Dental emergence stages and the pubertal growth spurt

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Longitudinal data on emergence of permanent teeth and pubertal growth in body height were collected as part of a prospective study of the growth and development of 212 randomly selected Swedish urban children. The onset, peak and end of the pubertal growth spurt were defined on the unsmoothed incremental curve of height. The dental development was assessed by means of dental emergence stages representing gingival emergence of various groups of permanent teeth.

There was a sex-specific pattern in the relationship between dental development and the pubertal growth spurt. At all pubertal growth events the dental development was more advanced in boys than in girls. A statistically significant association between dental development and pubertal growth was found only in girls, and was then only weak. Because of the low correlation between age at the occurrence of pubertal growth events and age at the attainment of dental emergence stages, these stages have little value as indicators of the pubertal growth spurt. The sex-specific pattern and the great individual variation in the relationship between dental development and somatic growth may have implications for orthodontic treatment.

Key-words: Pedodontics; orthodontics, dental development; tooth eruption; maturity indicators

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INTRODUCTION

The pubertal growth spurt is considered an advantageous period for certain types of orthodontic treatment and should be taken into account in treatment planning (2, 11, 12). The association between dental development and pubertal growth spurt has generally been found to be weak and not statistically significant (for review see 6, 23). However, in clincial work the relationship between the emergence of groups of permanent teeth (5) and the pubertal growth is of particular interest (2, 3) and no detailed report on this subject has been published.

The aims of the present study were:

- to determine the timing of the emergence of specified groups of permanent teeth (dental emergence stages) in a representative, prospective, longitudinal sample of Swedish children, and
- to describe the relationship in time between these dental emergence stages (DES) and the pubertal growth spurt.

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SUBJECTS AND METHODS

Data on the emergence of permanent teeth and pubertal growth in height were collected from 212 randomly selected Swedish urban children (90 girls and 122 boys) as part of a prospective longitudinal and interdisciplinary study of growth and development from birth to adulthood (18, 19). The subjects were born between 1955 and 1958. The sampling procedures and representativeness of the sample have been reported previously (18, 19). During the age period covered in this paper the subjects were examined once a year up to the age of 18 years. At this age 160 (75.5 %) subjects were examined. At the age of 20–22 years height was measured in 148 (69.8 %) subjects.

Pubertal growth spurt

Height was measured with the stretching-up technique as proposed by Tanner (26). Each measurement was adjusted to exact target ages (19). The incremental curve of height was analysed graphically without any smoothing (25). In this study three events were used, representing the beginning (ONSET), peak (PHV) and end (END) of the pubertal growth spurt. (Fig. 1) (25).

Permanent tooth emergence

Tooth emergence was recorded by direct inspection. A tooth was considered to have emerged if any part of the crown was visible. Marked deviations in emergence of certain teeth were systematically adjusted for before the statistical analysis (15), e.g. DES 3 was adjusted to a later age interval in 24 (21 %) boys and 4 (5 %) girls due to the accelerated emergence of a premolar. The dental development was judged on the basis of gingival emergence of specific groups of teeth by *dental emergence stages* (DES) which correspond to the dental stages (DS) devised by Björk et al. (5). However, some of the dental stages (DS) represent gingival emergence and others full eruption to the occlusal level (Table 1).

Statistical methods

The age of a subject at the attainment of a dental emergence stage (Table 1) or at the occurrence of a pubertal growth event (Fig. 1) was defined as the midpoint of the age interval during which the stage/event was observed. If more than one of the teeth included in a stage (DES) emerged during an interval, this interval was divided into appropriate equal parts. The individual age was used to analyse the relationship in time between the various stages and the correlation analysis. The mean age at the occurrence of each stage/event was calculated by probit analysis (10). In this analysis maximum information was extracted from the sample according to the principles described earlier (24), which will give an unbiased estimate of the mean value (22). The cumulative percentages were calculated on the raw figures of the probit analysis (Tables 3, 4, 6, 7, 8).

