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Age and Sequence of Emergence of Permanent Teeth
in a Population of Costa Rican Schoolchildren

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Edad y secuencia de erupción de la dentición permanente
en una población de niños escolares en Costa Rica

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ABSTRACT: The aim of this study was to determine the average age and sequence of eruption of permanent dentition in the school population of the province of Cartago, Costa Rica. **Methods:** A cross-sectional observational study included children between the ages of 5 and 12 from public and private schools. Clinical examination was performed, and the presence or absence of permanent teeth recorded. **Statistical analysis:** An estimation of means of eruption was used through binary variables, building the probabilities of the presence of a dental piece through a logistic regression. **Results:** 833 children were examined: 433 (51.90%) girls and 400 (48.10%) boys. The permanent teeth erupt first in the female sex; however, this difference is not statistically significant. The maxilla eruption sequence for girls was 6-1-2-4-3-5-7 on both sides; for boys, the sequence of eruption was 6-1-2-4-5-3-7 for the right side and 6-1-2-4-3-5-7 for the left side. In the jaw, the sequence in boys was 6-1-2-3-4-5-7, and in girls, 1-6-2-3-4-5-7. **Conclusions:** For the first time, at the Central American Level, the pattern of permanent dentition eruption could be established. The age of permanent dental eruption does not vary according to sex in this population.

KEYWORDS: Tooth emergence; Eruption sequence; Permanent teeth; Teeth; Children.

RESUMEN: El objetivo de este estudio fue determinar la edad promedio y la secuencia de erupción de la dentición permanente en la población escolar de la provincia de Cartago, Costa Rica. Metodología: se realizó un estudio transversal que incluyó niños con edades comprendidas entre los 5 y 12 años provenientes de escuelas públicas y privadas. Se realizó un examen clínico y se registró la presencia o ausencia de dientes permanentes. Análisis estadístico: se utilizó una estimación de las medias de erupción a través de variables binarias, construyendo las probabilidades de la presencia de una pieza dental por medio de una regresión logística. Resultados: se examinaron 833 sujetos: 433 (51,90%) niñas y 400 (48,10%) niños. Los dientes permanentes erupcionaron primero en el sexo femenino, sin embargo, esa diferencia no fue estadísticamente significativa. La secuencia de erupción maxilar para las niñas fue 6-1-2-4-3-5-7 en ambos lados; para los niños la secuencia fue 6-1-2-4-5-3-7 para el lado derecho y 6-1-2-4-3-5-7 para el lado izquierdo. En la mandíbula, la secuencia en los niños fue de 6-1-2-3-4-5-7-, y en las niñas fue de 1-6-2-3-4-5-7. Conclusiones: por primera vez a nivel de Centroamérica se pudo establecer el patrón de erupción de la dentición permanente. La edad de erupción dental permanente no varía según el sexo en esta población.

PALABRAS CLAVE: Erupción dental; Secuencia de erupción; Dentición permanente; Dientes; Niños.

INTRODUCTION

The definition of the term “eruption” is the “axial or occlusal movement of a tooth from its developmental position within the jaws to its functional position in the occlusal plane” (1). The age of dental eruption is very important for orthodontics as well as for pediatric dentistry, since it assists in establishing a diagnosis and type of treatment; it is also useful in forensic science and anthropology because it allows age to be estimated when such information is not available (2,3). All the mechanisms involved in the timing of tooth eruption are not fully known because odontogenesis is a complex process and could be influenced by different aspects (4-6).

The eruption of permanent teeth is influenced by climatic, racial, as well as genetics, hormonal factors, nutritional status, body composition, fluoride intake, season of birth, and various temporal and growth parameters. There are also general pathological

conditions, irradiations, and developmental syndromes that can alter the eruption pattern (1). Gender is one of the factors that play an important role in eruption pattern, as many studies conclude that girls’ teeth tend to erupt earlier (7-9). Moreover, studies have established that ethnicity and geographic variation lead to differences in eruption times (10). For example, the teeth of black children in Africa erupt earlier than those of Caucasians and Asians (11); a similar situation is the case for Cook Island children compared to Europeans (12).

