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Acceleration in dental development: fact or fiction

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SUMMARY The aim of this investigation was to determine whether an actual acceleration in dental development has taken place over the last 30 years in a European population group, as is so readily observable in relation to body height.

In this study, radiographs of 1038 healthy European children, 516 boys and 522 girls, were evaluated. The methodology and norms given by Nolla (1960) for both sexes were used and compared with the tooth developmental stages in our subjects.

In girls, no difference to Nolla's norms could be detected. However, in boys, dental development has accelerated. This difference was most apparent in the 3- to 9-year-old age group and was statistically significant. Thus, over the last 30 years, a small acceleration in dental development has taken place in very young males.

Introduction

Studies conducted during the last several years have yielded new information in relation to human growth and maturation in developed countries. Today, children are maturing earlier than they did at the beginning of this century, and, moreover, they are growing faster than their grandparents and great grandparents (Shuttleworth, 1939; Marshall, 1974; Filipsson and Hall, 1976; Houston, 1980; Eckström, 1982). Between 1920 and 1990, body height increased approximately 7 cm in females and approximately 11 cm in males. Today the average female reaches a height of 168 cm, and the average for males is 182 cm (Kenntner, 1995). This rapid physical development is simply called acceleration. The reasons for this are not well understood; however, it is assumed that better general nutrition and a widespread higher standard of living in industrialized countries play leading roles.

Various studies have shown that an analogous correlation between skeletal and dental maturity, as is found in the relationships between growth, skeletal, sexual and somatic maturation, does not exist (Siemmons and Greulich, 1943; Eveleth, 1966; Lacey, 1973; Marshall, 1974; Demirjian *et al.*, 1985). Even in cases of pronounced growth deficiency or precocious puberty with accelerated skeletal development, dental maturity, unlike growth, appears to remain relatively unaffected which indicates that, in general, dental development is relatively independent from other maturation phenomena (Levy, 1940; Adler and Végh, 1950; Filipsson *et al.*, 1965; Keller *et al.*, 1970; Garn *et al.*, 1972; Lacey, 1973; Lindston *et al.*, 1974; Edler, 1977; Kosowicz and Rzynski, 1977; Fleischer-Peters and Ziegler, 1983; Demirjian *et al.*, 1985; Midtbø and Halse, 1992). Studies have found, however, an acceleration in tooth eruption between 1946 and 1958 in healthy children. In 1958, tooth eruption in children started 6–12 months earlier than it did in their counterparts at the turn of the century (Schützmannsky, 1957; Adler, 1958). Whether children today also reach their permanent dentition at an earlier age is open to question. Recent studies have detected considerable variation in the tempo of tooth mineralization and duration of the teething process among children from different geographical regions, which may indicate that the variability in calcification of permanent teeth is much greater than has been assumed up to the present time (Harris and McKee, 1950; Moorrees and Kent, 1977; Loevy, 1983; Mappes *et al.*, 1992; Maccioni *et al.*, 1993).

Given the indeterminate nature of the results of previous investigations, the aim of this study was to determine whether an actual acceleration

in dental development has taken place over the last 30 years in a European population group, as is so readily observable in relation to body height.

Materials and method

Several different methods to determine dental age are available, but tooth eruption is relatively imprecise as a parameter for determining dental age. A higher degree of accuracy is achieved by determining the mineralization stage of each tooth separately using radiographs. Thus, Nolla's (1960) 10 stage development methodology was used for determining the mineralization stage of each tooth. The radiographs were matched as closely as possible with the comparison figures given by Nolla (1960). If one-third of the crown was completed, the observation was given the value 3.0; if one-third of the root was completed, the observation was graded 7.0. When the radiograph reading lay between two grades, this appraisal was indicated as the value 0.5 and the observation corrected to 7.5. When the radiograph showed a reading that was only slightly greater than the illustrated grade, but not as much as half way between that stage and the next, the value 0.2 was added.

In this study, panoramic radiographs of 1038 healthy children of European origin, 516 boys and 522 girls, were evaluated. All were born after 1970 and they ranged in age from 3 to 18 years (Table 1). Children with aplasia, missing or severely decayed teeth, or other systemic diseases were excluded from this study. As per Nolla (1960), norms by dental age were then calculated. For each tooth and age category, the maturation stages and the mean and median values were calculated for boys and girls separately. The latter seemed to be more suitable as maturation stages in the different categories proved to be highly skewed.

