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Perspective article

Survey of the distribution of dental X-ray machines in Taiwan's hospitals

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The X-ray was discovered by Wilhelm Conrad Roentgen in late 1895 and the first dental radiograph was born by a German dentist Otto Walkhoff who obtained an X-ray film of his own teeth in early 1896. However, the first X-ray machine for dentistry was manufactured by the current German company Siemens in 1905. In addition to the application of medical radiographic imaging for the diagnosis of whole body diseases, dental radiographic imaging has also been comprehensively used for the diagnosis of tooth and jawbone diseases all over the world.[1,2]

In fact, the development of dental radiology in Taiwan started as early as the Japanese colonial period (1895–1945), and its development is almost synchronized with the world.[3,4] Although there is no direct evidence to confirm when the first dental X-ray machine was introduced

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to Taiwan, there was an article that introduced the value of X-ray for the diagnosis of dental diseases with photobook published in the Journal of the Formosan Medical Association by the Taiwan Government Taipei Hospital in 1913.[5] To the best of our knowledge, this might prove that Taiwan already had dental X-ray machines before the early 1910s. Especially after the 1920s, the dental X-ray machines might have been the common equipment in the hospitals or the dental clinics in Taiwan.[6] In addition, there was another article that introduced the dental X-ray photography technology published in the Journal of the Taiwan Radiology Association by the Radiology Department of Taiwan Government Tainan Hospital in 1932.[5] This indicates that the dental X-ray machines may have been commonly used by the dentists for their dental practice in Taiwan by the 1930s. Therefore, the usage of dental X-ray machines has a history of more than 100 years in Taiwan.

Furthermore, dental radiology is crucial in daily dental practice. Various types of dental radiographies are used for the evaluation and diagnosis of dental and jawbone diseases. These include periapical, bite-wing, occlusal, panoramic, cephalometric, and temporomandibular joint (TMJ) radiographies, and cone-beam computed tomography (CBCT). Since Taiwan implemented National Health Insurance (NHI) in 1995, which covered the payment for treatment of a great proportion of medical and dental diseases, the usage of dental imaging equipment in Taiwan's dental profession has developed rapidly. In this article, we explored the distribution of dental X-ray machines among different levels of hospitals in Taiwan through an online survey study.

In Taiwan, however, dental radiology work is usually performed by the dentists themselves, especially in the dental clinics, while among the larger hospitals, it may be possible to have the dental radiation technologists (DRTs) who are responsible for the dental radiology work in the dental departments. The dental radiology division of National Taiwan University Hospital (NTUH) informally organized a group of the DRTs together in Taiwan.[7] Currently, there were 60 hospitals (including their branches and a dental hospital) in this informal group. During December 2023, we sent a questionnaire to the senior DRTs of these 60 hospitals using an online form for the survey of the content of dental X-ray machines in their hospitals through the interpersonal network of the dental radiology division of NTUH.

We divided dental X-ray machines into four major items based on the dental image types. These included dental X-ray machines for periapical radiography (type A), those for only panoramic/cephalometric radiography (type B), those for only CBCT (type C), and those for both panoramic/cephalometric radiography and the CBCT (type D). In addition to periapical radiography, type A machines also had the function for bite-wing and occlusal radiographies. Among type B machines, they included those for only panoramic radiography, those for only cephalometric radiography, or those for both panoramic and cephalometric radiographies combined in one machine. Among type D machines, they included those for both panoramic radiography and the CBCT combined in one machine (so-called two-in-one machine), or those for panoramic radiography, cephalometric radiography, and the CBCT combined in one machine (so-called three-in-one machine). In this survey, the respondents self-evaluated the content of dental X-ray machines in their departments to confirm that their dental X-ray machines belonged to which of the above-mentioned machine types. Furthermore, every respondent needed to fill in the number of each machine type they owned. Of the 60 senior DRTs who received the questionnaire, 59 completed the questionnaires and returned them to us for further analysis with a valid response rate of 98.33 %. The survey results are shown in Table 1.

