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# The dental teleradiology in the National Taiwan University Hospital system

The teleradiology is the transmission of radiological images such as X-ray, computed tomography (CT), and magnetic resonance imaging (MRI) images from one location to another location to share the imaging information with the clinicians in other hospitals or locations. The concept of teleradiology has a long history with the earliest recorded transmission of dental radiographs in 1929.[1] There is a special dental teleradiology operation model formed with the development of teleradiology in the National Taiwan University Hospital (NTUH) system. It is mainly constructed by the Department of Dentistry of NTUH, while the Department of Imaging Medicine of NTUH plays the role of teleradiology management center as its intermediary. In brief, the dental teleradiology refers to the practice of a dentist interpreting dental images while the dentist is not physically present in the hospital or location where the dental images are generated. In this study, we used an on-site investigation to explore the distribution of dental departments within the NTUH system and the overview of their dental radiation equipment, and interviewed with the current senior medical radiation technologist (MRT) of NTUH to describe the architecture of the dental teleradiology operation model.

Based on the on-site investigation and interview, we obtained the results which are shown in Fig. 1. In addition to general radiography, the teleradiology of the NTUH system covered the imaging information of CT, MRI, sonography, nuclear medicine scan, angiography, angiocardiography, gastrointestinal endoscopy, optical coherence tomography, and dental radiography. Therefore, a special dental teleradiology operation model was constructed within the teleradiology of the NTUH system.

As shown in Fig. 1A, the NTUH system included the Hospital 1, the Main Hospital and Children's Hospital (in Taipei City) and 8 branch hospitals in other regions of Taiwan: Hospital 2, the NTU Cancer Center (in Taipei City); Hospital 3, the Bei-Hu Branch (in Taipei City); Hospital 4, the Jin-Shan Branch (in New Taipei City); Hospital 5, the Hsin-Chu Branch (in Hsinchu City); Hospital 6, the Chu-Bei District of BioMedical Park Branch (in Hsinchu County); Hospital 7, the Chu-Tung District of BioMedical Park Branch (in Hsinchu County); Hospital 8, the Dou-Liu District of Yun-Lin Branch (in Yunlin County); and Hospital 9, the Hu-Wei District of Yun-Lin Branch (in Yunlin County) (Fig. 1A). All the hospitals in the NTUH system have dental departments. The Main Hospital had the largest number and most complete variety of dental radiation equipment including 24 dental X-ray machines: 17 for periapical radiography (PA), one for panoramic radiography (Pano), 5 for panoramic/cephalometric radiography (Pano/Ceph), and one for cone-beam computed tomography (CBCT). The majority of the branch hospitals (except the Hospitals 4, 7, and 8) had dental X-ray machines for PA, Pano, Ceph, and CBCT (please see the detailed dental radiation equipment for each branch hospital in Fig. 1A).

The server location and the actions related to the dental teleradiology operation model of the NTUH system are shown in Fig. 1B. In the Main Hospital, there was a main server (Location A) for access to all medical images except dental images, and a dental dedicated server (Location B) for access to all dental images. Moreover, all other branch hospitals had their own servers (Location C) for access to all medical images including dental images (Fig. 1B). There were 3 actions under the dental teleradiology operation model of the NTUH system. First, the dental radiographs of patients were taken and the dental image files were saved in the dental dedicated server of the Main Hospital (Location B) or the servers of the respective branch hospitals (Location C). Sometimes the branch hospitals might transfer their patients to the Main Hospital for advanced dental radiography. Second, the teleradiology management staff might be authorized to upload dental image files of

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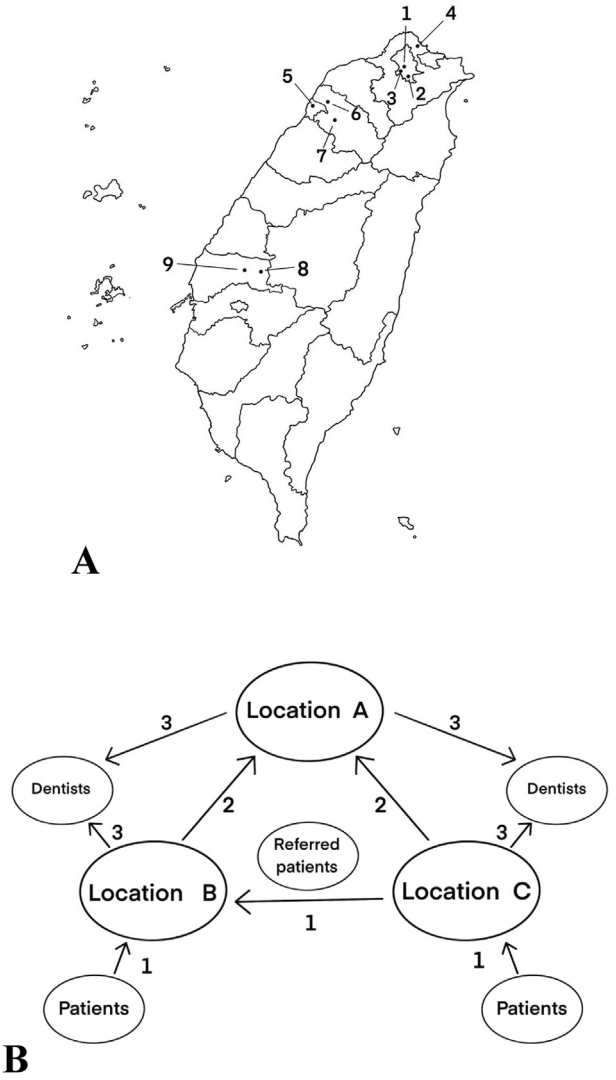


