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## Dental Identification of Aircraft-Accident Fatalities

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The identification of the dead represents a humane and moral responsibility that often comes to rest upon the shoulders of the dentist. The identification of unknown human remains is mandatory for legal certification of death, which is prerequisite to the culmination of subsequent legal events, such as the settlement of wills, awarding of insurance benefits, termination of business affairs, and remarriage of survivors. In deaths resulting from accidents, certification of death is necessary prior to the possible institution of legal action involving negligent parties. From the standpoint of the aerospace pathologist or other persons concerned with air safety and improvement of the man-machine relationship as it applies to aircraft, the identification of air-crash victims enables an assessment to be made regarding the seating location of those involved so as in turn to allow reconstruction of crash mechanics and the mechanism of injury patterns. In addition, identification of the crewmembers enables the pathologist to assess the role played by natural disease in a given accident. As an example, a question may arise as to whether the pilot suffered a fatal heart attack that resulted in the accident. The pathologist may have found a diseased heart, but is it from the pilot or whom?

The relevance and position of dental identification in the overall format of general identification of unknown remains has been presented in an earlier article by the author [1]. Pertinent points regarding the role of dental identification are:

(a) Unlike other individual features of the human body, the great resistance of teeth and dental restorations to physical and chemical destruction places dental identification in a paramount position whenever human remains have decomposed or been exposed to fire or mutilation.

(b) The comparison of antemortem dental records with postmortem dental remains represents an internationally accepted scientific method of identification.

(c) Identification by fingerprint and dental methods represents the most scientifically reliable modes of identification.

This article is a review and discussion of the role of dental identification following aircraft disasters.

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### **Identification and the Air Accident**

In terms of feasibility of identification of remains, an advantage and a disadvantage apply to the aircraft accident as compared to other mass disasters, such as floods, fires, explosions in public buildings, mine disasters, and other mass-transportation accidents. The advantage concomitant to the air disaster is that a passenger-crew manifest is usually available, which greatly narrows the probable population segment involved, thus allowing the identification team to concentrate upon a comparison between postmortem data on a set of "unknowns" with a determined set of "known" antemortem data. Such a list of putative identities is essential for the process of dental identification, as the antemortem record for comparison must be retrieved from an attending dentist. In other forms of mass disaster, however, in which no previously established list of possible identities is available, almost endless possibilities of identity exist, which necessitate prolonged investigations involving extremes of time and effort. The dental identity of victims of a military air crash is generally more easily proved than the corresponding civilian disaster because the dental records maintained on military personnel are generally more up to date and are more readily located. In addition, the military air crash rarely involves the large number of victims so commonly associated with the commercial air-carrier disaster.

The disadvantage regarding identification that pertains to the air-crash setting centers upon the mutilating high-impact forces common to such accidents and the frequent intensity and duration of subsequent conflagration. Both of these aspects inherent to the air-crash lead to loss of physical features, which frequently precludes the use of the visual and fingerprint methods of identification and may even jeopardize the efficacy of the dental method.

When dealing with identification in aircraft disasters, one faces a conflicting situation. On the one hand, cognizant of the medical, legal, and emotional aspects involved, one would prefer to utilize the most scientifically specific modes of identification—the fingerprint or dental methods. On the other hand, one must not lose sight of the practical facets of the total situation. In the aftermath of a plane crash, when faced with 70 or 100 (or more) bodies, many of whom can be identified by clothing, documents, jewelry, and personal belongings, the realm of practicality must prevail, and these less reliable methods may have to suffice as modes of identification. This is not to say that, with time and effort, dental identification of many of these victims could not be accomplished. Given personnel and time, dental identification could be achieved, but this represents the ideal situation and not the more commonly encountered actual situation in which time and skilled personnel are in short supply. This point must be kept in mind when interpreting numerical data regarding the role of dental identification in air crashes. A statement such as "Dental features were responsible for the identification of 15%" of a given number of victims often reflects the outcome of what was practical versus what was ideal. This must not necessarily be interpreted to mean that only 15 percent of the victims could be identified by dental means. The correct interpretation is that 15 percent were easily resolved by this means. An important point that surfaces from the foregoing discussion is that a pre-established dental disaster squad (DDS), namely, an organized team of several dentists, can more effectively implement dental identification among disaster victims and, thereby, more nearly approach the ideal situation.

