 of female and 14 of male subjects) were again excluded, because the number was insufficient to represent the following age groups: 3.5-4.4, 4.5-5.4 and 14.5-15.4, 15.5-16.

The final sample which we used in our survey included 441 radiographs of patients aged between 5.5 and 14.5 years (218 girls and 223 boys, Fig.1).

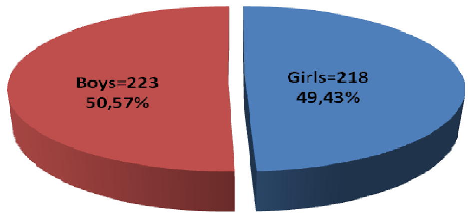


Fig.1 The distribution of children by gender

For 218 girls, average age is *10.03* with standard deviation of *2.32* and the 95% confidence interval for the chronologic age is (5.57, 14.49) years (Fig.2).

For 223 boys, average age is 9.73 with standard deviation of 2.14 and 95% confidence interval for the chronologic age is (5.45,14.01)years (Fig.2).

The average age is insignificant increased in girls compared to boys (unpaired t test, p=0.15, α=0.05), (Fig.2).

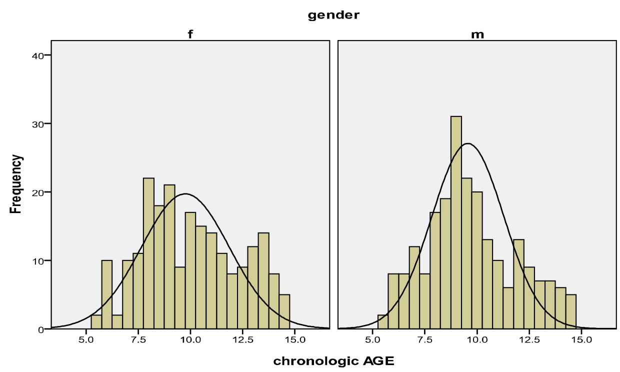


Fig.2 Histograms of chronologic age by gender

The radiographs were rated by two examiners, which trained together. Each examiner rated all the radiographs (467 orthopantomograms). Disagreement between two examiners occurred in 9.2% of the films (43 orthopantomograms), including maximum 3 teeth and differed never more than one stage. Fifty radiographs were reexamined by each examiner, at one month interval. The first examiner gave different results in 12% of the cases and the second examiner in 4% of the cases, meaning 6 respectively 2 radiographs. Disagreement between the same examiners included maximum 2 teeth and was never more than one stage. These differences have been considered reasonable in other studies [3].

Each examiner rated each of the seven left mandibular teeth. The third molar was excluded. In all the cases in which we had anodontia, extractions of permanent teeth or premature loss of primary teeth on this side, we rated the corresponding teeth on the right side (Fig. 3).

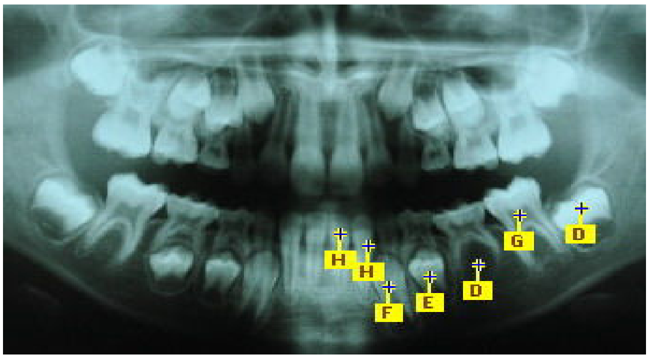


Fig.3 The panoramic radiograph of a female patient aged 7, 9 years, with unilateral anodontia of second lower premolar

Tooth formation is divided into eight stages (A-mineralization of single occlusal points without fusion of the calcifications, B- fusion of the calcifications - occlusal outline recognizable, C- enamel development of the crown completed, beginning dentine deposition, D-crown development completed up to the enamel-cement-verge, E-root length shorter than height of the crown, F- root length greater or equal to height of the crown, G- root development completed, Foramen apicale still open, H- Foramen apicale closed) on which adds the 0-stage (tooth germ without any signs of calcification). Each tooth included has an individual development stage (Fig.3, 4) and then a corresponding score, according to normal standards, which are gender dependent. We calculated for each radiograph a score sum depending on the development stage of the tooth buds from the left mandible quadrant (except the wisdom tooth).

