Dental age estimation in children with chromosomal syndromes

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The authors declare that they have no conflict of interest.

KEYWORDS

age estimation, London Atlas, Down syndrome, Williams syndrome, dental maturation, forensic age assessment

J Forensic Odontostomatol 2018. May; (35): 44-52
ISSN :2219-6749

ABSTRACT

When the age of an individual is unknown, age assessment refers to the procedures through which authorities try to establish the chronological age of an individual. Dental evidence demonstrated to be very effective in estimating age and dental mineralization is largely deemed a process scarcely influenced by major diseases and nutritional or environmental factors which can affect child growth. This research aims to understand the possible influence of genetic syndromes on dental maturation of affected individuals.

The sample is composed of a test sample of 159 chromosomal affected children, 69 males and 90 females, and a control sample of 157 healthy children, 77 males and 80 females aged between 4,49 and 19,8years. London Atlas was applied to estimate dental age on OPGs (orthopantompographies).

No statistical significant difference has been found in dental estimates between syndromic and healthy individuals. Moreover no statistical significant difference emerged between sexes and age cohorts. Children affected by Down or Williams syndromes nor mean error neither the mean accuracy per cohort of age show differences compared to non-affected subjects.

The London Atlas can be validly applied to age estimation of individuals with multiple agenesis as in Down and Williams syndromes, even if it a slight overestimation of age occurs systematically in syndromic as well as in healthy samples. The current findings suggest that dental maturation is a very stable biological process scarcely affected by even serious illnesses as genetic syndromes.

INTRODUCTION

Age is one of the main characteristics of the biological profile reconstruction of an individual and age estimation is necessary to determine if the subject is accountable for his actions in criminal law, shall undergo specific obligations (educational, for instance) or should receive specific aides or other providences from the state administration or for other important administrative and civil issues (health care, immigration, adoption, driving license, passport release, marriage - to cite only the most common fields of application).

When the age of an individual is unknown, age assessment refers to the procedures through which authorities try to establish the chronological age of an individual, utilizing any attempts including documentary evidence, psychological

assessment, medical examination. The latter procedures try to estimate the age of an individual by converting age-related biological markers to chronological age. The term "estimation" (other than age "determination") defines more precisely the real limits inherent to this sort of expertise.

Biological age is measured through recognition of growth and maturational milestones achieved in different biological systems as the skeleton, the dentition or some soft tissues. Generally speaking, the estimation is much easier till the age threshold of full maturity of the main used indicators (which is around 16 years), because after that age problems rise due to the completion of the maturation of the main parameters for the estimation, i.e. ossification of the wrist and the second molar roots apex. As soon as the child reaches maturity, and therefore the examined markers become mature, the same markers are no longer informative; the only information they provide is the likely age, or better, range of ages, when the individual reached the adult state, again based on population norms, and this serves only as a lower limit for their likely chronological age.

Methods based on the permanent teeth calcification provide reliable and accurate tools for estimating the age of children. They are largely adopted for auxological reasons, when just an evaluation of the overall developmental stage of the individual is requested and therefore just an approximate result is needed, a practice very far from the requested accuracy of an examination performed for forensic purposes.

When estimating age in medico-legal and forensic practice, dental mineralization is largely deemed a process scarcely influenced by major diseases and nutritional or environmental factors which can affect child growth, unlike the maturation of, for example, the skeleton, probably because the skeletal age is more sensitive than dental age to whatsoever insults.

According to the latter affirmation, the aim of this research is to understand the possible influence of genetic syndromes on dental maturation of affected individuals.

Moreover, since individuals affected by Down syndrome often undergo adoption, and sometimes are undocumented [1,2], aim of the present research is also the analysis of the accuracy of the dental methods of age estimation applied on individuals affected by genetic syndromes and the understanding if the dental methods are reliable tools to estimate age in the syndromic individuals[3-6].

MATERIALS AND METHODS:

This study was conducted with the prior approval of the local ethical committee.