Eruption studies have been carried out in different populations: European (10,13), African (14), and North America (15). However, in Central America, and specifically in Costa Rica there are no studies regarding the age of eruption of the permanent dentition. Given the importance of knowing such ages for correct decision-making in the management of children in stages of mixed dentition, the aim of the present study was to investigate permanent tooth emergence in children living in Cartago, Costa Rica.

MATERIALS AND METHODS

STUDY AREA

An observational and retrospective study was conducted in the province of Cartago, Costa Rica. Cartago was selected because it is in the metropolitan area of the country; it has an area of 287.77 km² and a population of 515,385.

SUBJECT SELECTION

The size of the sample was calculated based on data provided by the Regional Directorate of Cartago within the Ministry of Public Education; they reported that by 2017, the number of schools in the Central Canton was 18 schools and the number of schoolchildren enrolled was 7,788. The calculation of the sample allows estimations with a confidence level of 95% (error type I 5%, type II 20%), a maximum permissible error of two children with differentiated dental age and a prevalence of 21 individuals per group grade with an expected tooth eruption pattern.

The schools were listed in alphabetical order and one out of two schools were selected; the total of schools selected was nine. From each participating school, one group from every grade (first through sixth). The sample contains a 25% estimate of non-response, either due to non-participation in the study or due to the absence of a child on the day of the data collection.

Once the six groups from each school had been selected; a letter was sent to parents to explain the study details and to invite them to participate. Those who agreed to participate in the study received the informed consent form to be signed.

The inclusion criteria were boys and girls between 5 and 12 years in mixed dentition with signed informed consent forms. The children with enamel or dentin malformations, orthodontic

treatments, premature dental extractions, or conditions that alter dental eruption, like amelogenesis imperfecta, ectodermic dysplasia, or Rieger syndrome were excluded. The exclusion of children with these characteristics was done when the clinical examination was performed. No selection was made concerning differences in physical or mental development, social status, religion, ethnicity, or whether the child was born in Cartago or not.

ETHICAL CONSIDERATIONS

This study was approved by the Institutional Committee on Research of the University of Costa Rica (No 440-B7-348). Through the school/ kindergarten administrations, informed consent forms were sent to the parents of each child. Only children whose forms had been signed by a parent could participate in the study. Each participant's parents were asked to fill out a form with their children's sex and exact birth date.

CALIBRATION OF EXAMINER

The clinical examination was performed by a single dentist previously calibrated with a gold standard specialist, with an inter-examiner kappa of 0.83.

DATA COLLECTION

Clinical examinations were conducted in a classroom the school provided, with the support of a dental assistant. Children were examined within schools' hours in portable dental chair with external light and an oral mirror, following all infection control protocols. The clinical examination for each child lasted 5 minutes approximately. An average of 50 children were examined daily.

During dental examination, all erupted permanent teeth, except third molars, were recorded. A tooth was recorded as "emerged" if any part of it had penetrated the oral mucosa and become clinically

visible (1,7,14). Age was calculated from the date of birth reported in the schools' documents to the day of oral examination. The variables studied were age, gender (female/male), and present teeth.

STATISTICAL ANALYSIS

The data were recorded in an Excel spreadsheet (Microsoft, Inc., Redmond, WA, USA), entered, and corrected for inconsistencies. Descriptive data analysis was performed for all variables, with the calculation of proportions and measures of central tendency and variability. The variable of presence/absence of teeth was codified in a binary form. The distribution of probabilities for each age was calculated using a binary logistic regression model, and the average and standard deviation of the eruption age for each tooth was calculated ($p < 0.05$, CI 95%).

