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An epidemiological survey of the time and sequence of eruption of permanent teeth in 4–15-year-olds in Tehran, Iran

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Summary. *Aim.* The aims of this study were to define the average time of eruption of permanent teeth, the range of variation of the eruption time of each tooth, and their sequence of eruption amongst boys and girls in Tehran, Iran.
Methods. The population under study comprised 3744 pupils and students in the 4–15-year-old age group (1786 girls and 1958 boys) who were randomly selected from schools and training centres in the 20 districts covered by the General Department of Education and Training in Tehran. The research was carried out on a cross-sectional basis. The average age at eruption of permanent teeth, excluding third molars, was given as the mean (± SD) and median in months for each gender. A table of percentiles of the eruption time was also determined.
Results. The results show that, with the exception of the maxillary second premolars, the average age at eruption of permanent teeth in girls is less than in boys. The results also show that mandibular teeth have an earlier eruption time than maxillary teeth in both boys and girls. By the age of 96 months, 97% of the girls had all their first permanent molars. In boys, the corresponding age was 99 months. Amongst girls, maxillary canines erupt earlier than maxillary second premolars.
Conclusion. On average, girls have their permanent teeth erupt earlier than boys. The sequence of eruption differs between girls and boys for maxillary canines and maxillary second premolars.

Introduction

Human beings have two sets of natural teeth, the primary and the permanent dentitions. The primary dentition comprises 20 teeth which erupt from the age of 6 months up to the age of 30 months. The permanent dentition comprises 32 teeth which erupt after the age of approximately 5 years. Human teeth do not appear simultaneously in either dentition. In general, the eruption time of permanent teeth is subject to more variability than that observed in primary teeth. Studies on the eruption pattern of both primary and permanent teeth have been conducted since the middle of the twentieth century [1–6]. Genetic and hormonal factors, geographical, tribal, gender and ethnic differences, as well as economic status, nutrition and growth parameters have been shown to exert an influence on eruption patterns [1]. Studies have suggested that Caucasians have a delayed time of eruption when compared to other ethnic groups [1,3]. In addition, Negroes have been shown to have an earlier eruption pattern than Caucasians [2].

Since the end of the nineteenth century, a trend towards earlier eruption of permanent teeth has been reported in industrialized countries. This is thought to be primarily caused by earlier puberty, which, in turn, is a result of better nutrition and healthcare for children [3]. Relationships between the time of eruption, and the weight and height of children have also been reported [4,5]: children who are below

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average weight and height for a specific age show a later eruption time than those children who are within the standard range.

Economic and social status exert an influence on nutrition, and personal hygiene has been shown to be related to an eruption lag in anterior teeth and an earlier-than-normal eruption of posterior teeth [2]. The time of eruption of anterior teeth is thought reflect the general condition of the child, whereas that of posterior teeth shows the effect of oral hygiene as a means of protection for primary teeth [2]. Taking the differences into consideration, it has been reported that the time of eruption in girls is earlier than that in boys [1–3].

There are different opinions concerning the cause of later- or earlier-than-normal eruption of teeth, but there is little or no information about the time and sequence of the eruption of permanent teeth and their range of natural variability in Iran. Therefore, the aims of this study were to define the average time of eruption of permanent teeth, the range of variation of the eruption time of each tooth, and their sequence of eruption amongst boys and girls in Tehran, Iran.

It is assumed that the Tehran population is relatively homogenous in terms of ethnicity, and therefore, that there are no marked ethnic differences in collected samples. School age is similar for all children.

Subjects and methods

Population and sample

The population used for this cross-sectional study comprised pupils and students from nurseries, kindergartens, primary and guidance schools, and students in first-year high schools in Tehran, Iran. The underlying assumption of this research was the 'ethnic uniformity' of the samples. Any possible ethnic differences, such as those of religious and ethnic minorities, are very negligible in Tehran, and therefore, their possible effects have been disregarded. These educational institutions are scattered over in 20 districts of the city in the vicinity of the Research Department of Medical Science of Shahid Beheshti University. A systematic stratified random sample was drawn from the institutions.