The sample is composed of a total of 316 Ortopantomographies (OPGs) of subjects aged between 4,49 and 19,98 years, 146 male and 170 female Italian subjects who underwent dental check-up or treatments provided by the Meyer Children University Hospital in Florence. The total sample is divided in a test sample of 159 chromosomal affected children, 69 males and 90 females, and a control sample of 157 healthy children: 77 males and 80 females. Since no data about the family origins were available for the study we therefore assumed as "Italian" all the children with an Italian surname.

The syndromes included in the sample are: Down (DS), Turner , Williams (WS), Klinefelter, De George and Wolf-Hirschorn (table 1)

Table 1: Composition of the sample

	Females	Males	Tot OPGs
DOWN	46	37	124
WILLIAMS	5	5	21
TURNER	5	0	7
DE GEORGE	0	1	1
KLINEFELTER	0	2	5
WOLF-HIRSCHORN	0	1	1
OPG of Affected children	69	90	159
OPG of Non-affected children	80	77	157

These syndromes were chosen for the research because they have similar genetic and/or chromosomal influence on the overall somatic development [7-18]. Age and other clinical information of the patients, except sex, were not disclosed to the operator for both samples. The control sample was chosen with a quite similar

distribution of age and gender as the test sample, and subjects had unremarkable medical history.
The London Atlas of tooth development and eruption (LA)[19] was adopted as the method of choice to estimate the age for both samples, and the procedure has been performed by a forensic odontologist expert in age estimation of children. This method was chosen because it enables the age estimation even in the case of multiple agenesis, an anomaly very often present in these syndromes [20]
The Demirijan's and Cameriere's methods, commonly applied in age estimation procedures [21-25], cannot be comfortably applied in our sample of syndromic patients: very often multiple agenesis are present and very often is found an agenesis of the premolars[26], teeth necessary even for the four teeth Demirijan method[27]. Moreover, in such syndromic children some teeth can appear distorted in the OPG due to lack of cooperation during the radiography execution [26]. In these cases, also the Cameriere method cannot be used. Such type of difficulties are confirmed also by Van der Linden [28] who pointed out the lack of collaboration of the DS children and especially of the youngest. He also reported difficulties due to the different shape of the roots (shorter and blunter), a morphological characteristic which is present in DS and in other syndromes.

Data were collected in Excel 2003® and analyzed with Windows MiniTab®. After the test for normal distribution, an One-way Anova was carried out in the male and female samples.
The results obtained from the sample affected by chromosomal syndromes were then compared with the estimations obtained from the non-affected children control sample in order to evaluate the possible influence of chromosomal syndromes on the dental maturation process.
Three months after the first evaluation, the concordance correlation coefficient and the intra-rater agreement were calculated on 30 OPGs randomly chosen and submitted to a second qualified forensic odontologist.

RESULTS

The normality test showed a normal distribution in all groups and the One-way ANOVA adopted in the males and females samples revealed no statistical differences. (fig. 1)
The intra- and inter-rater agreement resulted to be 93% and 90% respectively.
The results are reported in table 2, which shows the difference between the chronological age (CA) and the estimated age (EA) in both genders and reveals that the trend is similar with no significant difference in affected children (AFF C) compared with non-affected population (NAFF C.) The mean, minimum and maximum errors are quite similar in AFF C and NAFF C.

Figure 1: One-way ANOVA between male and female. No statistical differences. P< 0,05.