The statistical significance of dental identification in any particular air crash is inversely related to the workability of the visual, fingerprint, and personal-effects methods of identification. In instances in which there is relative absence of mutilating injuries and conflagration, these nondental methods will inevitably rank as the primary modes of identification. This, of course, assumes that next of kin are available for interrogation and

for recognition of remains and that antemortem fingerprint records are available. These assumptions are not usually the case in instances of international carrier disasters, in which relatives are not near by nor are fingerprint records of citizens maintained by the country in question. It is the very problem of dental identification in international disasters that has prompted the Fédération Dentaire Internationale to establish a universal dental numbering system that enables easy telegraphic transmission of dental records between countries.

The effectiveness of dental identification in any particular instance is directly related to the recovery of dental remains (all, none, or partial), the retrieval of antemortem records, and the recency and accuracy of these records. A breakdown in recency or accuracy of records may lead to disturbing inconsistencies and incompatibilities. The lack of available antemortem records leaves one with a relative's recollections regarding the teeth of the victim or, at best, the memory of the attending dentist.

### Dental Identification in Aircraft Accidents

Table 1 is a collation of statistical data relating to the use of dental identification in aircraft-accident fatalities. These figures represent international experience, as British [2,8,10], New Zealand [7], Scandinavian [4], South African [12], Canadian [13], and American [3,5,6,9,11,14] identification data are cited. Twenty-one accidents, involving 1,002 fatalities, are represented. The number and percentage of victims identified solely by dental means and in instances in which dental examination was of assistance in identification are presented in columns A and B, respectively. The summation of data indicates that dental examination alone or in conjunction with other methods was responsible for the identification of 36.7 percent of all fatalities. Dental examination alone achieved the identification of 29.5 percent of the victims.

TABLE 1—Dental identification in aircraft-accident fatalities.

Author(s) or Accident	Number of Accidents	Number of Fatalities	A. Identification by Dentition Only		B. Identification Assisted by Dentition	
			No.	%	No.	%
Teare [2] 1951	1	28	3	11	...	...
Honolulu, H. I. [3] 1962	1	27	14	52	...	...
Keiser-Nielsen [4] 1963	1	42	10	24	18	43
Salley et al [5] 1963	2	127	62	49	...	...
Fisher [6] 1963	1	81	3	4	13	16
Blair [7] 1964	1	23	3	13	10	43
Stevens and Tarlton [8] 1966	8	218	21	10	...	...
Harmeling et al [9] 1966	1	57	43	75	...	...
Haines [10] 1967	1	72	34	47	6	8
Boone County, Ky. [11] 1967	1	67	19	28	...	...
Van Wyk et al [12] 1969	1	123	6	5	25	20
Peterson and Kogon [13] 1971	1	109	53	49	...	...
Luntz and Luntz [14] 1972	1	28	25	89	...	...
Total	21	1 002	296	29.5	72	7.2

This overall figure of 29.5 percent represents a mean percentage inclusive of much variability. Examining the data more closely, one sees the following extremes represented: Luntz and Luntz [14] and Harmeling et al [9] presented data revealing that 89 and 75 percent of the respective victims were identified by the teeth. At the opposite end of the spectrum, Stevens and Tarlton [8], Teare [2], and Blair [7] reported percentages of 10, 11,

and 13, respectively. The explanation of such variability depends upon the many factors in operation at the time of the accident. Obviously, not all air accidents present the same circumstances as the degree of mutilation and conflagration varies. As has been mentioned earlier, the condition of the victims also varies with regard to the efficacy and practicality of application of the various methods employed in general identification. The mere availability and utilization of a dentist or team of dentists may also be reflected in these data.