RESULTS

The means and ranges at the occurrence of the pubertal growth events and the dental emergence stages are given in Table 2 and Figs. 2–3. The cumulative percentage of subjects who had attained a certain stage at the end of each age interval is given in Tables 3 and 4. The correlation coefficients between the occurrence of the pubertal growth events and the dental emergence stages are given in Table 5. The relationship in time between the growth events and six dental emergence stages are given in Tables 6–8 and Figs. 4–5. The distrib-

Table 1. *Definitions of dental emergence stages (DES) of the permanent dentition. The corresponding dental stages (DS) are given within brackets*

Emerged teeth	
Teeth anterior to the molars	
DES 1 (DS 1)	1–7 incisors
DES 2 (DS 2)[b]	all incisors
DES 3 (DS 3)	1–11 canines and/or premolars
DES 4 (DS 4)[b]	all canines and premolars
Molar teeth	
DES M1 (DS M_0)	1–3 first molars
DES M2 (DS M1)[b]	all first molars
DES M3	1–3 second molars
DES M4 (DS M2)[b]	all second molars
DES M5	1–3 third molars
DES M6 (DS M3)[b]	all third molars[a]

[a] This stage was not analysed in this study
[b] Dental stages (5) which represent fully erupted teeth

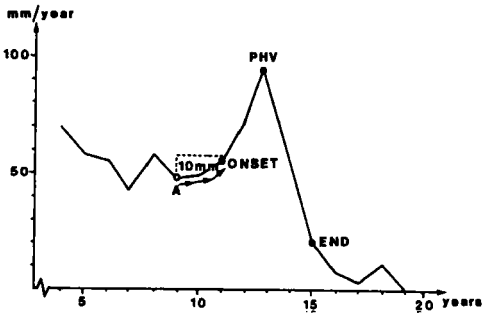

Fig. 1. The pubertal growth spurt.
Onset of the spurt (ONSET) is the smallest annual increment from which there is a marked continuous increase in growth rate to PHV. ONSET is found by locating the smallest annual increment (A) from which there is a continuous increase in growth rate to PHV. The curve is then followed towards PHV until the growth rate has accelerated 10 mm. ONSET will be indicated by the annual increment which is next below or coincides with this growth rate.
Peak height velocity (PHV) is the greatest annual increment during puberty.
The end of the spurt (END) is the first annual increment after PHV below 20 mm.

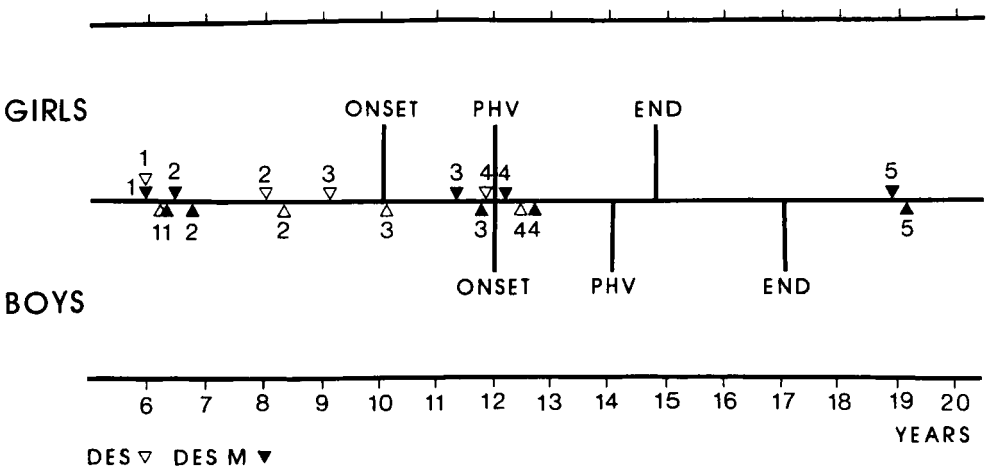

Fig. 2. A linear illustration of the mean ages at onset of dental emergence stages and pubertal growth events in girls and boys. (For definitions and abbreviations, see Table 1 and Fig. 1).

ution of subjects according to actual dental emergence stages (DES) at the beginning (ONSET), peak (PHV) and end (END) of the pubertal growth spurt is shown in Fig. 6.

On an average, the pubertal growth events occurred about two years earlier in girls than in boys (Table 2). The sex difference in age at the attainment of the various dental emergence stages was considerably less but statistically significant and varied from 2.5 to 10 months (Table 2). The correlation coefficients between ages at the occurrence of the pubertal growth events and the attainment of the dental emergence stages were low in both sexes, and statistically significant only in girls except