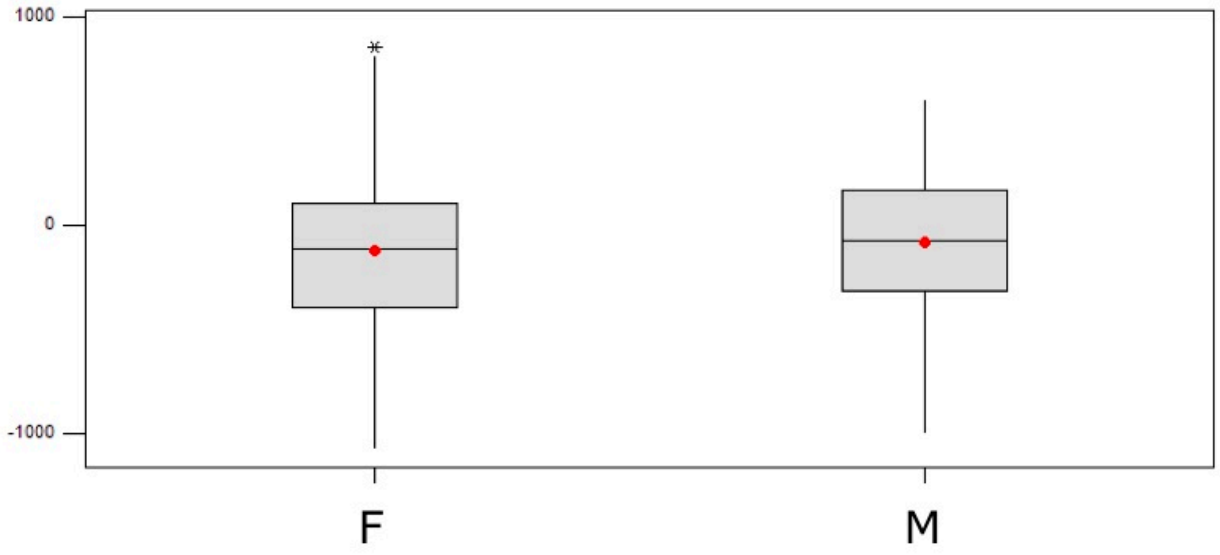


Table 2: Differences between CA and EA(CA-EA) in Chromosomal affected children and non-affected children. Minimum, maximum and mean values are reported.

		CA-EA MIN days	CA-EA MAX days	CA-EA Mean days
AFF C	Male	-8	-745	-37,8
	Female	2	-889	-165
NAFF C	Male	-7	-1004	-141
	Female	0	-1072	-188

The range of difference between the chronological age and the estimated age of the affected children is not different from the non-affected children and from the error range very commonly found in dental age estimation procedures performed with the usually adopted methods in healthy individuals. Errors of estimated age are slightly lower for males both for NAFF C and AFF C.

Table 3 shows the mean estimated age compared to mean chronological age per cohort of ages in affected and non affected children. A trend to overestimate age emerged for both samples and all cohorts of ages. The last cohorts for AFF C should be evaluated with caution since several children presented the agenesis of the third molars. This condition implied a constant underestimation when the complete mineralization of the second molar was reached. The operator continues to assign the maximum age that London atlas provides for the second molar complete formation (16.5 years) since no useful information is available from the third molar.

Table 3: Comparison of mean CA and mean EA for age cohort in both populations (Affected and non-Affected)[1] Mean CA=Mean Chronological age, Mean EA = Mean Estimated age , [2]Diff= Mean CA – Mean EA

	AFF C			NAFF C		
Age cohort	Nr	Mean CA/ MeanEA [1]	Diff [2]	Nr	Mean CA/ MeanEA[1]	Diff[2]
4	6	4,73/5	-0,27	3	4,77/5,16	-0,39
5	8	5,63/5,62	0,01	7	5,62/5,78	-0,16
6	14	6,46/6,71	-0,25	10	6,47/6,5	-0,03
7	9	7,34/7,38	-0,05	12	7,46/7,91	-0,46
8	7	8,35/9,07	-0,72	19	8,46/8,39	0,07
9	11	9,47/10,04	-0,58	10	9,41/9,5	-0,09
10	14	10,53/11,21	-0,69	16	10,43/10,75	-0,32
11	16	11,51/12,43	-0,93	18	11,42/11,36	0,06
12	14	12,64/13,64	-1	17	12,47/13,02	-0,55
13	10	13,57/14,4	-0,83	11	13,43/13,68	-0,25
14	12	14,42/14,5	-0,08	9	14,34/14,61	-0,27
15	9	15,45/16,05	-0,61	8	15,31/15,87	-0,57
16	12	16,41/16,91	-0,5	8	16,48/15,75	-0,73
17	6	17,57/17,33	0,24	4	17,71/18	-0,29
18	5	18,45/18,1	0,35	2	18,52/18,5	0,02
19	4	19,50/19,25	0,25	5	19,59/19,9	-0,31