Initially, all schools were given a number on the basis of being nurseries, kindergartens, primary and guidance, or first-year high schools. Using a table of random numbers, 14 schools from each level were then selected. Overall, 56 schools, including nurseries, were selected; half of these were assigned to girls and the other half to boys.

Before starting, introductory letters from the research deputy of the University were sent to the General Department of Education and Training of Tehran, and to the country's Health Welfare Organization. After agreement from the General Department of Education and Training, introductory letters were then sent to the 20 districts of the city, and by visiting each district's specific department, permission was gained to approach the schools which were under its supervision. Permissions were issued separately on the basis of being assigned for girls or boys.

Interviews and clinical examination

The research team visited each school and kindergarten that had been selected for the study. After giving the necessary explanations to the school authorities, sessions were arranged for pupils and their parents to describe and discuss the study, and obtain consent. Students were randomly selected from the school census records. One member of the research team reviewed the students' files to obtain basic information, such as age, gender, occupation of the father, educational level of the parents, place of residence and home ownership status. The information was recorded on forms. If necessary information was missing, questions were checked during the interviews with the students (or their parents). Information collected at interview relating to general health included the frequency and duration of toothbrushing, condition of fingernails, and hair and facial colour. Students were weighed in kilograms using a scale after removal of outdoor clothes and shoes. The height of the children was measured using a wall-mounted ruler on the child's head with their back and knees completely straight, and their feet together. The height was then rounded to the nearest centimetre.

The mouths of the students were then examined, and the number of decayed, filled and extracted teeth was recorded on the forms using the standard recommended by the World Health Organization [9].

In the final step, the students' mouths were examined by one examiner (M.M.) using a spatula to retract soft tissues, and the status of eruption of each permanent tooth was recorded. If any part of a tooth was visible, however small, the tooth was regarded as erupted and recorded on the survey sheet accordingly. In the absence of a visible sign, the corresponding space on the form was left blank.

The average time of eruption in months for each tooth according to gender was estimated in terms of the mean (± SD) and median. Minimum and maximum values, and the range of variation of the eruption time of each tooth were also estimated. Different percentiles (P3, P10, P25, P50, P75, P90 and P97) of the time of eruption of the permanent teeth, excluding the third molars, are presented separately for boys and girls. The sequence of eruption of permanent teeth amongst each group is also shown in years. Student's *t*-test was used to test for differences between the sexes in the sequence of eruption of permanent teeth.

Results

Table 1 shows the mean (± SD), median, minimum and maximum values, and the range of variation of the eruption time (in months) of permanent teeth in boys and girls in Tehran. With a few exceptions, the minimum age of eruption of permanent teeth in girls was, on average, younger than in boys. The results show that the first teeth to erupt in girls were 31 and 41, i.e. the mandibular central incisors. The eruption of 41 occurred at a mean age of 78 months (range = 57–86 months). For 31, the mean age was 78 months (range = 53–86 months). The eruption of the lower incisors was followed by the eruption of the mandibular first molars at a mean and median age of 80 months (range = 56–92 months for the mandibular right first molar and range = 57–92 months for the mandibular left first molar).

The range of variation in eruption time differed for differing permanent teeth, and between girls and boys. In girls, the minimum range of variation in eruption (29 months) was seen in tooth 41 (the mandibular right central incisor). The maximum range of variation in girls (72 months) was seen for the second premolars, particularly the maxillary right second premolar (tooth 15). In boys, the minimum range of variation of eruption (35 months) was seen in the mandibular left central incisor (tooth 31); the maximum range of variation in boys was seen in the mandibular right first premolar (75 months), followed by the maxillary left canine (74 months) (Table 1).

Table 1. Mean and standard deviation (SD), median (med), minimum (min) and maximum (max) values, and the range of variation of the eruption time (in months) of permanent teeth in boys and girls in Tehran.

