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CASE REPORT

ODONTOLOGY

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Differential Identification of Three Young Housefire Victims: Methods when Age Assessment Fails*

ABSTRACT: Multiple fatality incidents involving more than one child of statistically same age (including twins) can be challenging from an identification standpoint. This case details an urban fire, in which four children perished. Age assessment on three of the victims utilizing maturity staging described by Moorrees, Fanning, and Hunt yielded insignificant results. However, a plot of the MFH data shows the difference between two identical twins and a third child. The twins share a similar growth pattern, whereas the other was different. Based on this graphical interpretation, the nontwin victim was positively identified through exclusion. These results were verified through statistical testing. This case demonstrates a method to repurpose age assessment data to graphically distinguish between child victims. Further, it is shown that radiographic and clinical presentation in childhood identical twins can elicit genetic versus acquired similarities and differences, which can be used for identification of individuals and exclusion of others.

KEYWORDS: forensic science, forensic dentistry, age determination by teeth, forensic anthropology, twins, monozygotic, data interpretation, statistical

There is precedent for the need to differentially identify young children of the same estimated age in multiple and mass fatality incidents. Housefires in low-income urban areas, such as the present case, account for many of these situations. Shared living of multiple families can place several children of similar ages together in the same dwelling. Due to the familial nature of these incidents, the possibility also exists for identification of young monozygotic twins, as in the present case. In addition, any time children are grouped by age in an institutional setting, the potential for these difficult identifications arise. Notorious examples include the Bath School massacre of 1927 in which a disgruntled school board member carried out a bombing, killing 38 school children, and the Oklahoma City bombing in 1995 where 15 daycare children died. Forensic identification of children is often hampered by the fact that unlike their adult counterparts, they often do not experience dental trauma or treatments in their short lives (1). Despite the need for specialized identification techniques for children, the only literature addressing this topic is osteological (2) in nature and does not fully address use of dental age assessment as a tool for identification in subadult victims. Although it is possible to differentiate between subadult victims that exhibit significantly different age estimations, the conclusions in near same-age victims are not so clear. The dental presentation in monozygotic twins can sometimes offer a solution to pairing them against other unrelated victims of the same estimated age.

Three academic odontological questions can be considered in solving these cases. First, if scientifically derived age estimations are statistically insignificantly different between victims, does that mean that this dental evidence is insignificant for identification purposes? The present case presents a method to repurpose dental age estimation data to differentiate between young victims in a closed population. Second, can age estimation principles be used to help identify between identical twins, and differentiate them from other unrelated victims of the same estimated age? The present case compares a commonly used maturity staging method of 12 teeth to graphically establish a pattern of growth, which can be useful in parsing out twins from other victims. Subtle dental differences between twins will also be noted. Third, if victims of the same age can be distinguished by visually comparing radiographic dental growth patterns, can intermediate statistical analysis support what is seen? Statistical analysis proved useful in supporting the conclusions made in the present case.

Case Report

In July 2014, a house fire consumed an urban row home in the Kingsessing section of Philadelphia. Two immigrant families occupied it, each with young children of similar ages. The two families were close friends, but not related. All of them were of Liberian (West African) descent. A total of four children perished in the fire. They were reported as all occupying the same bedroom in the upstairs rear of the dwelling at the time of the nighttime fire. Due to these circumstances,

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the event was considered a closed population of victims for identification purposes. Because of the density of the housing and narrow streets in these row house fires, they can be characterized as having intense heat that is hard to firefight and typically consume the entire contents with a lot of collateral damage. Such was the case in this instance; body recovery at the end of the event was carried out from the basement of the building.

Victim Profiles

The first victim was a male infant who was initially identified by exclusion by the pathologist, based on his body size and dentition. This death is reported for completeness but was not considered part of the odontological investigation presented in this report.

