

## ORIGINAL ARTICLE

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## Odontological identification of fire victims – potentialities and limitations

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**Abstract** A retrospective study was performed to analyse the power of odontological evidence in burn victims. The material comprised 292 single fire cases registered at 4 centers of forensic odontology in Scandinavia (DK: Aarhus, Copenhagen; N: Oslo; S: Goteborg) covering a 10-year period. Filed antemortem (am) and postmortem (pm) data were critically reviewed and registered. New systems for classification of the degree of injuries to the teeth and jaws and of the quality of dental records were developed. Matching dental am-pm units/features were recorded using the tooth as unit. Units were scored as either ordinary or extraordinary if the frequency of occurrence in a Danish reference population was  $\geq 10\%$  or  $< 10\%$ , respectively. The ID conclusion of a single case was classified into one of the categories: no conclusion, ID possible, ID probable or ID established, depending on the number of ordinary/extraordinary matching units. All age groups were represented. Most fatal burns occurred in house fires (62%) and there was a preponderance of males (71%). Detailed written records supplied by single or by systematic radiographs were available in 71% of cases. About 50% of burn victims were classified into the no-injury group and approximately 25% of cases showed injuries to the anterior teeth only. The number and complexity of dental restorations increased with age. The dental examination was a powerful tool in identification of burn vic-

tims. Thus, dental identity (ID) was established in 61% of burn victims and dental evidence assisted the identification in another 31% (ID possible 19%; ID probable 12%). The improvement in dental health status seems to interfere with the discriminating potential of dental restoration as reflected in a lower fraction of established dental ID among fire victims younger than 20 years old. General use of denture marking would improve the proportion of established dental ID. Oral radiographs play an important role in personal identification and systematic exposures are therefore valuable tools.

**Key words** Identification · Forensic dentistry · Forensic odontology · Fire victims · Oral radiology

**Zusammenfassung** In einer retrospektiven Studie von 292 odontologisch untersuchten Brandleichen aus vier rechtsodontologischen Zentren in Skandinavien aus den Jahren 1981–1991 wurde die Bedeutung der odontologischen Identifizierung ausgewertet. Alle Altersstufen waren einbezogen. Ante- (am) und postmortem (pm) Daten wurden kritisch untersucht und neue Systeme für eine Klassifikation der Verbrennung und der Qualität der Behandlungskarteien, Röntgenaufnahmen eingeschlossen, wurden benutzt. Übereinstimmende am. und pm. Informationen wurden registriert und diejenigen, die eine Frequenz  $< 10\%$  in der dänischen Referenzpopulation hatten, wurden als ungewöhnlich angesehen. Folgende Rückschlüsse, abhängig von gewöhnlichen und ungewöhnlichen übereinstimmenden Informationen wurden gezogen: keine Aussage oder odontologische Identität möglich, wahrscheinlich, sicher. Die meisten Brandleichen stammten von Hausbränden (71%). 50% wiesen keine Brandschäden an den Zähnen auf und weitere 25% nur Schäden an den Frontzähnen. Behandlungskarteien mit einer oder mehreren Röntgenaufnahmen wurden in 71% der Fälle registriert. Odontologische Identität wurde in 61% der Fälle festgestellt und der odontologische Vergleich war in anderen 31% hilfreich bei der Identifikation (odontologische Identität wahrscheinlich in 19% und möglich in 12%). Bei Brandleichen  $< 20$  Jahren war eine odontologische Identifizierung ein wichtiger Faktor bei der Identifizierung.

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titätsbestimmung nicht so häufig möglich, da weniger Restaurationen vorhanden waren. Das Vorhandensein von Röntgenaufnahmen war wichtig für viele Identifikationen. Ein Röntgenstatus und systematische Bildeinstellung am Patienten (wie Bite-wing) werden empfohlen. Kennzeichnung von Prothesen könnte zu einem höheren Prozentsatz odontologischer Identifizierungen von Brandleichen führen und wird ebenfalls empfohlen.

