Eruption of the primary dentition in human infants: a prospective descriptive study

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Abstract

Purpose: This study investigated the clinical process of the emergence phase of eruption of the primary dentition including length of time taken to erupt and the association between soft tissue changes and stages of eruption.

Methods: Twenty-one children aged 6 - 24 months at commencement of the study were recruited from three suburban daycare centers in Melbourne, Australia. Daily oral examinations of each child were conducted for seven months.

Results: One hundred twenty-eight teeth were observed during eruption. Swelling very infrequently accompanied tooth eruption and in all cases was mild. Forty-nine percent of observed teeth demonstrated gingival redness during the emergence stages of eruption, but there was no significant relationship between redness and specific stages of eruption. Mean duration of eruption, from palpable enlargement of the gingival tissue to full eruption, was 2.0 months (range 0.9-4.6 months). The average rate of eruption was 0.7 mm per month. Many of the deciduous teeth appeared to demonstrate an "oscillating" pattern of eruption, (emerging and then retreating before emerging again). Timing of oscillation was not specific to stage of eruption or tooth type. This was defined as a "transitional" phase of eruption which appears to be common.

Conclusion: The results suggest that eruption of the primary dentition is often accompanied by redness, but not swelling, of the gingival tissues. For some children, there also appears to be a "transitional" eruption phase for primary teeth. (Pediatr Dent 22;415-421, 2000)

Teething is viewed by parents and health care professionals as a significant event in the growth and development of the child. It has been suggested that this experience often causes distress and discomfort to both infants and their parents.[1-4] To dentists and physicians, the eruption of teeth has long been a source of intrigue and controversy with incomplete understanding of the mechanisms of tooth eruption, the process initiation and determination and the chronology of clinical events.[5-7]

Teething is the biological expression of tooth movement, in a predominantly axial direction, from the tooth's developmental position within the jaws to its emergence in the oral cavity.[8] How this process occurs is yet to be clarified but several theories have been suggested including the alveolar bone growth theory; the root growth and pulpal proliferation theory; and the blood and tissue fluid pressure theory.[7-10] The most likely source of eruptive forces has been identified as those associated with the periodontal ligament.[7-9] Research in this area has revealed that no single causative factor adequately explains the mechanism of tooth eruption although it is clear that a complete, essentially time-specific, biological interaction occurs between multiple tissue coordinates to create the eruptive event.[7-9]

For human teeth to erupt, they must proceed through three phases. The first is pre-emergent development which involves the early part of tooth formation, when the dental follicle enlarges until partial root development has been completed. The overall dental movement is minimal, but it may have a slight facial transposition in the alveolar bone.[11] The second phase involves the movement of the tooth intra-osseously through the processes of resorption of the overlying tissues creating an eruptive path, and generating an eruptive force to move the tooth vertically.[12] The third phase is post-emergent development which involves the movement from the time the tooth emerges through the gingiva until it reaches occlusal contact with its antimere.[13] The source of the eruptive force has not yet been established, but it has been suggested that the metabolic activity within the periodontal ligament may play a role, particularly for the post-emergent stage of eruption.[14] Human growth hormone (HGH) is known to affect growth and tooth eruption and it has been suggested that the periodontal ligament is influenced by a diurnal-nocturnal rhythm in HGH secretion.[15-18]

From the time the crown of the tooth emerges, it may erupt at a rate of 1 to 2 mm/mo until the full eruption is reached and then it will continue eruptive movement at a slow rate throughout its lifespan, as determined by studies of the permanent dentition.[8] In the permanent dentition, the tooth typically erupts about 4mm in 14 weeks (1.1 mm/mo), but the equivalent values for the primary dentition have not yet been established.[13] The complete eruptive size for the primary dentition, measured from the incisal or cuspal height to the

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Fig 1. E0; no clinical signs of eruption.

cemento-enamel junction, has been determined to be 5.6mm,[19] but the rate of eruption has not been reported in the literature.