The Chief Medical Examiner requested that odontology be employed to compare age estimations and dental uniqueness for the remaining three 4-year-old victims. This was done to corroborate the correct identity of each with their provisional identities, based on circumstantial clues determined for each. The three children were designated by the author as “Child A,” “Child B,” and “Child C.” Full series radiographs were taken as shown in Fig. 1. At the outset of the odontological analysis, victims “Child A” and “Child B” were circumstantially identified as female identical twins. The twins had a

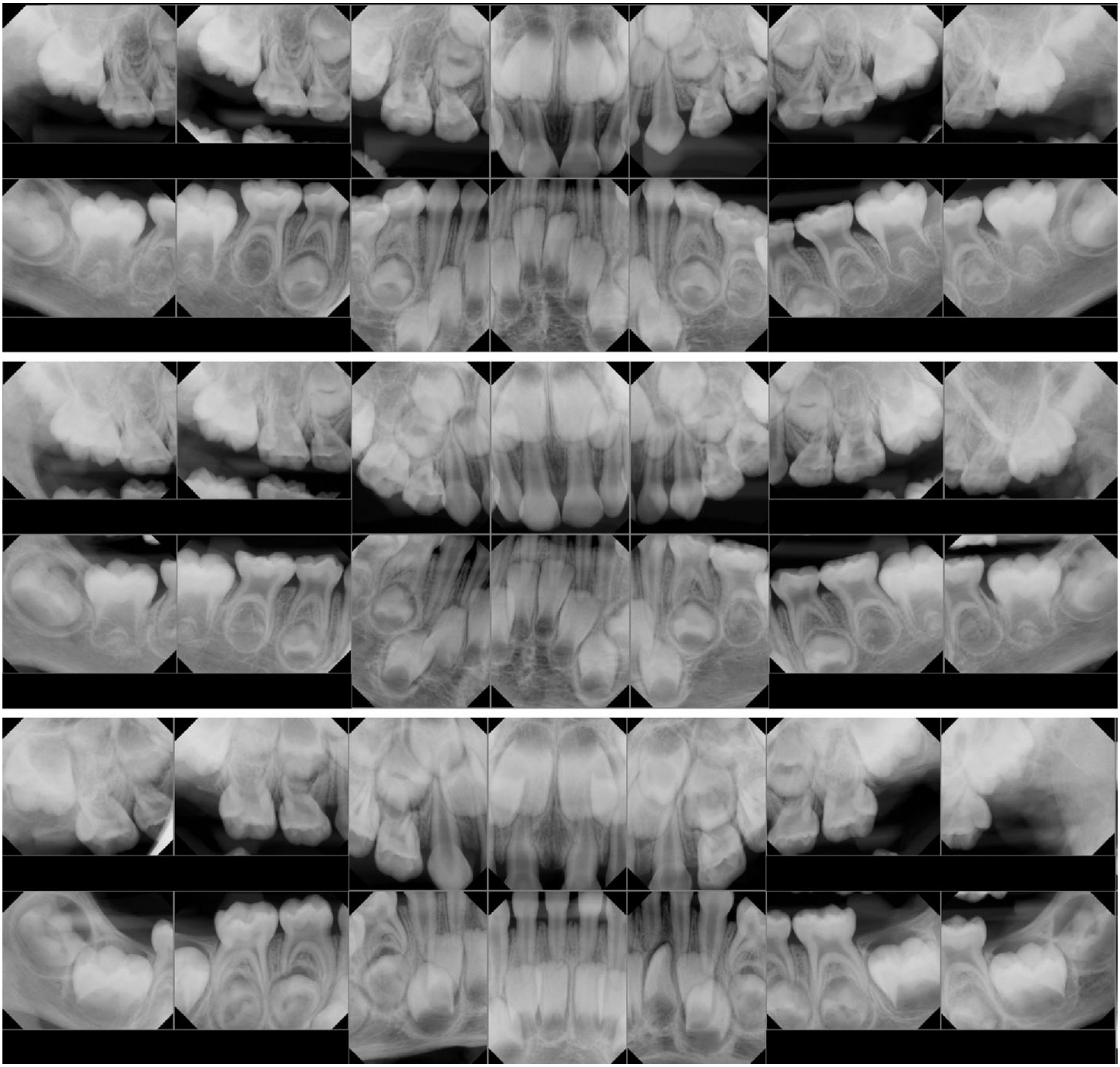

FIG. 1—*“Child A” radiographs (top); “Child B” radiographs (middle); “Child C” radiographs (bottom).*