**Schlüsselwörter** Identifikation · Forensische Odontologie · Brandleichen · Orale Röntgenologie

## Introduction

Identification by dental means has been reported to be among the most reliable methods in personal identification [1, 2]. Changes brought about by age, pathological conditions, developmental disturbances or by intervention of the dental surgeon result in the mouth being unique to the individual. Most often the dental identification is based on a detailed consideration of the restorative work replacing areas damaged by dental caries. A full description of the individual dental restoration, including the type of material used and surfaces restored, serves as a baseline for the comparison of dental status antemortem (am) and postmortem (pm). Moreover a comparison between am and pm radiographs may often lead to identification or convincing proof of exclusion of an individual.

Identification of fire victims by means of visual recognition and fingerprints is often impossible due to serious damage to and/or disintegration of the deceased bodies. The jaws and teeth are frequently relatively well preserved as the latter is protected by the tongue, lips and cheeks [3, 4]. The importance of dental evidence in the identification of burn victims has been emphasized in a number of case reports and in papers dealing with mass disasters [5–16]. The latter papers mainly focus on planning and organization of the identification work rather than discussing factors important for the decision-making process in the dental identification work. No systematic study of fire victims is available, where odontological identification was attempted.

The aim of this study was to re-analyse case files of fire victims from 4 Scandinavian centers of forensic odontology covering a 10-year period. Cases were classified using new classification systems reflecting the degree of injury to teeth and jaws, the quality of dental records, and the power of the odontological evidence.

## Material and methods

The material comprised 292 fire victims registered at 4 forensic odontological case files in Scandinavia from 1982 to 1991 (Denmark: Aarhus and Copenhagen, n=128; Norway: Oslo n=130; Sweden: Goteborg, n=34). Fire cases of 1–4 burn victims were included in the study. The proportion of burn victims, where dental assistance was requested was estimated to be about 25% of fire deaths based on Danish figures (range: 10–48% of cases per year).

Filed am and pm data were critically reviewed by the home dental consultant among the present authors. Each consultant was asked to register on a similar form for recording.

### General data

Recording of file number including year and date of original examination, country and forensic center.

### Postmortem data

Registration of the material with regard to siting of the accident (car, home, boat, flight, vacation cabin etc); fire injuries to teeth and jaws were classified into one of the following 6 categories:

grade 0: no injury

grade 1: injury to anterior teeth (in one or both jaws)

grade 2: injury to anterior and posterior teeth, unilaterally (in one or both jaws)

grade 3: injury to anterior and posterior teeth bilaterally (in one or both jaws)

grade 4: fragments of jaw bone including teeth and/or roots

grade 5: no dental remains

A detailed pm-registration of the dentition was performed from files using the categories: intact/sound, filled (restoration material, surfaces, root fillings) and missing teeth. Furthermore, fixed (crowns and bridges) and removable prosthetics were recorded. Presence of developmental disturbances of tooth eruption and of the morphologic occlusion were noted i.e. hypo- and hyperodontia, ectopic/transpositioned/retained teeth, and various types of malocclusions i.e. mesial molar occlusion, frontal open and deep bite >5 mm, crossbite, scissorsbite, midline displacement, crowding and spacing. Finally, history and presence of sequelae of pathological changes i.e. jaw fractures, tumors, major infection of the jaws including sinusitis were recorded.