It has been suggested that the eruption of primary teeth may be accompanied by certain local disturbances such as 'ballooning of the gums' over unerupted teeth, flushing of one or both cheeks (sometimes with a bright spot referred to as the 'hectic spot' in the center of the flushed area), inflammation of the gingiva, oral ulcers and increased drooling.[1] Soft tissue responses to the eruptive process have been reported since the second century A.D.[2] Redness of the mucosa has been considered a sign of impending tooth eruption with the prevalence of this phenomenon reported to be in the range of 30–90% of children.[1,2]

Although the literature clearly presents information on the estimated ages of eruptive and exfoliative history for the life span of each primary tooth,[20,21] there is little information available to describe the 'typical' clinical eruptive history for each tooth. The majority of information available regarding the rate of eruption has been derived from studies on the permanent dentition with the results extrapolated to describe the primary dentition. The aim of the present study was to describe the emergence phase of eruption of the primary teeth, including the length of time individual primary teeth take to emerge through the soft tissues, and the association of soft tissue changes with the stages of tooth eruption.

Methods

This prospective cohort study was conducted in three suburban day care centers situated in close proximity to the Royal Children's Hospital, Melbourne, Australia.

Eligible subjects were healthy infants aged between 6 and 24 months at commencement of the study who attended one of the participating long day care centers three or more days per week. No child was known to have a medical condition that might have influenced tooth eruption. Written parental consent was obtained prior to commencement. Parents and day care staff were informed that they would be participating in a study of health and minor illness (including the effects of common conditions such as teething) in children attending long day care centers.

In the week prior to commencement of the study, a pilot study was conducted in one of the participating centers to establish standardized working procedures. During this time a trained dental hygienist underwent specific training with a senior pediatric dentist focusing on examination techniques, recognition of stages of tooth eruption and standardized record keeping.

During mid-morning on each weekday for seven months beginning May 1997, the dental hygienist conducted an oral examination of each participating child when present at daycare, with the aid of a back reflecting dental mirror. The examination involved tactile and visual observations of the alveolar ridges at each of the primary dentition sites to identify any redness or swelling and stage of tooth eruption. All observations were recorded on a separate sheet each day and placed immediately into a locked study box to minimize recorder bias (aura effect). Teeth were numbered using standard dental notation. Once each tooth was recorded as reaching the full eruption state (one quarter of the crown of the tooth erupted) consistently, it was pre-entered on the record forms as being in that state constantly.

Redness was recorded as the presence (R1) or absence (R0) of redness on the alveolar ridge. Four stages of swelling were defined: (S0) normal alveolar ridge (absence of swelling); (S1) slight soft tissue swelling—slight enlargement of the soft tissue on or lingual to the alveolar ridge; (S2) obvious soft tissue swelling—fluctuant swelling over the tooth without sign of cystic formation; (S3) eruption cyst—fluid filled enlargement which might be blue in color if filled with blood. Five stages of eruption were defined: (E0) no signs of eruption (Fig 1);

Fig 2a. E1; palpable- enlargement of tissues suggesting imminent eruption (incisor).

Fig 2b. E1; palpable- enlargement of tissues suggesting imminent eruption (molar).

Fig 3a. E2; emergent- gingival parting but incomplete incisal edge emergence (incisor).

Fig 3b. E2; emergent- gingival parting but incomplete cusp emergence (molar).

Fig 4a. E3; partial eruption- the incisal edge is fully revealed but less than a quarter of the height is visible (incisor).

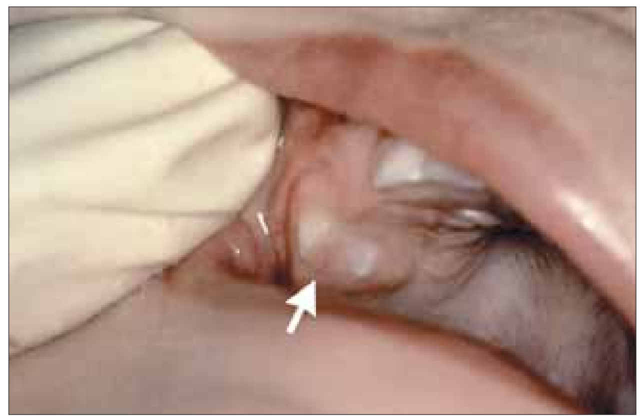

Fig 4b. E3; partial eruption - all cusps visible but the complete occlusal surface is not visible (molar).

