Tohoku J. Exp. Med., 2017, **241**, 219-223

Disaster Victim Identification using Orthopedic Implants in the 2011 East-Japan Earthquake and Tsunami

Norio Numata,[1] Haruka Makinae,[2] Wataru Yoshida,[3] Masao Daimon[4] and Hideki Murakami[5]

[1]Department of Orthopedic Surgery, Tochinai Hospital, Morioka, Iwate, Japan
[2]Department of Cardiology, Iwate Medical University Hanamaki Onsen Hospital, Hanamaki, Iwate, Japan
[3]Department of Orthopedic Surgery, Tokyo Kousei Hospital, Tokyo, Japan
[4]Department of Clinical Laboratory, The University of Tokyo, Tokyo, Japan
[5]Department of Orthopedic Surgery, Iwate Medical University, Morioka, Iwate, Japan

On March 11, 2011, an earthquake (magnitude 9.0) devastated Japan's east coast, and the associated tsunami resulted in social and mechanical destruction. Search for the missing people is still ongoing. Surgical implants are common in the general population. Medical implants usually have lot numbers, and their forensic use is common for victim identification. This investigation was conducted mainly in the cities of Kamaishi and Otsuchi, both of which were affected by the tsunami disaster in 2011. We visited 6 mortuaries with the police between March 20 (9 days after the tsunami) and April 20 (40 days after the tsunami) to examine the presence of surgical scars and related information. Unidentified human remains were investigated by visual and tactile examination. We also visited temples where the ashes were preserved. If implants were found, their lot numbers and estimated surgical procedures were recorded to determine positive identification. Ten of 233 sets of unidentified human remains before cremation displayed characteristics of a potential past surgical history. However, only 2 of these 233 sets had orthopedic implants. Instead, non-combustible orthopedic implants were found and recognized in 8 of the 331 sets of unidentified human ashes in the temples after cremation; the lot numbers were fully legible in 2 of the 8 sets. We estimated the surgical procedures, which led to positive identification. In conclusion, lot numbers and the surgical knowledge of orthopedic surgeons could assist with the positive identification of disaster victims. However, the relevant information can be erased after cremation.

Keywords: disaster victim identification; implant; lot number; orthopedic surgery; tsunami
Tohoku J. Exp. Med., 2017 March, **241** (3), 219-223.

Introduction

On March 11, 2011, an earthquake (magnitude 9.0) devastated Japan's east coast, and the associated tsunami resulted in social disorder as well as mechanical destruction (Ishigaki et al. 2013). Search for the missing people is still ongoing. Tsunami and earthquake resulted in more than 15,000 deaths over 20 districts, with more than 90% of the deaths caused by drowning (Cabinet Office, Government of Japan 2011).

Orthopedic implants are common in the general Japanese population. Because 3 of the authors had been practicing in Kamaishi and Tono at that time, this investigation was performed mainly in Kamaishi. Of the approximate 50,000 individuals in the study area of Kamaishi, a small city that is approximately 600 km from Tokyo by car (Fig. 1), more than 300 people annually (approximately 75% are > 60 years old) undergo an orthopedic implant operation at Iwate Prefectural Kamaishi Hospital, which is one of the two local hospitals with department of orthopedics in the Kamaishi area. Surgical implants and the industry-tracked lot numbers have been used forensically for decades to identify victims.

In the present investigation, we collected the information of unidentified human remains and ashes at mortuaries and temples to search surgical information that may have led to identification. Here, we explain our attempts to obtain medical information to positively identify unidentified human remains from the 2011 tsunami.

Materials and Methods

The institutional review board of Iwate Prefectural Tono Hospital approved the study. In all cases, forensic scientists conducted forensic examinations, and the police recorded specific characteristics of the human remains and belongings. The records of unidentified tsunami victims are disclosed on the official website of

Received October 24, 2016; revised and accepted February 17, 2017. Published online March 18, 2017; doi: 10.1620/tjem.241.219.
Correspondence: Haruka Makinae, M.D., Ph.D., Department of Cardiology, Iwate Medical University Hanamaki Onsen Hospital, 2-85-1 Dai, Hanamaki, Iwate 025-0305, Japan.
e-mail: cyp02060@nifty.com

the Iwate Prefectural Police.