Error of measurement

The same examiner took measurements of 20 orthopantomographs on two separate occasions approximately 3–4 weeks apart. The method of error was investigated using an analysis of variance. For an acceptable method error, the variance ratio of the difference of the two measurements taken on two different occasions should be below 10 per cent of the variance of the first set of measurements. None of the measurements exceeded this percentage. The highest difference was 0.5.

Table 1 Number of patients in the different age categories.

Age category	Patients (*n*)	
	Girls	Boys
3	8	12
4	34	21
5	30	37
6	36	28
7	38	41
8	90	84
9	87	106
10	56	72
11	39	41
12	27	31
13	25	17
14	17	13
15–18	29	19
Total	$n = 516$	$n = 522$

The sum of dental maturation stages for the teeth of the upper and lower jaw separately and for both jaws combined, excluding the third molars, were then determined. The highest value for 7 developed teeth in one jaw was 70 and for both jaws 140 (one side).

The norms given by Nolla for both sexes were then compared with the tooth developmental stages in our subjects in order to prove or disprove the hypothesis that an acceleration in tooth development had taken place after 1960. Since only mean values were available from Nolla's investigation, the means were used in order to make comparisons between the two studies.

An unpaired Mann–Whitney *U*-test was used to assess possible differences of tooth development with respect to the different age categories.

For each age group (boys and girls were evaluated separately), 95 per cent confidence intervals were computed. The groups which were outside the corresponding confidence interval

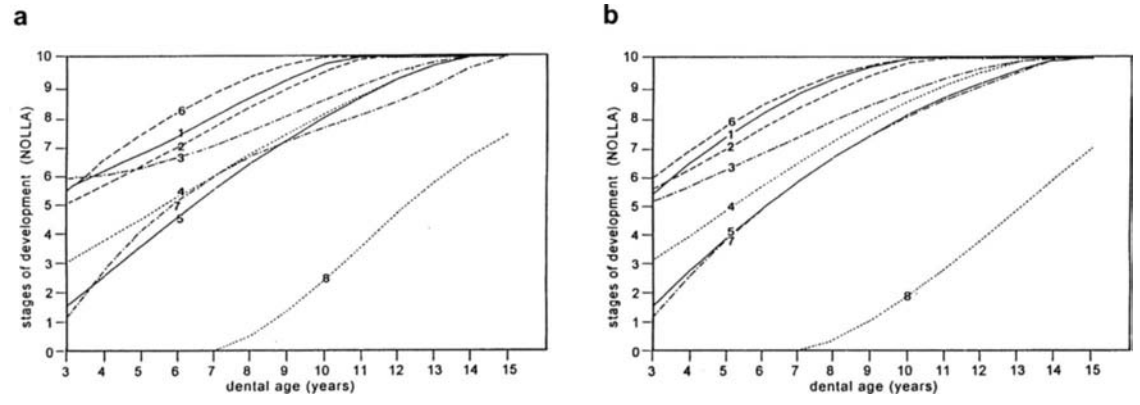

Figure 1 (a) Developmental curves for upper teeth (smoothed curves) in girls. Central incisor (1), lateral incisor (2), canine (3), first premolar (4), second premolar (5), first molar (6), second molar (7), third molar (8). (b) Developmental curves for lower teeth (smoothed curves) in girls. Central incisor (1), lateral incisor (2), canine (3), first premolar (4), second premolar (5), first molar (6), second molar (7), third molar (8).