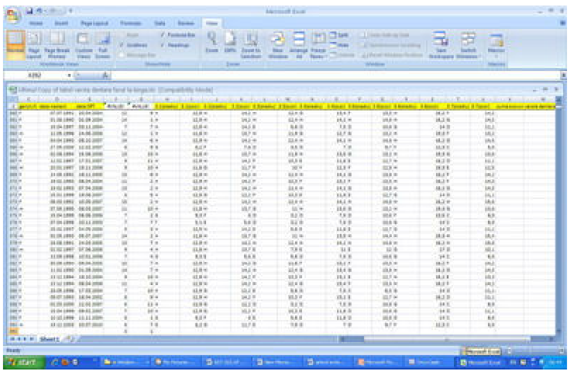


Fig.4 The Excel table with the registration of each patient's data including the score sum

The parameters birth date, date of radiograph were used to calculate chronological age; gender and developmental stages of the teeth and the score tables from Demirjian et al. were used to calculate the scores for each tooth (Fig. 5). The values are added and the sum is transformed to dental age. The standard values for the dental age assessment are given.

1. Valorile caracteristicilor lotului pentru care s-au efectuat prelucrarile statistice:

cod	gen(m,f)	Varsta (ani)	Varsta (luni)	Varsta	suma scoruri	varsta dentara (ani)	varsta dentara (luni)	varsta dentara
1	f	5	7	5,6	41,2	6	3	6,2
2	f	5	8	5,7	53,1	7	1	7,1
3	m	5	8	5,7	27,2	5	2	5,1
4	m	5	9	5,8	34,4	6	1	6,1

Fig.5 The characteristic values of the sample on which we have done the statistics

This methods and clinical norms developed by Demirjian et al. are recommended by Thomas Rakosi [3, 11] and are used by *OnyxCeph^{3TM} software*, developed by the firma Image Instruments GmbH, Germany (Fig.6), [54, 57].

All the determined data where included in a large database in order to be analyzed with statistical methods in the Department of Medical Informatics and Biostatistics from Timisoara (Fig.4). The program used was *Statistica v. 16*.

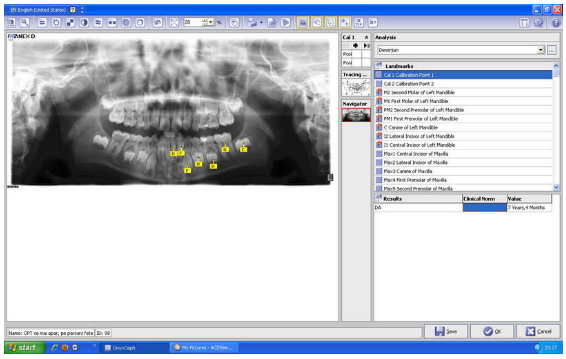


Fig.6 Dental age determination with the dedicated Software

B. Results

We divided the sample in groups, considering an age interval of one year (Fig.7).

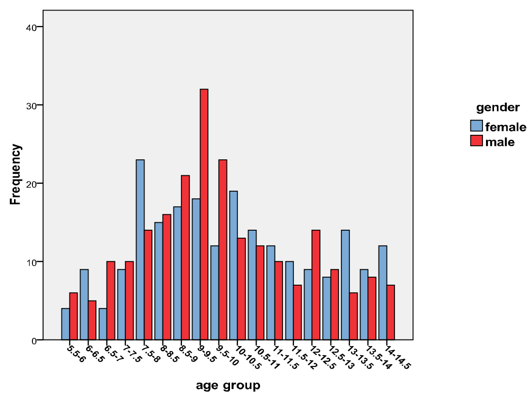


Fig.7 The distribution of cases by age groups and gender

A paired t-test was used to assess the difference between chronological age (the true age) and dental age (the assessed age), according to the method of Demirjian (Fig. 8, 9). The differences were insignificant considering the whole sample (-0,36 years, meaning 132 days, p=0,129, α = 0.05 for girls and 0.04 years, meaning 15 days, p = 0.852, α = 0.05 for boys). They were significant in the following age groups: 5.5 to 6.4 (-0.82y, p <0.001), 11.5 to 12.4 (-0.51y, p = 0.026), 12.5 - 13.4 (-0.82y, p = 0.013) and 13.5 to 14.4 (-0.56y, p = 0.016) for girls and 13.5 to 14.4 (-0.74y, p = 0.028) for boys. In girls, dental maturation was ahead of chronological age for all age groups, whereas in boys the chronological age is ahead of dental maturation in most age groups, except the following age groups: 5,5-6,4, 6,5-7,4 and 13,5-14,4.