date of birth of January 25, 2010 (4 years, 5 months at the time of death). “Child C” was male and unrelated to the twins, but approximately the same age with a date of birth of May 24, 2010 (4 years, 1 month at the time of death). Based on the autopsy findings of male and female, it was concluded which were the twins, but with no individual identities. Unfortunately, none of these children had previous dental care, so antemortem comparison was not possible. The mother reported that the only difference between the identical twins was a facial mole apparent on one of them. However, autopsy revealed that it was burned off and not recognizable on either victim. The mother also reported that Child “B” was wearing a “shirt with a rose pattern.” Subsequently, this turned out to be the only substantial evidence differentiating individual identities of the twins. Child “C” was found to be male, which ultimately identified him by exclusion.

Since these identifications were ultimately established with means other than forensic dentistry, the odontological analysis of these “same-age” subadults presented in this report can be considered empirical and therefore may be useful in similar subsequent cases.

Child Dental Age Assessment

It was decided to begin the age assessment process by “ball-parking” utilizing the London Atlas (3). The average maturation of tooth buds, calcification of tooth structure, and eruption pattern as seen on the postmortem radiographs indicated an age estimation of 4.5 years for “Child A” and “Child B.” According to AlQahtani’s work on validating the accuracy of the London Atlas (4), he determined that the standard deviation of this particular age diagram is ± 58 years. The maturation in “Child C” was more difficult to standardize, because it fell in-between the 3.5-year and 4.5-year depictions on the London Atlas. Therefore, the age estimation using the atlas technique was simply listed as 4 years of age (with no published standard deviation). Statistically, this represents an insignificant difference between the three victims due to usual population variations and cannot be used to definitively differentiate between them.

Staging analysis was then performed on the three sets of radiographs, utilizing 12 permanent teeth, and using the appropriate sex data set for each victim as described by Moorrees, Fanning, & Hunt (5) and modified by Harris & Buck (6) (aka: “MFH Staging”). All 3 victims had good images of the 12 specific teeth to

TABLE 1—*MFH age estimation of the three victims in years.*

Victim	Known Age	Sex Data Set	Data Point	Tooth# (Universal)	Maturity Stage	Mean	Average Mean Age	SD	Average SD	Average Age Range (2SD)
Child “A”	4.45	Female	UI1R	8	Crc	4.9		0.54		
			UI1L	9	Crc	4.9		0.54		
			LI2L	23	Rl/4	4.7		0.53		
			LI2R	26	Rl/4	4.7		0.53		
			C	22	Ri	4.7		0.52		
			P1L	21	Cr3/4	4.2		0.49		
			P1R	28	Cr3/4	4.2		0.49		
			P2L	20	Coc	4.1		0.47		
			P2R	29	Cco	3.5		0.40		
			M1L	19	Rl/4	5.1		0.57		
			M1R	30	Rl/4	4.6		0.52		
			M2R	31	Cr3/4	5.4		0.59		
							4.6		0.52	3.6–5.6
Child “B”	4.45	Female	UI1R	8	Crc	4.9		0.54		
			UI1L	9	Crc	4.9		0.54		
			LI2L	23	Rl/4	4.7		0.53		
			LI2R	26	Rl/4	4.7		0.53		
			C	22	Ri	4.7		0.52		
			P1L	21	Cr3/4	4.2		0.49		
			P1R	28	Cr3/4	4.2		0.49		
			P2L	20	Coc	4.1		0.47		
			P2R	29	Cco	3.5		0.40		
			M1L	19	Rl/4	4.6		0.52		
			M1R	30	Rl/4	4.6		0.52		
			M2R	31	Cr3/4	5.4		0.59		
							4.5		0.51	3.5–5.5
Child “C”	4.12	Male	UI1R	8	Crc	5.3		0.59		
			UI1L	9	Crc	5.3		0.59		
			LI2L	23	Rl/4	5.3		0.60		
			LI2R	26	Rl/4	5.3		0.60		
			C	22	Crc	4.0		0.46		
			P1L	21	Cr3/4	4.4		0.52		
			P1R	28	Cr3/4	4.4		0.52		
			P2L	20	Cr3/4	5.3		0.59		
			P2R	29	Cr3/4	5.3		0.59		
			MIL	19	Cli	3.5		0.41		
			MIR	30	Cli	3.5		0.41		
			M2R	31	Crl/2	5.1		0.54		
							4.7		0.54	3.6–5.8