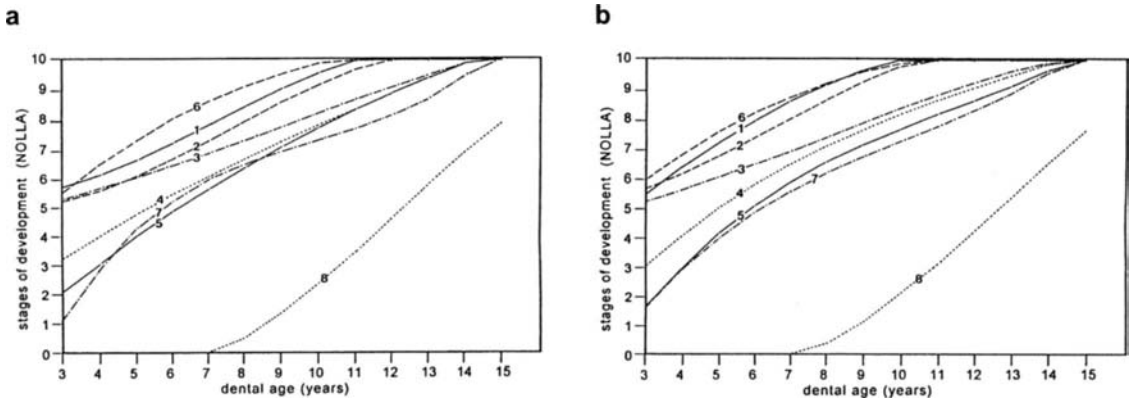

Figure 2 (a) Developmental curves for upper teeth (smoothed curves) in boys. Central incisor (1), lateral incisor (2), canine (3), first premolar (4), second premolar (5), first molar (6), second molar (7), third molar (8). (b) Developmental curves for lower teeth (smoothed curves) in boys. Central incisor (1), lateral incisor (2), canine (3), first premolar (4), second premolar (5), first molar (6), second molar (7), third molar (8).

can be regarded as differing significantly from Nolla's results.

Results

Growth pattern of each tooth

As can seen from Figures 1a, b and 2a, b, the growth pattern for each tooth is equal in both sexes, i.e. the development of teeth is the same for boys and girls. This is in agreement with Nolla (1960).

Development of maxillary and/or mandibular teeth

When the developmental stages for maxillary and mandibular teeth, excluding the third molars are combined, it can be clearly shown that in both sexes the development in the lower jaw is faster over the whole maturation period with a maximum of 6 months at the age of 6–8 (Figure 3a, b, Table 2a, b). This was the case in both sexes.

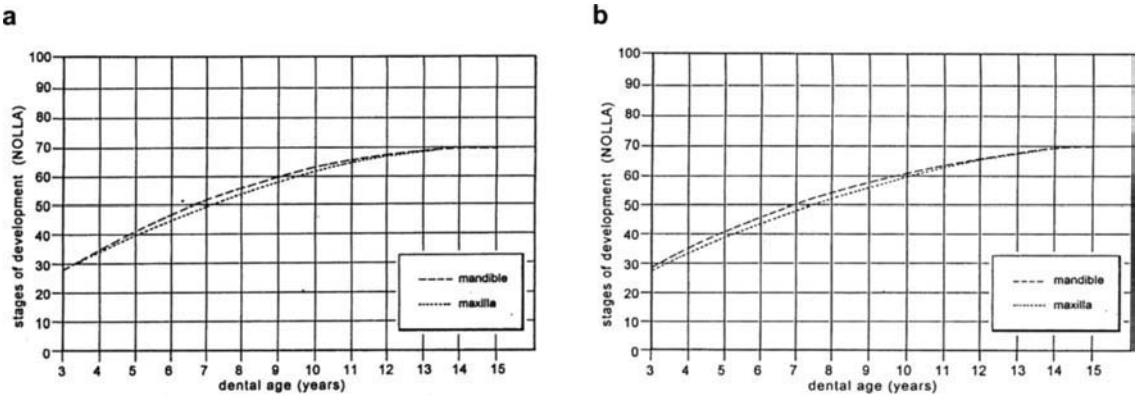

Figure 3 (a) Developmental curves for upper and lower teeth, excluding third molars, in girls (smoothed curves). (b) Developmental curves for upper and lower teeth, excluding third molars, in boys (smoothed curves).

Table 2a Sum of stages of 7 maxillary teeth and 7 mandibular teeth and sum of stages (14 teeth) belonging to age categories 3–15 in boys.