As dental maturity assessed using Demirjian method and chronological age showed a curvilinear relation on a scatter plot (logistic regression), therefore, logit transformation $\text{Ln}\{y/100 - y\}$ was performed to make the relationship linear, where "y" is the dental maturity and "x" is the chronological age (significant, direct and strong linear correlation-Pearson coefficient r=0,813, p<0,001) (Fig.10, 11).

Male

Group 1 year	N	age (mean±SD)	dental age (mean±SD)	Mean difference	P value[sign]	The limit of significant (α)
5.5-6.4	11	5.97±0.22	6.24±0.74	-0.27	0.26[ns]	0.05
6.5-7.4	20	6.89±0.26	7.09±0.61	-0.20	0.185[ns]	0.05
7.5-8.4	30	7.97±0.27	7.76±0.6	0.21	0.086[ns]	0.05
8.5-9.4	53	9±0.27	8.96±0.83	0.04	0.74[ns]	0.05
9.5-10.4	36	9.86±0.26	9.56±1.01	0.30	0.089[ns]	0.05
10.5-11.4	22	10.89±0.28	10.54±0.95	0.35	0.105[ns]	0.05
11.5-12.4	21	12.02±0.25	12±1.09	0.02	0.935[ns]	0.05
12.5-13.4	15	12.91±0.31	12.96±1.43	-0.05	0.897[ns]	0.05
13.5-14.4	15	14.01±0.35	14.75±1.19	-0.74	**0.028**[s]	0.05
Total	**223**	**9.73±2.14**	**9.69±2.39**	**0.04**	0.852[ns]	0.05

[s] – significant differences

[ns] – insignificant differences

Fig.8 Comparisons between the dental age and chronological age for girls, for each age group (1 year)

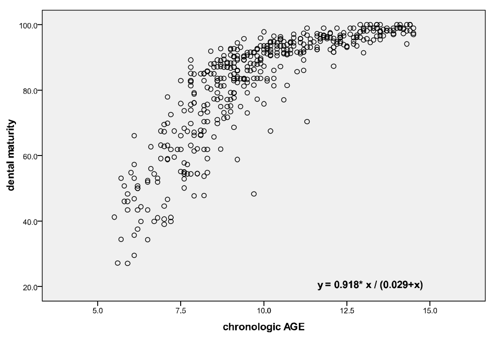
Female

Group 1 year	N	age (mean±SD)	dental age (mean±SD)	Mean difference	P value[sign]	The limit of significant (α)
5.5-6.4	13	6.02±0.23	6.84±0.39	-0.82	**<0.001**[s]	0.001
6.5-7.4	13	7.03±0.23	7.27±0.43	-0.24	0.08[ns]	0.05
7.5-8.4	38	7.94±0.29	8.03±0.67	-0.09	0.449[ns]	0.05
8.5-9.4	35	8.93±0.27	9.14±0.86	-0.21	0.173[ns]	0.05
9.5-10.4	31	10.03±0.28	10.29±1.12	-0.26	0.215[ns]	0.05
10.5-11.4	26	10.94±0.3	11.24±1.24	-0.30	0.236[ns]	0.05
11.5-12.4	19	11.95±0.29	12.46±0.91	-0.51	**0.026**[s]	0.05
12.5-13.4	22	13.03±0.26	13.85±1.46	-0.82	**0.013**[s]	0.05
13.5-14.4	21	13.96±0.35	14.52±0.96	-0.56	**0.016**[s]	0.05
Total	**218**	**10.03±2.32**	**10.39±2.61**	**-0.36**	0.129[ns]	0.05

[s] – significant differences

[ns] – insignificant differences

Fig.9 Comparisons between the dental age and chronological age for boys, for each age group (1 year)



The average values of score sums for girls and boys, for each age group were determined (Fig.12, 13).

Fig.10 Scatter plot between dental maturity and chronological age

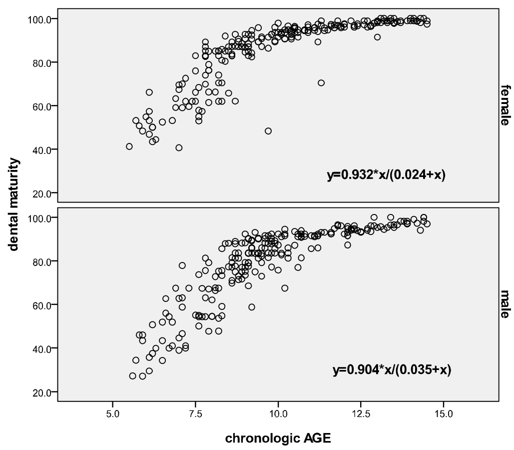


Fig.11 Scatter plot between dental maturity and chronological age by sex

FEMALE

The group of age	Sum scor (means±SD)
5.5-6	48,33±5,14
6-6.5	51,77±7,09
6.5-7	56,95±5,14
7-7.5	62,46±9,54
7.5-8	72,82±11,25
8-8.5	77,77±9,55
8.5-9	84,39±8,18
9-9.5	88,63±4,01
9.5-10	87,42±12,61
10-10.5	93,33±1,96
10.5-11	94,65±1,44
11-11.5	93,19±7,55
11.5-12	96,46±1,15
12-12.5	96,96±0,96
12.5-13	97,45±1,1
13-13.5	98,41±2,12
13.5-14	98,43±0,73
14-14.5	99,05±0,83