Figure 2: Means of CA-EA in Affected children and Non affected children per cohort of age; whole sample

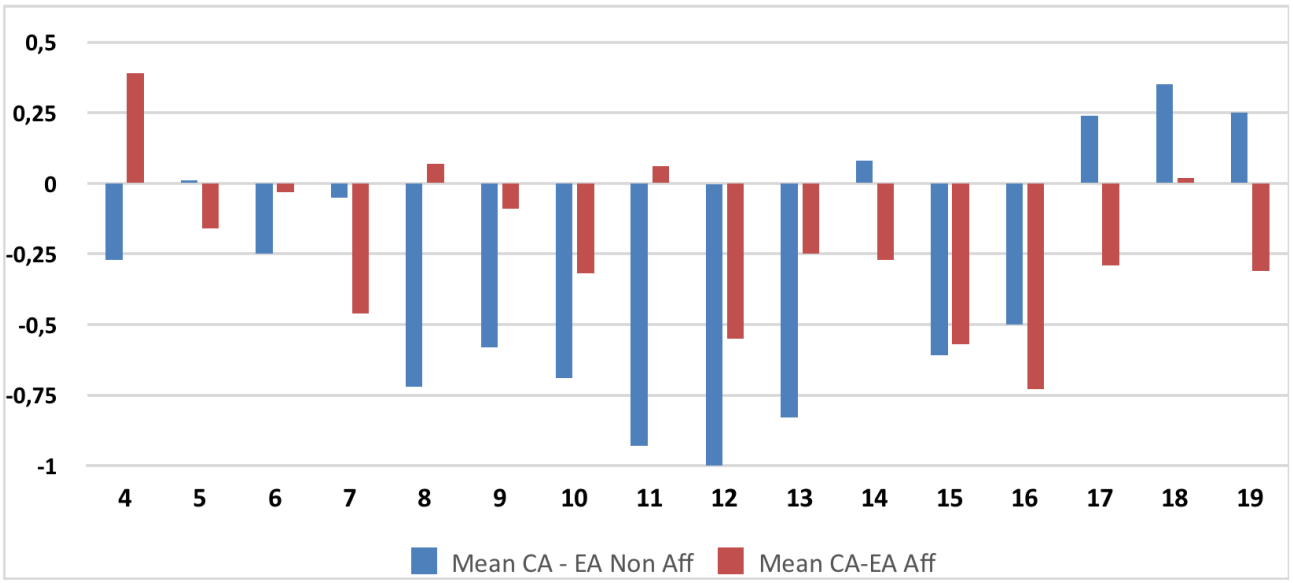


Fig. 2 reports the comparison of the mean differences of CA – EA for the affected and non-affected samples per cohort of age. The London Atlas shows an evident tendency to overestimate age for both populations and differences between affected and non-affected samples are not significant.

Given the large prevalence of children affected by Down and Williams syndromes, a specific analisys of the results was provided for these two syndromes. The test sample (non affected children) was recalibrated for number of subjects, gender and age to be quite similar to the affected samples separately considered for Down or Williams syndrome.

For these samples the mean error, but also accuracy, intended as |CA-EA| was calculated. Since the absolute value of the errors has been considered, there is no mutual compensation from the mean and it is therefore possible to determine the deviation of the predicticted value (estimated age) from the real one (chronological age).

Table 4 and figures 3,4 show the value of mean errors and mean accuracy attributable to non affected samples compared to DS or WS individuals.