Age (years)	Sum of stages (7 max. teeth)	Sum of stages (7 mand. teeth)	Sum of stages (7 max. and 7 mand. teeth)
3	27.60 (25.50/29.55)	29.50 (27.60/31.15)	56.70 (54.05/59.75)
4	33.20 (31.60/35.60)	34.00 (31.70/35.10)	66.80 (63.95/70.35)
5	38.20 (35.95/41.80)	40.90 (36.00/43.50)	78.00 (73.25/84.80)
6	43.20 (40.05/46.37)	44.60 (41.55/48.37)	87.05 (81.65/93.925)
7	49.20 (46.25/50.85)	52.00 (49.00/43.50)	101.00 (94.85/104.35)
8	52.50 (51.00/54.42)	55.50 (53.20/57.20)	107.95 (103.90/111.40)
9	56.35 (53.50/59.00)	58.50 (55.70/60.00)	114.50 (109.22/118.60)
10	59.50 (57.50/61.00)	61.00 (59.25/62.50)	120.85 (116.77/123.07)
11	62.70 (60.25/64.70)	63.00 (61.80/65.00)	127.70 (122.70/130.00)
12	65.00 (63.00/67.00)	65.00 (63.00/67.00)	130.00 (126.00/133.00)
13	69.00 (66.00/70.00)	68.00 (65.50/70.00)	137.00 (131.50/140.00)
14	70.00 (69.00/70.00)	70.00 (69.00/70.00)	140.00 (138.00/140.00)
15	70.00 (70.00/70.00)	70.00 (70.00/70.00)	140.00 (140.00/140.00)

Median values ($x_{0.5}$). Percentile $x_{0.25}$ and $x_{0.75}$ in parentheses.

Table 2b Sum of stages of 7 maxillary teeth and 7 mandibular teeth and sum of stages (14 teeth) belonging to age categories 3–15 in girls.

Age (years)	Sum of stages (7 max. teeth)	Sum of stages (7 mand. teeth)	Sum of stages (7 max. and 7 mand. teeth)
3	29.00 (27.00/31.00)	28.70 (27.45/31.95)	59.20 (54.45/62.20)
4	33.35 (31.75/34.70)	34.95 (33.30/36.27)	68.45 (65.15/70.50)
5	37.35 (35.00/39.62)	38.85 (35.87/41.67)	75.20 (71.20/81.05)
6	45.30 (42.47/48.30)	46.70 (44.12/50.42)	91.80 (87.15/98.65)
7	50.50 (48.07/51.35)	53.10 (50.65/54.90)	103.60 (97.30/106.72)
8	54.05 (51.97/56.77)	57.00 (54.85/58.55)	110.80 (107.40/114.50)
9	56.35 (53.50/59.00)	60.00 (57.90/61.50)	117.70 (113.20/121.50)
10	59.50 (57.50/61.00)	63.25 (61.00/65.50)	125.25 (121.12/129.97)
11	62.70 (62.20/67.00)	65.50 (62.90/67.00)	130.00 (125.00/133.50)
12	67.00 (65.50/68.00)	68.00 (65.50/68.00)	135.00 (131.00/137.00)
13	69.00 (68.50/70.00)	69.00 (68.50/70.00)	138.00 (137.50/140.00)
14	70.00 (69.00/70.00)	70.00 (69.00/70.00)	140.00 (138.00/140.00)
15	70.00 (70.00/70.00)	70.00 (70.00/70.00)	140.00 (140.00/140.00)

Median values ($x_{0.5}$). Percentile $x_{0.25}$ and $x_{0.75}$ in parentheses.

Table 3 Sexual specific difference between boys and girls.

Age category	*P*
5	0.1334
6	0.0637
7	0.0790
8	0.0006*
9	0.0003*
10	0.0000*
11	0.0012*
12	0.0026*
13	0.0634
14	0.4069

*$P < 0.05$.

Tooth development in boys and girls

When comparing boys and girls, it was found that tooth development was faster in girls. However, at the beginning there were no sex differences. At 8 years, tooth development in girls started to move ahead of boys and reached its peak at 13 years (Table 3, Figure 4) Boys reached this peak at 14. In comparison, boys at the same age were retarded in dental development by about 1 year. Thus, differences of tooth development between boys and girls in the age categories between 8 and 12 years were found to be statistically significant (Table 3).

A noticeable phenomenon was a difference in the development of the second premolar and second molar in both sexes. The development of both teeth was faster in the lower jaw in girls. In boys, the second premolar was more advanced in the lower jaw, whereas in the upper jaw the second molar was ahead at ages 4–8. Thereafter this was no longer the case. The sequence of tooth maturation in both jaws was: first molar, first incisor, second incisor, canine, first premolar, second premolar, second molar, third molar.