Fig 5a. E4; full eruption - a quarter or more of the crown of the incisor is visible above the surface of the gingiva (incisor).

Fig 5b. E4; full eruption - the complete occlusal surface is visible (molar).

(E1) palpable – firm enlargement of tissue suggesting imminent eruption (Figs 2a and 2b); (E2) emergent—gingival parting but incomplete incisal edge emergence (incisors) or incomplete cusp visibility (molars) (Figs 3a and 3b); (E3) partial eruption—the incisal edge is fully revealed but less than a quarter of the height is visible (<1.4mm[22]) (incisors), or all cusps visible but the complete occlusal surface is not visible (molars) (Figs 4a and 4b); (E4) completion of emergence phase – a quarter or more of the crown of the incisor is visible above the surface of the gingiva (incisors), or the complete occlusal surface is visible (molars) (Figs 5a and 5b). This stage of eruption was considered to represent full eruption for this study, as the focus was to investigate clinical signs of eruption during the emergence phase of the process. This is consistent with parent reports that the periods leading up to and during the first observation of a new tooth are the most likely to coincide with both local and systemic symptoms.[3]

Table 1. Proportion of Days in Which Redness Observed

		Eruption stage* No. of days red / total days observed (% at each stage)				
Tooth	**N**	**E0**	**E1**	**E2**	**E3**	**E4**
Maxillary second primary molars	3	1/3712 (0)	12/131 (9)	24/37 (65)	0/30 (0)	**
Maxillary first primary molars	22	0/1257 (0)	77/159 (48)	130/227 (57)	4/182 (2)	3/1985 (0)
Maxillary primary canines	21	6/1881 (0)	200/448 (45)	104/234 (44)	4/267 (2)	0/1080 (0)
Maxillary primary lateral incisors	12	2/275 (1)	68/100 (68)	39/89 (44)	0/146 (0)	3/3300 (0)
Maxillary primary central incisors	9	7/66 (11)	48/76 (63)	29/46 (63)	3/112 (3)	2/3610 (0)
Mandibular primary central incisors	7	0/63 (0)	12/39 (31)	23/55 (42)	1/90 (0)	0/3152 (0)
Mandibular primary lateral incisors	15	2/835 (0)	85/187 (46)	57/95 (60)	2/107 (2)	0/2686 (0)
Mandibular primary canines	21	0/1982 (0)	102/389 (26)	68/190 (36)	2/177 (1)	0/1172 (0)
Mandibular first primary molars	15	0/1395 (0)	99/257 (39)	48/115 (42)	3/120 (3)	0/2023 (0)
Mandibular second primary molars	3	0/3753 (0)	9/113 (8)	4/11 (36)	1/32 (3)	**

* Refer to text for description of eruption stages.
** Values not determined as no teeth observed to full eruption.

Simple descriptive statistics were used to describe patterns of redness, swelling, and eruption. Conditional logistic regression was used to compare the frequency of redness at stage E1 and E2 for each tooth type. All analyses were conducted using the computer statistical package SPSS for Windows® Release 6.1.

Results

Informed consent was obtained for 21 of the 27 children eligible for the study (78% response; 12 males, 9 females). All children completed the study, although two children enrolled after commencement of the study and thus contributed only six and five months of data respectively. The mean age at commencement of the study was 14.4 months (SD 4.9 months; range 6.8 to 22.5 months). During the course of the study, 2,067 child days of observations were recorded and a total of 128 teeth were observed erupting.

