Eruption Chronology of the Permanent Dentition in Spanish Children

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Background - Little information is available regarding the eruption chronology of Spanish children. Therefore, it is important to acquire accurate eruption parameters for the Spanish population. Aim - To establish the chronology of the permanent dentition. Design - A cross-sectional study based on a sample of 1123 Spanish Caucasian children ranging from 5 to 15 years of age, from three different schools in Barcelona, Spain. Results - The sample is representative of the Spanish population with regards to age, height and weight; and large enough to achieve the desired 95% confidence level. The results appear in the eruption tables included in the body of this paper. Conclusions - In both boys and girls, the lower left central incisor is the first, and the upper right second molar is the last tooth to erupt. Mandibular teeth tend to erupt before the corresponding maxillary teeth; however, there is no difference between the left and right sides of each arch. The results obtained are in agreement with similar studies performed in other groups of Caucasian children.

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INTRODUCTION

Knowledge related to the chronology and sequence of dental eruption is essential for establishing a standard criterion for dental and preventive healthcare, as well as for diagnosis and treatment of children. It is important to know both, average eruption parameters as well as normal margins of variation, to establish whether dental development is normal, premature or late, and thereby, adopt an optimal and time appropriate course of action.[1,2]

Tooth "eruption" encompasses the entire process starting with the embryonic development of the tooth bud in the jaw, including the formation of the crown and the root, and continuing until the establishment of occlusion.[3] Strictly speaking, eruption is not merely the appearance of a cusp through the gingival tissue; this is just one stage of the process known as the pre-functional stage and should properly be called emergence, although generally people do use the term eruption for this stage.[4] In order to establish criteria to use uniform points of reference to ensure global standards in clinical and academic studies, Carr[5] established the age of clinical dental eruption as the age at which the tooth breaks through the gingival tissue, becoming partially visible. This criterion has been adopted by other researchers and it will be followed in this study.

The chronology and sequence of eruption, and the relationship to other physiological parameters have determined the path followed by research. Little information is available regarding dental parameters for Spanish children. Since characteristics may vary from one geographical location to another, it is preferable not to adopt references from other countries as our standard. Therefore, it becomes important to acquire accurate chronological eruption parameters for the Spanish population.

The objectives of this study are: to estimate the age of eruption of the different permanent teeth in a group of children from three different schools in the province of Barcelona, Spain; to study eruption symmetry in the dental arches; and to establish the permanent dentition eruption sequence of the children studied.

MATERIALS AND METHODS

A cross-sectional study was designed, using a sample of 1123 Spanish Caucasian children ranging from 5 to 15 years of age. The children included in the study were free from growth or congenital anomalies or severe medical conditions.

The children were divided into 10 chronological age

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groups with one-year intervals. The initial sample consisted of 1132 children within the given age range. Children who were not Caucasian were excluded to achieve maximum homogeneity in the growth and eruption patterns. The exclusion of nine non-Caucasian children was based on marked genetic differences, a confounding variable when considering the aim of this study. The age of the children was taken at the time of data collection and converted to a decimal age for statistical analysis.

Dental diagrams were used to record the presence of permanent teeth with a circle, as described in Carr.[5] The same pediatric dentist performed every dental examination.

The quantitative variable (age) is given as the mean and the standard deviation of each distribution. The categorical variable (presence of each tooth) is expressed as a percentage. Both the means and the percentages are estimated by calculating the corresponding 95% confidence interval.

Weighted means were calculated for the eruption age of each tooth for boys and girls using Kärber's method, as described in Hayes and Mantel.[6] The assumption was made that the eruption ages have a normal distribution in order to calculate the lower and upper limits of the 95% confidence level for each mean eruption age.

The mean eruption ages were compared using 95% confidence intervals and the difference was considered to be statistically significant if the 95% confidence interval of one of the two means did not include the other mean.

All hypotheses were contrasted bilaterally, using a statistical significance level of 5%.

RESULTS.

The study group was statistically validated in terms of sample size, and children's age, height and weight.

Sample size - To estimate the average eruption age for each tooth with a confidence interval of 95%, a precision of ± 0.2 years, and admitting a maximum population standard deviation of 2, requires at least 385 subjects of each gender distributed between the different age groups. Therefore, the study group consisted of 605 boys and 518 girls.

Sample age - The Student t-test was applied to the mean values of each age group by gender. The comparison of the average ages for girls and for boys revealed no significant differences between genders in any of the age groups. This comparison for gender equality corroborates group homogeneity.

Sample weight and height - No significant differences were found between the mean weights and heights of the study group compared to the data provided by Hernández *et al*.[7] for the Growth and Development Research Institute of the Spanish *"Fundación Orbegozo"*. These data on height and weight curves is inclusive of the entire Spanish population from zero to 18 years of age.

Tables 1, 2, 3 and 4 show the mean eruption age for each of the permanent teeth in both arches by gender. In both girls

Table 1. Mean eruption ages for boys. Upper jaw. (95% confidence interval).