	Boys						Girls					
Tooth	Mean	SD	Med	Min	Max	Range	Mean	SD	Med	Min	Max	Range
11	97	8	96	66	107	41	93	8	92	66	104	38
12	113	10	110	79	125	46	103	8	102	76	113	37
13	151	12	149	114	167	53	146	14	144	100	164	64
14	138	14	136	94	155	61	133	14	131	84	152	68
15	150	14	148	107	167	60	151	16	149	101	173	72
16	82	9	81	56	95	39	80	8	80	57	92	35
17	157	12	156	114	173	59	151	11	149	110	164	54
21	96	9	95	66	107	41	88	6	86	64	95	31
22	110	9	108	69	122	53	108	11	106	76	122	46
23	158	16	157	108	182	74	146	14	144	101	164	63
24	136	12	133	94	149	55	133	14	131	84	152	68
25	147	12	144	102	161	59	151	16	149	103	173	70
26	82	9	81	56	95	39	81	8	80	57	92	35
27	154	11	152	114	167	53	151	11	149	114	164	50
41	80	7	79	52	89	37	78	6	77	57	86	29
42	101	10	100	68	113	45	94	8	93	74	104	30
43	141	11	139	96	155	59	126	10	125	85	140	55
44	146	16	144	92	167	75	134	13	113	100	152	52
45	154	14	153	105	173	68	152	16	150	103	173	70
46	82	9	81	57	95	38	80	8	80	57	92	35
47	155	13	153	114	173	59	149	13	146	104	164	60
31	82	8	81	57	92	35	78	6	77	53	86	33
32	101	10	100	68	113	45	96	8	95	74	107	33
33	141	11	139	103	155	52	120	8	119	94	131	37
34	140	12	138	95	155	60	132	11	130	97	146	49
35	157	15	156	107	179	72	151	15	148	103	170	67
36	82	9	82	57	95	38	80	8	79	56	92	36
37	149	11	147	114	161	47	149	13	146	104	164	60

Table 2. Different percentiles (Ps) of eruption time (in months) of the 28 permanent teeth in girls from Tehran, Iran.

	Percentile						
Tooth	P97	P90	P75	P50	P25	P10	P3
11	108	102	100	93	86	79	78
12	118	112	108	103	96	89	88
13	172·3	161	155	146	134	125	119·6
14	159·3	149	142	133	122	112	106
15	181	168	163	151	137	126	121
16	95	90	86	80	74	68	65
17	171	162	158	151	141	132·2	130
21	99·3	94	92	88	81	77·7	76·7
22	128·7	119	115	108	100	90·3	87·3
23	172·3	161	156	146	135	125	119·6
24	159·3	149	142	133	121·7	112	106·6
25	181	168	163	151	137	125	121
26	96	90	87	81	75	69	66
27	171·7	162	158	151	141	132	130·3
41	88·3	84	81	77·5	72	67·5	65·7
42	111	105	101·5	96	89	81·6	81
43	137	129	126	120	114	105	103
44	152·7	144	139	132	123	113	111·3
45	179·2	166	161	151	138	126	122·7
46	95	90	86	80	73·5	67	65
47	173·4	162	157	149	138	127	124·5
31	89·3	84·7	82	78	72	68	66·7
32	109	102·8	100	94	88	81	79
33	144·8	138	134	126	117	110	107
34	158·4	149	143·7	134	124	113·3	109·5
35	182	168	163	152	138	127	126
36	95	90	87	80	74	68	65
37	173·4	161	157	149	137·5	128	124·5

Table 3. Different percentiles (Ps) of eruption time (in months) of the 28 permanent teeth in boys from Tehran, Iran.

