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# Teletriage for patients with traumatic finger injury directing emergency medical transportation services to appropriate hospitals: A pilot project in Nagoya City, Japan

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ABSTRACT

*Introduction:* Emergency medical technicians in Japan have experienced difficulties in identifying hospitals that will accept patients with severe finger injuries. We developed and managed a system named Interactive Teletriage using mobile phone photos to aid efficient patient transportation. The aim of this study was to investigate features related to the transportation of patients with severe finger injuries and to evaluate the feasibility of this system.

*Materials and methods:* We prospectively analysed data from the medical association of Aichi Prefecture and the Nagoya City Fire Department in Japan. We investigated features related to the transportation of 474 patients with severe finger injuries in Nagoya from 2010 to 2013: 100 in 2010, 134 in 2011, 125 in 2012, and 115 in 2013. We began using Teletriage in August 2011 and compared the periods before and after its implementation.

*Results:* The time of injury showed two different peaks from 09:00 to 11:00 h and at 13:00 h. The number of patients injured during each weekday was generally the same, while cases on Saturdays and Sundays reflected 70% and 47% of the weekday average, respectively. Of the 474 patients, 395 (83%) were accepted to hospitals after 3 or fewer requests for admission: 160 of 202 (79.2%) before and 235 of 272 (86.4%) after Teletriage, constituting a significant increase ($p = 0.039$). Furthermore, the number of patients who required 4 or more requests significantly decreased after implementation of Teletriage ($p = 0.039$): 42 patients (20.8%) before and 37 (13.6%) after Teletriage. Our data showed that as the number of requests until final determination increased, the transportation period increased. Furthermore, the mean transportation period significantly decreased from 22.3 min before to 18.1 min after Teletriage ($p = 0.021$). As the number of requests until final determination increased, the proportion of patients transported to Level I and II hospitals decreased; conversely, the proportion of patients transported to Level III, IV, and V hospitals increased.

*Conclusions:* Our results indicated that the implementation of Teletriage has the potential to ease the problem of emergency medical transportation for those with severe finger injuries.



## Introduction

Severe finger injuries such as amputation, degloving injury, and arterial injury are not only emergency conditions but also require technically challenging operations that may include microsurgery [1–4]. Because the primary treatment can directly affect the final function of the hand, a swift, accurate evaluation to determine whether or not patients should be transported to a highly specialised hospital is needed [5–9].

The system of emergency medical services and pre-hospital rescue in Japan is different from that in the United States [10–12]. In the United States, the Medical Priority Dispatch System (MPDS) operates in many places. Japan has no systematic triage protocol like the MPDS [13]. Japanese emergency medical technicians (EMTs) need to evaluate the condition of patients and transport them to appropriate hospitals by themselves. However, the number of highly specialised medical facilities is limited, and it is often difficult for EMTs to properly evaluate and convey accurate information to the hospitals before acceptance of

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patients. This situation, unfortunately, is typical in the Japanese medical system. In addition, there is no law in Japan corresponding to the Emergency Medical Treatment and Active Labor Act (EMTALA) of the United States, which may punish hospitals for turning patients away from an emergency department. Therefore, many hospitals in Japan refuse to accept patients with a severe finger injury. This has been a nationwide problem, especially in urban areas, where there are many hospitals but also many patients [10].

To address this problem, we developed a system that incorporates timely direct communication and mobile phone photos to aid in the smooth transport of patients with severe finger injury to appropriate hospitals. We named the system Interactive Teletriage. The purpose of this study was to investigate features related to the transportation of patients with severe finger injuries in the city of Nagoya from 2010 to 2013. We began managing patient transportation using Interactive Teletriage in August 2011 and subsequently evaluated the system by comparing results before and after its implementation.