The Shapiro-Wilks test was used to verify the normality and Levene's test to assess the equality of variances. A t-test was used for means comparison between sexes ($p < 0.05$, CI 95%). All analyses were developed in SPSS version 22.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

A total of 833 boys and girls of ages between 5 and 12 were examined, 433 (51.90%) girls and 400 (48.10%) boys. The overall mean age was 9.30 years (2.07 SD) and by gender, the average

age was 9.20 years (0.09 SD) for girls and 9.39 years (0.10 SD) for boys. Table 1 summarizes the distribution of boys and girls according to the age groups studied.

Table 1. Distribution of girls and boys according to age group.

Age	Girls (n)/ porcentaje (%)	Boys (n)/ porcentaje (%)
5	22 (57.9)	16 (42.1)
6	66 (60.0)	44 (40.0)
7	48 (45.7)	57 (54.3)
8	69 (55.6)	55 (44.4)
9	64 (49.6)	65 (50.4)
10	64 (53.8)	54 (46.2)
11	48 (43.6)	62 (56.4)
12	52 (52.5)	47 (47.5)
Total	433 (100)	400 (100)

The eruption of permanent teeth seems to occur earlier in girls than in boys, except in the first lower molar, but without statistical significance. The maxilla eruption sequence for girls was 6-1-2-4-3-5-7 on both sides. In boys, the sequence of eruption differs according to the side, being 6-1-2-4-5-3-7 for the right side and 6-1-2-4-3-5-7 for the left side. In the jaw, there was no difference between the left and right sides in either sex. The sequence in boys was 6-1-2-3-4-5-7 and in girls 1-6-2-3-4-5-7. The lower incisors and canines erupted first than the upper ones in both boys and girls (Table 2).

Table 2. Mean and standard deviation (SD) of eruption time (in years) of permanent teeth in children by according to sex.

Tooth	Total			Male			Female			p*
	- 1 SD	Mean	+ 1 SD	- 1 SD	Mean	+ 1 SD	- 1 SD	Mean	+ 1 SD	
17	10.96	12.33	13.71	10.99	12.37	13.75	10.52	11.84	13.16	0.79
16	5.82	6.55	7.27	5.83	6.56	7.30	5.81	6.54	7.27	0.96
15	9.95	11.20	12.45	9.98	11.23	12.49	9.82	11.05	12.28	0.81
14	9.03	10.16	11.30	9.13	10.28	11.42	8.91	10.03	11.15	0.63
13	9.94	11.19	12.44	10.15	11.42	12.69	9.62	10.83	12.03	0.52
12	7.38	8.30	9.23	7.60	8.55	9.51	7.16	8.06	8.96	0.48
11	6.35	7.15	7.94	6.44	7.25	8.06	6.26	7.05	7.83	0.78
21	6.39	7.20	8.00	6.49	7.30	8.11	6.31	7.10	7.89	0.79
22	7.37	8.30	9.22	7.63	8.59	9.55	7.12	8.01	8.91	0.50
23	9.89	11.13	12.37	9.99	11.24	12.49	9.71	10.93	12.15	0.69
24	9.10	10.24	11.38	9.24	10.40	11.56	8.93	10.05	11.18	0.56
25	9.97	11.22	12.47	10.05	11.31	12.57	9.72	10.94	12.16	0.66
26	5.80	6.52	7.25	5.77	6.49	7.22	5.80	6.53	7.26	0.96
27	10.92	12.29	13.66	10.96	12.34	13.71	10.59	11.92	13.25	0.77
37	10.40	11.70	13.00	10.54	11.86	13.18	10.17	11.44	12.72	0.76
36	5.58	6.28	6.98	5.55	6.24	6.94	5.61	6.32	7.02	0.88
35	9.91	11.16	12.40	10.09	11.36	12.62	9.65	10.86	12.07	0.58
34	9.22	10.38	11.54	9.43	10.61	11.79	9.00	10.13	11.26	0.52
33	9.14	10.29	11.44	9.41	10.59	11.77	8.87	9.98	11.09	0.49
32	6.64	7.47	8.30	6.69	7.53	8.37	6.58	7.41	8.23	0.83
31	5.50	6.19	6.88	5.54	6.24	6.93	5.46	6.15	6.83	0.84
41	5.51	6.20	6.89	5.65	6.36	7.07	5.40	6.08	6.76	0.66
42	6.55	7.37	8.19	6.59	7.42	8.24	6.49	7.30	8.11	0.88
43	9.13	10.28	11.42	9.33	10.50	11.68	8.92	10.04	11.16	0.57
44	9.18	10.33	11.48	9.32	10.49	11.66	9.01	10.13	11.26	0.55
45	9.93	11.18	12.42	10.11	11.38	12.65	9.67	10.89	12.10	0.61
46	5.52	6.21	6.91	5.46	6.14	6.83	5.56	6.25	6.95	0.87
47	10.42	11.72	13.03	10.51	11.83	13.15	10.19	11.47	12.75	0.73

