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Original Article

# The usage of dental cone-beam computed tomography during the COVID-19 pandemic (from 2020 to 2022): A survey of a regional hospital in the northern Taiwan

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## KEYWORDS

COVID-19 pandemic;  
Cone-beam computed  
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**Abstract** *Background/purpose:* In Taiwan, cone-beam computed tomography (CBCT) has already widely used in dentistry. This study explored preliminarily the usage of dental CBCT during the COVID-19 pandemic (from 2020 to 2022) through a survey of a regional hospital in the northern Taiwan.

*Materials and methods:* This study used purposeful sampling to select a regional hospital in the northern Taiwan to survey its usage of dental CBCT during the COVID-19 pandemic.

*Results:* In the surveyed hospital, the number of patients' visits for the usage of dental CBCT

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increased from 355 in 2020 to 449 in 2021 and further to 488 in 2022 with a growth rate of 37.46 %, while the growth rates compared to the previous year were 26.48 % in 2021 and 8.69 % in 2022, respectively. There were a total of 1292 patients' visits for the dental CBCT. The ages of the 1292 patients (573 males and 719 females) ranged from 4 to 89 years. The 50-59-year age group had the highest number of patients' visits (371, 28.72 %), followed in a descending order by the 60-69-year (293, 22.68 %) and 40-49-year (206, 15.94 %) age groups. The dental CBCT was used mainly for the assessment of dental implants, accounting for 1148 (78.85 %) of the total 1456 irradiations.

*Conclusion:* During the COVID-19 pandemic, the medical services for dental care and treatments in Taiwan are still maintained normally, and the dental CBCT is also used widely and popularly by the dental patients of all ages, various dental procedures, and various dental specialties.

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## Introduction

A pneumonia pandemic caused by a new coronavirus occurred globally at the end of 2019. The World Health Organization (WHO) named the disease as Coronavirus Disease 2019 (COVID-19), while the pathogen was named as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). This pandemic continued to expand internationally since 2020. The severe pandemic broke out in many countries and regions, while clusters of cases also occurred in many medical institutions. Therefore, all affected countries and regions closed their public facilities and schools, and restricted people's social activities as measures to prevent the pandemic or isolate the virus.<sup>1,2</sup> This also included stopping or postponing non-COVID-19 or non-life-threatening medical activities to focus medical care on COVID-19 related medical activities.

In fact, dental procedures for diagnosis and treatment involve the usage of dental and surgical instruments, such as dental handpieces, ultrasonic scalers, and air-water syringes. The usage of these instruments may produce droplet particles that contain water, saliva, blood, microorganisms, and other debris to create the risk of transmission of COVID-19 within the medical institutions.<sup>3,4</sup> Therefore, during the severe period of COVID-19 pandemic, some countries or regions even suspended dental activities. Although the medical and dental institutions in Taiwan could operate normally during this pandemic period, the government still recommended that patients shall postpone their non-urgent dental care (such as regular oral health check-ups or teeth scaling).

On the other hand, cone-beam computed tomography (CBCT), which is specifically designed for the examination of the jawbones and teeth, is a three-dimensional radiographic imaging technology that has become increasingly common in dentistry in recent years. Different from the traditional two-dimensional images, the three-dimensional images of CBCT can provide effective diagnosis and simulation information in dental implants, orthognathic surgery, extraction of impacted and supernumerary teeth, pathological evaluation of the jawbone and tooth diseases and oral cancer, and various oral and maxillofacial surgeries.<sup>5</sup> Even before the COVID-19 pandemic, dental institutions in Taiwan, especially dental departments in hospitals, had

already widely used this three-dimensional radiographic imaging technology in their daily dental procedures. The CBCT is usually used for planned dental treatment rather than temporarily urgent dental treatment. This study used a survey of a regional hospital in the northern Taiwan for its usage of dental CBCT during the COVID-19 pandemic (from 2020 to 2022) to understand the changes in the distribution of patients who received the dental CBCT examination during this pandemic period, and the application of CBCT for the evaluation of dental implants, impacted teeth, supernumerary teeth, and various dental treatments.