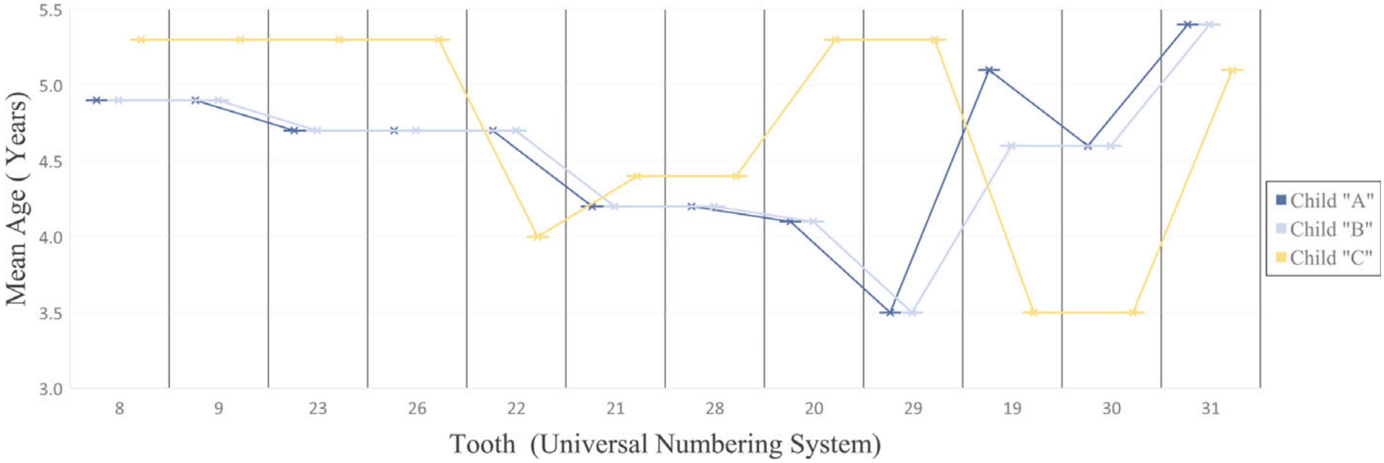

FIG. 2—*Box plot (available in color online) showing graphical depiction of differential age assessment.*

be used in common. As expected, Table 1 shows that the mean average dental ages of the three victims were also not statistically different at a 95% confidence interval using this method.

Differential Age Assessment for Identification

Although the London Atlas and MFH age estimations both yielded overlapping results between victims, further analysis of the age assessment data revealed quantifiable differences which were useful from a victim identification standpoint.

The 12 individual tooth age scores from each victim's MFH staging results were graphed on a layered box plot as depicted in Fig. 2. This graph clearly shows a similar pattern in the variation of growth of individual teeth of the two identical twins and a different pattern for the third victim. Both twins exhibit a permanent dentition with the same stage of growth on each tooth with only one exception (tooth #19). Of particular interest is the same delayed calcification of the lower second bicuspids, as compared to the advanced maturation stage of the permanent lower second molars. Conversely, the plot for "Child C" has a very different pattern of tooth maturity.

In addition, although the actual age of "Child C" is younger than the twins, his overall age estimation is older. This means that he is relatively more precocious *on average* than the twins. This variable of precociousness must be appreciated as a possibility when evaluating these cases. Without the presence of monozygotic twins and their genetically driven phenotype, comparison of unrelated same-age subjects needs to be approached with extreme caution.

Based solely on this visual analysis, it can be argued that "Child C" is most likely the nontwin victim and thus could be identified through exclusion. However, intermediate level statistics can help validate this analysis by determining if the three box plots are in fact, significantly different from each other. Comparison through two-sample Kolmogorov-Smirnov tests as follows were utilized toward that end.