Figure 3 shows the means of CA-EA and accuracy assumed as the absolute value of the differences between chronological age and estimated age for different cohorts both for NAFF C and children AFF by DS. Both samples consisted of 124 OPGs and NAFF sample was chosen from the general sample considered above (table 1) in order to have a very similar composition to AFF C (age and gender distribution) .

Figure 4 reports the mean CA-EA and accuracy for different cohorts both for NAFF C and children affected by WS. The compared sample (NAFF C and AFF C) were composed of 21 children.

The London Atlas resulted to overestimate age in both populations and this result is quite relevant especially in the control sample of unaffected individuals. Even if the analyzed sample is too small to draw definitive conclusions, the present results suggest to apply caution when London Atlas is used to Italian individuals, exactly because of its tendency to overestimate age in all cohorts and in both genders.

Table 4: Comparison of non affected children with children affected by Down and Williams syndrome. Mean accuracy and mean error per cohorts of age

	DOWN SYNDROME 124 OPGS NAFF C 124 OPGS				WILLIAMS SYNDROME 21 OPGS NAFF C 21 OPGS			
Age cohorts	Mean Accuracy AFF C	Mean Accuracy NAFF C	Mean CA-EA AFF C	Mean CA-EA NAFF C	Mean accuracy AFF C	Mean accuracy NAFF C	Mean CA-EA AFF C.	Mean CA-EA NAFF C
4					0,42	0,69	0,42	-0,69
5	0,43	0,7	-0,23	-0,15			-0,43	-0,61
6	0,73	0,41	-0,19	0,24	0,43	0,61		
7	0,79	0,38	-0,28	-0,05				
8	0,63	1,11	0,14	-0,72	0,22	0,78	-0,16	-0,78
9	0,41	0,71	-0,01	-0,58	0,8	1,13	-0,11	-0,4
10	0,9	1,17	-0,15	-0,69	0,27	0,4	0,02	-0,4
11	0,87	1,41	0,17	-0,93	1,02	0,78	-0,05	-0,78
12	0,99	0,45	0,45	-1	1,21	0,59	-1,21	-0,59
13	0,95	0,88	-0,08	-0,83	0,78	0,76	-0,78	-0,76
14	1,23	1,06	-0,19	-0,51	1	1,01	-1	-1,01
15	0,71	0,7	0,44	-0,5	0,07	0,34	-0,03	0,11
16	0,74	0,77	0,73	-0,56				
17	1,04	0,75	-0,18	0,03	0,74	1,37	-0,74	1,37
18	0,52	0,46	-0,52	0,24				
19	0,66	0,64	-0,43	-0,16				

Figure 3: Mean error and accuracy for non affected children compared to children affected by Down syndrome. Accuracy = Mean |CA-EA|; AFF C : affected children, NAFF C: non affected children