DISCUSSION

The age and sequence of eruption varies among genders and ethnicities (1). In this study, most of the permanent teeth erupted first in the female sex, without being a statistically significant difference. This situation was also present in various studies conducted in South Africa, Jordan

(8,14), Lithuania (11), and Syria (16), where the male participants had a statistically significantly later eruption than the females (11). Some authors try to explain this situation with hormonal factors. Their theory is based on the effect of the maturation on the dental development and tooth eruption, so the fact that girls mature faster causes earlier emergence of permanent teeth (17).

The sequence of eruption did not show statistically significant differences between the sexes, although there were certain differences. For example, in the jaw, the first tooth to erupt in males was the first permanent molar, while in females, it was the central incisive tooth; these results coincide with a study conducted in Turkey in 2016 (10). A similarity in both sexes was observed in the maxilla, where the first tooth to erupt was the first molar, a result prevalent in several investigations: Turkey in 2015, Jordan in 2011, and Tokyo in 2018 (8,10,18). In addition, in girls, the sequence of eruption in the maxilla is not altered according to the side, contrary to what happens in the male sex, where the premolars erupt first, but on the left side, the canine erupts before the second premolar. This situation in the male sex was also observed in a study conducted in Iran in 2004 (19). Some authors explain that this situation could happen due to an early loss of primary molars (10,20).

When comparing our results with those obtained worldwide, the eruption age averages are close to the results of the United States (15) and Spain (13). However, the research conducted with a black population (14), as in Cuban children (21), had an earlier eruption age, as opposed to the population of India, which had a later eruption (1). The above reinforces that ethnicity and geographical variations influence the age of permanent dentition eruption (19).

In this study, radiographs were not used; for this reason, the hypodontias, or impacted teeth, could not be identified, which could lead to overestimating the age of eruption of a tooth (10). Despite this, most of the reference literature uses cross-sectional studies with clinical evaluation as the only method to determine the sequence of eruption age, like this study, a situation that allows its comparison with other investigations. However, ideally, a cohort study from 6 to 14 years

to observe the growth and development of human jaws, like the Yeoncheon Project (22), should be done because it could provide high level evidence due the continuous evaluation of each child during his/her development.

This investigation was a transversal study conducted only in the province of Cartago. This type of study was selected due the absence of a previous investigation in the country, and Cartago was selected because it belongs to the Central Valley, where most of the country's population lives. In the future, a prospective cohort study of timing and sequence of emergence of permanent teeth is planned in Costa Rica, with a significant sample of the entire country, to validate the results obtained in this study and provide high level of evidence.

CONCLUSION

For the first time, in Costa Rica children, the pattern of permanent dentition eruption could be established, being a precedent at Central American. The age and sequence of permanent dental eruption do not vary according to sex in this population. A similar pattern was observed between the results obtained in this study and others worldwide.

COMPLIANCE WITH ETHICAL STANDARDS

Conflict of interest All authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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