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Third molar development by measurements of open apices in an Italian sample of living subjects

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ABSTRACT

The aim of this study is to analyse the age-predicting performance of third molar index (I_{3M}) in dental age estimation. A multiple regression analysis was developed with chronological age as the independent variable. In order to investigate the relationship between the I_{3M} and chronological age, the standard deviation and relative error were examined. Digitalized orthopantomographs (OPTs) of 975 Italian healthy subjects (531 female and 444 male), aged between 9 and 22 years, were studied. Third molar development was determined according to Cameriere et al. (2008). Analysis of covariance (ANCOVA) was applied to study the interaction between I_{3M} and the gender. The difference between age and third molar index (I_{3M}) was tested with Pearson's correlation coefficient. The I_{3M}, the age and the gender of the subjects were used as predictive variable for age estimation. The small F-value for the gender ($F = 0.042$, $p = 0.837$) reveals that this factor does not affect the growth of the third molar. Adjusted R^2 ($AdjR^2$) was used as parameter to define the best fitting function. All the regression models (linear, exponential, and polynomial) showed a similar $AdjR^2$. The polynomial (2nd order) fitting explains about the 78% of the total variance and do not add any relevant clinical information to the age estimation process from the third molar. The standard deviation and relative error increase with the age. The I_{3M} has its minimum in the younger group of studied individuals and its maximum in the oldest ones, indicating that its precision and reliability decrease with the age.

1. Introduction

Assessing dental age is important to know whether children and youths are growing properly and is especially useful in orthodontics, paediatric dentistry, forensics, and anthropology.[2] For pedodontist and orthodontist, knowing child's developmental status is especially significant in diagnosis and treatment planning.[3] In forensic field, dental age is mostly used in resolving issues regarding immigration and prosecution in the criminal and civil courts.[4]

However, a particular limitation of dental development standards is that the reliability of age estimation is not uniform from birth to adulthood. Age estimation for children up until the age of 14–15 years can be reliably assessed using both skeletal and dental development.[5] In fact, up to this time, age estimation is more rewarding and accurate. As a person grows beyond these years, developmental variability increases, thus making age estimations relative imprecise during adolescence.[5] Toward the end of human skeletal growth and development, only a few age-dependent features can be evaluated by morphological methods.[6]

The third molar is the latest tooth to initiate and complete development and therefore is the last available dental morphologic predicator of age.[7,8] The possibilities of using this tooth for assessing age are limited by the duration of its development. The third molar is more variable than for all the other maturity markers, such as the clavicle and the knee.[9] In addition, the third molar is

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often congenitally missing and some individuals do not grow it at all. Indeed, a great variation in position, morphology, and time of formation exists.[10]

Dental ageing comes in two forms: calcification (tooth development) and eruption patterns.[11] Third molar emergence spans the age interval of 12–22 years.[11] However, radiographic analysis of third molar development expands the years of age estimation to 9–23 years as crown and root development can be studied independent of eruption.[11,12]

The degree of development of this tooth may be recorded as a measure of observed tooth length,[13] classified in various stages according to scores assigned to its maturation and eruption 14, or as a ratio of perceived tooth dimensions.[15]

Regarding to those methods based on tooth measurements, some typical features make them a precise and highly reproducible tool of registration.[1,14] Conversely, Thevissen et al.[14] showed that the third molar staging and related scoring should be recommended over complicated dimensions measurements or ratio calculations for age estimation. The staging of third molar crown and root mineralization can be also accomplished easily and non-invasively through evaluation of dental radiographs. According to Olze et al.,[16] the Demirjian method achieved the highest values for both the observer agreement and for correlation between the stages, as defined by the method, and chronological age. However, it is fundamental to study different ethnic groups to verify this observation or to discover differences. Interestingly, in all of the studies completed till date, an individual having third molars with Demirjian stage "H" development had very likely reached the chronologic age of 18, indicating that the use of this technique for determining the legal age of majority is valid.[11,17]