MALE

The group of age	Sum scor (means±SD)
5.5-6	37,35±8,98
6-6.5	38,66±7,75
6.5-7	50,3±10,55
7-7.5	54,13±13,62
7.5-8	62,75±11,28
8-8.5	66,17±11,79
8.5-9	79,04±6,1
9-9.5	82,81±7,33
9.5-10	85,72±4,9
10-10.5	85,37±7,63
10.5-11	89,53±5,19
11-11.5	90,77±2,71
11.5-12	94,51±1,85
12-12.5	93,42±2,26
12.5-13	94,96±2,21
13-13.5	96,22±1,96
13.5-14	97,19±1
14-14.5	97,96±2,08

Fig.12 The mean values of scores by age groups (at half of year) and gender

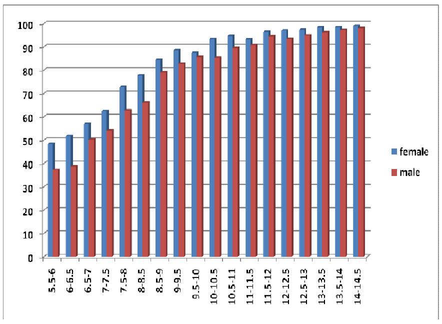


Fig. 13 The sum of scores distribution by age groups and gender

We compared our score sums with the Demirjian score sums. The differences are *insignificant* for both males and females (unpaired t test, p=0.579 for girls and p=0.933 for boys, α=0.05).

The correlation between the scores of our boys and Demirjian's boys scores is significant, direct and almost perfect (Pearson coefficient 0.92, p<0.001) (Fig. 14).

The correlation between our girls and the Demirjiam's girls scores is significant, direct and almost perfect (Pearson coefficient 0.966, p<0.001) (Fig. 15).

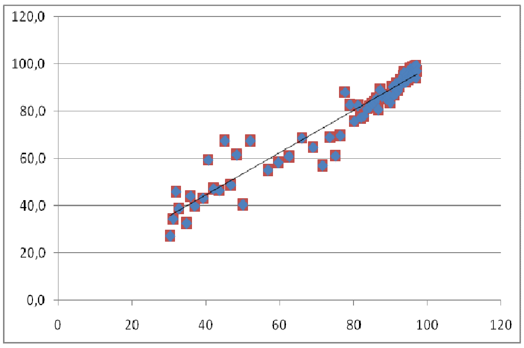


Fig.14 The correlation between the scores of our boys and Demirjian's boys' scores

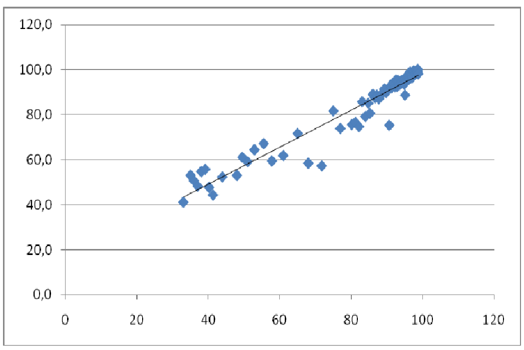


Fig.15 The correlation between the scores of our girls and Demirjian's girls' scores

We also determined *the median development stage*, for each tooth by age and sex. For 3.1(the lower left central incisor) the apex was closed (stage H) in the age interval 7.5-8.4 in females and 8.5-9.4 in males. For 3.2(the lower left lateral incisor) the apex was closed (stage H) in the age interval 8.5-9.4 for females and 9.5-10.4 for males. For 3.3(the lower left canine) the apex was closed in the age interval 12.5-13.4 for females and 13.5-14.4 for males. For 3.4(the lower left first premolar) the apex was closed in the age interval 12.5-13.4 for females and 13.5-14.4 for males. For 3.5 (the lower left second premolar) the apex was closed in the age interval 12.5-13.4 for females and 13.5-14.4 for males. For 3.6(the first left lower molar) the apex was closed in the age interval 9.5-10.4 for females and 10.5-11.4 for males. For 3.7(the second left lower molar) the apex was closed in the age interval 14.5-15.4 for both females and males.

