

The “Scandinavian Star” ferry disaster 1990 – a challenge to forensic odontology

Tore Solheim¹, Magne Lorentsen², Per Kristian Sundnes³, Gisle Bang⁴, and Lasse Bremnes⁵

¹Section of Forensic Odontology, Department of Oral Pathology, University of Oslo, N-0316 Oslo, Norway

²Military Hospital, Bardufoss Airport, Bardufoss, Norway

³The Norwegian Dental Association, Oslo, Norway

⁴Department of Oral Pathology and Forensic Odontology, University of Bergen, Bergen, Norway

⁵Nordregt. 12, Trondheim, Norway

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Summary. With 158 victims, the fire on board the “Scandinavian Star” was one of the world’s worst ferry disasters. A team of identification experts, including dentists, were employed to secure evidence for identification and to remove the victims from the ferry. Four parallel teams, each with 2 dentists, examined and autopsied the victims at the Institute of Forensic Medicine, University of Oslo. Using the INTERPOL Disaster Victim Identification forms and aided by computers, all victims were identified within 17 days. Dental identity could be established in 107 cases (68%).

Key words: Mass disaster – Disaster planning – Identification – Forensic dentistry

Zusammenfassung. Mit 158 Opfern war das Feuer an Bord der “Scandinavian Star” eines der schlimmsten Fährerunglücke in der Welt. Ein Team von Identifizierungsexperten inklusive zweier Zahnärzte arbeitete auf dem Schiff, um die Leichen zu bergen. Vier Teams, jedes mit zwei Zahnärzten besetzt, untersuchten und obduzierten die Leichen am Rechtsmedizinischen Institut, Universität Oslo. Mit Hilfe des Interpol-Massenunglücks-Schemas und unterstützt von Computern hat die Norwegische Identifizierungskommission die Identität von allen Opfern innerhalb von 17 Tagen festgestellt. Die zahnärztliche Identität konnte in 107 Fällen festgestellt werden (68%).

Schlüsselwörter: Massenkatastrophe – Einsatzplanung – Identifikation – Forensische Odontologie

Introduction

On Saturday, April 7, 1990 at 02.05 a.m. an arsonist started a fire on board the ferry “Scandinavian Star”

Offprint requests to: T. Solheim

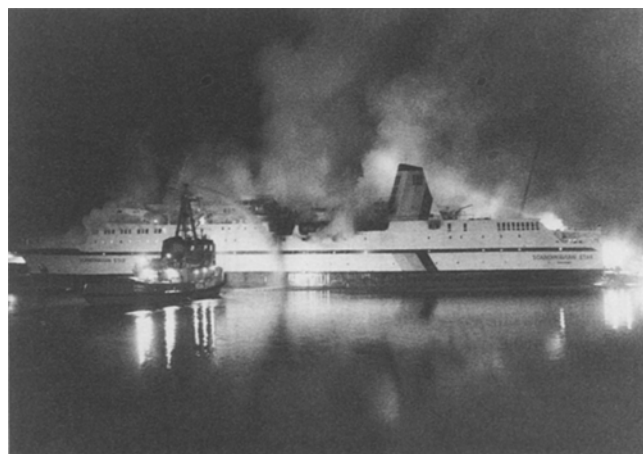


Fig. 1. “Scandinavian Star” on fire April 7, 1990

which was on her way from Oslo, Norway, to Fredrikshavn, Denmark. The fire spread extremely rapidly (Fig. 1), and of 494 passengers and crew, 158 lost their lives. The ferry was towed to the port of Lysekil on the western coast of Sweden but the fire was not brought under control until the next afternoon, 36 h later. The victims were recovered, brought ashore and transported to Oslo in refrigerated vans for forensic examination and identification. As most of the victims were Norwegian citizens, the Norwegian Identification Commission (ID-Commission) became responsible for the identification. Assistance was received from the Danish Identification Commission because as many as 27 Danish citizens were listed as missing (Table 1).

The Norwegian ID-Commission

Following a fire in Oslo in 1938 with 29 victims, an *ad hoc* ID-commission including 2 dentists was appointed [1] and this practice was followed for later accidents.