Luntz and Luntz [14] reported 25 of 28 burned victims identified by the dentition within 72 h after the accident. The success of these authors attests to the efficiency of a local dental disaster squad. This team of dentists was completely prepared to handle such a disaster. The personnel, necessary equipment for examination, and liaison with the local police, medical examiner's office, and legal authorities had been established months beforehand. Harmeling et al [9] had a team of four dentists operating in the dental identification of 75 percent of the 57 victims of the 1965 Cincinnati air crash. Both this accident and the Luntz' Connecticut crash involved severe conflagration, and the work of these dental teams portrays what can reasonably be expected from the mandatory utilization of dental identification when other methods of identification are useless. The Canadian Woodbridge air disaster, discussed later in this article, represents another example of the results obtained when the team approach is utilized. These accounts should serve as models for similar dental teams, prepared in advance to assist in the event of any mass disaster. It is hoped that the dental schools of the world will serve as the centers for the establishment of such teams, each assisting within their area of legal jurisdiction under the auspices of the responsible medical examiner, coroner, or law-enforcement system. Currently, in the USA, the American Society of Forensic Odontology is establishing a list of dental practitioners willing to participate in dental identification cases arising in their locality.

Salley et al [5] reported on two air-disaster experiences within a 2-year period, each involving extreme burning of victims, wherein contrasting results were forthcoming. The first crash wreckage burned for 10 h before the bodies could be extracted, making dental examination possible on only 17 of the 50 remains. Of these 17 cases, however, these workers were able to identify 13 by teeth alone. In the second crash, which burned for 6½ h prior to body recovery, dental examinations were performed on 76 of the 77 fatalities, and dental identification was established on 49 (64 percent).

Haines [10] reported on the Stockport, England, air disaster, in which the majority of remains were severely damaged by fire. In no instance were the jaws sufficiently damaged to prevent employment of dental identification. Thirty-four of the 72 victims (47 percent) were identified by dentition alone, including 18 persons who possessed full dentures. An additional six identifications initially established by other methods were subsequently verified by dental examination. In two cases of supposed visual identification of remains, these were proved to be in error by the dental examination.

One must not become so enmeshed in such a statistical scorecard as to forget that the overall value of dental identification rests not only on those cases in which identification solely by teeth is effected, but also upon those in which the dental examination was utilized to assist the credibility of other methods of identification, thus playing a contributory role. Blair [7] identified by teeth alone 3 of 23 victims (13 percent) of the Kaimai, New Zealand, crash, but the dentition assisted the identification of 10 more victims; thus the dental examination was of value in over one-half of the total identifications. Similarly, Keiser-Nielsen [4] reported a Scandinavian airlines crash in Ankara, Turkey, responsible for the death of 42 passengers. Dental evidence played an important role in 28 identifications

(66 percent), although the dental method alone accounted for 10 identifications only. Twenty-one of these 28 persons were identified exclusively or primarily by the dentition; 3 children were identified by age determination based upon their dentition; in 4 victims identification by the teeth assisted other methods. In 3 of the 42 deaths, no dental remains were located; 9 victims had examinable dental remains, but no antemortem records existed. Dental identification of the 123 Windhoek, South Africa, air-crash deaths, as reported by Van Wyk et al [12] accounted for only 5 percent of the total bodies, but the dental method assisted in an additional 20 percent of the identifications. In the 1963 Elkton, Maryland, accident Fisher [6], although utilizing primarily fingerprint identification, found that 20 percent of the total identifications of 81 victims were assisted to varying degrees by dental examination.

The account by Stevens and Tarlton [8] of 218 fatalities resulting from 8 air accidents provides some insight into the relative frequencies, in their experience, of the different modes of identification. They reported that dental identification was effective in 10 percent of these fatalities. By comparison, documents (25 percent), jewelry (20 percent), clothing (16 percent), and medical records (12 percent) accounted for the majority of the identifications. The extent to which dentists or dental methods were utilized is not indicated in the article.