## Patients and methods

Nagoya, in Aichi Prefecture, is the largest city in central Japan with a population of 2.27 million people and an area of 326.43 $km^2$. It is the fourth most populous city in Japan [14]. This study was based on an ongoing prospective analysis of data from the medical association of Aichi Prefecture and the Nagoya City Fire Department. Herein, we report on our investigation of features related to the transportation of patients with severe finger injuries in Nagoya from 2010 to 2013, including periods before and after implementation of Interactive Teletriage, our system for managing emergency transportation. This study consisted of 100 patients in 2010, 134 patients in 2011, 125 patients in 2012, and 115 patients in 2013. The evaluation included the number of patients managed by the Teletriage system, time of injury, day of the week injured, number of requests for the admission to the hospitals until final determination, and mean transportation period as well as classification level of hospital according to the number of requests. We compared the periods before and after the implementation of Teletriage.

When responding to a finger injury, emergency medical services adopted Teletriage when it was difficult for them to determine whether the patient should be transported to a highly specialised hospital. After reaching the patient at the accident scene or shortly thereafter in the ambulance before leaving, the EMTs took digital photos of the injured fingers and called us while simultaneously sending the photographs by Then, we assessed the necessity for highly specialised treatment such as performing revascularisation, provided authoritative information, and directed the ambulance to the most appropriate hospital. In turn, the EMTs called the recommended hospitals and their doctors directly following our advice. We may have also accepted the patient depending on the circumstances. The individuals assessing and providing the information were hand surgery specialists in the Department of Hand Surgery, Nagoya University Graduate School of Medicine. We used mobile phones that could transmit and receive images with a 3.2 megapixel digital camera. Before Teletriage program initiation, we collaborated with EMTs to establish the protocol. Doctors from the Department of Hand Surgery then provided training to EMTs, giving specific details on how to most effectively photograph the injury. Our protocol stipulated taking photos on site giving views of the palmar and dorsal sides with the patient's fingers spread as much as possible (Fig. 1).

We conducted a questionnaire survey that was distributed to all hospitals within Aichi Prefecture in 2012. The questionnaire items were: (1) the number of medical doctors (orthopaedic surgeons, plastic surgeons, vascular surgeons, and anaesthesiologists); (2) the number of specialists in hand surgery; (3) the number of microsurgical operations and replantations performed in 2011; (4) the number of occupational therapists; and (5) the ability to perform emergency operations for severe finger injuries. Based on this survey, we classified hospitals into levels from I to V. Level I hospitals provided the highest level of surgical care to patients with severe finger injury. Level I and II hospitals were able to accept severe finger injury patients any time of any day. They were officially authorised as "Hand Surgery Educational Facilities" by the Japanese Society for Surgery of the Hand. Level I, but not Level II, hospitals performed more than 50 operations which included microsurgery in 1 year and had two or more hand surgery specialists as well as occupational therapists. Levels III and IV hospitals were able to accept patients with severe finger injuries in some cases. Level III hospitals had at least one hand surgery specialist, but Level IV hospitals had none. Level V hospitals were unable to accept patients with severe finger injuries.