Table 1. Nationality, sex and age of missing persons

Nationality	Female (years)				Male (years)				Sum
	<10	10–20	21–50	>50	<10	10–20	21–50	>50	
Norwegian	7	8	39	19	3	4	28	13	121
Danish	1	4	8			1	10	3	27
Swedish							3		3
British						2	1		3
Spanish		1					1		2
American			1						1
Portuguese							1	1	
Sum	8	13	48	19	3	7	44	16	158

However, in 1975 the Ministry of Justice appointed a permanent ID-Commission consisting of 6 policemen, 5 forensic pathologists and 5 forensic odontologists [2]. The ID-Commission is under the direction of the National Bureau of Crime Investigation in Oslo and members are located in the main regions of the country.

The Norwegian ID-Commission is responsible for identification after disasters both within Norway and abroad when Norwegian citizens have perished. The Commission has gained experience after several disasters during the last 10 years [3–5] and members are also responsible for identification in problem cases involving only one death. Thus, the Commission operates on a regular basis unlike in many other countries. Working instructions have been drafted and necessary equipment is packed for immediate use. Each specialist group has equal authority in the final identification of a victim, and the ID-declaration must be signed by a member from each group.

Organization of the ID-team following the "Scandinavian Star" fire

Approximately 6 h after the fire started, members of the ID-Commission in Oslo were summoned to the National Bureau of Crime Investigation to prepare for a large scale identification operation, and an organization plan was drafted (Fig. 2). A complete ID-team consisting of several policemen, 2 forensic pathologists and 2 forensic odontologists was required on board the ferry.

At the Institute of Forensic Medicine, University of Oslo, 4 autopsy teams were formed requiring 8 forensic odontologists, 2 in each team. The collection of dental records, transcription of the information to the ante-mortem yellow INTERPOL disaster victim identification (DVI) form and computer registrations required at least another 4 personnel. It was thus necessary to engage a minimum of 14 dentists for an unspecified period of time. As the recovery and autopsies were finished, the team at the National Bureau of Crime Investigation could be reinforced for comparison and identification work. In addition to the 5 appointed forensic odontologists of the ID-Commission, 8 members of the Norwegian Society for Forensic Odontology were recruited from the Oslo area.

Two forensic odontologists from the Danish ID-commission arrived to assist the Norwegian Commission the

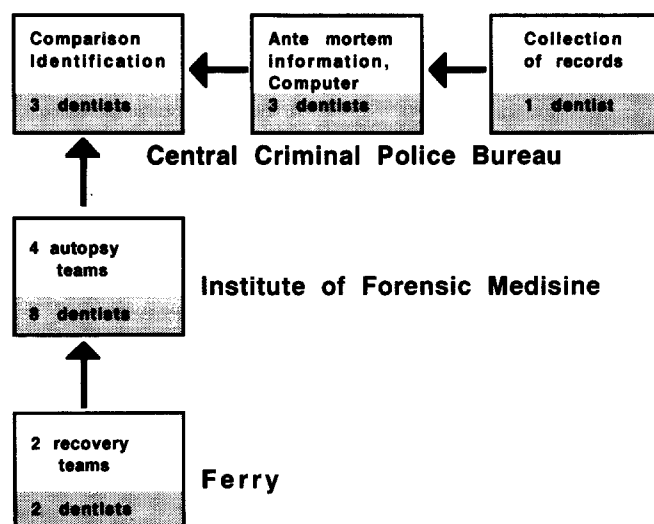


Fig. 2. Organization plan for the identification team after the "Scandinavian Star" disaster. The plan was basically followed although personnel were, according to requirement and their own desires, moved from one section to another during the operation. Also a number of persons were dismissed as their part of the work was finished

next day. One was allocated to the examination of bodies, the other assisted at the ante-mortem information center. In addition, 2 odontologists worked in Denmark to collect dental records of missing Danish citizens.

