Australian Journal of Basic and Applied Sciences, 2(4): 1120-1128, 2008
ISSN 1991-8178

Eruptive Process of Second Permanent Molar among Egyptian Group

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Abstract The aim of this study was to investigate the eruptive process of the second permanent molar and observe the developmental changes in dental arches during its eruption among a group of Egyptian children. A sample consisted of 191 panoramic radiographs 95 boys and 96 girls aged from six to fifteen years old. It was collected from non identified panoramic x- ray films from patient records of the National Research Centre. The second permanent molars were rated according to the dental developmental stage into four phases (Stage I, whole crown calcified, Stage II, root formation beginning, Stage III, initial formation of the radicular bifurcation, Stage IV, root length is equal to the crown height). Nine reference points were traced from the radiographs for each arch to measure the mesiodistal crown width of the first and second molars, axial inclination and eruptive rate of the second molar as well as the space available in the dental arch for its emergence at each stage. The results of this study revealed that the maxillary second molar inclined distally while mandibular one's inclined mesially (Inclination angle ranged from 71.9º to 86.6º and 110º to 100º respectively). These axial inclinations of the second molars showed a tendency to upright all over the four developmental stages and were prominent in stage IV. This up righting accompanied by gradual increase of the available spaces in both arches and sexes. In both sexes, there is a significant correlation between the mesiodistal crown width, the axial inclination and the available space of the second permanent molars during the fourth stage. Consequently, the eruptive rate was significantly accelerated. In Conclusion, the rate of eruption, available space and changes of the axial inclination of the maxillary and mandibular second permanent molars are closely related and intertwined with each other.

Key words: Eruption, Permanent, Second Molar Tooth, Dental Arch.

INTRODUCTION

The most commonly used parameter for assessing dental maturity has always been the assessment of dental eruption because it is both rapid and convenient. Historically, the first use of eruption as a maturity indicator is recorded in England 1837, and it was stipulated that a child without a second permanent molar would not be allowed to work in factories. Since that time dental criteria were used as an indicator of maturity for school purposes (Demirjian, 1976).

The eruption process is not an instantaneous phenomenon, corresponding to the movement when a tooth pierces the gum. Rather, it is the continuous movement of the dental bud, from the depth to the edge of the alveolar bone and further to the occlusal level (Kitamura, 1998).

During this process, the tooth undergoes different stages of maturation, starting with actual formation of the crypt, and ending with the fully mature tooth. During these maturational stages, one can see continuous changes in the size and shape of the tooth.

Each tooth follows the same sequence and in order to study the entire process, arbitrary stages must be selected and fully described tracing the entire developmental process from beginning to end. Each individual tooth contributes to the process of dental maturity and studying the developmental pattern of a single tooth or a certain group of teeth can allows the follow up the dental maturity. This has clinical applications and can be used in the field of pediatric dentistry where formative stages of individual teeth and their emergence are very important for achieving occlusal harmony, function and dento-facial esthetics.

Tooth eruption is intimately associated with normal dentofacial growth and occlusal development, and the exact time of eruption is clinically important. Scientists recognized the importance of monitoring the normal

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eruptive pathway during growth or remodeling changes of both jaws. Disturbance in the sequence of development or eruption of posterior teeth can be challenge controlling molar relationship and consequently may lead to skeletal discrepancies or malocclusion (Tasi, 1997, Haruki *et al* 1997 and Brin *et al.,* 2006).

The second permanent molar is located distally to the first permanent molar. Marshall, 2003 noted that we must be aware of its positioning and stage of development when we plane to distallize the first permanent molar.

Regarding the sequence of its eruption, the mandibular second permanent molar typically precedes its maxillary counterparts, and both arrive in the oral cavity after the emergence of the anterior permanent dentition. Several authors have investigated the association between the emergence and root formation. They concluded that the second permanent molars usually begin to emerge when the roots reach a quarter of their length. Two to three years elapse before they subsequently reach the occlusal level of alveolar process. At this stage two thirds of the roots are formed (Garn, 1958; Shumaker, 1960 and Demirjian, 1985).