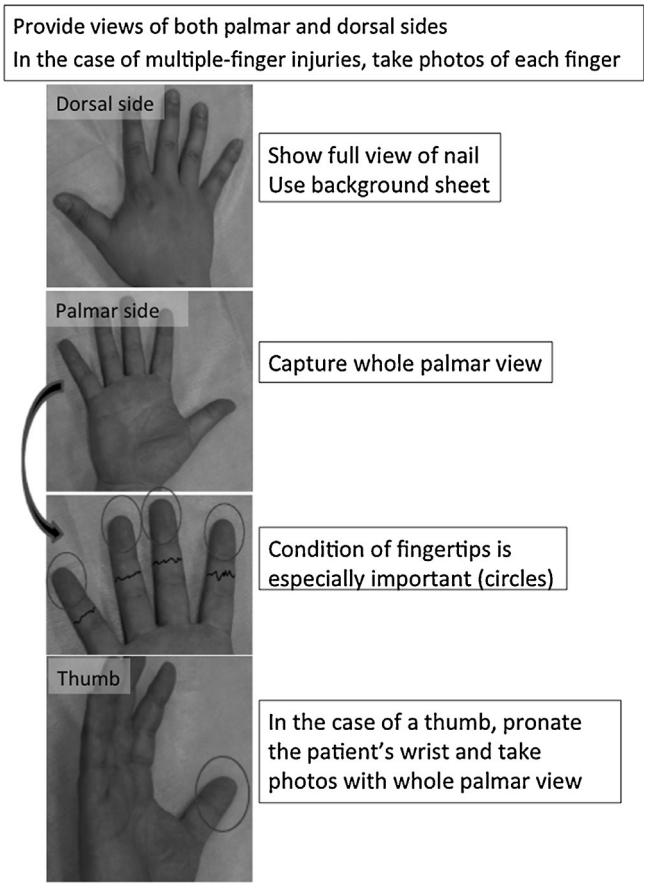


**Fig. 1.** Our protocol for taking digital photos.

Data were summarised using descriptive statistics. The comparison between before and after Teletriage of number of requests to the hospitals until final determination and patients with emergency conditions was done by $\chi^2$ analysis. The mean transportation period before and after implementation of Teletriage was assessed using the Mann-Whitney $U$ test. Statistical significance was set at $p < 0.05$. IBM SPSS software version 20 (IBM Corp., Armonk, NY) was used for statistical analysis.

## Results

The Teletriage system was employed for 45 patients beginning in August 2011. The time of injury showed two different peaks

from 09:00 to 11:00 h and at 13:00 h (Fig. 2). The number of patients injured during each weekday was generally the same; in comparison, cases on Saturdays and Sundays reflected 70% and 47% of the weekday average, respectively (Fig. 3).

The number of requests for hospital admission until final determination before and after Teletriage is shown in Fig. 4. The mean number of requests was 2.3 times before and 1.2 times after Teletriage was implemented. Eighty-three percent of all patients were admitted after 3 or fewer requests: 79.2% before and 86.4% after Teletriage implementation (Fig. 4), which was a significant difference ($p = 0.039$). Furthermore, the proportion of patients who required 4 or more requests significantly decreased after implementation of Teletriage: 20.8% before and 13.6% after Teletriage ($p = 0.039$). The details of these patients are shown in Table 1. This group consisted of 42 cases before and 37 cases after Teletriage. We focused on those patients with emergency conditions such as digital amputation, degloving injury, open fracture, and arterial injury (Table 1), including 29 cases before and 15 cases after Teletriage. The proportion of patients with emergency conditions requiring 4 or more requests significantly decreased after Teletriage ($p = 0.046$).

When the number of requests until final determination increased, the subsequent transportation period increased (Fig. 5). When comparing the transportation period before and after Teletriage, the mean period significantly decreased from 22.3 to 18.1 min ($p = 0.021$) (Fig. 6). This 18.1 min period after Teletriage was implemented reflects the average period of patients who underwent Teletriage (24.0 min) and those who did not (17.0 min). The classification level of hospitals according to number of requests is shown in Fig. 7. As the number of requests until final determination increased, the proportion of patients transported to Level I and II hospitals decreased; conversely, the proportion of patients transported to Level III, IV, and V hospitals increased.

There were 45 patients for whom Teletriage was employed, as detailed in Table 2. All of these patients were admitted within 3 requests. Seventy-two percent of Teletriage cases had emergency conditions as previously described (Table 2). Over the study duration, no patients required reassignment to a higher level of care among the Teletriage cases.