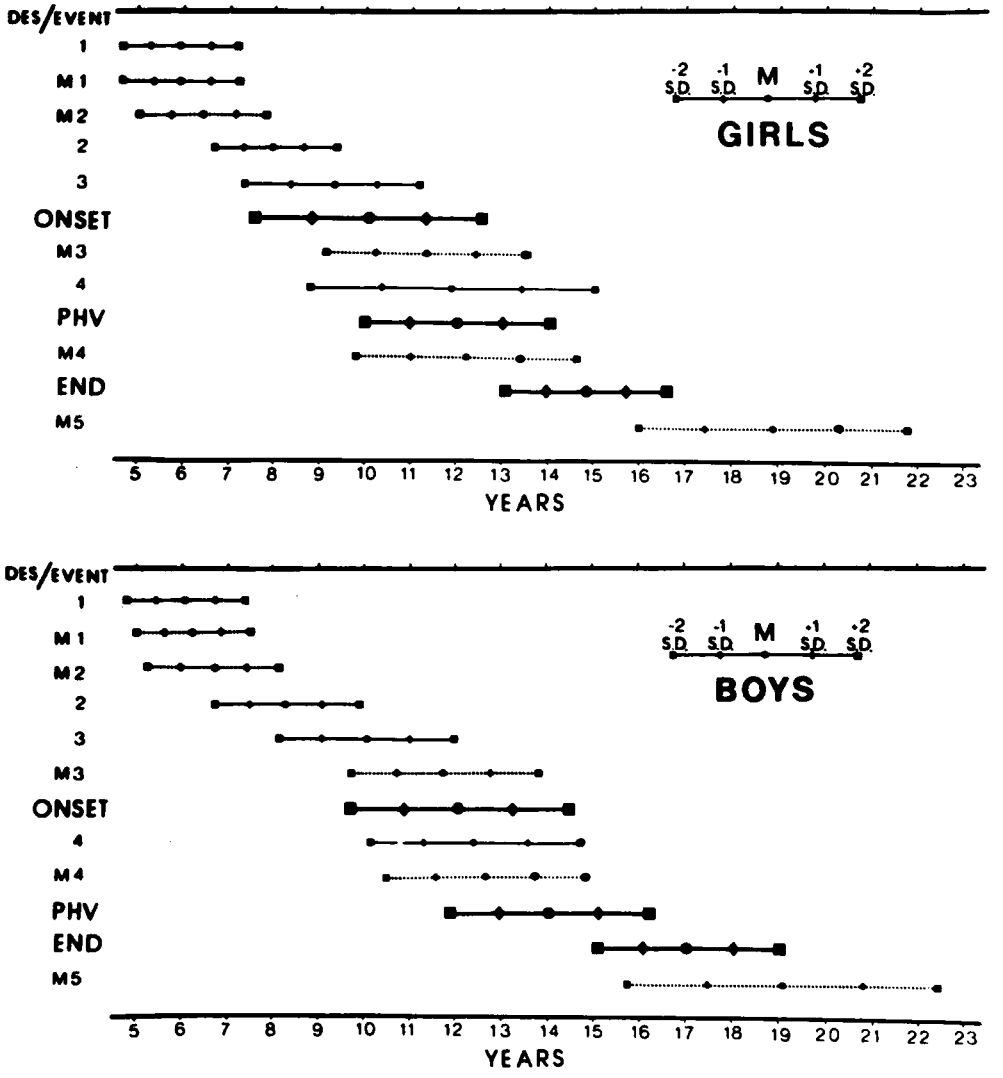

Fig. 3. Mean times and standard deviations of onset of dental emergence stages and of events of the pubertal growth spurt in girls and boys. (For definitions and abbreviations, see Table 1 and Fig. 1).

for DES 1 and DES M5 (Table 5). Since tooth emergence was not recorded after 18 years, only 19 girls and 26 boys had attained DES M5 (Tables 3, 4).

According to the mean values, DES 1, DES 2, DES 3, DES M1 and DES M2, occurred before ONSET in both sexes, while DES 4, DES M3 and DES M4 occurred around PHV in girls and around ONSET in boys. DES M5 occurred after END in both sexes (Table 2, Fig. 2). However, the individual variations in occurrence of these stages and growth events and in their relationships were great (Tables 3, 4, 6, 7, 8, Figs. 3–6).