Demirjian and Levesque 1980 reported that clinical emergence of the mandibular second molars occurs about 1.3 years after attainment of three quarters of root formation.

Several factors can affect the normal pattern of eruption of the second permanent molars, the most obvious local environmental factor being the premature loss of the deciduous molars and first permanent molar. However, other factors are mentioned in the literature.

This study aims to investigate the eruption process of the second permanent molar and observe the developmental changes in dental arches during its eruption among a group of Egyptian children.

MATERIALS AND METHODS

The material for the present study consisted of 191 panoramic radiographs (95 males and 96 females aged from six to fifteen years old). The sample was collected from National Research Centre data base. The number of panoramic radiographs for boys and girls of each stage is given in table 1.

Table 1: Number of panoramic radiographs by sex and stages of calcifications.

Sex	N	Stage of Calcification			
		I	II	III	IV
Boys	95	14	8	12	61
Girls	96	15	11	10	60
Total	191	29	19	22	121

Dental problems such as impacted teeth, abnormal eruptive pathway, congenital missing teeth, supernumerary teeth, fillings on the mesial or distal surfaces of the first molars, extracted first molars, and initial movement of the first molar due to proximal caries or premature loss of the second primary molar were excluded.

Dental developmental stage of the second permanent molar was assessed by panoramic radiograph. Each panoramic radiograph was scanned and the second permanent molars (maxillary and mandibular) of the scanned panorex film were rated according to the dental developmental stage into four phases (Fig 1):

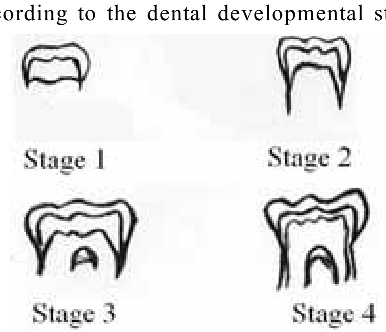


Fig. 1: The developmental stages of the second permanent molar.
Stage I: Whole crown calcified.
Stage II: Root formation beginning.
Stage III: Initial formation of the radicular bifurcation.
Stage IV: Root length equal to the crown height.

The number of second permanent molar in each stage is shown in table 2.

Table 2: Distribution of the second permanent molar by stage of calcification, side and dental arch in both sexes.

Dental arch	Sex	Side	Stage of calcification			
			I	II	III	IV
Maxillary	Boys	Rt.	14	15	19	47
		Lt.	14	8	12	61
	Girls	Rt.	13	17	12	53
		Lt.	15	11	10	60
Mandibular	Boys	Rt.	14	13	17	51
		Lt.	15	7	12	61
	Girls	Rt.	14	16	12	54
		Lt.	16	8	11	59

The eruptive position of the second permanent molar was assessed by the radiographs which were traced using a digital image tracer specially designed for dental research work (Dental Tracer © , Nile Delta for software).

Nine reference points were traced for each arch to measure the mesiodistal crown width of the first and second molars, axial inclination and eruptive rate of the second molar as well as the space available in the dental arch for emergence of the second molar at each stage (Fig. 2a, b).

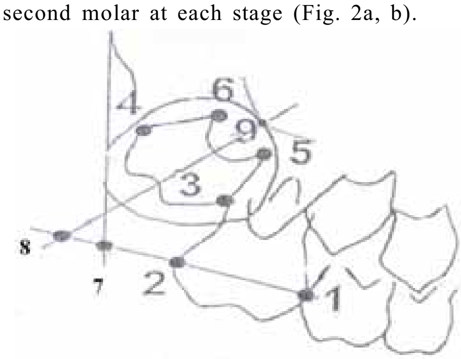


Fig. 2a:

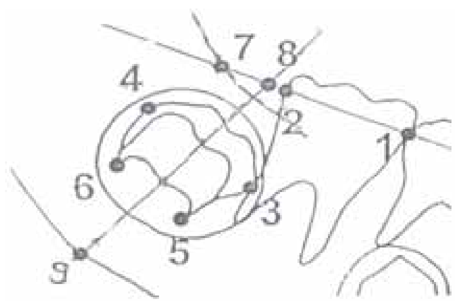


Fig. 2b: Reference points (mandible)