There were only 16 observations of swelling. As all of these were of slight soft tissue swelling (S1) with not a single record-

Table 2. Mean Ages at Commencement (E1*) and Completion (E4*) of Eruption by Tooth Type

		E1		E4	Mean eruption duration (in months†) (range)
Tooth	**N**	**Mean age (mths) (range)**	**N**	**Mean age (mths) (range)**	
Maxillary second primary molars	6	24.4 (21.6 – 27.3)	**	**	**
Maxillary first primary molars	17	14.2 (13.0 – 15.4)	19	17.7 (15.2 – 20.2)	1.9 (0.9 – 2.9)
Maxillary primary canines	22	17.4 (15.3 – 19.6)	15	22.3 (20.2 – 24.3)	3.7 (2.8 – 4.6)
Maxillary primary lateral incisors	6	11.0 (9.2 – 12.9)	16	13.1 (10.6 – 15.7)	2.7 (1.8 – 3.5)
Maxillary primary central incisors	5	9.5 (8.3 – 10.7)	10	10.9 (9.6 – 12.1)	2.1 (1.3 – 3.0)
Mandibular primary central insicors	4	10.1 (8.3 – 12.0)	10	11.2 (9.2 – 13.2)	2.0 (0.8 – 3.2)
Mandibular primary lateral incisors	12	12.0 (8.5 – 15.5)	19	14.9 (11.5 – 18.3)	2.2 (1.4 – 3.1)
Mandibular primary canines	22	16.0 (14.3- 17.7)	19	21.5 (19.6 – 23.3)	3.1 (2.5 – 3.7)
Mandibular first primary molars	15	14.1 (13.1 – 15.2)	16	17.8 (15.3 – 20.3)	2.2 (1.1 – 3.3)
Mandibular second primary molars	5	26.1 (24.4 – 27.8)	**	**	**

* Refer to text for description of eruption stages.
** Values not determined as no teeth observed to full eruption.
† Calculated for teeth observed through full emergence process (E1-E4).

Table 3. Time Spent in Each Stage of Eruption by Tooth Type

		Eruption Stage** *mean number of days*						
Tooth	N*	E0 - E1	E1	E1 - E2	E2	E2 - E3	E3	E3 - E4
Maxillary second primary molars	3	31.0	31.2	†	18.0	‡	‡	‡
Maxillary first primary molars	22	30.3	21.6	8.5	24.0	12.0	16.8	8.4
Maxillary primary canines	21	32.9	31.1	14.1	21.5	12.2	22.1	15.7
Maxillary primary lateral incisors	12	39.1	23.5	9.5	15.0	8.0	15.7	12.5
Maxillary primary central incisors	9	31.7	21.5	10.1	7.6	6.5	16.8	7.5
Mandibular primary central incisors	7	23.2	3.0	34.5	11.9	9.7	12.5	8.9
Mandibular primary lateral incisors	15	31.2	11.7	4.7	10.8	7.0	12.8	4.0
Mandibular primary canines	23	23.3	28.4	12.5	16.5	7.5	20.7	8.9
Mandibular first primary molars	15	31.0	15.3	10.0	12.6	13.7	11.0	10.5
Mandibular second primary molars	3	56.5	31.5	†	4.5	‡	‡	‡

* Some teeth were not observed through every stage of eruption, therefore numbers may not be the same as in Table 2.
** Refer to text for description of eruption stages.
† No fluctuating observed.
‡ Values not determined as no teeth observed in these stages of eruption.

ing of S2 or S3 throughout the study, no further analyses of swellings were conducted.

Most redness was observed during stages E1 and E2 of the eruption process for all tooth types (Table 1) with redness occurring for 37% of teeth at stage E1 and 48% of teeth at stage E2. Conditional logistic regression showed no significant differences between observed redness at stage E1 and E2 for any tooth sites except the maxillary left second primary molar (Odds Ratio (OR) = 14.4, $P<0.001$) and maxillary right primary lateral incisor (OR = 5.1, $P<0.01$) with these odds ratios being derived from only two and six teeth respectively.