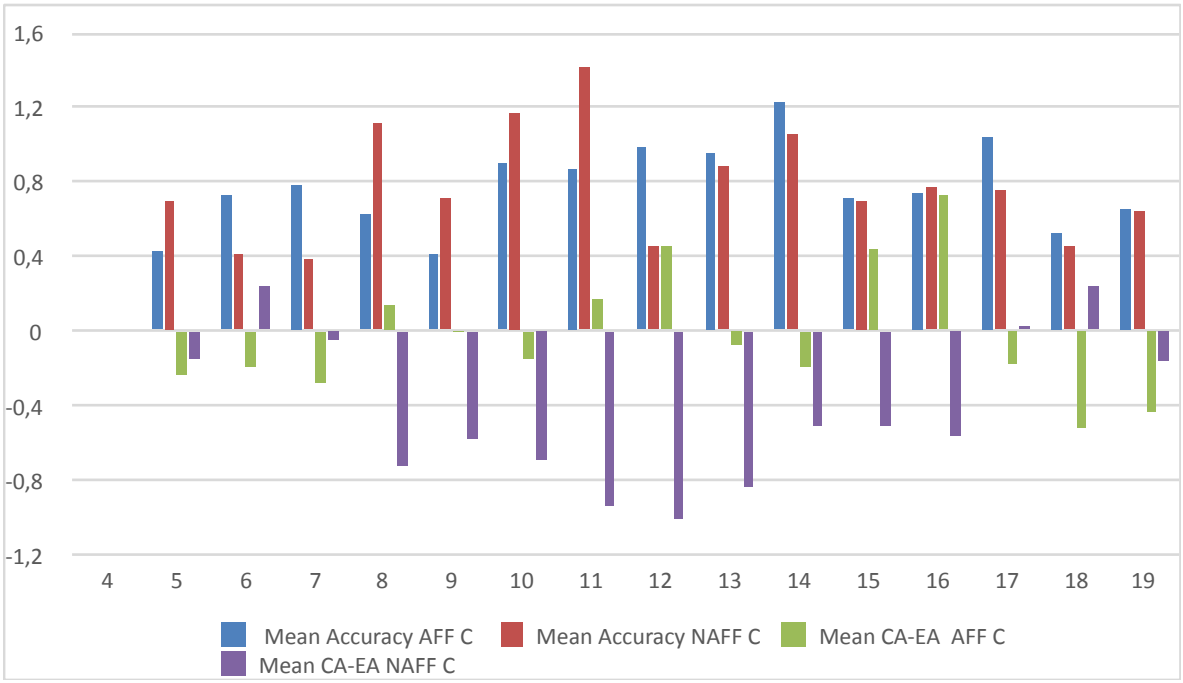
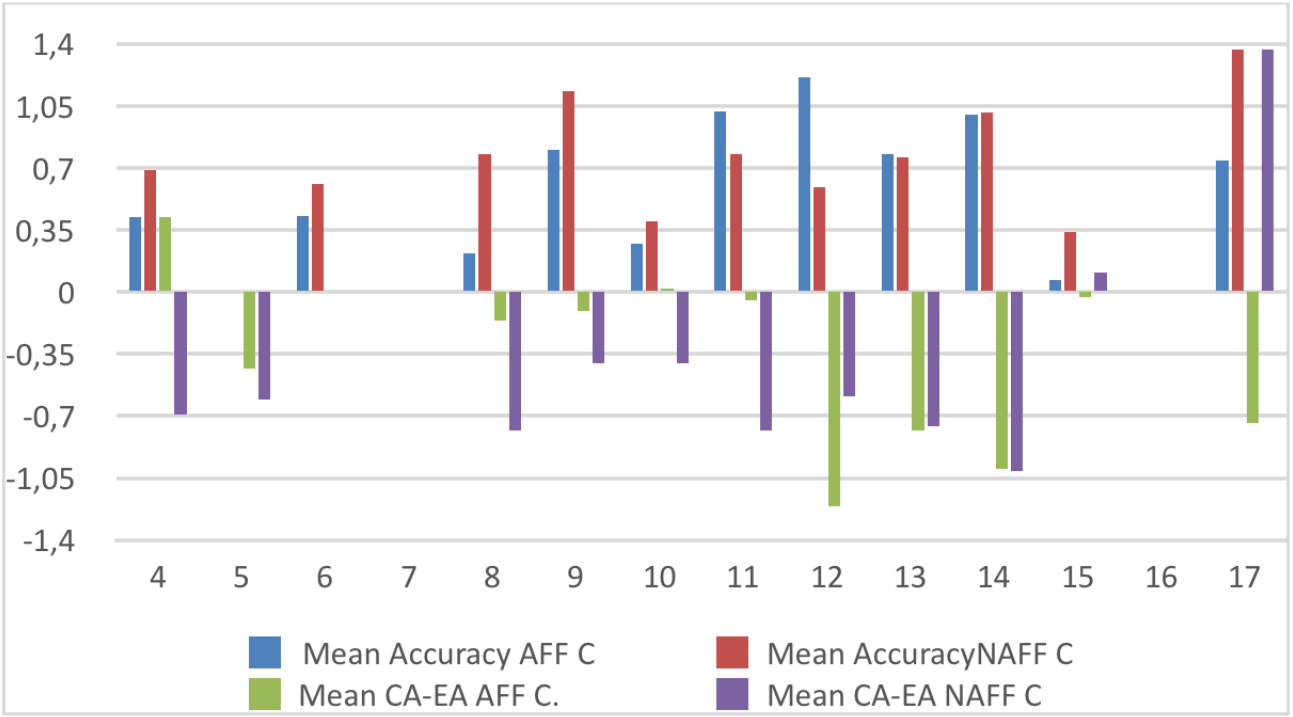