1: The most convex mesial point of crown of first molar.
2: The most convex distal point of crown of first molar.
3: The most convex mesial point of crown of second molar.
4: The most convex distal point of crown of second molar.
5: The most concave mesial point of crown of second molar.
6: The most concave distal point of crown of second molar.
7: The point of intersection of a line through the most mesial and distal convex points of crown of first molar and anterior border of ramus.
8: The point of intersection of a line through the most mesial and distal convex points of crown of first molar and a line tilt of second molar
9: The point of intersection of a line of tilt of second molar and inferior border of mandible.

The following five measurements were calculated using the previous reference points (Fig. 3):

Axial inclination of the second molar: The angle formed between the line drawn through the most mesio distal convex points (point 1 and 2) of the first molar and the long axis of the second molar. The long axis of the second molar was drawn through a line connecting the most mesial and distal convex points (points 3 and 4) of the crown and the midpoint of a line connecting the most mesial and distal concave points (points 5 and 6) of the cervix.

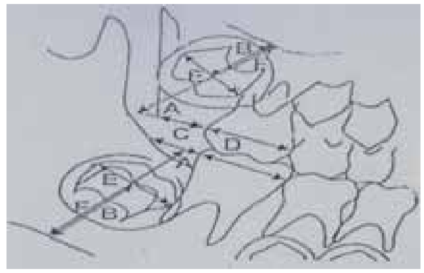


Fig. 3: Measurements

A: Axial inclination of second molar.
B: Eruptive rate of second molar.
C: Space available for emergence of second molar.
D: Mesiodistal crown width of first molar.
E: Mesiodistal crown width of second molar.

Eruption rate of the second molar (the percentage of B in F, figure 3) B is the linear distance to the midpoint of the most mesial and most distal convex points of the second molar (points 3 and 4) from the point of intersection of the long axis of the second molar and inferior border of the mandible or inferior border of the maxillary sinus (point 9) . F is the linear distance to the point of intersection of a line drawn through the most mesial and most distal convex points of the first molar and the long axis of the second molar (point 8) from the point of intersection of the long axis of the second molar and inferior border of the mandible or inferior border of the maxillary sinus (point 9).

Available space for emergence of the second molar (C in figure 3): the linear distance between the most distal convex point of the first molar (point 2) and the point of intersection of a line drown through the most mesial and most distal convex points of the first molar and anterior border of the mondibular ramus or posterior border of the maxillary tuberosity (point 7) .

Mesiodistal crown width of the first molar (D in figure 3): the linear distance between the most mesial and most distal convex point (point 1 and 2) of the first molar.

Mesiodistal crown width of the second molar (E in figure 3): the linear distance between the most mesial and most distal convex points (points 3 and 4) of the second molar.

Statistical analysis was carried out by calculating Mean and Standard Deviation for each measurements in each developmental group. T. test of statistical difference between right and left sides was done and sex difference was calculated.

RESULTS AND DISCUSSION

The Mean and Standard Deviation of each measurement for each stage in both dental arches for boys and girls are shown in table 3 and 4. No significant difference between right and left sides were detected.

Regarding the developmental changes of the maxillary second permanent molar (Figure 4):

- Axial inclination: for both sexes; the maxillary second molar inclined distally at first stage, and was upright gradually till the fourth stage. There were significant differences in angles of inclination between first and second stages for boys ($P > 0.01$) and between third and fourth stage for girls($P > 0.0001$).
- Eruptive rate: there was a gradual increase in the rate of eruption for boys, while for girls there was almost no change in the first three stages. However, there were significant differences in both sexes between the third and fourth stages. There was a significant difference in eruptive rate for boys between first and second stages and between third and fourth stages($P > 0.01$),While for girls there was a significant difference between third and fourth stages($P > 0.01$).
- Available space: there were significant differences between all the developmental stages, with girls being a head. There was also a slight increase in available space from first stage till fourth stage which is shown in (Figure 5). The mandibular second molar was inclined mesially and there was a gradual decrease in the axial inclination for both sexes through all the stages. There was a significant difference noticed between stage three and four for girls. Regarding the available space in the lower arch, boys showed a gradual increase in all stages, while girls showed a significant differences between third and fourth stages where ($P > 0.01$).