### Antemortem data

These data comprised gender and age, and a detailed am-registration of the previously recorded information following the guidelines described for the pm-registration. The quality of filed dental records was finally classified into one of the following 6 categories:

grade 0: no information

grade 1: information without written records

grade 2: written records only

grade 3: records combined with unsystematic, periapical radiographs

grade 4: records combined with bitewings

grade 5: records combined with a full mouth survey, an orthopantomogram or similar

### Dental comparison

Matching dental am and pm units/features were recorded using the tooth as unit. The relative importance of concordant features, i.e. matching units, was scored as ordinary if its estimated frequency of occurrence was  $\geq 10\%$ , and as extraordinary if it was  $< 10\%$  using epidemiologic studies of a Danish subpopulation as the reference [17–18]. A final classification of identity (ID)-conclusion of the single case was performed using the following number of either ordinary or extraordinary units:

	Minimum number of matching am-pm units	
	Ordinary	Extraordinary
No conclusion	0	0
ID possible	1	1
ID probable	8	2
ID established	12	4

## Results

### Age, gender and type of accident

The material comprised fire victims representing all age groups. The largest number of cases was observed in the 3rd, 4th and 5th decades (Table 1). Most fire victims were males (71%). The fatal burns occurred in house fires (62%) rather than in vehicles or aircrafts. A major fraction of victims in the 3rd decade, largely males, died in car accidents.

### Antemortem dental records

The quality of am dental information was excellent to good in two-thirds of the cases. Thus professional records with written dental charts and systematic radiographs covering the posterior teeth (bitewing radiographs) or the whole dentition was available in 45% of cases (Table 2). Records with single periapical radiographs were on hand in another 26% of cases. Formal dental records were absent in 13%.

### Postmortem dental material

Substantial dental remains were present in the majority of the bodies examined (Table 3). About one half of the burn

victims were classified into the no-injury category and approximately one-quarter of cases showed injuries to anterior teeth only. Even among the bodies recovered from burnt-out cars, dental evidence of these 2 categories accounted for approximately 60%. More severe damage to the dentition accounted for the remaining 25% of fire cases.

Sound dentitions or dentitions with a few simple fillings in posterior teeth were common features among victims below the age of twenty. From 20 to 40 years of age restorations of posterior as well as anterior teeth were common. Advanced dental restorations (crowns, root canal fillings, etc) were regularly seen above 40 years of age. Bridgework and unusual conditions related to the dentition and its function are extraordinary features of all age groups. The denture wearers, that accounted for 12% of the burn victims, were 35 years of age or more. Only one victim had an indication of identity on the denture.

### Dental comparison

In total, dental ID was established in approximately 60% of cases. Dental evidence assisted in identification in another one-third of burn victims (ID possible: 19%; ID probable: 12%). Established dental identity amounted to 85% among fire victims with no injury or injury to anterior teeth only (Table 3). Radiographic comparison upgraded the ID conclusion in 37 cases (13%). A relatively low fraction (< 50%) of fire cases with established dental ID was found for younger victims (< 20 years) and in the elderly (> 64 years; Table 4).

Dental evidence was a non-contributing factor in the personal identification in 26 burn victims (9%) where no dental records were available in 21 cases, including 14 dentate victims with restorations present and 7 edentulous

**Table 1** Classification of the case material with regard to age, gender and siting of the accident

Age	F	M	Car	Home	Boat	Flight	Mic.	N	%	%§
< 20	12	25	9	23	0	2	3	37	12.7	8.4*
20–29	17	46	25	31	1	4	2	63	21.6	19.1
30–39	19	47	13	41	0	4	8	66	22.6	20.5
40–49	15	38	8	31	2	3	9	53	18.2	14.9
50–64	9	30	7	28	0	1	3	39	13.0	20.8
64+	14	19	5	26	0	0	2	33	11.3	16.4
Unknown	0	1	0	0	1	0	0	1		
Total	86	206	67	180	4	14	27	292		

§ Age distribution of the Danish population of January 1st. 1982; equal sex distribution in all age groups but 64+: F = 9.3% vs M=7.1%; \* age group: 16–19 years old

**Table 2** Quality of antemortem material and type of ID-conclusion

	No concl.	Possible	Probable	Established	N	(%)
No information	22	4	1	0	27	(9)
Information without records	0	10	0	1	11	(4)
Written records only	1	22	12	15	50	(17)
Records + unsystematic radiographs	2	10	7	55	75*	(26)
Records + bitewings	1	6	8	80	95	(33)
Records + full mouth survey	0	3	6	25	34	(12)
Total	26	55	34	176	292	(100)