	NO. OF TOOTH	RIGHT SIDE			NO. OF TOOTH	LEFT SIDE		
		C.I.- L.	M.E.A.	C.I.- U.		C.I.- L.	M.E.A.	C.I.- U.
Central I.	11	6.99	7.17	7.34	21	7.07	7.23	7.39
Lateral I.	12	8.04	8.21	8.39	22	7.99	8.16	8.33
Canine	13	11.44	11.63	11.82	23	11.39	11.59	11.79
F. Premolar	14	10.66	10.86	11.06	24	10.68	10.88	11.07
S. Premolar	15	11.29	11.48	11.67	25	11.27	11.46	11.66
F. Molar	16	6.08	6.28	6.48	26	6.11	6.31	6.50
S. Molar	17	12.27	12.48	12.69	27	12.18	12.37	12.56

M.E.A.: Mean eruption age.
C.I.- U: Confidence interval. Upper limit.
C.I.- L: Confidence interval. Lower limit.

Table 2. Mean eruption ages for boys. Lower jaw. (95% confidence interval).

	NO. OF TOOTH	RIGHT SIDE			NO. OF TOOTH	LEFT SIDE		
		C.I.- L.	M.E.A.	C.I.- U.		C.I.- L.	M.E.A.	C.I.- U.
Central I.	41	6.10	6.29	6.45	31	6.06	6.25	6.45
Lateral I.	42	7.34	7.52	7.70	32	7.23	7.40	7.57
Canine	43	10.41	10.61	10.81	33	10.46	10.65	10.85
F. Premolar	44	10.45	10.65	10.85	34	10.55	10.76	10.96
S. Premolar	45	11.46	11.66	11.87	35	11.31	11.52	11.73
F. Molar	46	6.13	6.32	6.51	36	6.10	6.29	6.49
S. Molar	47	11.76	11.96	12.16	37	11.67	11.89	12.10

M.E.A.: Mean eruption age.
C.I.- U: Confidence interval. Upper limit.
C.I.- L: Confidence interval. Lower limit.

Table 3. Mean eruption ages for girls. Upper jaw. (95% confidence interval).

	NO. OF TOOTH	RIGHT SIDE			NO. OF TOOTH	LEFT SIDE		
		C.I.- L.	M.E.A.	C.I.- U.		C.I.- L.	M.E.A.	C.I.- U.
Central I.	11	6.71	6.89	7.07	21	6.66	6.83	7.00
Lateral I.	12	7.58	7.37	7.89	22	7.58	7.72	7.87
Canine	13	10.70	10.95	11.20	23	10.67	10.92	11.16
F. Premolar	14	10.14	10.36	10.58	24	9.93	10.15	10.37
S. Premolar	15	10.89	11.15	11.41	25	10.83	11.09	11.36
F. Molar	16	5.96	6.16	6.36	26	5.96	6.16	6.36
S. Molar	17	12.00	12.24	12.48	27	11.90	12.15	12.40

M.E.A.: Mean eruption age.
C.I.- U: Confidence interval. Upper limit.
C.I.- L: Confidence interval. Lower limit.

Table 4. Mean eruption ages for girls. Lower jaw. (95% confidence interval).

	NO. OF TOOTH	RIGHT SIDE			NO. OF TOOTH	LEFT SIDE		
		C.I.- L.	M.E.A.	C.I.- U.		C.I.- L.	M.E.A.	C.I.- U.
Central I.	41	5.83	6.00	6.18	31	5.81	5.99	6.17
Lateral I.	42	7.08	7.26	7.44	32	7.03	7.21	7.39
Canine	43	9.59	9.79	9.99	33	9.55	9.75	9.95
F. Premolar	44	10.00	10.29	10.52	34	9.77	10.00	10.23
S. Premolar	45	10.98	11.28	11.55	35	10.71	10.98	11.25
F. Molar	46	5.91	6.09	6.26	36	5.88	6.06	6.24
S. Molar	47	11.22	11.46	11.70	37	11.15	11.40	11.65

M.E.A.: Mean eruption age.
C.I.- U: Confidence interval. Upper limit.
C.I.- L: Confidence interval. Lower limit.

Table 5. Mean eruption ages in decimal and chronological age format. (in brackets, years and months). Boys.

	UPPER JAW	LOWER JAW
CENTRAL INCISOR	7.20 (7y, 2m)	6.27 (6y, 3m)
LATERAL INCISOR	8.17 (8y, 2m)	7.46 (7y, 6m)
CANINE	11.61 (11y, 7m)	10.63 (10y, 8m)
FIRST PREMOLAR	10.87 (10y, 10m)	10.71 (10y, 9m)
SECOND PREMOLAR	11.47 (11y, 6m)	11.59 (11y, 7m)
FIRST MOLAR	6.30 (6y, 4m)	6.31 (6y, 4m)
SECOND MOLAR	12.43 (12y, 5m)	11.93 (11y, 11m)

Table 6. Mean eruption ages in decimal and chronological age format. (in brackets, years and months). Girls.