Table 3: Means and Standard Deviations of the studied measurements in right and left sides of maxillary dental arch in both sexes.

Stage		1st Molar width (m m)	2nd Molar width (m m)	Available space (m m)	Axial inclination (degree)	Eruptive rate. (percentage)
Boys (n=95)						
I	Rt.	1.5±0.2	1.3±0.2	0.7±0.4	66.2±7.3	0.5±0.1
	Lt.	1.3±0.1	1.2±0.1	0.9±0.4	71.9±6.2	0.5±0.1
II	Rt.	1.4±0.2	1.3±0.2	0.1±0.4	78.3±9.6	0.5±0.01
	Lt.	1.3±0.1	1.3±0.01	1.1±0.3	81.9±8.8	0.4±0.01
III	Rt.	1.3±0.2	1.3±0.1	1.0±0.4	77.2±10.3	0.5±0.1
	Lt.	1.2±0.1	1.2±0.1	0.8±0.3	82.9±10.4	0.5±0.004
IV	Rt.	1.3±0.1	1.3±0.1	1.2±0.5	78.2±9.4	0.8±0.2
	Lt.	1.2±0.1	1.2±0.1	1.0±0.4	86.1±8.8	0.7±0.2
Girls (n=96)						
I	Rt.	1.4±0.2	1.1±0.2	1.4±0.4	69.2±9.7	0.4±0.1
	Lt.	1.2±0.1	1.1±0.1	1.2±0.3	74.2±5.8	0.4±0.01
II	Rt.	1.3±0.1	1.3±0.1	1.4±0.4	72.5±9.1	0.4±0.04
	Lt.	1.2±0.1	1.2±0.1	1.4±0.3	76.3±8.5	0.4±0.01
III	Rt.	1.3±0.1	1.4±0.08	1.4±0.8	70.8±12.5	0.5±0.01
	Lt.	1.2±0.01	1.2±0.01	1.3±0.2	75.6±7.2	0.4±0.004
IV	Rt.	1.4±0.1	1.3±0.10	1.5±0.4	77.8±10.8	0.8±0.2
	Lt.	1.2±0.01	1.2±0.01	1.5±0.4	86.6±8.7	0.8±0.2

Table 4: Means and Standard Deviations of the studied measurements in right and left sides of mandibular arch in both sexes.

Stage		1st Molar width (m m)	2nd Molar width (m m)	Available space (m m)	Axial inclination (degree)	Eruptive rate. (percentage)
Boys (n=95)						
I	Rt.	1.6±0.2	1.4±0.2	1.1±0.7	118.1±9.7	0.9±0.2
	Lt.	1.4±0.2	1.3±0.2	0.9±0.6	110.3±12.3	0.9±0.2
II	Rt.	1.6±0.2	1.4±0.1	1.5±0.5	106.9±9.4	0.7±0.004
	Lt.	1.4±0.1	1.3±0.1	1.2±0.2	103.5±9.8	0.7±0.004
III	Rt.	1.5±0.2	1.4±0.2	1.4±0.3	108.4±9.8	0.8±0.1
	Lt.	1.3±0.1	1.3±0.1	1.4±0.4	107.4±12.5	0.7±0.01
IV	Rt.	1.5±0.5	1.4±0.1	1.9±0.4	101.3±13.8	0. 9±0.2
	Lt.	1.4±0.2	1.3±0.1	1.6±0.4	101.6±9.8	0.9±0.3
Girls (n=96)						
I	Rt.	1.5±0.2	1.3±0.2	1.2±0.4	11.4±0.8	0.8±0.2
	Lt.	1.4±0.2	1.3±0.2	1.2±0.5	106.2±11.9	0.7±0.2
II	Rt.	1.5±0.2	1.4±0.1	1.4±0.3	110.2±8.2	0.7±0.01
	Lt.	1.3±0.01	1.3±0.1	1.1±0.2	104.9±8.9	0.7±0.01
III	Rt.	1.5±0.2	1.4±0.1	1.5±0.3	113.9±8.9	0.7±0.01
	Lt.	1.3±0.1	1.3±0.1	1.2±0.3	108.5±7.9	0.7±0.2
IV	Rt.	1.4±0.1	1.4±0.1	2.0±0.5	104.3±9.6	0.9±0.1
	Lt.	1.4±0.4	1.3±0.1	1.7±0.5	100.0±11.4	0.9±0.2