	Percentile						
Tooth	P97	P90	P75	P50	P25	P10	P3
11	112	105	103	97	90	83·5	82
12	118·8	124	117	113	103	95	92
13	173·5	164	160	151	141	132	128·4
14	164·3	152	149	138	127	115	111·6
15	176·3	164	159	150	139	128·7	123·6
16	99	93	89	82	75	69	62
17	179·5	170	165	157	148·2	139	134·4
21	113	105	102	96	89	82	79
22	127	119	115	110	102	95	93
23	188	178	170	158	145	136	128
24	158·5	148	142	136	125	115	113·4
25	169·5	159	154	147	137	128	124·4
26	99	93	89	82	75	69	65
27	174·7	165	161	154	145·2	137	133·3
41	97	91	88	82	76	69	67
42	119·8	113	108	101	93	87	82
43	161·7	152	149	141	131	124	120·3
44	162·6	152	149	140	129	117·5	117·4
45	185·2	175	168	157	145	137	128·7
46	99	93	89	82	76	70	65
47	169·7	160	156	149	140	133	128·3
31	93·2	89	85	80	74	68·4	66·7
32	116	113	108	101	93	87·7	82
33	159·8	152·5	149	141	131	124	120·3
34	176·1	163	157	146	134	129	116
35	180	169	164	154	143	133	127·6
36	99	93	89	82	74	69	65
37	179·4	169	164	155	144	137	130·5

Tables 2 and 3 show different percentiles (P3, P10, P25, P50, P75, P90 and P97) for the time of eruption of the 28 permanent teeth for girls and boys, respectively. In 3% of the girls examined, the maxillary right central incisor (tooth 11) had erupted by the age of 78 months, and by the age of 108 months, 97% of the girls had their four central incisors (teeth 11, 21, 31 and 41). By the age of 96 months, the first four permanent molars had erupted in 97% of the girls. In addition, the first four permanent molars had erupted between the ages of 65 and 96 months in 94% of the girls (Table 2).

Eruption of the four central incisors in boys occurred slightly later, but by the age of 113 months, 97% of the boys examined had all their central incisors. Only 3% of the boys had all four first permanent molars by the age of 65 months; 94% of them had all their first molars between the ages of 62 and 99 months, and 97% of them had all their first molars in the mouth by the age of 99 months (Table 3).

Figure 1 shows a comparison between the tenth, fiftieth and ninetieth percentiles of the eruption of the permanent teeth in girls and boys. The figure shows diagrammatically that, for most teeth, eruption time was earlier in girls than in boys.

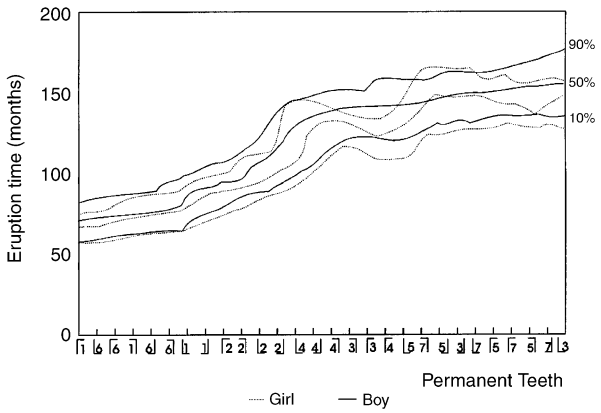

Fig. 1. Comparison between the tenth, fiftieth and ninetieth percentiles of the time of eruption of the permanent teeth in girls and boys in Tehran, Iran.

Figures 2 and 3 show the sequence of eruption of permanent teeth in years amongst girls and boys,