The mean duration of eruption from stage E1 (palpable) to stage E4 (fully erupted) for each primary tooth type is detailed in Table 2. No second primary molars had reached full eruption by the end of the study, so that it was not possible to calculate the duration of eruption for this tooth type. Teeth which had begun erupting prior to commencement of the study or which had not reached full eruption by the end of the study were not included in calculations of mean duration of eruption.

When all tooth types were grouped (with the exclusion of all the second primary molars), the average time to erupt was 2.0 months (SD 0.8 months; range 0.9-4.6 months). This represented an average eruption rate of 0.7 mm per month. However, the mean duration of eruption appeared to be consistent with tooth type and more particularly within each arch.

Many primary teeth observed during this study appeared to fluctuate ("oscillate") for a number of days between stages of eruption. Table 3 shows the mean length of time each tooth type remains in each eruption stage, as well as the length of time they oscillated between each eruption stage. Although many of the teeth demonstrated this pattern of eruption, the staging of the oscillation was not specific to stage of eruption or tooth type. In total, 67 teeth fluctuated from E0 to E1, 30 did not; 28 fluctuated from E1 to E2, 78 did not; 37 fluctuated from E2 to E3, 73 did not and 46 fluctuated from E3 to E4, 59 did not.

Discussion

During this study, it was observed that all tooth types have a potential for presenting with redness (presumably due to hyperemia) associated with eruption, particularly during the E1 and E2 (palpable and emergent) stages of eruption. By the time teeth had reached full eruption (E4), there was little redness observed. These observations suggest that some hyperemia around the emerging primary dentition is normal and should be expected. This probably reflects the known transient increase in vascularization in the region, as the connective tissue between the reduced dental epithelium and the oral epithelium degenerates.[10] As soon as the cusp tip begins to emerge in the oral cavity, there is initiation of an acute inflammatory response within the connective tissue underlying the oral epithelium. This process is the beginning of the development of the sulcular epithelium of the dentogingival junction.[10]

Swelling, however, was an unusual companion to erupting teeth and in all cases was mild. This is at odds with common parent beliefs.[3]

In this sample of children, the duration of eruption was consistent with previous reports, although the sequence of eruption was slightly different than that reported in the literature with the maxillary primary central incisors erupting ahead of the mandibular primary central incisors.[23-26] However, numbers were small and the pattern observed here seems most likely to represent a variant of normal. The primary canines appeared to take longer to erupt than the other teeth, but because they were few in number significance values were not calculated.

All tooth types appeared to demonstrate a random oscillating pattern of emergence from the time the tooth was palpable to the time of full eruption. The recording of the eruption stages may have been subject to some error, as the dental hygienist was not blinded to the nature of the study and was required to report a subjective measure of the eruption stage for each tooth in each child daily. However, she did place her record sheets in a locked study box at the completion of each day's recording to avoid biasing herself by having access to previous recordings. In addition, although the small children in the study were very compliant overall, the examinations were by necessity in some cases very quick. Although these sources of error might have amplified the reported pattern of oscillation, the high prevalence of oscillation between all stages of eruption and across all tooth types suggests that erupting teeth genuinely do respond in an alternating fashion to eruptive and intrusive forces over a period of months. This oscillating pattern of movement may represent a transitional phase of eruption associated with the post-eruptive phase of dental eruption. To confirm or refute these observations, a future study including daily photographic procedures interpreted by fully-blinded observers would be required.

It has been suggested that the non-continuous pattern of eruption observed may be associated with the rhythmic pattern in the application of forces opposing eruption.[27] In animal studies, the application of very light but continuous forces (1gm or less) can halt eruption or even cause intrusion of an erupting incisor.[19,28] Using the principles of equilibration, it may be extrapolated from this that light forces, such as those from tongue and lip pressure, applied for prolonged periods, may affect the pattern of eruption. Similarly, it is known that masticatory forces may intrude a tooth during function, but that the tooth recovers its position within an hour of cessation of the intrusive force.[20]