Dental development at the beginning of the pubertal growth spurt (ONSET)

In relation to the dental emergence stages, ONSET occurred significantly later in boys than in girls (Table 6. Fig. 4). At ONSET both boys and girls were

Table 2. *Probit analysis of the age (in years) at the occurrence of the pubertal growth events and dental emergence stages in girls and boys.*

	Sex	Mean	SD	Adjustment to probit line[a]		Range	Sex difference in years
				Chi^2	df		
Pubertal growth spurt							
ONSET	G	10.04	1.26	3.03	7	6.5–13.5	2.04***
	B	12.08	1.20	3.83	6	9.5–15.5	
PHV	G	11.98	1.02	9.41	6	9.5–15.5	2.09***
	B	14.07	1.08	2.53	6	11.5–17.5	
END	G	14.82	0.88	1.19	5	12.5–17.5	2.23***
	B	17.05	0.98	1.32	5	14.5–19.5	
Dental emergence stages							
DES 1	G	5.91	0.63	0.38	3	4.5– 7.5	0.21*
	B	6.17	0.64	1.35	4	4.5– 8.5	
DES 2	G	7.97	0.68	0.37	3	6.5– 9.5	0.33***
	B	8.30	0.79	9.86	5	6.5–11.5	
DES 3	G	9.21	0.97	5.61	5	7.5–12.5	0.86***
	B	10.07	0.97	5.70	6	7.5–13.5	
DES 4	G	11.87	1.56	6.32	8	8.5–16.5	0.59**
	B	12.46	1.14	5.00	5	10.5–15.5	
DES M1	G	5.91	0.63	1.74	3	4.5– 7.5	0.33**
	B	6.24	0.61	4.29	4	4.5– 8.5	
DES M2	G	6.42	0.60	2.05	2	5.5– 7.5	0.29**
	B	6.71	0.69	1.25	3	5.5– 8.5	
DES M3	G	11.34	1.11	7.69	5	9.5–14.5	0.42**
	B	11.76	1.03	1.00	6	8.5–14.5	
DES M4	G	12.20	1.21	4.08	6	9.5–15.5	0.48**
	B	12.68	1.08	3.90	5	10.5–15.5	
DES M5	G	18.88	1.44	1.30	2	15.5–	0.26
	B	19.14	1.69	1.51	3	14.5	

[a] No value of Chi^2 is statistically significant ($p > 0.05$)
* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

found to be in any dental emergence stage of the permanent dentition except for the first and last stages for molar teeth (Fig. 6). About 90 per cent of the subjects were in DES 3/DES 4, but a few subjects were still in DES 1 at ONSET. DES 1 was attained before ONSET by all subjects. The emergence of all teeth anterior to the molars (DES 4) at ONSET was completed in almost 60 per cent of the boys but only in about 25 per cent of the girls.

The first molars had emerged (DES M2) before ONSET in all subjects except for in one girl, in whom the first molars emerged (DES M1 – M2) in the same age interval as ONSET. This girl was the earliest maturing girl in this study (ONSET at 6.5 years, PHV at 9.5 years and END at 12.5 years). At ONSET no second molar was visible in 70 per cent of the girls, i.e. they were still in DES M2. At least one second molar was visible in 70 per cent of the boys, i.e. they were in DES M3/DES M4. All second molars had emerged (DES M4) in more than half of the boys but in only 16 per cent of the girls. Accordingly, about 75 per cent of the girls and 40 per cent of the boys were in DES 3, and about 85 per cent of the girls and 50 per cent of the boys were in DES M3 within the pubertal growth spurt.

The periods of emergence started at or after ONSET for canines and premolars (DES 3) in more than 40 per

Table 3. *Cumulative percentage of girls who had attained pubertal growth events and the dental emergence stages at the end of each age interval*

Age interval in years	Pubertal growth spurt			Dental emergence stages								
	ONSET	PHV	END	DES 1	DES 2	DES 3	DES 4	DES M1	DES M2	DES M3	DES M4	DES M5
4– 5				4.9				6.1				
5– 6				54.8				60.2	27.7			
6– 7	1.2			95.2	8.3			94.0	81.0			
7– 8	3.7			100.0	51.8	10.5		100.0	100.0			
8– 9	21.0				92.8	45.2	1.2					
9–10	49.4	1.2			100.0	78.6	9.5			9.4	2.4	
10–11	79.0	19.8				97.6	35.7			42.9	14.1	
11–12	95.0	46.9				98.8	54.8			78.6	49.4	
12–13	97.5	88.8	1.2			100.0	79.1			90.7	76.5	
13–14	100.0	97.5	17.3				90.6			97.6	91.8	
14–15		98.7	61.7				96.5			100.0	97.6	
15–16		100.0	90.1				98.8				100.0	3.6
16–17			98.8				100.0					7.8
17–18			100.0									27.6

Table 4. *Cumulative percentage of boys who had attained pubertal growth events and the dental emergence stages at the end of each age interval*