The recovery work on board the ferry

Because of dangerous flare-ups, the fire brigade did not allow the ID-team at the disaster site to enter the ferry until Sunday afternoon, 36 h after the fire started. They were met by horrifying scenes (Fig. 3). In corridors and cabins victims were piled upon each other, suffocated by poisonous smoke, and initially the identification personnel had to use gas masks. Approximately 90 relatively undamaged victims were recovered in the initial phase. The remaining victims had varying degrees of burns and some were almost completely incinerated. Melted metal indicated temperatures of more than 1000°C, and some of the corpses had to be excavated from charred constructions in the cabins and corridors. Medical and dental knowledge proved essential for the recovery and preservation of the evidence.



Fig. 3. Horrifying scene in a corridor on board the ferry

Table 2. Source of dental information ($n = 158$)

Type of record	No.	%
Original record	112	71
Copy of record	23	15
Per telefax	1	1
Total number of records	136	87
Information from relatives	6	3
Information about age only	16	10
Sum	158	100

The forensic odontologists were responsible for packing and securing the heads and dental remains. To minimize damage during transportation to the mortuary, gas cushions and plastic bags were tied around the heads. In case of incineration, a preliminary description of the teeth was made and dental radiographs taken with portable X-ray equipment.

Within 5 days all 158 victims were registered and sent to Oslo for further examination and autopsy.

The ante-mortem dental material

Since the passenger list was lost in the fire, the police had to reconstruct it from inquiries and reports from the public. However, several persons first reported missing were later discovered never to have been on board; a fact which complicated and delayed the collection of dental records.

One forensic dentist with the full time assistance of 3 police officers managed to obtain 136 records (Table 2). As the Easter vacation had already started, some of the dental practitioners were difficult to locate. Valuable help was provided by the Norwegian Dental Association's complete list of home and surgery addresses of Norwegian dentists. A special form for recording the progress in obtaining the record(s) for each missing person was constructed and found to be very useful. Danish records were collected by a home commission in Denmark, transferred to Norway, and transcribed onto the

Table 3. Radiographs in the dental records ($n = 136$)

Type of radiographic exposure	No.	%
Full mouth	11	8
Panoramic roentgenogram	8	6
Bite-wing + others	64	47
Bite-wing only	34	25
Special periapical	7	5
Total	124	91
Without radiographs	12	9
Sum	136	100

yellow INTERPOL DVI-form by members of the Danish Commission. One British and one U.S. record without such transcription created interpretation difficulties.

As collecting dental records was time-consuming, only 1 or 2 dentists were needed to transcribe the information onto the INTERPOL DVI-forms. Each record was transcribed by one dentist only, and this gave room for error. Several of the records did not comply with the legal requirements for dental record-keeping in Norway. However, only 8 records (6%) were characterized as practically illegible.

Radiographs were included in 124 of the 136 records (Table 3). Only 19 of these were full mouth surveys with either periapical exposures or panoramic roentgenograms.

Post-mortem dental examinations

The dental examination of each victim was made together with the autopsy and included photography of the front teeth (Fig. 4), registration on the post-mortem pink INTERPOL DVI-form and radiography. One forensic odontologist examined the teeth while another filled in the form and observed and controlled the registration. Even so errors were inevitable, and tooth-colored fillings were sometimes overlooked.

The teeth of all the victims were examined regardless of whether the deceased were undamaged or not, or

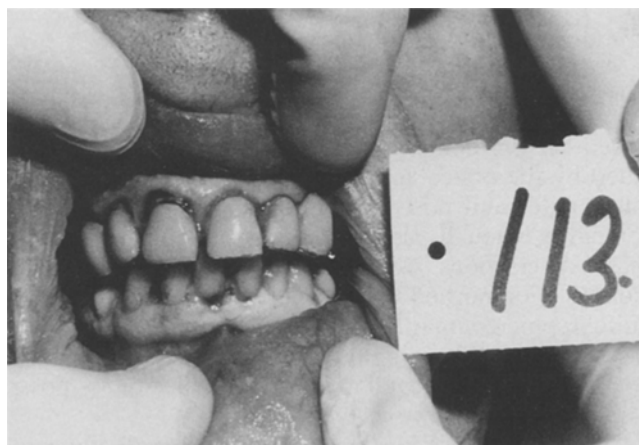


Fig. 4. Photo of front teeth for documentation

Table 4. Results from the odontological comparisons ($n = 158$)