Of the 59 hospitals with the DRTs responsible for the dental radiology work in their dental departments, the largest number was the metropolitan hospitals (22, 37.29 %), followed by the medical centers (21, 35.59 %), the local community hospitals (13, 22.03 %), and the would-be medical centers (3, 5.08 %). Among the total number of different types of dental X-ray machines, the largest number was the type A (195), followed by the type B (59), the type D (42), and the type C (19). Among the proportion of hospitals with different types of dental X-ray machines, the most popular type was the type A (100 %), followed by the type D (69.49 %), the type B (67.80 %), and the type C (30.51 %) (Table 1).

For the type A dental X-ray machines, all levels of hospitals had such machines. Among different levels of hospitals, the average number of the type A machines was largest in the medical centers (5.14), followed by the would-be medical centers (3.33), the metropolitan hospitals (2.45), and the local community hospitals (1.77) (Table 1).

For the type B dental X-ray machines, the proportion of hospitals with such machines was highest in the would-be medical centers (100 %), followed by the medical centers (80.95 %), the metropolitan hospitals (59.09 %), and the local community hospitals (53.85 %). Among them, the average number of the type B dental X-ray machines was largest in the would-be medical centers (1.67), followed by the medical centers (1.48), the local community hospitals (0.69), and the metropolitan hospitals (0.64) (Table 1).

For the type C dental X-ray machines, the proportion of hospitals with such machines was highest in the medical centers (52.38 %), followed by the would-be medical centers (33.33 %), the metropolitan hospitals (22.73 %), and the local community hospitals (7.69 %). Among them, the average number of the type C dental X-ray machines was largest in the medical centers (0.57), followed by the would-be medical centers (0.33), the metropolitan hospitals (0.23), and the local community hospitals (0.08) (Table 1).

For the type D dental X-ray machines, the proportion of hospitals with such machines was highest in the metropolitan hospitals (77.27 %), followed by the local community hospitals (76.92 %), the would-be medical centers (66.67 %), and the medical centers (57.14 %). Among them, the average number of the type D dental X-ray machines was largest in the metropolitan hospitals (0.77) and the local community hospitals (0.77), followed by the would-be medical centers (0.67) and the medical centers (0.62) (Table 1).

Furthermore, the proportion of hospitals comprehensively providing periapical radiography, panoramic/cephalometric radiography, and the CBCT was 93.22 % in overall. Among them, the highest proportion was in the would-be medical centers (100 %), followed by the metropolitan

Table 1 Distribution of dental X-ray machines among different levels of hospitals with the dental radiation technologists (DRTs) responsible for the dental radiology work in the dental departments.

	Medical center	Would-be medical center	Metropolitan hospital	Local community hospital[a]	Overall
Number of hospitals with the DRTs	21	3	22	13	59
A. Dental X-ray machines for periapical radiography					
Number of machines					
1 machine	0	0	6	6	12
2 machines	1	1	9	6	17
3 machines	5	1	3	0	9
4 machines	5	0	0	0	5
5 machines	2	1	3	1	7
6 machines	5	0	1	0	6
7 machines	2	0	0	0	2
17 machines	1	0	0	0	1
Total number	108	10	54	23	195
Average number	5.14	3.33	2.45	1.77	3.31
Range of machine quantity	2—17	2—5	1—6	1—5	1—17
Number of hospitals with such machines	21	3	22	13	59
Proportion of hospitals with such machines	100 %	100 %	100 %	100 %	100 %
B. Dental X-ray machines for only panoramic/cephalometric radiography[b]					
Number of machines					
None	4	0	9	6	19
1 machine	8	1	12	6	27
2 machines	6	2	1	0	9
3 machines	2	0	0	1	3
5 machines	1	0	0	0	1
Total number	31	5	14	9	59
Average number	1.48	1.67	0.64	0.69	1.00
Range of machine quantity	0—5	1—2	0—2	0—3	0—5
Number of hospitals with such machines	17	3	13	7	40
Proportion of hospitals with such machines	80.95 %	100 %	59.09 %	53.85 %	67.80 %
C. Dental X-ray machines for only cone-beam computed tomography (CBCT)					
Number of machines					
None	10	2	17	12	41
1 machine	10	1	5	1	17
2 machines	1	0	0	0	1
Total number	12	1	5	1	19
Average number	0.57	0.33	0.23	0.08	0.32
Range of machine quantity	0—2	0—1	0—1	0—1	0—2
Number of hospitals with such machines	11	1	5	1	18
Proportion of hospitals with such machines	52.38 %	33.33 %	22.73 %	7.69 %	30.51 %
D. Dental X-ray machines for both panoramic/cephalometric radiography and the CBCT[c]					
Number of machines					
None	9	1	5	3	18
1 machine	11	2	17	10	40
2 machines	1	0	0	0	1
Total number	13	2	17	10	42
Average number	0.62	0.67	0.77	0.77	0.71
Range of machine quantity	0—2	0—1	0—1	0—1	0—2
Number of hospitals with such machines	12	2	17	10	41
Proportion of hospitals with such machines	57.14 %	66.67 %	77.27 %	76.92 %	69.49 %
E. Hospitals providing only periapical and panoramic/cephalometric radiographies					
Number of such hospitals	1	0	1	2	4
Proportion of such hospitals	4.76 %	0	4.55 %	15.38 %	6.78 %