C. Discussions

Before starting the statistical analysis we had to exclude some age groups from the sample, because the number of radiographs was not sufficient for these age groups. The number of radiographs recommended at young ages (3.5-5.4 years age intervals) is small according to low treatment need and radiation management bioethical reasons. We also had to exclude the age groups included in 14.5-16 years age interval, because the frequency of radiographs recommended was also lower as in 5.5-14.4 age subgroups. We would need to add more radiographs to the existent in order to extend our study for the groups mentioned before.

The present findings in our study reveal that *our girls indicated a more advanced dental age* compared to French-Canadian children as presented by Demirjian. *The dental age was advanced to chronological age, for all age groups, in girls*. The differences were significant at the beginning of tooth eruption, in small girls, aged between 5.5 and 6.4, and at the end of tooth eruption, between 11.5 and 14.4, around the peripuberal growth spurt. In boys, the dental age was little advanced between 5.5 and 7.4 years and significant advanced between 13.5 and 14.4 years, around their growth spurt. Between 14.5 and 12.4 dental age was delayed in boys.

In our study, girls indicated advanced dental development in all age groups and reached dental maturation earlier than boys, according to earlier maturation of other parameters of growth and development: sexual maturation, weight, height and skeletal development.

We compared the mean differences between chronological and dental age for boys and girls with the mean differences of other populations. The Romanian population was compared to the following populations: Indian, Belgaum (-0.04y for girls and -0.14y for boys)[36]; Pakistani(-0.83y for girls and -0.59y for boys)[6]; Senegalese(-0.48y for girls and -0.89y for boys)[38]; Indian, South(-2.82y for girls and -3.04y for boys)[35]; Turkish(dental age advanced between 0.50y and

1.44y for girls and between 0.36 and 1.44 for boys)[47]; Dutch(-0.6y for girls and -0.4y for boys)[2]; Poland (dental age accelerated in boys and girls at different ages)[48]; Chinese, Chengdu(in all, girls were more advanced 0.45y than boys)[37]; Hungarian (boys and girls were approximately 1 year ahead to French-Canadian children)[46]; Finnish (dental age advanced between 0.35y and 0.9y for girls and between 0.45y and 0.7y for boys)[40,41]; Norwegian (dental age ahead 0.3y for girls and 0.2y for boys)[42]; Swedish(dental age advanced between 0.5y and 1.8y for girls and between 0.4y and 1.8y for boys)[43];

The dental apex is closed approximately one year latter for boys, then girls for all the mandibular teeth examined, except the second lower molar for witch the apex closes at the same age(between 14.5 and 15.4 years), possible because boys have also reached their growth spurt. For the lower canine and both premolars the apex closes almost at the same time.

Digital radiographs have a lot of advantages: the irradiation is reduced with 80% when comparing with the classic ones, the clarity of the image is much improved (the clarity is very important when we want to distinguish between two proximal stages, for example when we want to decide if the apex is closed-stage H or the apex is not closed-G) and less artifacts (Fig 16, 17). When we do retrospective cross-sectional studies we have to use conventional radiographs, to scan them with special scanners, to take picture of them or to evaluate them on the negatoscop. When we choose the last possibility, we can not digitize our radiographs and we can not benefit of the advantages offered by OnyxCeph^{3TM} or similar software [51].

Except the conversion tables, that we had to update for our population with OnyxCeph^{3TM} we can save, review and control the stages previously given each time without the need of any other elements, except our computer. If there are significant differences between the chronological age and the dental age calculated directly with OnyxCeph^{3TM} and we respected the inclusion criteria for normal population, we develop new conversion tables for the investigated population [51].

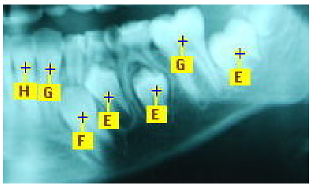


Fig.16 Germination stage for each tooth, determined on classical panoramic radiograph

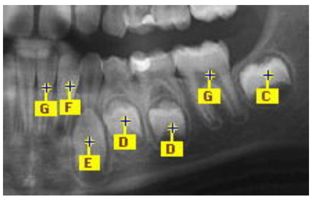


Fig.17 Germination stage for each tooth, determined on digital panoramic radiograph

IV. Conclusion

We can apply on our children the Demirjian standards prescribed for French-Canadian children for most age groups.

We have to use the developed tables for those age groups, where the differences between dental and chronological age were significant, which results from the paired t-test applied.

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