Comparison with Nolla's norms (1960) (girls and boys separately)

In order to answer the question whether an actual acceleration in dental development has taken place over the last 30 years, the developmental stages of both jaws for both sexes have to be compared with those given by Nolla. In girls, no difference to Nolla's norms could be detected. This becomes apparent when we overlie our curve on those of Nolla (using the same scale) (Figure 5a). Thus, it can be concluded that an acceleration in the dentition in girls has not taken place over the last 30 years.

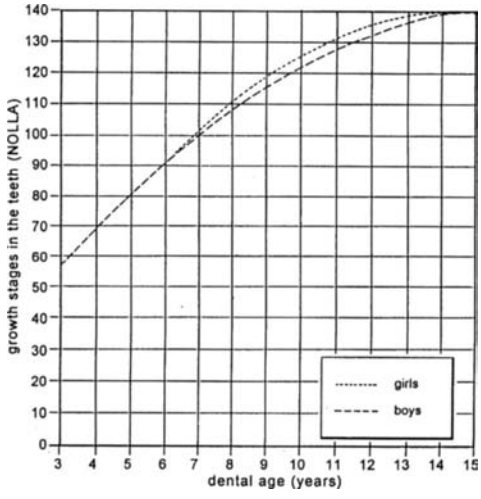

Figure 4 Developmental curves for maxillary and mandibular teeth, excluding third molars, according to Nolla (1960). Boys and girls.

In the group of boys, a difference was found. The pace of dental development has quickened. In boys, this difference was most apparent in the 3- to 9-year-old age group. These differences were proven to be statistically significant (Table 4). The curve of Nolla was found to lie outside the parameters of our confidence intervals (Figure 5b).

In general, it can be concluded that dental development in boys in younger age groups has become similar to that in girls, but only until the former are around 9–10. Thereafter, further development is as described by Nolla (1960).

Thus, over the last 30 years, a small acceleration can be detected in very young males.

Discussion

A study with the aim of detecting an acceleration in dental development requires the following.

1. A representative sample of children in all age categories.

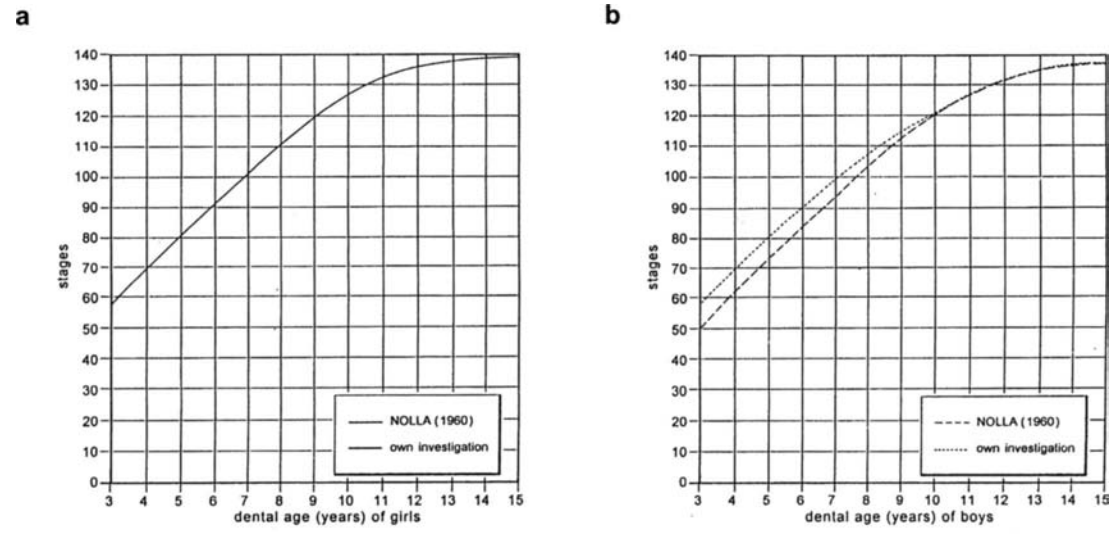

Figure 5 (a) Developmental curves for maxillary and mandibular teeth for girls (this study versus Nolla's investigation). There is no difference. (b) Developmental curves for maxillary and mandibular teeth for boys (this study versus Nolla's investigation). There is a difference only in young boys, indicating a small acceleration.