Age interval in years	Pubertal growth spurt			Dental emergence stages								
	ONSET	PHV	END	DES 1	DES 2	DES 3	DES 4	DES M1	DES M2	DES M3	DES M4	DES M5
4– 5				0.9				2.3				
5– 6				37.6				31.9	17.4			
6– 7				94.9	5.1			92.3	65.8			
7– 8				99.2	32.2	1.7		99.2	96.6			
8– 9				100.0	88.4	11.8		100.0	100.0	0.8		
9–10	5.3				95.8	48.3				4.2		
10–11	14.7				100.0	88.5	9.4			22.0	5.1	
11–12	51.4	1.9				97.5	37.4			58.6	28.4	
12–13	79.4	15.9				99.2	71.9			89.6	63.2	
13–14	92.5	51.4				100.0	89.7			98.3	89.8	
14–15	99.1	79.8	1.0				97.5			100.0	96.6	0.8
15–16	100.0	96.2	15.2				100.0				100.0	4.3
16–17		99.0	50.5									7.7
17–18		100.0	81.9									26.5
18–19			97.1									–
19–20			100.0									–

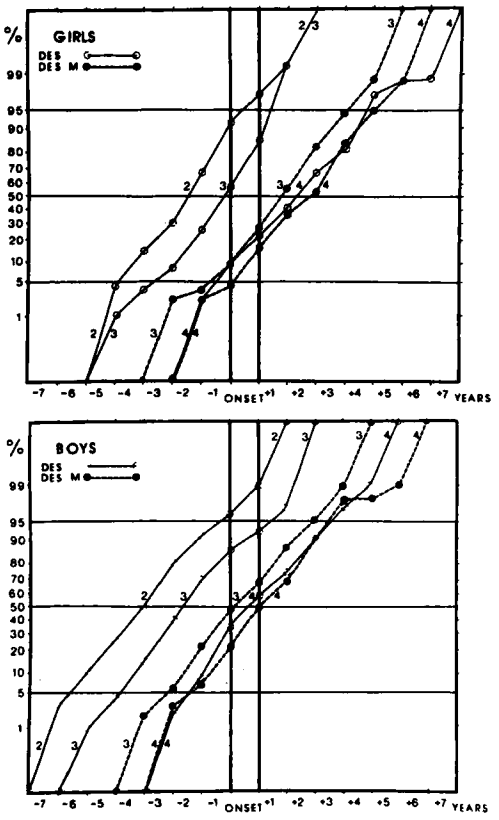

Fig. 4. Probit-diagram showing the cumulative percentage of girls and boys who had attained certain dental emergence stages (Table 1) at each annual interval in relation to the interval during which the beginning og the pubertal growth spurt (ONSET) was attained.

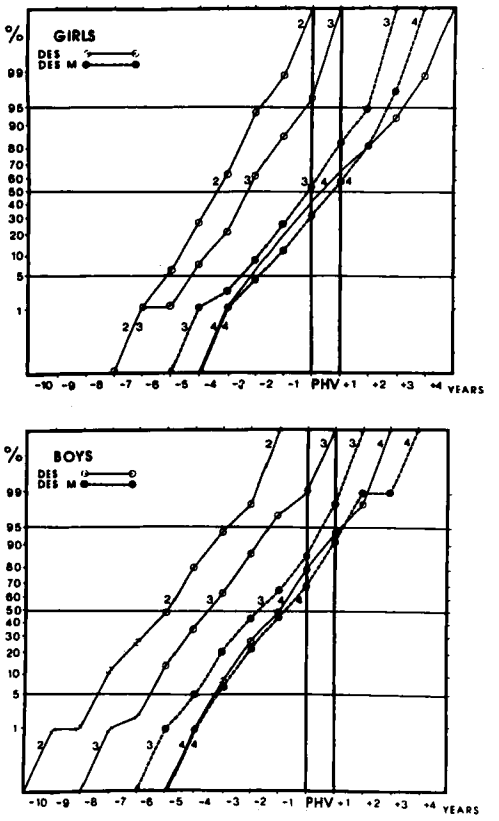

Fig. 5. Probit-diagram showing the cumulative percentage of girls and boys who had attained certain dental emergence stages (Table 1) at each annual interval in relation to the interval during which peak height velocity (PHV) was attained.

cent of the girls but in only 14 per cent of the boys, and for second molars (DES M3) in about 90 per cent of the girls and about 50 per cent of the boys (Table 6, Fig. 4).