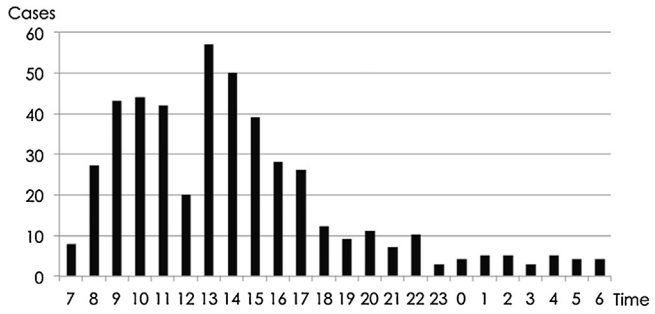


**Fig. 2.** The time of day that injury occurred. Note the peaks from 09:00 to 11:00 h and at 13:00 h.

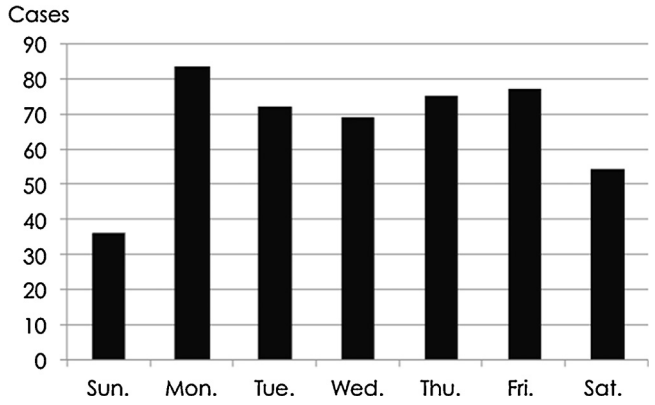


**Fig. 3.** The day of the week that injury occurred.

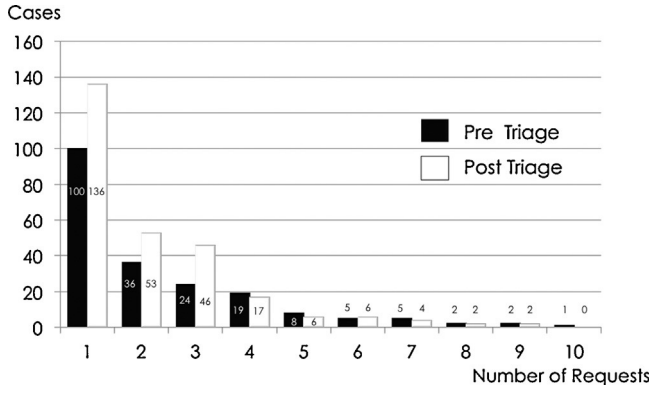


**Fig. 4.** The number of requests for admission to hospital until final determination before and after the implementation of Teletriage.

## Discussion

In Nagoya, patients with severe finger injuries being turned away by hospitals have been a problem. It is not only a social problem in Nagoya, but also a pervasive problem of urban areas in Japan. The present study showed that 83% of all patients were admitted after 3 or fewer requests, whereas 17% of all patients required 4 or more, even up to 10, requests before admission. Furthermore, our data showed that as the number of requests until final determination increased, the transportation period increased. On average, there are 100 to 130 patients with severe finger injuries per year in Nagoya. However, the number of highly specialised hospitals is limited. Thus, we have to make effective use of limited medical resources.

It is difficult to convey accurate information through only a verbal description of traumatic injury. Previous studies have suggested that digital images are feasible and valuable in a telemedicine system for emergency medical care management and

**Table 1**
Types of injuries of the patients requiring 4 or more requests before admission to hospital.

| Diagnosis | Number of cases | |
|---|---|---|
| | Pre Teletriage | Post Teletriage |
| *Non-emergency conditions* | | |
| Soft tissue injury or defect | 18 | 12 |
| Fingertip amputation | 5 | 8 |
| Closed fracture | 5 | 4 |
| Nerve injury | 4 | 5 |
| Flexor tendon injury | 5 | 2 |
| Extensor tendon injury | 3 | 6 |
| *Emergency conditions* | | |
| Arterial injury | 3 | 3 |
| Degloving | 3 | 1 |
| Open fracture | 8 | 3 |
| Digital amputation | 15 | 8 |
| *Total* | 59 | 52 |

The number of cases listed here differs from that in the text because some patients had more than 1 injury.