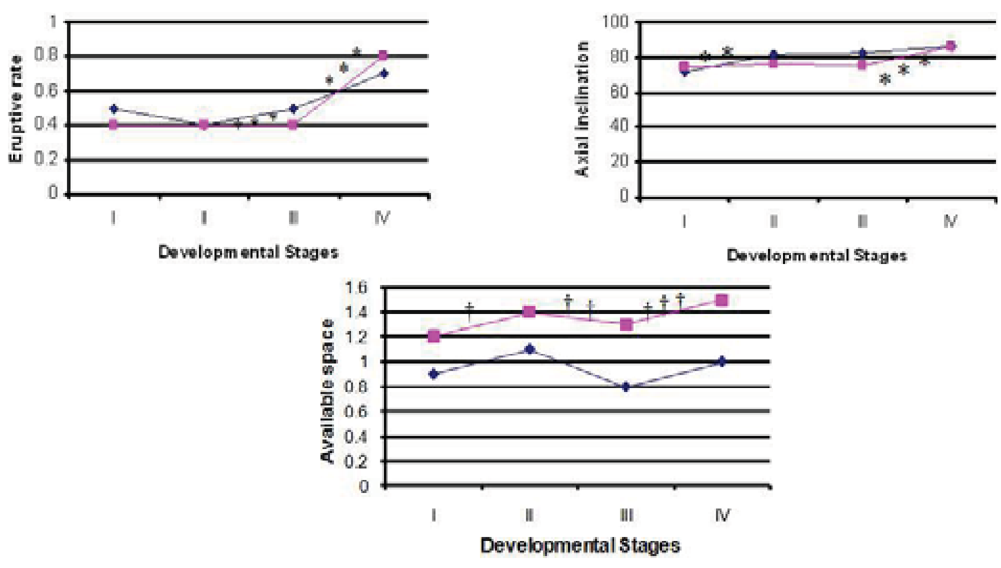
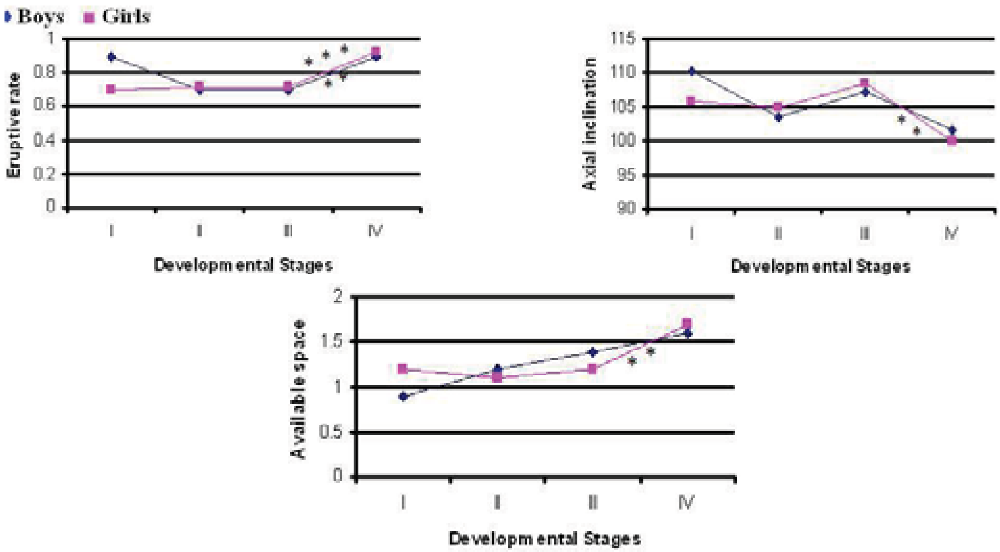


Fig. 4: The developmental changes of the maxillary second molar for both sexes.