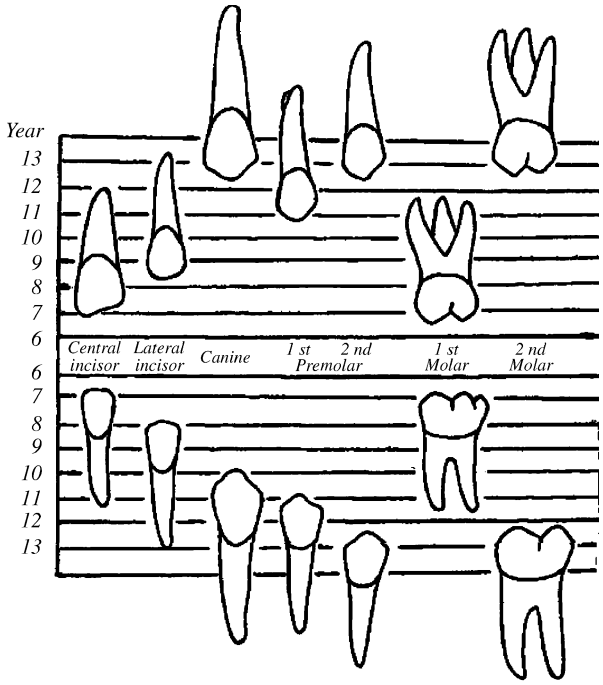

Fig. 2. Sequence of eruption of the primary teeth in girls.

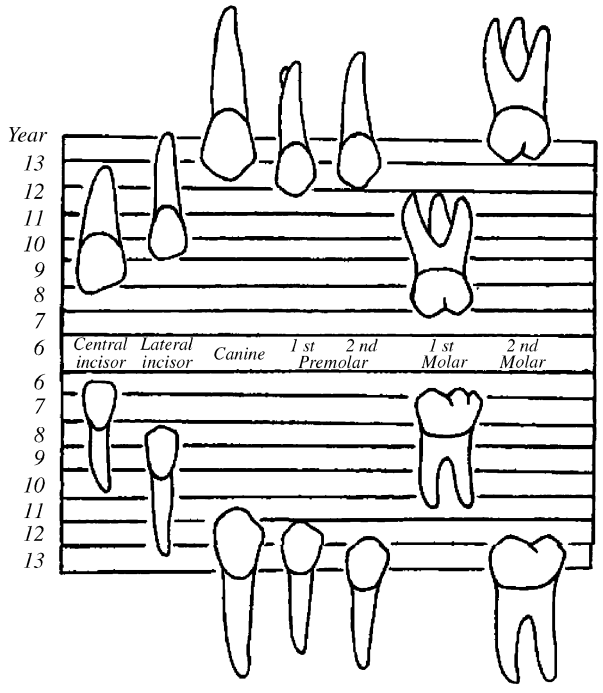

Fig. 3. Sequence of eruption of the primary teeth in boys.

respectively. The sequences of eruption of the maxillary and mandibular teeth are distinct. A difference in the sequence of eruption is also observed between girls and boys. For the maxillary teeth, the sequence of eruption amongst girls was first molars, central incisors, lateral incisors, first premolars, canines, second premolars and, finally, second molars (Fig. 2). Amongst boys, the sequence was first molars, central incisors, lateral incisors, first premolars, second premolars, canines and second molars (Fig. 3). Thus, amongst girls, canines erupt earlier than the second premolars; this was not true in boys. The difference in mean age at eruption of maxillary canines and second premolars in girls was statistically significant ($P < 0{\cdot}001$). This difference was not significant amongst boys, suggesting that maxillary canines and second premolars erupt almost simultaneously in males. For mandibular teeth, the sequence of eruption was similar amongst girls and boys, and was central incisors, followed by first molars, lateral incisors, canines, first premolars, second premolars and second molars (Figs 2 & 3). Thus, the first permanent teeth to erupt were the mandibular central incisors and the last were the maxillary second molars.

Amongst girls, differences between the mean time of eruption of the maxillary and mandibular first molars, and the first premolars were not significant. The same was true for the mandibular second premolars and second molars, which erupted almost simultaneously.

Amongst boys, the temporal differences between the eruption time of the maxillary and mandibular first molars, first premolars, canines, central incisors, second premolars and second molars were not statistically significant.

Discussion

This study has described the average timing and the sequence of eruption of permanent teeth amongst 4–15-year-old girls and boys in Tehran, Iran.