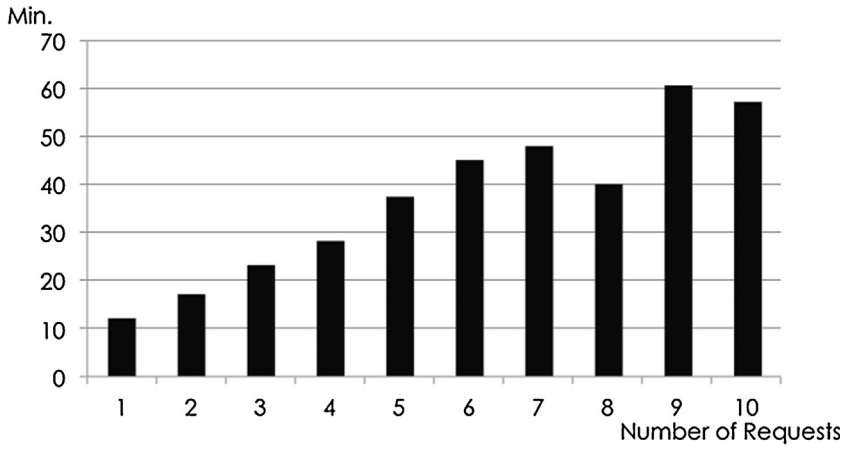


**Fig. 5.** Mean transportation period according to the number of requests before admission to hospital.

routine consultation in neurosurgery [15,16], plastic surgery [17,18], vascular surgery [19,20], radiology [21,22], and orthopaedics [23,24]. There are many potential benefits of telemedicine, such as increased efficiency of existing medical resources, pre-hospital care, prevention of unnecessary transfers, and promotion of early transfer [25–29]. For severe finger injury, Hsieh et al. suggest that the camera phone is feasible for remote diagnosis of completely amputated fingers, as there was 90% sensitivity and 83% specificity for recognising replantation potential [25]. We also consider that it is valuable to evaluate the condition of severe finger injuries with a rigid protocol for taking photos and adequate image quality.

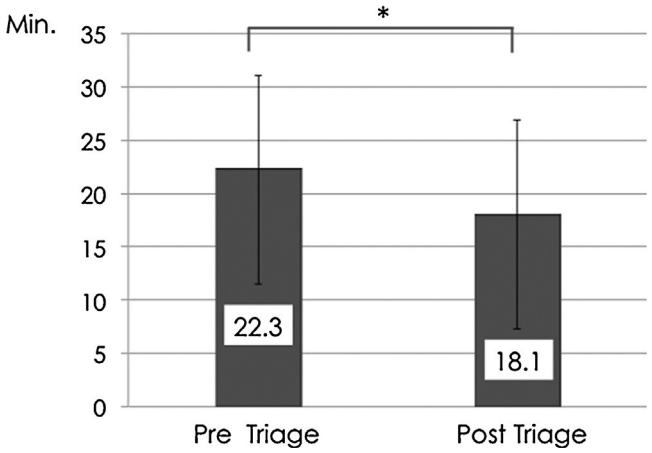


**Fig. 6.** Comparison of transportation period before and after the implementation of Teletriage.

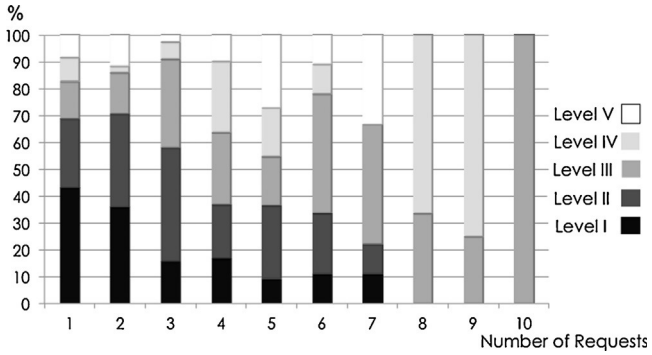


**Fig. 7.** The classification level of hospital according to the number of requests before admission.

The present study showed that when the number of requests until final determination increased, not only the transportation period increased but also the proportion of patients transported to Level III, IV, and V hospitals increased. In addition, we examined in detail the patients who required emergency treatment (29 cases before and 15 cases after Teletriage) and were included in the group requiring 4 or more requests before hospital admission. A detailed comparison before and after Teletriage of the patients requiring 4 or more requests revealed that the proportion of patients with emergency conditions was significantly decreased after Teletriage. Considering that 72% of the Teletriage cases were emergency conditions and that all Teletriage cases were admitted within 3 requests, our results indicated that after implementation of the Teletriage, the patients with emergency conditions were shifted to the group requiring 3 or fewer requests. These results indicated that our system was feasible for the smooth transportation and efficient pre-hospital triage of patients with severe finger injury.