Conclusion	Female (years)				Male (years)				Sum	%
	<10	10–20	21–50	>50	<10	10–20	21–50	>50		
Dental identity										
Established	1	5	39	13	0	4	34	11	107	68
Probable	1	4	3	1	1	2	2	2	16	10
Possible	4	3	2	5	2	1	5	1	23	14
No conclusion	2	1	4	0	0	0	3	2	12	8
Total	8	13	48	19	3	7	44	16	158	100

whether belongings indicated their identity. This turned out to be a wise precaution and prevented at least 2 erroneous identifications. The jaws were removed for further examination from about 60 of the most damaged bodies.

Twenty of the most incinerated bodies were examined by a forensic odontologist before autopsy to avoid further damage to the dental remains. In these cases reconstruction of the teeth and jaws was often necessary. Special radiographs had to be taken, preferably in the same projection as the ante-mortem exposures.

The autopsies were performed over a period of 5 days and, in order to prevent errors due to fatigue, only between 8.00 a.m. and 6.00 p.m. Each team managed to examine an average of 10 bodies per day.

Computer registrations

Both ante- and post-mortem registrations were entered into a microcomputer using the new ID-program, IDEN-TOPOL, of the Norwegian Identification Commission. The program, based on the data base program VISTA, enables both speedy computer-made comparisons and detailed visual comparison of the data to be made. Both medical and technical data can be included as they appear on the INTERPOL form.

During the comparison phase the computer provided some possible identifications. However, the police also quickly came up with a number of suggestions for identity based on papers, personal belongings, and place of recovery. In the most difficult cases where radiographic comparisons were necessary, no benefit was gained from the computer.

Comparison of dental information and conclusions

Based on preliminary indications of the identity provided by the police and computer comparisons, the detailed ante- and post-mortem dental descriptions were compared manually. For the comparatively intact bodies these descriptions were sufficient to establish dental identity. For burned and incinerated bodies a detailed radiographic comparison was often necessary. In some cases, only conclusions in terms of "probability" could be made, such as „dental identity probable" or "– possible" as the weakest conclusion.

The entire identification process was gradually completed in this way. Preliminary indications of identity

usually proved correct. However, passengers had sometimes run into other cabins trying to escape from the fire, and children were sometimes found together with adults other than their parents. Without careful description and comparison of dental data, incorrect identifications could easily have resulted.

The large number of children among the victims caused special problems as they had only a few restorations or none at all. When ante-mortem radiographs were available, identity could often be established based on the dental evidence alone. However, there is a tendency for the public Dental Health Service to avoid radiographs of children with little or no caries experience. In such cases no better conclusion than "dental identity possible" could be given (Table 4).

A special dental comparison form (Fig. 5) stating which missing person had been compared with which body, and the conclusion was written and signed by 2 dentists in cases where the presumed identity of a victim could be confirmed. In addition a description of the concordant details used in the conclusion was given in such terms as to be understandable for the police. Furthermore, if nonconcordant features were present, an explanation was provided.

To ensure strict control and accountability, the reports were signed by 2 forensic odontologists. Reports concerning Danish citizens were countersigned by a Danish forensic odontologist to ensure acceptance by Danish authorities.

The results of the comparisons were transferred to the ID-Commission for evaluation together with other evidence of identity. The conclusions of the dental comparisons are shown in Table 4.

A total of 18 forensic odontologists, including 4 Danish and one Icelandic observer, worked for a total of 960 h, an average of approximately 6 h per victim.

The final meetings of the ID-commission

In 5 meetings, the first one 6 days and the last one 17 days after the disaster, the Norwegian Identification Commission identified all 158 victims. In each case the evidence of identity was presented and discussed, and a decision was made whether further evidence was needed. Because of the large number of victims and variation in the degree of destruction, the identifications were made in groups.