With the exception of the maxillary second premolars, the average age at the eruption of permanent teeth in girls is younger than in boys. The difference in the average time of permanent teeth eruption between girls and boys ranged from 0 to 21 months, with the largest difference being seen in the mandibular left canine (21 months) and no difference being seen in the mandibular left second molar. These results agree with those described elsewhere in the literature. Goran *et al.* [3] reported the difference in the eruption time between genders to be a maximum of 3·4 years (40 months), and Stewart *et al.* [2] reported differences in the eruption time between genders of 2–10 months. In addition, Nanda [7] and Lysell

et al. [8] reported that the average age at eruption amongst girls was distinctly younger than in boys. Thus, the results of this survey clearly conform to previous findings.

The results of this study also show that the mandibular teeth have an earlier eruption time than maxillary teeth in both girls and boys. Again, these results confirm those of previous studies [1,3].

Comparing the eruption time of permanent teeth between the right and left sides, the greatest temporal differences amongst boys were seen in the maxillary canines, which was about 7 months, followed by the mandibular second molars, with a time difference of 6 months. Stewart *et al*. [2] have reported that these differences are not systematic, and can be any length between 6 months and 2 years.

With the exception of the mandibular second molars in girls, the average ages at eruption shown in this study are, in general, greater than those reported by Nanda [7] and Lysell *et al*. [8]. In order to carry out an accurate comparison, it would be essential that the two population variances were equal, but the variance was not indicated in either of the above studies [7,8]. Findings in previous studies have suggested that age at eruption is older in Caucasians than in other ethnic groups [1,3]. Considering the central incisors, lateral incisors and first molars of these children in Tehran, their eruption time was later than that reported in children from South Africa, Kenya, Gambia, Uganda, Ghana, Japan and Black Americans, which would seem to be in agreement with the literature. The timings reported here, however, may not be typical of all Caucasian populations. Nutritional status and socio-economic influences, for example, would seem unlikely to be the same as in other countries, and these are thought to be an important influence.

The sequence of eruption seen in this study is in accordance with previous reports [7,8], with the exception of the mandibular central incisors, which erupted slightly earlier than the four first molars in both girls and boys. In another study involving 1600 children, Carlos & Gittleshon [10] also found that mandibular central incisors erupted earlier than first molars, and Moyers [11] reported the sequence of eruption for the maxillary teeth to be first molars, central incisors, lateral incisors, first premolars, second premolars, canines and second molars. The equivalent for the mandibular teeth was reported as first molars, central incisors, lateral incisors, canines, first premolars, second premolars and second molars. In addition, the same author [11] also reported that the maxillary canines erupted before the second premolars in girls, which is ideal for the maintenance of the alveolar arch.

It may be concluded that the eruption timing and sequence seen in the large sample of children from Tehran followed the patterns seen in other populations. Both may alter with time and with changes in social status, patterns of health and healthcare.

Résumé. *Objectif*. Cette étude a eu pour objectifs de définir la période moyenne d'éruption des dents permanentes, la fourchette de variation pour chaque dent et les séquences d'éruption parmi les garçons et les filles à Téhéran, Iran.
Méthodes. La population étudiée a compris 3744 écoliers et collégiens âgés de 4 à 15 ans (1786 filles et 1958 garçons) sélectionnés au hasard d'écoles et centres des 20 districts couverts par le Département Générale d'Enseignement et de Formation de Téhéran. La recherche a été menée sur un mode transversal. L'âge moyen d'éruption des dents permanentes, hors troisièmes molaires, a été pris comme la moyenne (sd) et médiane en mois pour chaque genre. Une table de percentiles du moment d'éruption a également été déterminée.
Résultats. A l'exception des secondes prémolaires maxillaires, l'âge moyen d'éruption des dents permanentes est inférieur chez les filles par rapport aux garçons. Les dents maxillaires font leur éruption avant les dents maxillaires chez les garçons et les filles. A l'âge de 96 mois, 97% des filles ont toutes leurs premières molaires permanentes. L'âge correspondant chez les garçons est de 99 mois. Chez les filles, les canines maxillaires font leur éruption plus tôt que les secondes prémolaires maxillaires.
Conclusion. En moyenne, les dents permanentes font leur éruption plus tôt chez les filles que chez les garçons. La séquence d'éruption diffère entre les filles et les garçons pour les canines maxillaires et les secondes prémolaires maxillaires.