* Denotes sig. stages diff. at	* $P < 0.05$	** $P < 0.01$	*** $P < 0.0001$
† Denotes sig. sex diff. at	† $P < 0.05$	†† $P < 0.01$	††† $P < 0.001$

Fig. 5: The developmental changes of the mandibular second molar for both sexes.

Coefficients of correlation are shown in table (6a,b and 7a,b). There was a positive significant correlation between the mesiodistal crown widths of the first and second molars (maxillary and mandibular arches) in both sexes all over the four stages, ($P < 0.05$). There was a negative correlation between axial inclination and mesiodistal crown width of the first and second maxillary molars for boys at the fourth stage ($P < 0.05$), while for girls, there was a negative significant correlation between the axial inclination and mesiodistal crown width of the maxillary second molar in the second and fourth stages ($P< 0.05$, $P < 0.01$ respectively as shown in tables 6a,b). There was a positive correlation between axial inclination and mesiodistal width of the first mandibular molar for boys. However, girls showed a negative correlation ($P < 0.01$) in the fourth stage (table 7a,b). There was a negative significant correlation between eruptive rate and available space for maxillary second molar in girls ($P < 0.05$, table 6b).

There was a significant positive correlation for boys between eruptive rate and axial inclination of the mandibular second molar in the second and fourth stages, ($P < 0.05$, $P < 0.01$ respectively table 7,a). For girls, there was a negative correlation between eruptive rate and available space of the mandibular second molar in the first stage. While in the fourth stage, there was a positive significant correlation between eruptive rate and available space as well as axial inclination ($P< 0.05$, $P < 0.01$ respectively – table 7,b).

Development of dentition is a continuous process that consists of various phases starting from the sixth week of intrauterine life until complete maturation (Demirjian, 1980).

The life cycle of the tooth is a complex process including four phases of tooth growth, calcification of tissue matrix, eruption and attrition. Tooth eruption is more than mere movement. The movement must be of correct direction and rate. In spite of intensive research over the last three decades, the specific mechanism and regulating factors responsible for this process are still controversial. This is partly due to the complex nature of this process (Sandy and Jeffrey, 1992).

Previous reviews have concluded that there is no simple explanation for the mechanism of the eruption process. Teeth erupt during periods of active craniofacial growth and the eruption is considered to be a multifactorial process that seems to be compensatory and is controlled by rate limiting factors which vary in each developmental stage (Avery, 1994; Ten cate, 1998 and Diab, 2000).

Radiographic studies illustrate the general principle that the eruption process has a smooth course starting from follicular growth until the emerged stage. Fanning, 1961 reported that the tooth follicle showed a symmetrical expansion vertically and mesiodistally and the center remain at the same position until the entire crown has calcified and approximately 2-4mm of the root has formed. Steedle and Proffite, 1985 reported that during the pre-eruptive emergence stage, the tooth begins a rapid eruptive rate in an occlusal direction with lengthen of root as it approaches gingival periecing.

It is accepted that there are differences in the eruption process between maxillary and mandibular second molars which serve for orientation purposes.

Table 5: Means and Standard Deviations in each measurements of maxillary and mandibular arches in both sexes (Left Side).