2. The sample should be representative of the population.
3. The method of evaluation should be very precise.
4. The method used should be comparable with known parameters of other healthy children in the 1960s.

In our study radiographs of 1038 children were evaluated, a sample which is large enough to guarantee that all age categories were sufficiently represented.

Today several different methods to determine dental development are available. As has been repeatedly demonstrated, tooth eruption is relatively inprecise as a parameter for assessing dental age. A higher degree of accuracy is obtained by determining the mineralization stage of each tooth or each tooth category, as carried out by Demirjian *et al.* (1973), Liliequist and Lundberg (1971) and Nolla (1960).

The basis of Demirjian's method (Demirjian *et al.*, 1973) is to determine the beginning of mineralization up to the end of root formation. These authors looked at eight mineralization stages for premolars and molars (A–H) and six steps (C–H) for incisors and canines.

Table 4 Comparison between Nolla's study and this investigation in boys.

Age category	Confidence interval	Nolla's values (1960)
5+	76.26–84.83*	71
6	85.15–91.81*	83
7	98.00–101.96*	93
8	106.34–109.10*	103
9	112.85–115.51*	112
10	118.85–121.59	120
11	123.67–127.09	127
12	127.08–131.23	133
13	131.76–137.86	135
14	136.91–139.09	137

*$P < 0.05$.

According to Hägg and Matsson (1985), precision was found to be high, especially in younger age groups, but less precise was the method of Liliequist and Lundberg (1971). Nolla's method was preferred in which 10 mineralization stages of each tooth were evaluated, although in this method the varying mineralization time of different teeth is not covered. However, the precision was high enough and in this study the method error was below 0.5.

Of further importance is that the values were comparable.

In this investigation, only children of European origin were studied. Nolla's children came from the files of the Child Development Laboratories at the University of Michigan School. A study of Haavikko (1970), as well as of Bean (1914), has demonstrated no difference in tooth development between Finish i.e. European children and Caucasian children in the United States. Bean (1914) found that German and American children of both sexes have almost exactly the same number of permanent teeth at the ages of 6, 7 and 8.

In this study, differences in tooth development based on sex were found. This is in agreement with the findings of numerous other authors (Schour and Massler, 1941; Nolla, 1960; Schopf, 1970; Moorrees and Kent, 1977; Kahl and Schwarze, 1988). Girls are ahead of boys, but in this study it was found that this acceleration in girls did not extend over the whole maturation period. This difference does not occur until girls are 8 years of age and the difference is statistically significant, i.e. in the younger age groups no difference between boys and girls was found.

The most interesting conclusion of our study is that differences in the speed of tooth development occur in both sexes. In girls, the mean developmental process for each tooth, as well as for the upper and lower teeth, alone and combined, is the same as 30 years ago.

In contrast, it was found that boys, especially young boys between 5 and 9 years of age, are 6–9 months ahead in tooth mineralization compared to their 1960 peers. Thereafter development was as described by Nolla (1960). This means that boys in this age caterory have become similar to girls. This finding is especially interesting as most methods for determining dental maturation are more precise in lower age groups. Thus, significant differences would be exposed, if they exist.

However, it must be emphasized that tooth formation and eruption are essentially different processes which can be influenced by genetic, environmental and hormonal factors (Midtbø and Halse, 1992).

Thus, the determination of tooth mineralization stages is a more precise parameter than tooth eruption in order to detect an acceleration in dental development, and the method of Nolla (1960) was an exact procedure with a small method error. Our finding contrasts with the results of Kahl and Schwarze (1988), who found that dental mineralization in all children is retarded today in comparison with tables given by Schour and Massler (1944). These contradictory findings are difficult to explain and may be the result of the different methods used. If a method is very precise in young children and marked differences arise in older children, as is, for example, the case in the method of Demirjian *et al.* (1973), then underestimation may occur. The detected acceleration in tooth development of 6–8 months in young boys may be quite small and at present of low clinical interest. However, it may demonstrate that the speed of tooth mineralization can change with time. Whenever an acceleration in development and growth can be detected, especially in a representative sample with a precise procedure, an adaptation of well-known parameters should follow. This may also be of importance in tooth development, not only on a forensic basis.

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