	UPPER JAW	LOWER JAW
CENTRAL INCISOR	6.86 (6y, 10m)	6.00 (6y, 0m)
LATERAL INCISOR	7.55 (7y, 7m)	7.24 (7y, 3m)
CANINE	10.94 (10y, 11m)	9.77 (9y, 9m)
FIRST PREMOLAR	10.26 (10y, 3m)	10.15 (10y, 2m)
SECOND PREMOLAR	11.12 (11y, 1m)	11.13 (11y, 2m)
FIRST MOLAR	6.16 (6y, 2m)	6.08 (6y, 1m)
SECOND MOLAR	12.20 (12y, 2m)	11.43 (11y, 5m)

and boys, the first tooth to erupt was the lower left central incisor at 5.99 years (decimal age) or 5 years 11 months (chronological age) for girls, and at 6.25 years or 6 years 3 months for boys. The two genders also coincide in the last tooth to erupt: the upper right second molar. The mean eruption age for this tooth was 12.24 years or 12 years 3 months for girls and 12.48 years or 12 years 5 months for boys.

There is a clear overall tendency for mandibular teeth to erupt before the corresponding maxillary teeth in both genders, where this difference is statistically significant ($p<0.05$) for the following pairs of teeth: seconds molars, canines, central and lateral incisors.

Since no significant differences were observed between the left and right hemi-arches, an average of the mean eruption age of each pair of teeth (left and right) in each arch was calculated for the two genders. The results are shown in Tables 5 and 6, where the age appears in decimal and chronological formats. These tables show the corresponding eruptive sequences for both arches in the two genders. The sequence is the same for both genders in the mandible. In the maxilla the order of the second stage of exchange is as follows: first premolar, second premolar, canine and second molar for boys, and first premolar, canine, second premolar and second molar for girls. The first tooth to erupt in the maxilla is the first molar and in the mandible the central incisor, for both genders.

DISCUSSION

In medicine, both somatic growth curves and dental formulas are used to estimate biological age and to track children's growth. In dentistry, the eruption and exchange of teeth is of particular interest since dental problems often arise during this period. Furthermore, the eruption sequence and growth of the jaws are key elements in the development of a functional and aesthetic occlusion.

The findings of this study are very similar to the classic eruption tables for Caucasian populations contained in Logan and Kronfeld,[8] Hurme,[9] Cohen[10] and others.[11-13] In addition, our findings are in agreement with more recent studies in different Caucasian populations.[14-20]

This cross-sectional study used Kärber's method[6] to obtain mean eruption ages based on the accumulated proportion of the sample with each specific tooth present, for boys and for girls, in each age group. The method assumes that the distribution of eruption ages follows a normal probability distribution. The eruption ages of permanent teeth determined using longitudinal and cross-sectional studies by applying Kärber's method differ only very slightly.[5]

Given that the group of children in this study is comparable in terms of height and weight to the population studied by Hernández *et al.*[7] the eruption tables presented here are considered to be representative of the Spanish population.

When the maxillary and mandibular arches are compared, there is a tendency for mandibular teeth to be chronologically advanced when compared to maxillary teeth, as reported by several authors.[10,13-21] Specifically, a statistically significant difference was found for the incisors, canines and seconds molars. For premolars and first molars minimal differences in the time of eruption between the two arches were found.

Not surprisingly, our results agree with those of many other authors insofar as eruption on the left and right side of the arches is symmetric[11,12,14-20,22,23] Many authors also find that permanent teeth erupt earlier in girls than in boys.[1,10,14-21,24-26]

The resulting eruption sequences seem to favour a functional and aesthetic occlusion. In the mandible, for both genders, the eruption sequence is as follows: central incisor, first molar, lateral incisor, canine, first premolar, second premolar and second molar. The eruption of the canine before the premolars helps maintain the arch length. The eruption of the second premolar after the canine and the first premolar leads to improved redistribution of the drift space. The eruption sequence here depicted, agrees with that reported by many authors.[5,11-13,15,16,27] Other authors[14,19] report the most frequent variation as the first molar erupting before the central incisor.

The sequence observed in the maxilla for boys is as follows: first molar, central incisor, lateral incisor, first premolar, second premolar, canine and second molar; and first molar, central incisor, lateral incisor, first premolar, canine,

second premolar and second molar for girls. These sequences are considered adequate for maintaining drift space and avoiding the mesialization of the first molars. The sequence where the second premolar erupts before the canine has also been reported by Carr,[5] Hurme,[9] Savara and Steen[12] and others.[17,21] Sturdivant, Knott and Meredith,[11] Kochhar and Richardson,[15] Nanda,[27] and Sato and Parsons[28] have reported the canine erupting between the two premolars.

Since this study was not longitudinal, our findings did not include the different orders of eruption experienced by each gender nor the percentage of the different eruption sequences.

This study shows that the first tooth to erupt in both genders is the lower central incisor. From the error margin for this result together with the error margins for the maxillary and mandibular first molars, it becomes apparent that, in many cases, this order of eruption may be reversed or simultaneous.

CONCLUSIONS

The results of this study were obtained through straightforward, reproducible and non-invasive methodology.

The results of this study offer useful information pertinent to decision making.

This research is relevant for decisions regarding: a) whether or not to extract a tooth, b) the placement of space maintainers, and c) the start of orthodontic treatment.

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