Primary teeth could be influenced by masticatory forces as are the erupting permanent teeth. It could be hypothesised that, as the primary teeth emerge, they are immediately in contact with the opposing alveolar ridge, thus they do not proceed through the same pre-functional emergent stages that secondary teeth experience. Since occlusal stability is being developed in tandem with the emergence of the primary teeth, it is reasonable to suggest that these teeth are subject to a greater influence of masticatory forces and thus are more likely to be subject to frequent intrusive forces. Due to the age related under-development of the masticatory apparatus, teething infants are unlikely to generate masticatory forces as large as is the case for older children or adults, but they do have prolonged states of lighter forces, as observed through sucking behavior (both nutritive and non-nutritive) as well as mouthing behavior on self and foreign objects.[20] Although this study tried to correct for diurnal variances by examining the children at the same time each day, not all daily behavior variances in mouthing behaviors could be controlled for. It is suggested that the final eruptive state is therefore a product of the balance between the forces of eruption and the opposing more or less random intrusive forces.

It is known that the eruption of teeth is affected by growth hormone secretion.[15] Lee and Proffit[27] suggested that the known rhythm of human growth hormone (HGH) secretion was quite similar to the predominantly nocturnal pattern of eruption they observed in premolar teeth. More specifically, HGH secretion usually remains low during the day, but a substantial amount is secreted during the late evening-early morning period, suggesting that its secretion is related to the sleep cycle.[16-18] It is possible that HGH may play a role on the pattern of eruption by regulating the metabolic activity of the periodontal ligament.[18,27] If this is true, then the teeth would be at their maximum stage of eruption first thing in the morning, but by midday there would have been time for intrusive forces to have acted upon the tooth . The amount of intrusive forces varies on a daily basis thus an observed oscillating pattern of eruption may occur.

Conclusion

1. During eruption, a large proportion of teeth show signs of gingival reddening (hyperemia) particularly during the early stages of eruption. However, soft tissue swelling is an uncommon feature of tooth eruption and if ever present, is only mild. Thus, infants presenting with gingival swelling should be evaluated for causes other than tooth eruption.
2. Primary teeth take an average of two months to reach full eruptive position with an average rate of eruption being 0.7 mm per month. This suggests that young children are in an active state of eruption from approximately 6 months until 3 years of age.
3. Erupting primary dentition appears to demonstrate a pattern of oscillation through all stages of eruption until the final eruptive position is obtained. This can be defined as a transitional phase of eruption.

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Abstract of the Scientific Literature

Referrals for Dental General Anesthetics

This study was performed to determine how many patients for whom dental general anesthesia was requested actually needed it in order to complete treatment. Analysis of clinical outcomes supported by telephone canvassing of parents. In summer 1998, eighty two child patients were seen in the Community Dental Service in Rochdale with a request for the provision of dental general anaesthesia (DGA) for the extraction of teeth. Their ages ranged from 3 to 14 years and all were required to attend for a pre-anaesthetic visit. Unless objective indicators of a need for DGA applied, the parents and children were actively discouraged from having DGA, and the alternative of local anaesthetic (LA) was offered. Clinical outcomes and parent satisfaction were recorded after treatment was finished. In 75% of cases it proved possible to complete the extractions without need for DGA; in the 10% of cases where DGA was necessary, it was to deal with the sequelae of dental caries. Fifteen percent of subjects failed to complete treatment. Subjects found to have a need for DGA tended to be younger and with treatment required in more than one sextant. Pain as a presenting symptom, young age and multiple treatment needs were found to be poor predictors of need for DGA and did not automatically preclude successful treatment without DGA. The satisfaction ascertained from users of the service was high and explanation of proposed treatments, especially the comparative risks and benefits of DGA versus LA, was well received. There is scope for significant reduction in provision of dental general anaesthesia if current professional guidelines are followed.

Comments: The current trend of referring difficult patients to general anesthesia is worrisome. Less invasive patient management techniques should be utilized before suggesting general anesthesia. **AK**

Referrals for dental general anaesthetics—how many really need GA? Tyrer GL. Br Dent J 187(8):440-3, 1999