ODONTOLOGICAL COMPARISONS**BODY WITH UNKNOWN IDENTITY**

Found: Scandinavian Star	No: 64
Police district: Lysekil, Sweden	Date: April 8, 1990

IS ODONTOLOGICALLY COMPARED WITH

MISSING PERSON

Name: Nils Nilsen	Birth no: 110147.47574
Address: Tennisveien 8 0187 OSLO 1	Missed: April 7, 1990

ACCORDING TO OURMY OPINION THE FOLLOWING CONCLUSION CAN BE DRAWN:

CONCLUSION

DENTAL IDENTITY ESTABLISHED

BASED ON

- THE FOLLOWING COMPATIBLE DETAILS
 - 14 amalgam fillings
 - 9 tooth colored fillings
- Filling recorded on 12 L in the missing person may have been overlooked during the examination of the body.

SIGNATURE

Institution/expert: ODONTOLOGISK INSTITUTT FOR PATOLOGI Boks 1022, Universitetet, Blindern 0416 OSLO 3 Tore Solheim	Place and date: Oslo, April 14, 1990 Signature: <i>Tore Solheim</i>
Countersigned by: Magne Lorentsen	Signature: <i>Magne Lorentsen</i>

Fig. 5. The odontological comparison-report including the basis for the conclusion and signed by two dentists

After each meeting the chairman of the ID-Commission personally changed the recovery number on the coffins in the storage hangar to the name of the deceased person, after which the bodies could be released to the families for burial.

Discussion

Planning is crucial for successful victim identification in mass disasters and it has been recommended that special identification teams should be responsible for the work [4, 6, 7]. ID-Commissions in many countries may consist of only police officers with forensic odontologists and pathologists being called upon when deemed necessary. Sometimes they are not specially trained and have little influence on the final identification. In other countries a decision on identity is left to the coroner or the medical examiner [8]. In Britain identification may be left to private funeral companies with their own specialists [9]. In our opinion, the Scandinavian model with equal responsibility given to the different professional sections is the best guarantee for a correct identification. Identification of victims following a disaster must be the responsibility of an official authority. It is also highly recommended

that dentists and pathologists specializing in identification work are formal members of an identification commission. In Scandinavia the police have the ultimate responsibility for the identification of corpses.

The present disaster had many features in common with the "Noronic" ship fire in Toronto in 1949 where 115 of the 118 victims were identified over a period of 4 months [10]. The proportion of severely damaged bodies, 20 out of 158 in the present disaster, was lower than in the "Noronic" disaster with 45 out of 118. Both being ferry disasters, common traits also existed between the "Scandinavian Star" and the Zeebrugge disaster in 1987, in which 189 persons perished [11]. In addition, both disasters had international aspects and computers were used to facilitate identifications [12].

After the "Noronic" disaster no dentists were attached to the recovery teams on the ship [10]. Yet careless handling of the bodies may result in irreparable damage and thus reduce the possibility of identification. As has already been pointed out, the "Scandinavian Star" disaster demonstrated that the identification work must start at the scene of the accident [5, 7]. Without forensic pathologists and odontologists assisting during the recovery, all victims might not have been identified.

Special training of forensic odontologists will improve their assistance at the scene of an accident since this work is more unfamiliar than dental recording in a morgue. Special equipment should be available for work at the scene, and the use of radiography should always be considered in the case of charred bodies. In such situations even the most careful handling and transportation may cause the jaws to crumble. The forensic odontologist may also complete the first page of the pink DVI post-mortem dental form at the scene of the disaster. To avoid mistakes, the Norwegian Identification Commission wants to be in charge of all handling of the bodies from the first location at the disaster site until the label with the name of the victim is attached to the coffin.

After mass disasters the police usually collect information about a missing person, including the name and address of the dentist, on the ante-mortem DVI-form. However, this form is often forwarded to the ID-Commission without the person's dental record having been collected. It is recommended that forensic odontologists, with assistance from the police, immediately take charge of the collection of dental records. The police have a nationwide organization and can personally obtain the material from the dentists. In some cases it is advantageous that the forensic odontologist contacts the practitioner directly regarding the desired material. According to the Norwegian Dental Act the original dental record, including radiographs, photos and models of the teeth, should be handed over to the police. Furthermore the practitioner's explanation of special abbreviations and any additional information may be of great importance.

