Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Cadaver surgical training of orthopedic surgery during the SARS-CoV-2 pandemic in Japan

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Conflict of Interest:

The authors have no conflict of interest to declare.

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Text:

In the field of orthopedics, there are many parts of the body that cannot be replaced by animals, and therefore, cadaver surgical training (CST) is well implemented [1-3]. In addition, along with the development of medical engineering technologies such as surgical navigation systems and robotic arms, the development of orthopedic surgery is constantly evolving. It is not yet known when and at what level surgeons should acquire new skills in technologies that are constantly being developed in order to have the greatest effect. Will the new technology make it easier for residents to perform successful surgeries, or will only experienced specialists be able to use the technology?

For example, the question was whether a young, inexperienced orthopedic

surgeon could benefit from the latest robotic arm-assisted technology and successfully perform total knee arthroplasty (TKA) surgery as planned. Scholl et al. recently showed that with computer assistance, even inexperienced orthopedic surgeons could perform the surgery as planned better than with traditional manual TKA [4]. They reported, “The first robotic-arm assisted TKA (RATKA) performed by one of the two surgeons had higher stacked errors when compared with the manual procedure performed on the same cadaver. It was also noted that the stacked errors decreased after this first RATKA, indicating a learning curve”. Doesn’t this combination of an inexperienced orthopedic surgeon and robotic-arm technology indicate that learning RATKA initially via cadaver surgery training may reduce the risk to patients?

The laws and guidelines stipulating surgical technique training using corpses differ in each country [5-7]. In Japan, cadavers have been used almost exclusively for education of human anatomy and basic medical research on morphology; therefore, cadavers have only been preserved with formalin fixation, which is unsuitable for dynamic assessments and surgical training. For this reason, Japanese orthopedic surgeons have conducted surgical simulations and biomechanical research abroad.

The inability to use cadavers in clinical medical research has closed doors for companies that developed medical devices.

In addition, most companies had to go overseas to conduct demonstrative tests to confirm that the new medical devices they had developed would actually function in surgery. Amid these unfavorable circumstances for CST and research and development (R&D) using cadavers, the Japan Surgical Society and the Japanese Association of Anatomists have attempted to establish a more suitable environment. "Guidelines for autopsies in clinical medical education and research" were published in 2012 and have gradually progressed over time [8]. With the publication of the guidelines and the budgetary measures of the Ministry of Health, Labour and Welfare that began in 2018, 47% (n=38/81) of medical universities in Japan are now able to implement CST.

Many institutions in Japan use Thiel's embalming method [9-11] which maintains joint mobility; however fresh frozen cadavers, which do not suffer from tissue strength loss due to fixative solutions, are also necessary for studies that require biomechanical evaluation. The total number of CST and research programs reported to the CST Promotion Committee of the Japanese Surgical Association between

2012 and 2021 was 1173. Of these, 27% (314 programs) were reported from the field of orthopedics (Fig. 1), with a total of 21 CSTs for TKA. Following the introduction of the Ministry of Health, Labour and Welfare budgetary measures in 2018, there was a sharp increase from 6 cases in 2012-2017 to 15 cases in 2018-2021.

During the COVID-19 pandemic, orthopedic surgeons in the United States reduced the frequency of their surgical skills training [12]. In particular, training in the cadaver laboratory was greatly reduced and only skills training in the virtual laboratory could be continued. Similarly, in Japan, where CST has finally started to spread, activity decreased in 2020 and 2021 due to the COVID-19 pandemic [8].

This shows the significant impact of the SARS-CoV-2 pandemic on education and research in the field of orthopedic surgery. However, it is essential to continue building a practical foundation despite the unfavorable situation. Using donated cadavers should not be completely discontinued to preserve the availability of R&D. The risk of infection among participating doctors can be reduced by testing cadavers for SARS-CoV-2 antigens and limiting the number of participants in order to avoid crowded spaces. These measures in orthopedic surgery can make clinical autopsies

safer because of the minimal risk of aerosol infections from the respiratory tract and lungs of cadavers compared with the risk of aerosol infection during otolaryngology and respiratory surgeries. To maintain and develop the necessary medical standards, a minimum level of medical research using cadavers should be maintained even during a pandemic.

In 2021, the CST Promotion Committee organized a working group under a Ministry of Health, Labour and Welfare project on regional medical infrastructure research and development (“Research on promoting the dissemination of effective medical technology educational system using donated bodies”) and includes leading figures in CST from the fields of orthopedic surgery, neurosurgery, and otolaryngology. We have begun studying how to properly promote usage of cadavers in all clinical fields not only for surgical training but also development of medical devices. Recently, the working group established the following 4 proposals to stakeholders (academic societies, governments, businesses, citizens) how to properly develop clinical medicine through education and research using donated cadavers [13].

1. Improving the current reporting system: Optimize the reporting system so that each academic society can evaluate implementation programs and provide guidance.
2. Strengthening professional autonomy: Offer seminars at the conferences of each academic society to disseminate rules on implementation.
3. Prepare new guidelines and recommendations: Work with academic societies to prepare new guidelines on items of shared interest, including the implementation guidelines for medical device development, and take recommendations for academic societies by field that align with the new guidelines.
4. Activities to gain public acceptance: To gain public acceptance on the use of cadavers for clinical medicine and promote it, provide materials that review the historical background and status quo of CST in Japan.

All programs conducted at the universities were approved by their respective ethical boards. In addition, anonymized data reported to the JSS, in accordance with the guidelines, were used for the current study. No identifiable information of the participants is included in the manuscript.

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155 **Figure Legend:**

156 **Fig. 1. Annual trends in the number of programs**

157 The breakdowns of all programs and orthopedics programs are shown in the bar

158 graphs. The breakdown of the number of total knee arthroplasty (TKA) programs is

159 shown in the line graph.

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