Surgical scars and related information before cremation

The Iwate Prefectural Police disclosed 233 records of unidentified human remains at the time of the present investigation. Of these, 10 sets of human remains displayed characteristics of potential past surgical history as reported by the forensic scientists and police. We visited 6 mortuaries in Kamaishi and neighboring Otsuchi with the police between March 20 (9 days after the tsunami) and April 20 (40 days after the tsunami), 2011 to examine the presence of surgical scars and related information (Fig. 1). We investigated these unidentified human remains using visual and tactile examinations.

Non-combustible orthopedic implants found from unidentified ashes

After the cremation of 331 unidentified human remains before July 2011, non-combustible objects such as bone wires, pacemakers, and heart prostheses were found from 20 sets of human remains and collected by the police. Together with city officers, we visited the temples where these ashes were enshrined and visually identified these objects. We also referred to the list of unidentified victims disclosed by the Iwate Prefectural Police. If implants were found, their lot numbers and estimated surgical procedures were recorded to determine positive identification. In the geographic area we investigated, there were only 2 hospitals with orthopedics departments, which facilitated finding the surgical records that matched the estimated surgical procedure of the unidentified human remains.

Results

Surgical scars and related information before cremation

Of the 10 sets of 233 human remains that displayed characteristics of a possible past surgical history, a surgical implant was tactile in 1 set of unidentified human remains, while 1 other set was severely burned and part of an implant was exposed (Table 1). However, this set of human remains could not be investigated by autopsy at the mortuary because of the presiding Japanese law. Instead, the set of human remains was cremated later, and the orthopedic implant was found among the ashes. However, the implant lot number was destroyed by the cremation.

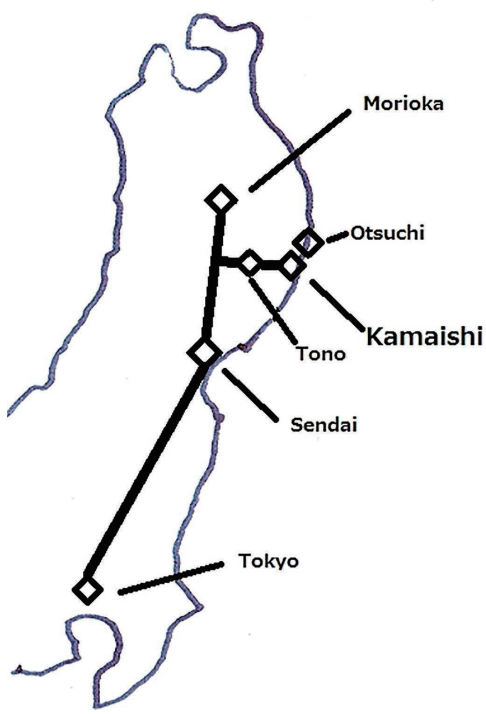

Fig. 1. Geographical location of the cities included in this investigation.

Non-combustible orthopedic implants found from unidentified ashes

Non-combustible objects were found in 20 sets of human remains from 331 unidentified human ashes. The implant types were recognized for all 8 of the objects that were identified as orthopedic implants (Table 2). The forensic scientists missed the presence of surgical scars in 5 of these 8 unidentified victims before cremation. The type and usage of implants could be recognizable in all 8 ashes. However, the lot numbers of only 2 ashes were fully legible. We estimated the surgical procedure, and combined this information with the lot number, size, and product type. After the surgical information was referred to operation records and tracking system, that led to positive identification.

Discussion

In our investigation, although forensic scientists and police had examined each unidentified disaster victim, their decisions regarding identification were not perfectly accurate. In the tsunami disaster, human remains degenerated and deteriorated over time, and missing subtle changes on the skin could not be avoided. Furthermore, the circumstances did not support the identification of remains (Iwase 2014).