Disappointingly, only 14% of the records contained a full radiographic survey of the mouth. To comply with requirements, dental records in Norway must contain relevant information about previous diseases and treatment [13]. Regarding caries and fillings the only alternative to a full mouth radiographic survey is to register all

fillings on an odontogram. Complete dental health control also demands full mouth X-rays. Dentists, however, seem to prefer bite-wing exposures only, and this was the case in 72% of the records in the present material. Such radiographs may be useful for identification, but in the 20 most incinerated cases where often only the roots remained in their sockets, they were far inferior to periapical exposures. As previously experienced only a few of the ante-mortem descriptions from relatives contained information about the front teeth. Such details would have supplemented the bite-wing exposures [3].

The transcription of ante-mortem dental information to the yellow DVI-form was done by one dentist alone. If 2 dentists had done this independently and checked for discrepancies, the number of errors might have been reduced [14]. However, this procedure is time-consuming, and as the records were available for later rechecking, transcription by one person only can be accepted. After the Zeebrugge disaster the dental identifications were severely hampered by wrong entries in the records [11] as was also experienced by us. Double transcriptions cannot correct erroneous recording by the practitioner.

Two dentists working together during the post-mortem registration was found to be advantageous, and this was also recommended after the "Noronic" disaster [10]. For each body the time spent on dental examination and the autopsy was approximately the same. Each dental team should therefore serve only one autopsy team. Consequently, a number of dentists may be required after a mass disaster. After the Abu Dhabi disaster it was found to be more efficient when dentists worked independently of the autopsy team as dental examination required less time [9]. In this particular accident, however, the victims had almost no fillings making the dental registration less time-consuming and no radiographs could be taken due to lack of equipment.

INTERPOL DVI-forms are authorized by the Norwegian Ministry of Justice and have been used by forensic odontologists for several years both in isolated cases and in mass disasters. We have found the forms very useful in describing dental data. They are designed by a number of experts from different countries and are recommended by INTERPOL for international use. Unfortunately in the present disaster both the American and the British records arrived as uncertified copies. Transcriptions to the INTERPOL DVI-form made by forensic odontologists from the respective countries would have been far more useful. This has also been a matter of concern in previous cases and suggestions have been a matter of concern in previous cases and suggestions have been presented for the transfer of dental information from one country to another [4]. The INTERPOL forms were successfully used in the cooperation between Belgian and British forensic odontologists after the Zeebrugge disaster [11] and also in the cooperation between Denmark and Norway after an aircraft accident off the Danish coast in 1989. Other types of forms are used in other countries [7, 15], but they often lack space for important information.

In Norway, a special form for dental comparison with the concordant features and an evaluation of their rela-

tive importance, is used to present the dental evidence in a way understandable to the police and other non-experts. In fact, we would find it very difficult to complete the entire identification task without this form. The importance of such a summary sheet has also been noted by others [14].

Despite identification of a few victims before dental records were collected, the percentage (68%) of victims with dental identity established was higher in the present material than in many earlier disasters (approximately 50%) [5]. In the "Noronic" disaster only 40 victims (34%) could be identified by dental means [10]. However, following an air crash in Norway in 1988 dental identity could be established for 89% of the victims [5].

The 18 forensic odontologists involved in the present identification work were necessary to keep up with the technical and medical examinations and comparisons. After the "Noronic" disaster more than 40 dentists were active [10] while 8 were engaged after the hotel Hafnia fire in Copenhagen involving 35 victims [16].

Six hours work per victim for dental identification is about twice the average used in single cases in Norway. In the latter cases the police collect the ante-mortem dental records without assistance from the forensic odontologist. Furthermore, in contrast to the present procedure, the forensic odontologist hardly ever participates in the work at the site of recovery, and computer registrations are not usually made. In view of the complexity of the present disaster the time taken for the dental identification agrees well with the 5 h per victim after the Hafnia fire where no dentist participated in the recovery work and no computer registrations were made [16].

In conclusion, the Norwegian Identification Commission succeeded in a task that was initially considered almost impossible. A well prepared organization, planning and experienced personnel contributed to the result. Close cooperation with the Danish Identification Commission was also of great importance. Without dental evidence in a number of difficult cases, many victims would never have been identified.

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