A two-sample Kolmogorov-Smirnov (K-S) test is a nonparametric statistical test that tries to determine whether two sets of data differ significantly (7). The K-S test is a versatile tool in that there is no requirement for normal distribution of data. The maximum difference between the cumulative distributions of two data sets (D) is calculated with a corresponding probability (P) that the two sets arise from a common source distribution. With three victims to compare, the K-S analysis is completed three times to cover every possible combination as shown in Table 2. With the null hypothesis stated as no statistically significant difference between the sets analyzed, in general we reject the null hypothesis when the P value is relatively "small." Alternatively, a probability of "1" is assigned as the most probable as coming from a common source distribution. In examining the probability value P in the present case, it can be seen that the probability of Child "A" and Child "B" being from a common source distribution is very high at $P = 1.0$. Comparatively, the probability for both Child "A" and Child "B" to Child "C" is quite low at $P = 0.1860$. It can be interpreted from these results that it is about 5 times more likely that Child "A" and Child "B" represent the twins than any other combination of victims in the present case. Furthermore, a method to assign a confidence interval to the two-sample K-S test is available (8). Due to the miniscule differences in these same-age comparisons, a confidence interval which is more lenient than the standard significance $\alpha = 0.05$ (95% confidence interval) may be warranted. In the present case, the K-S test found no difference between the plots of Child "A" and Child "B" (the twins) and proved a significant difference when they were compared to Child "C" at a significance $\alpha = 0.15$ (85% confidence interval).

The analyses presented are highly consistent with the conclusion that Child "A" and Child "B" are in fact the identical twins, and that Child "C" is significantly different.

TABLE 2—*Two Factor K-S Analysis, based on the three victims and twelve mean age by tooth values, derived from MFH staging.*

Sample Pair	D	P	α	$c(\alpha)$	n	m	D_{crit}	Ho?
A versus B	0.0833	1.0000	0.15	0.9739	12	12	0.3976	Accept
A versus C	0.4167	0.1860	0.15	0.9739	12	12	0.3976	Reject
B versus C	0.4167	0.1860	0.15	0.9739	12	12	0.3976	Reject

D, the maximum difference between the cumulative distributions; P, probability of originating from a common source; α, level of significance (0.15 translates to 85% confidence interval); $c(\alpha)$, a critical function of alpha defined as $(-0.5 * \ln \alpha)^{-2}$; n, size of the first sample; m, size of the second sample; D_{crit}, the critical value of the D statistic below which the null hypothesis is rejected and is defined as $c(\alpha)*((n+m/(n*m))^{-2}$; Ho?, effect of the result on the null hypothesis that there is no statistical difference between the sets analyzed.

FIG. 3—*Twins. "Child A" (left) presents with less carious activity and eruption of the lower left first permanent molar, whereas "Child B" (right) has more extensive lesions and no erupted permanent teeth.*