Dental development at peak height velocity (PHV)

In relation to the dental emergence stages, PHV occurred significantly later in boys than in girls (Table 7, Fig. 5). At PHV all subjects were in DES 3/ DES 4 (Fig. 6). At PHV only 7 per cent of the boys but more than one-third of the girls were still in DES 3. More than 90 per cent of the boys but only half of the girls were in DES M4. Only 2 boys (2 %) but 15 girls (18 %) were still in DES M2 at PHV.

In about 40 per cent of the girls and 35 per cent of the boys DES 4 was attained during the acceleration period of the pubertal growth spurt (ONSET - PHV). About 13 per cent of the girls and 8 per cent of the boys were in DES 2 during at least some part of that period (Table 7). In a few subjects (3 girls and 1 boy) the emergence of canines/premolars (DES 3) started at PHV, and in some subjects (15 girls and 2 boys) the emergence of second molars (DES M3) started at or after PHV.

Table 5. *Correlation coefficients between the ages at the occurrence of pubertal growth events and various dental emergence stages in girls (N = 78–80) and boys (N = 100–105)*

Pubertal growth spurt	Sex	Dental emergence stages DES 1	DES 2	DES 3	DES 4	DES M1	DES M2	DES M3	DES M4	DES M5[a]
ONSET	G	.18	.23*	.33**	.27*	.25*	.25*	.30**	.22*	.13
	B	−.07	−.04	−.05	.12	.08	.16	.04	.10	.15
PHV	G	.23*	.34**	.29**	.27*	.27*	.21	.26*	.23*	.01
	B	−.03	.03	.16	.14	.07	.14	.08	.13	.16
END	G	.23*	.28*	.31**	.35**	.28*	.26*	.34**	.31**	−.23
	B	.01	.04	.16	.11	.01	.07	.01	.07	.25

[a]19 girls and 26 boys were included in the analysis of DES M5
*$p<0.05$; ** $p<0.01$

Table 6. *Cumulative percentage of girls and boys who had attained a certain dental emergence stage (DES) at the end of each annual interval in relation to the interval during which the beginning of the pubertal growth spurt (ONSET) occurred*

Age interval to ONSET	DES 2		DES 3		DES 4		DES M3		DES M4	
	G	B	G	B	G	B	G	B	G	B
− 7		2.9								
− 6		11.5		1.0						
− 5	3.8	25.2	1.2	3.8						
− 4	15.0	50.0	3.7	14.6				1.9		
− 3	30.9	80.4	8.6	40.2		1.9	2.5	5.8		2.9
− 2	68.4	91.3	26.6	69.6	2.5	8.8	3.7	22.3	2.5	6.8
− 1	92.5	96.2	57.5	86.4	9.9	35.6	9.9	48.1	4.9	21.2
ONSET	97.5	99.0	86.4	92.3	23.5	57.7	28.4	67.6	16.0	52.4
+ 1	98.8	100.0	98.8	97.1	42.0	74.8	56.8	86.7	37.0	68.6
+ 2	100.0		100.0	100.0	67.9	90.3	83.8	95.2	53.8	91.3
+ 3					82.3	97.1	94.9	99.0	84.8	98.1
+ 4					97.5	99.0	98.8	100.0	95.0	98.1
+ 5					98.8	100.0	100.0		98.8	99.0
+ 6					98.8				100.0	100.0
+ 7					100.0					

Dental development at the end of the pubertal growth spurt (END)

At END all subjects but one girl were in DES 4, and all subjects had attained DES M4 (Table 8, Fig. 6). However, in 7 and 9 per cent respectively of the boys, and in 36 and 44 per cent respectively of the girls these stages were attained during the deceleration period of the pubertal growth spurt (PHV – END). There was still a statistically significant sex difference ($p < 0.01$) in dental development at this pubertal growth event since more boys (19 %) than girls (3 %) had attained DES M5 (Table 8, Fig. 6). No girl but six boys (6.5 %) had attained DES M5 before END).