Table 1 (*continued*)

	Medical center	Would-be medical center	Metropolitan hospital	Local community hospital[a]	Overall
F. Hospitals comprehensively providing periapical radiography, panoramic/cephalometric radiography, and the CBCT					
Number of such hospitals	20	3	21	11	55
Proportion of such hospitals	95.24 %	100 %	95.45 %	84.62 %	93.22 %

[a] Among them, there was a dental hospital.
[b] Such dental X-ray machines included those for only panoramic radiography, those for only cephalometric radiography, or those for both panoramic and cephalometric radiographies combined in one machine.
[c] Such dental X-ray machines included those for both panoramic radiography and the CBCT combined in one machine (so-called two-in-one machine), or those for panoramic and cephalometric radiographies and the CBCT combined in one machine (so-called three-in-one machine).

hospitals (95.45 %), the medical centers (95.24 %), and the local community hospitals (84.62 %) (Table 1). However, the proportion of hospitals that provided only periapical and panoramic/cephalometric radiographies but did not provide the CBCT was only 6.78 % in overall. Among them, the highest proportion of such hospitals was the local community hospitals (15.38 %), followed by the medical centers (4.76 %) and the metropolitan hospitals (4.55 %), while the would-be medical centers did not have this situation (Table 1).

According to the statistics of the Ministry of Health and Welfare, there were 7184 dental institutions (including 215 hospitals with dental services and 6969 dental clinics) with 15,996 dentists in Taiwan in 2022.[8] Therefore, the number of the surveyed hospitals in this study only accounted for less than one-third of the number of those hospitals with dental services. This research limitation should be noted.

It has been at least more than a hundred years since the first dental X-ray machine was introduced to Taiwan. Various dental radiographies are essential for the daily dental practice. Based on the results of this study, periapical radiography is an absolutely necessary tool in the dental practice, while the dental X-ray machine for panoramic/cephalometric radiography has also become a basic dental equipment. The vast majority of the surveyed hospitals provided the CBCT. As far as we know, the CBCT is also commonly used in the local dental clinics in Taiwan. As the technology of dental X-ray machines improves, new and convenient two- or three-in-one models are gradually coming out. The medium and small hospitals (such as the metropolitan hospitals and the local community hospitals) predominantly use two- or three-in-one dental X-ray machines. In addition to these two- or three-in-one models, the large hospitals (such as the medical centers and the would-be medical centers) also use those with the CBCT only. This may be due to the need of the high-resolution quality of images for the diagnosis of dental and jawbone diseases in the medical centers. In fact, there are very few high-level dental radiology courses offered to medical radiology students or dental students in Taiwan.[6,9] The usage of dental X-ray machines during dental practice will become increasingly important in the future. Therefore, for medical radiation technologists (MRTs) or dentists, it is necessary to add both basic and high-level dental radiology courses or training in the undergraduate education, the post-graduation training, and the continuing education. In addition, the dental radiology work is also a job with relatively low risk of radiation exposure.[10] Due to the fact that there are still many hospitals with dental services that have not adopted DRTs responsible for the dental radiology work in their dental departments. It is possible that the dental radiology work is a potentially viable career option for the MRTs.

Declaration of competing interest

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

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