Figure 4: Mean error and accuracy for non-affected children (NAFF C) compared to children affected by Williams syndrome. Accuracy = |CA-EA|



The separate evaluation of the results from the Down syndrome (DS) and Williams syndrome (WS) affected individuals was then performed to learn if special differences between the two syndromes could be detected. As seen in table 4 and figures 3-4, no statistically significant differences emerged between estimated age and chronological age between the DS and WS individuals compared to the NAFF children.
Just as an observational and not definitively or statistically significant data, considering the small number of cases examined in our sample, we observed that WS females showed a slightly faster dental maturation than WS males.

DISCUSSION

Chromosomal disorders and syndromes, which arise from numerical and structural defects of the chromosomes, often include manifestations affecting the craniofacial region. Many of these chromosomal and multifactorial disorders present characteristic oral manifestations[3], such as, for instance, multiple agenesis and delayed teeth eruption in deciduous and permanent dentitions. These dental features are not unique to people with DS even if they occur more frequently in people with DS [9,26].

Very few studies are present in the Literature, however, about the issue of the influence of these syndromic affections on dental maturation in syndromic individuals.
In the study of Leila Abou Hala, the accuracy of dental age and skeletal age methods was evaluated, in order to estimate chronological age in individuals with Down syndrome. In the conclusions she stated that "*more caution is required for age estimation for DS individuals, since they present much more variation than non-ds individuals*"[4].
Other Authors, on the other hand [1,5,6,28], reported that no difference is detectable between healthy and syndromic individuals.
With these opposite thesis in mind we therefore performed the age estimation of syndromic cases with a dental method, the London Atlas.
The analysis of the results we obtained and the comparison between the chronological and the estimated age with dental methods allow us to say definitely that there are no significant differences between the samples, and therefore that there is no difference in dental maturation between the syndromic individuals sample and the control one. We can therefore affirm, in full accordance with Diz et al.[1], Mari Ellis Leonelli de Moraes [5, 6], M. S. van der Linden et

al. [28], that no slowing or acceleration of the dental maturation can be seen in Down syndrome affected individuals.
The analysis of the results coming from the DS individuals shows that the CA/EA difference is negative, as shown exactly by the results from all the other samples, but the ranges are even lower than those coming from the healthy children.
The analysis of the results coming from the Williams syndrome affected individuals shows the same trend of the DS and healthy individuals. The sample, however, is made of just 21 cases; the conclusions which can be drawn in these cases are therefore just indicative and preliminary.
With these premises, we can say that the dental methods, as the LA is, can be anyway considered valid tools for the age estimation of syndromic individuals.

CONCLUSION

Despite any influence that the genetic and chromosomal alterations could have on the development of the oral system, no statistical significant difference has been found in dental age estimations between syndromic and healthy individuals in our samples. No statistical significant difference has been found between sexes and age cohorts. No difference has been found between syndromic and healthy individuals dental maturation.
From the data drawn from our research we can suggest that dental maturation is a very stable biological process scarcely affected by even serious illnesses as genetic syndromes are. In these cases the evidence taken from the dental system is the most reliable in age estimation procedures since dental maturation results much less affected by environmental, nutritional and pathological factors than the skeletal development.
The London Atlas, can be considered a valid tool for age estimation of individuals with multiple agenesis, a very frequent characteristic found in such syndromic cases, and especially in Down and Williams syndromes, even if slight overestimation of age occurs systematically in syndromic as well in healthy Italian individuals.

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