It is important to realize that what is considered acceptable evidence of positive identification rests with the authorities governing the investigation of the air accident and depends upon the presence or absence of certain circumstances surrounding the incident. Certainly, in any accident occurring as a result of criminal activity, such as skyjacking, terrorism, or extortion plots, it is mandatory that an attempt be made to identify all bodies conclusively by either the fingerprint or the dental method. One must keep in mind that personal effects and clothing may be unreliable, because such items may be borrowed, stolen, or switched with criminal intent.

An earlier article by Stevens and Tarlton [15] reveals the interplay of the various methods of identification as applied to air crashes. They reported on 4 aircraft accidents (the data from 3 of these were included in their later article [8]) involving 116 fatalities. Accident #1 involved extensive mutilation but minimal effects of conflagration, so that personal effects (clothing, documents, jewelry) accounted for 89 percent of the identifications. Dental identification accounted for 8 percent of the victims. The relative absence of fire, thus permitting identification by personal effects in this accident, was fortunate, as 34 of the 39 persons aboard were male children aged 12 to 14 years. Efficient dental identification in mass disasters involving large numbers of young children of approximately the same age is extremely difficult [16]. This especially pertains to a fluoride-treated population, in which decay and restorations are few. Fingerprint identification is also of no value in accidents involving children because of the lack of preexisting records. Ashley [17] reported on the identification of 14 child victims (from infants to those aged 14 years) from a single aircraft accident whose identity was established by exclusion based solely upon age estimation derived from the degree of dental development.

Air crashes #3 and #4 reported by Stevens and Tarlton [15] involved substantial post-crash fires. Dental identification was effective in 18 and 21 percent, respectively, among 15 and 26 victims. In three of their four reported accidents, they stated that the dental method was quantitatively of greater value in identification than a complete medical examination (autopsy and roentgenologic).

Just as the medical specialty of forensic pathology has shown rapid, recent growth in this country so has the allied field of forensic odontology. During the past decade, both dental and medical authorities have become more cognizant of the role of dentistry in the

sphere of legal medicine. The recently formed Canadian Society of Forensic Odontology was summoned by local authorities and played a major role in the identification of 109 victims of the Woodbridge, Canada, DC-8 crash in July, 1970 [13]. The task of identifying these dismembered victims necessitated the efforts of 12 dentists at one time or another over a 16 day period. The immense challenge facing these workers consisted of the identification of 134 separate jaw specimens and 37 denture fragments contained within 800 bags of remains retrieved from the accident site. These figures are presented to impress the reader with the fact that we are faced with the prospect of mass air disasters involving aircraft of yet greater size and capacity. Dental identification in the event of such an accident would almost demand an organized team of experts in dental identification. Perhaps some thought should be given to the establishment of government-funded squads of dental experts who would be able to assist at disaster sites such as the FBI Fingerprint Team does today in the United States.

The Woodbridge, Canada, team was able to retrieve antemortem dental records of 69 of the 109 victims. Primary identification by teeth was made in 53 (49 percent) of the 109 victims. The 53 identifications represented 60 percent of all the identifications effected in that disaster. Dental identification was made in 72 percent of the cases in which useful antemortem records were available. Age estimation based on dentition proved to be of extreme assistance in the eventual identification of infants, children, and young adults. The account of the Woodbridge disaster [13] should be studied by those interested in the field of mass-disaster identification, as it describes in detail the thorough investigation and presents the use of 35 mm slide photography of dental specimens for use in the comparison procedure.

While it is true that the purpose of this article is to survey and emphasize the role of dental identification in the air-crash setting, let me repeat that one must not lose sight of the overall relationship between forensic dentistry and the other methods of identification [1]. What the reader must not fail to realize is that, when circumstances permit, the use of fingerprint identification ranks superior in every respect to dental identification. This statement applies primarily to the United States and its citizens, because other countries do not maintain such extensive fingerprint files of their population. For this reason fingerprint identification is conspicuously absent from the foregoing accounts of foreign accident investigations. The lack of fingerprint files in other countries also attests to the even greater need for dental identification personnel in these countries. J. K. Mason, the internationally known British aviation pathologist, has stated that dental identification currently occupies a primary role in the identification of British air disaster victims [18].