In Japan, post-mortem incision and autopsy were strictly regulated by law at the time of this investigation. Therefore, even when a surgical scar or sign of an implant was observed on a set of remains, the examiners could not conduct a post-mortem incision of the remains for the purpose of identification outside of a certified hospital or institution. Shepherd et al. (2010) reported the utility of surgical scars, but this might be limited to certain situations. Furthermore, although lot numbers are printed on each orthopedic implant, these printed numbers are frequently destroyed during cremation or if the victim's body is severely burned.

Forensic use of medical implants

The alternate use of orthopedic implants and dental records for disaster victim identification (DVI) is a well-known technique in forensic science that has been used for decades (Petju et al. 2007; Schuller-Götzburg and Suchanek 2007; Simpson et al. 2007; Wilson et al. 2011; Berketa et al. 2015). However, most orthopedic surgeons in the study region were not very familiar with the forensic use of implants.

Table 1. Investigation of 232 sets of unidentified human remains.

Case number*	Findings of the forensic examination before cremation	Findings of the visual and tactile examinations before cremation	Objects found after cremation
A-1	A 19-cm long old surgical scar on the left knee	Surgical scar recognized, no palpable object	Dental implant
A-2	A plaster cast on the left leg	Plaster cast	No non-combustible object
B-1	A screw in the left foot	Tactile screw head	Intramedullary nail system for the tibia
B-2	An old surgical scar on the lateral side of the left femoral region	Surgical scar recognized, no palpable object	A φ4.5-mm cortical bone screw (46-mm long)
B-3	An old surgical scar on the lateral side of the left knee	No surgical scar recognized	No non-combustible object
D-1	An exposed screw- or bolt-like object	Exposed femoral stem; however, the serial number was burned and unreadable	Femoral stem
D-2	A 20-cm long surgical scar on the left knee	Surgical scar recognized, no palpable object	Victim identified by another method and could not be followed after cremation
E-1	A 5 × 0.5-cm surgical scar on the left knee	No surgical scar recognized	No non-combustible object
F-1	A 16-cm long surgical scar on the right femoral region	No surgical scar recognized	No non-combustible object
H-1	An 11-cm long surgical scar on the medial portion of the lower back	Surgical scar recognized, no palpable object	Victim identified by another method and could not be followed after cremation

*The letter in the case number represents the disaster site.

A questionnaire about knowledge of DVI was distributed to orthopedic surgeons at regional conferences in 2014 (Iwate Knee Seminar, The 48th Annual Meeting of the Japanese Scoliosis Society in Morioka, and the annual meeting of the Iwate Prefectural Hospital Association). Questionnaires were completed by 108 of 386 orthopedic surgeons (28.0%) at the conferences, with 18.8 ± 8.9 years of practice. The forensic use of dental records was known by 97 (89.8%) orthopedic surgeons, while 21 (19.4%) surgeons knew that lot numbers and serial numbers could be used for identification of unidentified victims. Twenty-three (21.3%) surgeons knew that an autopsy and local incisions were legally inhibited at mortuaries at that time. Only 6 (5.6%) of the orthopedic surgeons knew that lot numbers printed on orthopedic implants could be destroyed by cremation.

The presence of various orthopedic implants could help estimate the surgical procedures performed, and the combination of the implant size and lot numbers could potentially provide information for positive identification.

Table 2. Investigation of non-combustible objects found after cremation of 331 sets of unidentified human remains.

Case number*	Findings of the forensic examination before the cremation	Objects found after cremation	Lot numbers or information found on the non-combustible objects
B-1	A screw on the left foot	Intramedullary nail system for the tibia	The product name was recognized but had no readable numbers or letters.
B-2	An old surgical scar on the lateral side of the left femoral region	A φ4.5-mm cortical bone screw (46-mm long)	The product name was recognized but had no readable numbers or letters.
B-8	No surgical scar or surgical implant recognized by forensic examination	Bilateral artificial knee joints	The product name and size were recognized.
C-1	No description related to the surgical implant	Bipolar cup of an artificial hip joint	The product name and lot number were recognized.
D-1	An exposed screw- or bolt-like object (exposed femoral stem; however, the lot number was burned and unreadable)	Femoral stem	The product name was recognized but had no readable numbers or letters.
D-3	No description related to the surgical implant	A plate system for the radius	The product name was recognized but had no readable numbers or letters.
E-2	No description related to the surgical implant	Bilateral artificial hip joints	The product name and part of the lot number were recognized.
G-3	No surgical scar or surgical implant recognized by forensic examination	Nail system for the humerus	The product name and size were readable but no lot number was recognized.