Zusammenfassung. *Ziel*. Ziele dieser Studie waren die Bestimmung der mittleren Eruptionszeit bleibender Zähne, der Spannweite der Eruption und die Reihenfolge des Zahndurchbruchs zu bestimmen für Jungen und Mädchen aus Teheran, Iran.
Methoden. Die Studienpopulation bestand aus 3744 Schülern im Alter zwischen 4 und 15 Jahren, zufällig ausgewählt aus den 20 Distrikten der Hautverwaltung für Erziehung und Ausbildung in Teheran.

Die Untersuchung wurde als Querschnittstudie ausgeführt. Das mittlere Alter bei Eruption bleibender Zähne (außer den Weisheitszähnen) wurde als Mittelwert mit Standardabweichung und Median (in Monaten) für Jungen und Mädchen getrennt ermittelt. Eine Perzentilentabelle für die Eruptionszeiten wurde ebenfalls erstellt.
Ergebnisse. Die Ergebnisse zeigen, dass mit Ausnahme des zweiten Oberkiefer-Prämolaren die bleibenden Zähne bei Mädchen im Mittel früher durchbrechen als bei Jungen. Außerdem zeigte sich, dass Unterkieferzähne früher durchbrechen als Zähne im Oberkiefer, sowohl bei Jungen als auch Mädchen. Im Alter von 96 Monaten wiesen 97% aller Mädchen alle ersten bleibenden Molaren auf. Die entsprechende Zahl für Jungen betrug 99 Monate. Bei den Mädchen brechen die Eckzähne im Oberkiefer früher durch als die zweiten Prämolaren des Oberkiefers.
Schlussfolgerung. Im Durchschnitt haben Mädchen eine frühere Zahneruption als Jungen. Die Abfolge der Zahneruption unterscheidet sich für Jungen und Mädchen bei den Oberkiefer Eckzähnen und den OK 2. Prämolaren.

Resumen. *Objetivo*. Los objetivos de este estudio fueron definir el tiempo medio de erupción de los dientes permanentes, la amplitud de variación del tiempo de erupción de cada diente y su secuencia de erupción entre niños y niñas de Teherán, Irán.
Métodos. La población de estudio comprendió 3,744 alumnos y estudiantes en el grupo de edad de 4 a 15 años (1,786 niñas y 1,958 niños) seleccionados aleatoriamente de escuelas y centros de enseñanza de 20 distritos cubiertos por el Departamento General de Educación y Enseñanza de Teherán. La investigación se ha realizado de forma transversal. La edad media de erupción de los dientes permanentes excluyendo los terceros molares, se dio como la media (sd) y la mediana en meses para cada género. También se determinó una tabla de percentiles del momento de erupción.
Resultados. Los resultados mostraron que con la excepción de los segundos premolares superiores la media de erupción de los dientes permanentes en niñas es menor que en niños. Los resultados también mostraron que los dientes mandibulares tienen un tiempo de erupción más temprano que los dientes superiores tanto en niños como en niñas. A la edad de 96 meses, el 97% de las niñas tenía todos los primeros molares permanentes. En niños, la edad correspondiente era de 99 meses. Entre las niñas los caninos superiores erupcionan más temprano que los segundos premolares superiores.
Conclusión. Las niñas tienen una erupción más temprana de los dientes permanentes que los niños. La secuencia de erupción difiere entre niñas y niños para los caninos superiores y los segundos premolares superiores.

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