DISCUSSION

The emergence of permanent teeth, especially in the lateral segments, is often

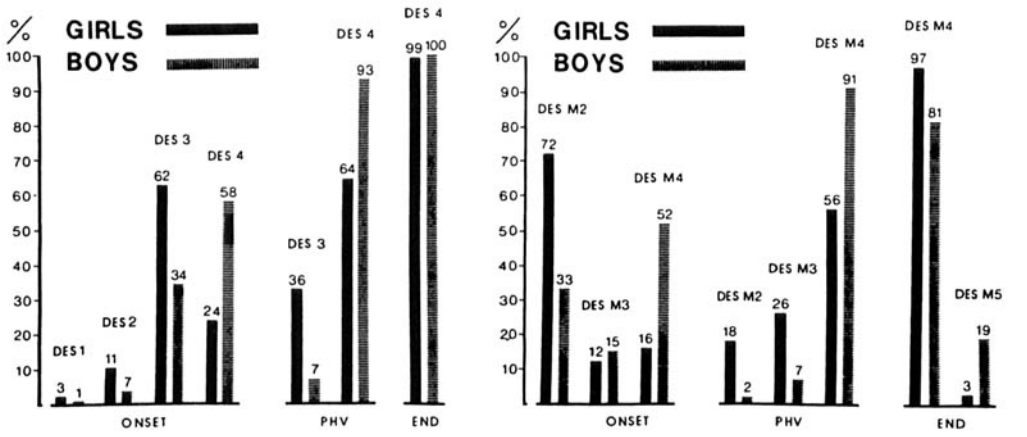

Fig. 6. Distribution of girls and boys (in per cent) by dental emergence stage (Table 1) at the beginning (ONSET), peak (PHV) and end (END) of the pubertal growth spurt.

accelerated or delayed by disturbing factors (6). These effects must be taken into consideration when the association between emergence of teeth and other somatic variables is analysed (6). In this study marked deviations from the inherent pattern of tooth emergence, which were mainly caused by early extraction of deciduous teeth (15), were systematically adjusted for before the analysis of the dental emergence stages (15). The influence of disturbing factors on the timing of the dental emergence stages was therefore reduced in this study.

In clinical work the *dental emergence stages* (DES) are easier to record than some of the dental stages (DS) (Table 1) because of the difficulty in deciding clinically whether a tooth is fully erupted or not. In fact, in one previous Danish study (13) a stage identical with DES M2 was recorded instead of DS M1 because of such difficulties.

Ages at the attainment of corresponding stages of dental development were in general accordance with other Scandinavian studies (1, 13, 20). However, the emergence of the first canine/premolar (DES 3/DS 3) occurred significantly later in boys in the present study, which may partly be due to the adjustments for markedly accelerated emergence of premolars (15, 21).

Moreover, the influence of environmental factors on the timing of the emergence of permanent teeth in the lateral segments may differ between the Scandinavian populations because of the differences in the organization of dental care for schoolchildren. The occurrence of the pubertal growth spurt in this study was in general accordance with contemporary studies, and a detailed comparison has been made elsewhere (25).

Since the sex difference in the pubertal growth events was much greater than that for the dental emergence stages, a significant sex difference in dental development in relation to pubertal growth was to be expected. At all pubertal growth events the dental development was more advanced in boys than in girls (Fig. 6). However, for evaluation of individual maturity such information is of limited value because of the great individual variation in both sexes. The weak correlations between dental development and physical growth found in this study have also been reported by others (6, 23). In this study a consistent, statistically significant association between dental devel-

opment and pubertal growth was found in girls (Table 5), which is a statistical verification of previous reports (3, 6, 23). This may be due to the more reliable estimates of PHV (25), the larger number of subjects and the adjustments for marked deviations of tooth emergence performed in this study. However, such a weak association (in this study r = .22 – .35) would hardly be of any value for evaluation of maturity in clinical work, since only about ten per cent of the variance in dental emergence would be explained by the variance in pubertal growth. Dental and skeletal development are largely independent (6, 23). The statistically significant but low correlation between dental and skeletal development found in girls but not in boys in this study, may be hormone-dependent.

Filipsson (7) has defined a reference point (RP) on the eruption curve of permanent teeth, which corresponds to the age at DES 2 plus 0.5 years. Due to this chronological relationship, the reference point (RP) will be located before the beginning of the pubertal growth spurt (ONSET) in most children and represents a maturity event during late prepuberty (Table 6). In girls the correlation between this reference point (RP) and PHV was not statistically significant (8). However, by means of multiple regression analysis a statistically significant correlation between dental development (RP) and somatic growth and maturation in girls was demonstrated (8, 9). So far no corresponding data have been reported for boys. Since the correlation coefficients between dental emergence stages and pubertal growth events were much lower in boys (Table 5), the corresponding multiple regression analysis will not be of the same value in boys.

The pattern of relationship in time between ages at attainment of two dental emergence stages (DES 4 and DES M4) and the occurrence of PHV in this study was in accordance with relationship between the corresponding dental stages (DS 4 and DS M2) and PHV in a Danish study (2). It is evident that these two stages do not give any information as to whether PHV is imminent, attained or passed in an individual (Table 7).