Measurements	Sex	Maxillary				Mandibular			
		I	II	III	IV	I	II	III	IV
1st Molar width(m m)	Boys	1.3±0.1	1.3±0.1	1.2±0.1	1.2±0.1	1.4±0.2	1.4±0.1	1.3±0.1	1.3±0.2
	Girls	1.2±0.1	1.2±0.01	1.2±0.01	1.2±0.01	1.4±0.2	1.3±0.01	1.3±0.1	1.4±0.4
2nd Molar width(m m)	Boys	1.2±0.1	1.3±0.01	1.2±0.1	1.2±0.1	1.3±0.2	1.3±0.1	1.3±0.1	1.3±0.1
	Girls	1.1±0.1	1.2±0.1	1.2±0.01	1.2±0.01	1.3±0.2	1.3±0.1	1.3±0.1	1.3±0.1
Available space(m m)	Boys	0.9±0.4	1.1±0.3	0.8±0.3	1.0±0.4	0.9±0.6	1.2±0.2	1.4±0.4	1.6±0.4
	Girls	1.2±0.3†	1.4±0.3†	1.3±0.2††	1.5±0.4†††	1.2±0.5	1.1±0.2	1.2±0.3	1.7±0.5**
Axial inclination (degree)	Boys	71.9±6.2	81.9±8.8**	82.9±10.4	86.1±8.8	110.3±12.3	103.5±9.8	107.4±12.5	101.6±9.8
	Girls	74.2±5.8	76.3±8.5	75.6±7.2	86.6±8.7***	106±11.9	104.9±5.6	108.5±7.9	100.0±11.4**
Eruptive rate (percentage)	Boys	0.5±0.1	0.4±0.01	0.5±0.00	0.7±0.2***	0.9±0.2†	0.7±0.00**	0.7±0.01	0.9±0.3***
	Girls	0.4±0.01	0.4±0.01	0.4±0.00	0.8±0.2***	0.7±0.2	0.7±0.01	0.7±0.02	0.9±0.2**

* Denotes sig. stages diff. at * P < 0.05 ** P < 0.01 *** P < 0.0001
† Denotes sig. sex diff. at † P < 0.05 †† P < 0.01 ††† P < 0.001

Table 6a: Correlation coefficients between four developmental stages of calcifications and examined measurements for boys in maxillary arch.

Stage	1st Molar width (m m)	2nd Molar width (m m)	Available space (m m)	Axial inclination (degree)	Eruptive rate. (percentage)
Stage I					
1st Molar width	-	0.796**	0.032	0.244	0.003
2nd Molar width		-	0.247	0.256	-0.396
Available space			-	0.519	0.075
Axial inclination				-	0.303
Eruptive rate					-
Stage II					
1st Molar width	-	0.779*	0.099	0.285	0.35
2nd Molar width		-	-0.237	-0.25	0.264
Available space			-	0.281	0.438
Axial inclination				-	0.151
Eruptive rate					-
Stage III					
1st Molar width	-	0.788**	-0.122	-0.345	-0.114
2nd Molar width		-	0.034	-0.286	-0.186
Available space			-	0.523	0.125
Axial inclination				-	0.066
Eruptive rate					-
Stage IV					
1st Molar width	-	0.688**	-0.061	-0.271*	-0.126
2nd Molar width		-	-0.152	-0.273*	-0.081
Available space			-	0.013	0.117
Axial inclination				-	-0.092
Eruptive rate					-

* P < 0.05 ** P < 0.01

Table 6b: Correlation coefficients between four developmental stages of calcifications and examined measurements for girls in maxillary arch.

Stage	1st Molar width (m m)	2nd Molar width (m m)	Available space (m m)	Axial inclination (degree)	Eruptive rate. (percentage)
Stage I					
1st Molar width	-	0.537*	0.025	-0.127	0.028
2nd Molar width		-	-0.2	0.114	0.31
Available space			-	-0.34	-0.155
Axial inclination				-	0.038
Eruptive rate					-
Stage II					
1st Molar width	-	0.538	0.051	-0.205	-0.076
2nd Molar width		-	0.43	-0.680*	-0.201
Available space			-	-0.477	0.21
Axial inclination				-	0.146
Eruptive rate					-
Stage III					
1st Molar width	-	0.690*	0.195	-0.009	-0.473
2nd Molar width		-	-0.046	-0.067	-0.206
Available space			-	-0.568	-0.761*
Axial inclination				-	0.106
Eruptive rate					-
Stage IV					
1st Molar width	-	0.551**	0.034	-0.253	-0.068
2nd Molar width		-	0.175	-0.382**	0.117
Available space			-	-0.098	0.089
Axial inclination				-	0.233
Eruption rate					-

* P < 0.05 ** P < 0.01

Table 7a: Correlation coefficients between four developmental stages of calcifications and examined measurements for boys in mandibular arch.