\* 1 case: conclusion = eliminated

**Table 3** Postmortem damage and type of ID-conclusion of the report

Damage	No concl.	Possible	Probable	Established	N
No injury	9	18	11	106	144
Injury to ant. teeth	6	12	11	45	74
Injury to ant. + post. teeth, unilat.	2	5	4	17	28 + 1*
Injury to ant. + post. teeth, bilat.	3	5	4	5	17
Roots and/or tooth fragments	3	14	4	3	24
No dental remains	3	1	0	0	4
Total	26 (9)	55 (19)	34 (12)	176 (61)	292 (100%)

Percentage in brackets

\* 1 case: conclusion = eliminated

**Table 4** Classification of material with regard to age and type of ID-conclusion

Age	No concl.	Possible	Probable	Established	Probable + established	N
< 20	2	12	9	14 (38)	23 (62)	37
20–29	2	7	8	46 (73)	54 (86)	63
30–39	6	11	7	42 (64)	49 (74)	66
40–49	3	7	5	38 (72)	43 (81)	53
50–64	5	6	4	23 (59)	27 (69)	38 + 1*
64+	7	12	1	13 (39)	14 (42)	33
Unknown	1	0	0	0	0	1
Total	26	55	34	176	210	292

Percentage in brackets

\* 1 case: conclusion = eliminated

victims wearing dentures. Among the remaining 5 victims without records it would have been possible to provide corroborative evidence of identification in 3 cases only due to lack of dental remains in 2 victims. Sparse dental remains, few restorations, or incomplete records accounted for the inconclusive identification among the 5 victims with am information.

## Discussion

The distribution of fire fatalities in the present study is in fairly good agreement with previously published reports which state that approximately 70% of all fires in Scandinavian countries are house fires and most fatalities are single cases and mostly males [19–20]. All age groups were represented and the age distribution mirrored the contemporary frequency of age distribution in a Danish reference population. Peaks in fire deaths among children below 4 years and in the elderly above 60 years as previously reported [20] were not apparent in the present survey population.

The material originating from 4 centers of forensic odontology in Scandinavia had major aspects in common, that is the distribution as regards to age, gender and site of the accident, and the pattern of injuries. The only background factor that differed among countries was the type of am radiographic exposures. Thus bitewings were less readily available among the Danish than Norwegian and Swedish fire victims. In this context it has recently been reported that Danish practitioners are less apt than their foreign colleagues to perform routine bitewing radiography [21].

The present success rate of identification by dental means was substantial. The criteria for requesting dental

assistance in identification of burn victims may have varied between and within forensic centers during the 10-year period, but the majority of cases showed extensive burning of the bodies. The extent of fire injury to the dentition varied from essentially intact dentitions to those with severe destruction. Previous information on post-mortem remains in forensic odontological studies have mainly been restricted to reporting on the fraction of severely injured bodies/dentitions [5, 12, 14]. We therefore introduced a classification based on the degree of dental fire injuries and using this systematic approach it appeared that approximately 75% of burn victims were categorized as having no oral injury or damage to the anterior teeth only. The latter situation occurred in concert with the lips of victims being parted. Our study thus confirms that the lateral tooth segments are relatively well protected in otherwise severely burned victims.

The quality of antemortem dental information was good to excellent. Dental records of high standard, that is detailed written records supplied with systematic radiographs, were available in 45% of all burn victims, a high figure in accordance with previous reports dealing with Scandinavian citizens [12, 14]. Bitewing radiographs were preferred to full mouth surveys in both general practice and in community dental services [21–22]. In line with this, bitewing radiographs were available in a considerable number of the present burn victims. The importance of dental radiography in identification work has previously been emphasized [12, 14]. From the present detailed review of fire victims it became apparent that radiographic comparison could have been used more frequently. The improvement in dental health status seems to interfere with the discriminating potential of dental restorations as reflected in a lower fraction of established dental identity among the present fire victims below 20

years of age. A similar trend was reported by Solheim and co-workers [12]. It can be foreseen that dental radiography may be essential in future identification work on dentitions with fewer restorations.