The other dental emergence stages were also poor indicators of the pubertal growth spurt, but the following findings may be useful, especially in girls:

- if all permanent incisors have not yet emerged, i.e. the individual is still in DES 1, the growth rate has not begun to accelerate
- if no canine/premolar has emerged, i.e. the individual has not reached or is still in DES 2, the period of maximum growth (PHV) has not been reached
- if 28 permanent teeth have not yet emerged, i.e. the individual is still in DES 3 and/or DES M3, the end of the pubertal growth spurt has not yet occurred
- if a third molar has emerged (DES M5) in a girl, she passed the end of the pubertal growth spurt

It is evident from the ranges for the dental emergence stages (DES) in relation to age at the pubertal growth events that orthodontic treatment based solely on dental maturity will be carried out in periods of greatly varying growth rate in both sexes (Tables 6–8, Figs. 4–6). If orthodontic treatment is carried out throughout the period of emergence of canines and premolars (DES 3) the treatment will at least partly take place during the pubertal growth spurt (ONSET – END) in about 75 per cent for girls and about 40 per cent for boys (Tables 6–8, Figs. 4–6). However, treatment will to a varying extent take place in the deceler-

Table 7. *Cumulative percentage of girls and boys who had attained a certain dental emergence stage (DES) at the end of each annual interval in relation to the interval during which the peak of the pubertal growth spurt (PHV) occurred*

Age interval to PHV	DES 2		DES 3		DES 4		DES M3		DES M4	
	G	B	G	B	G	B	G	B	G	B
- 10		1.0								
- 9		1.0								
- 8		12.4		1.0						
- 7	1.2	26.9	1.2	1.9						
- 6	6.2	48.5	1.2	14.4				1.0		
- 5	27.2	80.6	7.4	35.9		1.0	1.2	4.8		1.0
- 4	63.0	94.2	21.0	62.7	1.3	8.1	2.5	21.9	1.2	6.8
- 3	93.8	98.1	62.0	87.4	6.2	27.5	8.6	44.2	3.7	23.1
- 2	98.8	100.0	86.4	97.1	19.8	49.0	25.9	65.4	12.3	45.2
- 1	100.0		96.3	99.0	40.7	79.0	53.1	85.7	30.9	67.6
PHV			100.0	100.0	64.2	93.2	82.1	98.1	56.4	91.3
+ 1					81.5	98.1	94.9	100.0	81.0	99.0
+ 2					92.6	100.0	100.0		97.5	99.0
+ 3					98.8				100.0	100.0
+ 4					100.0					

Table 8. *Cumulative percentage of girls and boys who had attained a certain dental emergence stage (DES) at the end of each age interval in relation to the interval during which the end of the pubertal growth spurt (END) occurred*

Age interval to END	DES 4		DES M4		DES M5	
	G	B	G	B	G	B
- 2	84.0	97.1	82.1	97.1		1.0
- 1	93.8	100.0	95.0	100.0		6.5
END	98.8		100.0		2.6	19.0
+ 1	100.0				5.5	33.9
+ 2					16.7	-

ation period of the pubertal growth spurt (PHV - END) in some subjects, especially girls (Tables 7–8, Figs. 5–6).

In the present study a third molar emerged (DES M5) in some subjects around the end of the pubertal growth spurt (END, Table 8), at which time the average period of residual growth is about 2.8 and 2.3 years in girls and boys, respectively (25). The influence of the emergence of third molars on occlusion, especially on crowding in the incisor region of the mandible, is uncertain, but the timing of emergence of third molars in relation to residual growth capacity in the mandible (4) may be an important factor.

Patients in whom the outcome of orthodontic treatment for malocclusion is influenced by the change in facial and mandibular growth rate during the pubertal growth spurt, have a need for additional indicators besides dental development and chronological age, of the beginning, peak and end of that period. Such information can be collected from e.g. longitudinal records of growth in height, pubertal development and skeletal development in the hand and wrist (2, 3, 14, 15, 16, 17, 25).

Because of the large discrepancy in timing of the dental emergence stages and the pubertal growth spurt in many individuals, orthodontic treatment in

two periods may be necessary in some patients. Patients in whom orthodontic treatment is performed before the pubertal growth spurt should have orthodontic supervision over that period (11).

The findings of this study support the conclusion that in clinical work and in the evaluation of orthodontic measures both dental and somatic maturation should be registered (2, 3).

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