After implementation of Teletriage, the mean transportation period for the patients who did not use this system was 17.0 min. The Teletriage system was enacted when it was difficult for EMTs to determine whether or not the patient should be transported to a highly specialised hospital. Less complicated cases that did not require Teletriage in which the accepting hospital was clear tended to proceed more efficiently. Thus, the transportation period for

**Table 2**
Types of injuries of the patients in Teletriage cases.

| Diagnosis | Number of Teletriage cases |
|---|---|
| *Non-emergency conditions* | |
| Soft tissue injury or defect | 6 |
| Fingertip amputation | 2 |
| Closed fracture | 1 |
| Nerve injury | 2 |
| Flexor tendon injury | 2 |
| Extensor tendon injury | 0 |
| *Emergency conditions* | |
| Arterial injury | 3 |
| Degloving | 2 |
| Open fracture | 10 |
| Digital amputation | 18 |
| *Total* | 46 |

The number of cases listed here differs from that in the text because 1 patient had more than 1 injury.

patients who did not undergo Teletriage was 17.0 min which was shorter than before implementation of the system (22.3 min).

*Conversely*, the mean transportation period in Teletriage cases was 24 min, which was longer than the average transportation period for all of the cases together, most likely accounted for by the time it took to take the photos, send an email, and then have the patient's condition evaluated. Nevertheless, the mean transportation period significantly decreased from 22.3 to 18.1 min after Teletriage. The reasons we have considered are that both the proportion of patients who required 4 or more requests significantly decreased after Teletriage was implemented and Teletriage cases were admitted within 3 requests. Following the implementation of Teletriage, this reduction was most beneficial for such patients. We also believe that the time needed for taking photos and sending the email will shorten as the EMTs gradually become accustomed to the protocol.

This study has several limitations. First, we managed the Teletriage system only during our working hours from 09:00 to 17:00 h. Second, there is limited information regarding the accuracy of the diagnoses based on the digital photo images, even if we provided training to EMTs giving specific details on how to most effectively capture photographs of the injury. Finally, we did not evaluate the clinical outcomes such as survival rate and function of the hand following a finger replantation.

A strength of our study was the number of cases we were able to evaluate, which included all patients with severe finger injuries who needed emergency transportation in Nagoya during the course of our study with the cooperation of the medical association of Aichi Prefecture and the Nagoya City Fire Department. Because we used only mobile phone photos sent by email during our working hours, we did not engender any additional costs to manage this system. Nevertheless, our results indicate a definite improvement in emergency medical transportation of patients with severe finger injuries in Nagoya. Our final goal is to develop the system such that we can evaluate the clinical results. This process has been initiated. We are investigating the results of treatment and function of the hand in detail. Further, we began a regional expansion of the system beyond Nagoya. The entire prefecture has been covered since April 2014 and represents a considerable increase in size. Aichi Prefecture has a population of 7.44 million people and an area of 5.165.16 $km^2$, constituting about 3.4 times the population and 17 times the area of Nagoya. We plan to develop this model and promote its use throughout Japan utilising regional Teletriage hubs. In its evolution, a dynamic real-time online system would optimally synthesise all information and substantially advance the potential of Interactive Teletriage.

## Conclusions

In this study, we investigated features related to the transportation of patients with severe finger injuries in Nagoya from 2010 to 2013. After the implementation of Teletriage, the proportion of patients who were successfully directed with 3 or fewer requests between EMTs and an admitting hospital increased and the proportion of patients who required 4 or more requests significantly decreased. Therefore, the mean transportation period also significantly decreased. Our results indicated that the implementation of Teletriage has the potential to ease the problem of emergency medical transportation of patients with severe finger injuries in Japan.

## Conflict of interest

The authors declare that there is no conflict of interest.

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