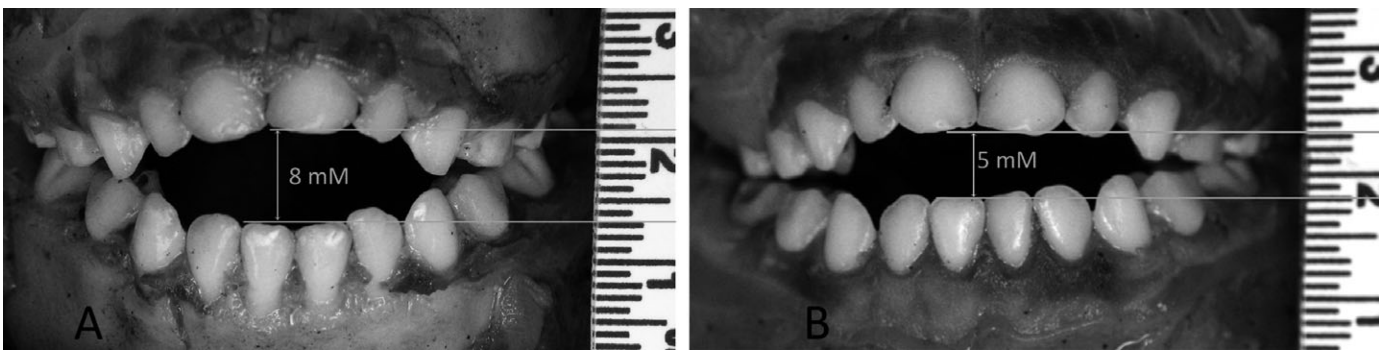

FIG. 4—*Twins. "Child A" (left) with an 8 mm anterior open bite, versus "Child B" (right) with only 5 mm anterior open bite.*

Identifiable Dental Differences in Twins

Recent studies of dental traits (9,10) within sets of twins have shown that monozygotic siblings may not be dentally identical, although they share the same genes. It has been suggested that epigenetic and environmental factors such as methylation of DNA, acetylation of histones, and in-utero and/or early childhood nurturing can account for these differences (11). It is these small differences that may lead to positive identification between identical twins, if antemortem dental records can be found. Unfortunately, in this case antemortem records did not exist on these socioeconomically challenged youngsters, as evidenced by the lack of dental restorations on frankly carious teeth (Fig. 3).

Nonetheless, several differences were noted between the identical twins in this case. Both twins showed evidence of a finger-sucking or pacifier habit with premaxillary protrusion, palatal constriction, and anterior open bite. (Fig. 4) However, the altered growth was more pronounced in "Child A." There is also a similarity to the pattern of decay, but the extent of decay is different between the two dentitions. Further, "Child A" had an erupted #19 clinically and "Child B" did not. Lastly, "Child A" presented with slightly advanced eruption of #25 compared to #24, whereas this was reversed in "Child B" (Fig. 5). It has

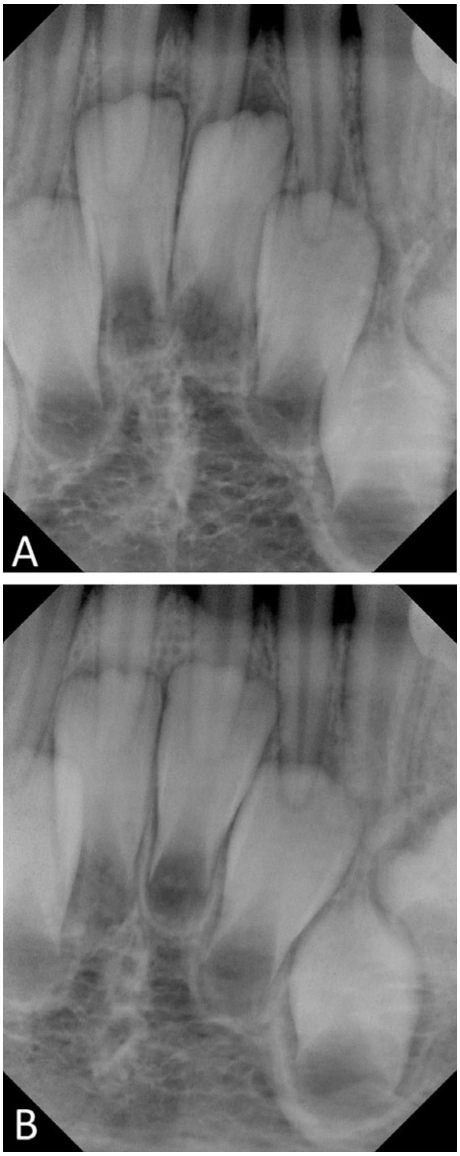

FIG. 5—*Twins. Showing radiographic evidence of subtle differences in eruption pattern.*

been suggested that one of the most variant characteristics of developing dentitions is the timing of gingival emergence (12). This inconsistency can be useful in identifying twins, as evidenced here.

Conclusions

The present case showed that individual tooth staging can be used to compare variation patterns between victims when the average mean dental ages are statistically the same. It is these differing patterns of tooth maturation which can aid in victim identification. Conversely, although identical twins can show dental variation, the degree of dental similarities can differentiate identical twins from other victims.

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