Dental identification is more difficult if teeth are missing, a situation found in age groups above 40 years old [17]. Full dentures often add little to the identification of the wearer unless marked. One denture in 34 denture wearers could be traced to a particular owner due to marking. Provided denture marking was in general use, as fixed by recommendations from the National Board of Health and Welfare in Sweden since 1986 [23], a further 25 cases of fire victims (9%) would have been identified.

Verification of identities of fire victims established by dental means has previously been reported to be in the range 34–89% [6, 12, 14–16]. The decision-making process behind these figures has not been described, although it may be as important as the presentation of data. The concept used in the present analysis included weighting of dentally significant factors as related to contemporary data of dental status in a Danish subpopulation [17–18]. A rare siting of some restorations may thus carry more weight than the more common ones and, as described in the results, the number and complexity of restorative work of a dentition is dependant on the age of the individual. An exact calculation of the probability of identification has been performed in a few cases from the Danish material, namely where singular units with estimated frequencies of occurrence in the lower part of the ordinary interval were found ( $\geq 10\%$  but  $< 50\%$ ). Such calculations may be extended in future studies in order to add more power to the dental identification [24].

The number of concordant characteristics that satisfy established dental identity has been and is still a subject for discussion [24–29]. Twelve concordant characteristics are required for fingerprint identification in most countries and are proposed by Keiser-Nielsen to be the threshold in dental ID work [24]. The ID scorings among Norwegian/Swedish victims are skewed to the right (possible  $\rightarrow$  probable  $\rightarrow$  established) as compared to the Danish victims. Below 40 years old the proportions of established identities are 12–32% lower among the Danish burn victims. This difference may in part be explained by the fact that bitewing radiographs were less frequently available among the Danish victims of these age groups (37% vs 48%) and as a whole (27% vs 37%).

When dealing with fire victims much weight is put on the dental evidence and a strict criterion for identification (“established”) would therefore be needed. Verification of identities of “known” victims might justify a change in the decision process to more relaxed criteria, that is accepting both “possible” and “established” as positive identity. Using such an approach on the present fire victims, the fraction of established dental identifications would increase from 61 to 73%.

In a minority of cases am dental records were not available to compare with the pm data. Dental identification or corroboration might have been obtained in some of these victims if efforts had been made to provide records.

However, major identity criteria could have been satisfied during the initial ID procedure. The proportion of inconclusive dental identification of victims (9%) resulting from the present investigation is comparable to those previously reported, ranging from 8 to 26% [6, 10, 12, 14].

The main conclusion of this systematic study is that dental examination is a powerful tool in the identification of burn victims. Appropriate indication of the patients identity on original records, radiographs etc. is a prerequisite for valid results in the identification procedure and performance of other examinations. Radiographs play an important role in personal identification due to their accurate recording of dental details and anatomical landmarks. From a forensic-odontological point of view, systematic radiographic examinations at regular intervals between repeated performance would therefore be desirable. Such “routine”/“screening” procedures may, however, not fulfil recent radiographic guidelines which state that every radiation exposure should be ordered on the basis of a clinical examination and/or a dental history of the patient [30–31]. Taking into account both aspects we would recommend performance of posterior bitewing radiographs at intervals of 1–3 years depending on the age of the individuals and their status of risk group as regards dental caries (low- or high-risk). Even though the improvement of dental health in all age groups is continuing, national surveys performed in Scandinavia in the 1980s indicate that edentulousness is still common in the elderly populations (DK: 60%, N: 31% and S: 20%) [32–33]. It is therefore advisable to recommend to the patient an appropriate marking method for the dentures. This would help the owner of a lost denture, a situation occurring at regular intervals among elderly in institutional care, and would moreover save much work for the forensic team.

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