In 2008, Cameriere at al. 1 developed a new method for assessing adult age based on the relationship between age and the third molar maturity index (I_{3M}), according to measurement of the open apices of the third molar. This technique records continuous data and is based on ratios between measurements of apical pulp widths and tooth lengths. A cut-off value of $I_{3M} = 0.08$ was determined to assign an individual to juvenile or adult age.[1] De Luca et al.[18] and Cameriere et al.[19] showed that the probability that a subject positive on the test (i.e., $I_{3M} < 0.08$) was 18 years of age or older was 95.6% and 90.1% respectively. In spite of these results, to date, no studies have been carried out for analysing the bias of the third molar maturity index. Liversidge and Marsden[20] showed that most dental methods using M3 root formation estimate age with significant bias. The bias is, according to Liversidge et al.,[21] the most useful way to quantify how good a method is at estimating age. As they noted, there is an urgent need for an evidence–based reference to address some issues such as accuracy and bias of this age marker.

The main aim of this study is to analyse the age-predicting performance of third molar in age estimation by measurements of the third molar index (I_{3M}) on orthopantograms of living children and adolescents.

2. Material and methods

2.1. Sample origin

A retrospective, cross-sectional study was conducted with the analysis of panoramic radiographs (OPTs) of 975 Italian healthy subjects (531 female and 444 male) aged between 9 and 22 years. In this study, a minimum of 27 (9 years) and a maximum of 151 (13 years) individuals were studied per age and sex (Table 1). Sample scores range from 0.03 to 3.11 depending on the age group as detailed in Fig. 1.

The panoramic radiographs were collected, in the period between 2011 and 2013, at the Radmedica, *Radiologia Odontoiatrica Digitale* (Rome, Italy) in order to assess the dental maturation of children for orthodontic and auxological purposes. No other information on the ethnicity of these individuals was available, except their Italian surname. All patients came from middle-class families in an urban region.

Patients' identification number, gender, date of birth and date of X-rays were recorded. Medical records were also obtained for all individuals, in order to exclude children with abnormal stature, overweight, preterm birth or a history of serious disease or chronic illness. Patients or their parents, if under the age, had signed agreements with dental institutions that dental records and radiographs could be used only for research and educational purposes, without the possibility of personal identification. Protocols to collect radiographs for human subjects were approved by the Ethics Committee for Research Involving Human Subjects of the University of Rome (Italy), and the study was conducted in accordance with the ethical standards laid down by the Declaration of Helsinki (Finland).

Patients with no medical history and no obvious dental pathology related to the development of permanent teeth or third molars were included in the study. The exclusion criteria were as follows: image deformity and gross pathology affecting the area of interest, hypodontia, premature birth,[22] obesity,[23,24] patients who are undergoing orthodontic treatment, agenesis or extraction of

Table 1
Age and sex distribution of the Italian sample with the I_{3M} average and standard deviation (StDev) values. Last column reports the normalized StDev obtained dividing the StDev values by the smallest one (age group 21 years).

Age (years)	Males			Females			Total			
	N	I_{3M}	StDev	N	I_{3M}	StDev	N	I_{3M}	StDev	Normalized StDev
9	14	2.47	0.38	13	2.47	0.47	27	2.47	0.42	14.00
10	56	2.30	0.49	85	2.07	0.43	141	2.16	0.47	15.67
11	29	2.10	0.49	20	1.90	0.53	49	2.02	0.51	17.00
12	21	1.55	0.44	20	1.46	0.39	41	1.50	0.41	13.67
13	72	1.33	0.47	79	1.34	0.47	151	1.34	0.47	15.67
14	55	0.86	0.47	59	0.95	0.47	114	0.91	0.47	15.67
15	41	0.60	0.41	60	0.56	0.34	101	0.58	0.37	12.33
16	36	0.36	0.29	35	0.53	0.38	71	0.44	0.35	11.67
17	21	0.35	0.23	37	0.46	0.33	58	0.42	0.30	10.00
18	19	0.28	0.20	34	0.44	0.32	53	0.38	0.29	9.67
19	16	0.24	0.08	24	0.37	0.17	40	0.31	0.15	5.00
20	19	0.11	0.10	13	0.28	0.16	32	0.18	0.15	5.00
21	24	0.06	0.01	26	0.08	0.03	50	0.07	0.03	1.00
22	21	0.07	0.02	26	0.07	0.06	47	0.07	0.05	1.67
Total	**444**			**531**			**975**			