**Figure 1** Overview of the dental teleradiology in the National Taiwan University Hospital (NTUH) system. (A) The schematic diagram presented the distribution of the Main Hospital (including Children's Hospital) and 8 branch hospitals in the NTUH system. All of them had dental departments with some dental radiation equipment. The detailed dental radiation equipment in the Main Hospital and branch hospitals of the NTUH system was described as follows: (1) The Main Hospital had 24 dental X-ray machines including 17 for periapical radiography (PA), one for panoramic radiography (Pano), 5 for panoramic/cephalometric radiography (Pano/Ceph), and one for cone-beam computed tomography (CBCT); (2) The NTU Cancer Center had 3 dental X-ray machines including 2 for PA, one for Pano/Ceph/CBCT; (3) The Bei-Hu Branch had 2 dental X-ray machines including one for PA and one for Pano/Ceph/CBCT; (4) The Jin-Shan Branch had 2 dental X-ray machines including one for PA and one for Pano; (5) The Hsin-Chu Branch had 4 dental X-ray machines including 3 for PA, one for Pano/Ceph/CBCT; (6) The Chu-Bei District of BioMedical Park Branch had 2 dental X-ray machines including one for PA and one for Pano/Ceph/CBCT; (7) The Chu-Tung District of BioMedical Park Branch had 2 dental X-ray machines including one for PA and one for Pano/Ceph; (8) The Dou-Liu District of Yun-Lin Branch had 2 dental X-ray machines including one for PA and one for Pano; and (9) The Hu-Wei District of Yun-Lin Branch had 3 dental X-ray machines including one for PA, one for Pano/Ceph, and one for Pano/Ceph/CBCT.
(B) The schematic diagram presented the dental teleradiology operation model of the NTUH system. Action 1: The dental radiographs of patients were taken and the dental image files were saved in the dental dedicated server of the Main Hospital (Location B) or in the servers of the respective branch hospitals (Location C). Sometimes the branch hospitals might transfer their patients to the Main Hospital for advanced dental radiography. Action 2: The teleradiology management staff might be authorized to upload dental image files of designated patients to the main server of the Main Hospital (Location A). Action 3: The dentists could read and interpret the dental radiographs of their patients retrieved from the servers of their institutions (Location B or C), while they could also read and interpret the dental radiographs of designated patients retrieved from the main server of the Maim Hospital (Location A).

designated patients to the main server of the Main Hospital (Location A). Third, the dentists could read and interpret the dental radiographs of their patients retrieved from the servers of their institutions (Location B or C), while they could also read and interpret the dental radiographs of designated patients retrieved from the main server of the Maim Hospital (Location A, Fig. 1B).

The teleradiology has been widely used in the medical field, and there are even reports about the remote interpretation through a mobile handheld device.[2] Few studies have addressed the use of teleradiology in dentistry.[3] However, this study was focused on investigation of the dental teleradiology operation model within the NTUH system only. In the NTUH system, the main server of the Main Hospital acted as an intermediary and played a role of the dental imaging information sharing center. All the dental imaging files which were obtained in the dental departments of the Main Hospital or the respective branch hospitals could be uploaded to the main server of the Main Hospital, while all the clinicians (including the dentists and the physicians) of the NTUH system could read the dental images they specified through the dental teleradiology operation model. This operation model worked very well. For example, the otolaryngologists who needed to diagnose and treat their patients with sleep apnea could use the dental teleradiology operation model to obtain the cephalometric radiographs of their patients.

From an economic perspective, the use of the teleradiology operation model is efficient.[4,5] The dental teleradiology operation model of the NTUH system has the function of permanently saving and effectively managing dental imaging information. It serves as a platform for sharing dental images to ensure patient safety and reduce the risk of repeated radiological examinations. Introduction of the concept of teleradiology into the general dental practice may help in the differential diagnosis of jawbone and teeth-related lesions and reduce unnecessary radiation exposure and costs.[3]

## Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

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