*The letter in the case number represents the disaster site. Cases B-8 and C-1 were positively identified.

Furthermore, medical objects and their implantation sites could provide valuable information to estimate the past medical history of unidentified human remains. For example, bone wires might indicate a history of thoracic surgery; the exact wire location, e.g., the rib cage or sternum, could provide a more specific history of surgery, such as for mediastinal or heart disease. Makinae et al. (2013) used pacemaker programmers to noninvasively scan patient information from the pacemaker for DVI in the 2011 tsunami. The object type as well as the object location is important; because of these two reasons, a whole body X-ray before cremation is required.

The authors also noted that whole body X-ray should be used for screening in mass disasters. In cases of severe

destruction or degradation of human remains, it is difficult to estimate the age and sex using visual appearance. In addition to the detection of dense objects, estimation of age and/or determination of whether the remains are human are important. Prieto et al. (2007) reported their successful and well-organized DVI in the Madrid terrorist attacks using X-ray screening. Because the tsunami expanded longitudinally along the coast where the towns are scattered and the fragile traffic system connecting the local towns was heavily devastated, we used a portable X-ray device that is usually used at Iwate Prefectural Tono Hospital, near Kamaishi, for home medical care in remote areas; the difficult geographic conditions and lack of electricity did not allow the use of large, whole-body X-ray and computed tomography (CT) equipment despite their reported usefulness for screening human remains for medical information and estimation of age and sex (Simpson et al. 2007; Blau et al. 2008; Wilson et al. 2011; Brough et al. 2012). In the present study, we also used a portable X-ray for home medical care, namely the AeroDR (Konica Minolta, Tokyo), to detect X-ray opaque objects and estimate the age and sex of the remains (data not shown); an orthopedic surgeon provided the estimated age and sex to regional police. Further forensic examinations, before cremation, including autopsy, would have been possible with whole body X-ray. Therefore, in disaster situations, whole body radiography should be performed before cremation to screen for medical implants in unidentified remains, particularly because surgical scars can diminish with time and the degradation of human remains.

Limitations

The main limitation of the present study was that the number of unidentified human remains represents those available at the time of the investigation and not the total set of accumulated remains.

Conclusion

Lot numbers of implants and surgeon knowledge can help to determine valuable information for positive identification.

Acknowledgments

The authors would like to express their appreciation to the city officers of Kamaishi, Otsuchi and Tono, Iwate Prefectural Police Office, and the priests of the temples along the coast of Kamaishi and Otsuchi for their support; Mr. Hidetoshi Ogasawara for his professional assistance in the radiological investigation; and Hirofumi Kitaoka, M.D., Ph.D. (Dept. Internal Medicine, Iwate Prefectural Tono Hospital), Hidehiko Endo, M.D., Ph.D. (Dept. Surgery, Iwate Prefectural Chubu Hospital), Motoki Sakuraba, M.D., Ph.D. (Dept. Thoracic Surgery, Sapporo City General Hospital), Yukinori Sakao, M.D., Ph.D. (Dept. Thoracic Surgery, Aichi Cancer Center Hospital), and Noriyoshi Kobayashi, M.D., Ph.D. (Dept. Nephrology, Japanese Red Cross Society, Azumino Hospital) for providing information from their clinical majors.

This work was partly supported by a Grant-in-Aid for Scientific Research C (15k01327) from the Japan Society for the Promotion of Science (Masao Daimon).

Conflict of Interest

The authors declare no conflict of interest.

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