Stage	1st Molar width (m m)	2nd Molar width (m m)	Available space (m m)	Axial inclination (degree)	Eruptive rate. (percentage)
Stage I					
1st Molar width	-	0.722**	-0.345	0.054	0.136
2nd Molar width		-	-0.235	0.402	-0.187
Available space			-	-0.587	-0.266
Axial inclination				-	0.004
Eruptive rate					-
Stage II					
1st Molar width	-	0.695	0.177	0.551	0.248
2nd Molar width		-	0.706	-0.086	-0.162
Available space			-	-0.579	-0.623
Axial inclination				-	0.795*
Eruptive rate					-
Stage III					
1st Molar width	-	0.539	0.054	0.113	0.061
2nd Molar width		-	0.339	0.005	0.119
Available space			-	-0.087	-0.053
Axial inclination				-	-0.062
Eruptive rate					-
Stage IV					
1st Molar width	-	0.265*	-0.07	0.484**	0.711**
2nd Molar width		-	0.313*	0.146	-0.061
Available space			-	0.223	-0.054
Axial inclination				-	0.487**
Eruptive rate					-

* $P < 0.05$ ** $P < 0.01$

Table 7b: Correlation coefficients between four developmental stages of calcifications and examined measurements for girls in mandibular arch.

Stage	1st Molar width (m m)	2nd Molar width (m m)	Available space (m m)	Axial inclination (degree)	Eruptive rate. (percentage)
Stage I					
1st Molar width	-	0.727**	0.281	0.409	0.047
2nd Molar width		-	0.338	0.435	-0.294
Available space			-	0.345	-0.599*
Axial inclination				-	0.0122
Eruptive rate					-
Stage II					
1st Molar width	-	0.812*	-0.284	0.237	0.032
2nd Molar width		-	-0.464	0.356	-0.251
Available space			-	-0.078	-0.301
Axial inclination				-	-0.488
Eruptive rate					-
Stage III					
1st Molar width	-	0.737*	0.396	0.535	-0.405
2nd Molar width		-	0.435	0.226	-0.549
Available space			-	0.581	-0.362
Axial inclination				-	0.315
Eruptive rate					-
Stage IV					
1st Molar width	-	0.24	-0.032	-0.425**	0.109
2nd Molar width		-	0.345**	0.029	0.101
Available space			-	-0.178	0.298*
Axial inclination				-	0.410**
Eruptive rate					-

* $P < 0.05$ ** $P < 0.01$

Regarding the axial inclination, the results of this study reveal that the maxillary second molar inclined distally while the mandibular one inclined mesially. The inclination angle ranged from 71.9° to 86.6o and 110° to 100° respectively.

The axial inclination of the second molars showed a tendency to upright over the four developmental stages. This up righting was accompanied by gradual increase of the available spaces for the second molars in both arches and sexes, leading to a remarkable acceleration in the eruptive rate particularly in girls (Table 5). These results are in agreement with Garn, 1958 and with the previous results of Nolla, 1960 where they concluded that the eruption movement of maxillary and mandibular second molars is not identical.

The mesiodistal crown width of the second permanent molars shows a significant correlation with both its axial inclination and available space during the fourth stage in both sexes. This shows that the available space causes in the second permanent molar to become upright and significantly accelerated in its eruptive rate.

Many factors related to tooth eruption have been studied, and several appear to be important to the eruptive process. Elongation of the root, dental pulp proliferation, growth and pull of the periodontal ligament, growth of the dental follicle and bone remodeling have been evaluated by several authors as essential factors in the eruptive process (Kardos, 1996).

Also, genetics, hormonal, nutritional, environmental as well as sex and race differences are important factors which should be considered when studying tooth development and emergence (Proff et al., 2006).

Finally, the findings showed that rate of eruption, available space and changes of the axial inclination of the maxillary and mandibular second permanent molar are closely related and intertwined with each other.

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