In the United States, the establishment of Federal Bureau of Investigation fingerprint records on approximately 84 million citizens places fingerprint identification as the primary method of identification of human remains in this country. Because of the availability of such a fingerprint agency, it is impractical to initially apply dental identification procedures to every body recovered from an air accident. The crash situation must be surveyed, and the potential need for dental methods should be evaluated. The fingerprint method should immediately be used on suitable bodies, and the dental examiners should then concentrate on those cases in which the fingerprint method is unworkable. In the ideal situation, if time and personnel permit, dental identification can substantiate those identifications established on the basis of personal effects. This represents a rational approach to the matter and is the course commonly followed in air crashes occurring in the United States. The identification data of the 1963 Elkton, Maryland, crash handled by Fisher [6] exemplify this. Of 81 victims, 53 were identified by fingerprints and 3 were

TABLE 2—Utilization of fingerprint identification in continental U.S. air-accident fatalities.

Accident	Number of Victims	Fingerprint Identification	Other Identification
Boston, Mass. Electra [19] 1960	61	All identified by fingerprints, acquaintances, or personal effects.	
Lake Tahoe, Nev. Constellation [20] 1964	85	79	2 dental
Portland, Ore. DC-9 [21] 1966	18	5	10 dental and personal effects
Urbana, Ohio Midair [22] 1967	25	18	7 dental or autopsy or both
Blossburg, Pa. BAC-111 [23] 1967	34	26	4 dental
Elkton, Md. Boeing 707 [6] 1963	81	53	16 dental and/or other methods

identified by teeth alone; the teeth assisted in 13 other identifications. Other continental United States accidents involving U. S. nationals reveal similar data [19-23] (see Table 2).

In the United States, under circumstances where postmortem tissue is available for fingerprinting and an antemortem record exists for comparison, dental identification will never surpass the fingerprint method as the primary mode of identification. The fingerprint identification is more quickly and easily performed, and the antemortem records for comparison are centrally coded and classified. Fingerprint identification can be established in a matter of hours, if necessary. The process of dental identification does not possess these attributes. The dental postmortem examination is time-consuming; the acquisition of antemortem dental records is a lengthy, frustrating experience necessitating direct voice or mail communication or both with the attending dentists. The use of airline information sheets or transmittal of dental records via airline clerks has proved unsatisfactory [5,13]. The actual dental comparison, once both antemortem and postmortem data are in hand, is, again, a tedious and time-consuming procedure. Dental identification, however, emerges in a paramount role whenever fingerprint identification cannot be employed, as when the fingers of victims are mutilated or destroyed.

The loss of fingerprint tissue applies not only to cases of conflagration but also to instances of skeletonization of remains. The application of dental identification to skeletal remains and the relative indestructibility of the dentition and dental restorations is revealed by the recent experience of Sophor and Angel [24]. These authors had occasion to identify the remains of 17 military personnel who died in an air crash of a World War II military transport. The remains were found in the jungle highlands of New Guinea 27 years after the loss of the aircraft. Dental remains were recovered from 12 of the 17 victims, and subsequent conclusive dental identification was effected in these 12 persons by virtue of available, accurate antemortem military dental records.

### Summary

The identification of aircraft-accident fatalities is of primary importance in serving the interests of surviving family members as well as the fields of medicine and law. The effects of mutilating high-impact forces and the subsequent post-crash conflagration, two conditions frequently inherent in the air crash, position dental identification in a paramount role within the armamentarium of methods employed in the identification of unknown human remains. The interrelationship of dental identification with the other

methods of identification utilized in the air-crash setting are discussed. A review of statistical data regarding the role of dental identification in air-crash fatalities discloses that dental methods alone or in conjunction with other methods of identification accounted for 36.7 percent of 1,002 victims of 21 aircraft accidents. Use of the dentition alone achieved identification of 29.5 percent of these victims. These data reflect international experience in air-disaster identification. The point is made that organized dental disaster teams can best implement the effectiveness of dental identification in any mass-disaster setting. The comparison between the two scientific methods of identification, fingerprint and dental identification, is discussed.

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