## Materials and methods

This study used purposeful sampling to select a regional hospital in the northern Taiwan where its dental department had an independent dental radiology division. We interviewed a senior medical radiation technologist who was responsible for supporting the dental radiology work in the dental department. The purpose of the interview was mainly to understand the dental radiology equipment, dental radiology manpower, and dental radiology execution model in this hospital. In addition, a survey was designed for collecting the data related to the usage of dental CBCT in this hospital during the COVID-19 pandemic (from 2020 to 2022). When performing each CBCT scan, the medical radiation technologist would summarize the basic information of each CBCT scan in the records. We collected the records of CBCT scan from 2020 to 2022, and extracted the data related to the gender and age of patient, the specialty department that requested the CBCT scan, the scan pattern, the inspection purpose, and the inspection sites. All research data obtained from the survey were stored in excel files and used for statistical analysis.

## Results

### The operations of dental radiology in the surveyed hospital

There was a Department of Diagnostic Radiology in the surveyed hospital where its medical radiation technologists

were responsible for all kinds of medical radiology work in the hospital. An independent dental radiology division was located within the Department of Dentistry where its dental radiology work was supported by the medical radiation technologists from the Department of Diagnostic Radiology. Three medical radiation technologists who had the ability to operate dental imaging equipment were responsible for supporting this work in the dental department. There were 2 radiography rooms in the dental radiology division. One had dental X-ray machines for periapical, panoramic, and cephalometric radiographies, while the other had dental X-ray machines for periapical, panoramic, and CBCT radiographies. Two medical radiation technologists were deployed every working day to maintain the operation of these 2 radiography rooms and were responsible for taking dental X-rays of the patients sent from various dental specialty departments.

### The number of patients' visits for dental CBCT in the surveyed hospital from 2020 to 2022

During the COVID-19 pandemic, the number of patients' visits for the usage of dental CBCT increased from 355 in 2020 to 449 in 2021 and further to 488 in 2022 with a growth rate of 37.46 %, while the growth rates compared to the previous year were 26.48 % in 2021 and 8.69 % in 2022, respectively (Table 1). During the three years of the pandemic, there were a total of 1292 patients' visits for dental CBCT with an average of 35.89 visits per month. Of the 1292 visits, there were 573 visits by males (44.35 %) and 719 visits by females (55.65 %). The ages of these patients ranged from 4 to 89 years. Among different age groups, the 50-59-year age group had the highest number of patients' visits (371, 28.72 %), followed in a descending order by the 60-69-year (293, 22.68 %), 40-49-year (206, 15.94 %), and

**Table 1** The number of patients' visits for the usage of dental cone-beam computed tomography (CBCT) in the surveyed hospital during the COVID-19 pandemic (from 2020 to 2022).

	2020		2021		2022		Increased number and growth rate <sup>a</sup>		Overall	
Number of patients' visits of the whole year	355		449		488		133		37.46 %	
Number of patients' visits per month	29.58		37.42		40.67		-		35.89	
Growth rate compared to the previous year	-		26.48 %		8.69 %		-		-	
<b>Gender distribution (number and proportion)</b>										
Male	153	43.10 %	201	44.77 %	219	44.88 %	66	43.14 %	573	44.35 %
Female	202	56.90 %	248	55.23 %	269	55.12 %	67	33.17 %	719	55.65 %
<b>Age distribution (number and proportion)</b>										
Age range (years)	6–89		6–88		4–89				4–89	
0–9 years	9	2.54 %	11	2.45 %	20	4.10 %	11	122.22 %	40	3.10 %
10–19 years	13	3.66 %	9	2.00 %	10	2.05 %	–3	–23.08 %	32	2.48 %
20–29 years	43	12.11 %	39	8.69 %	40	8.20 %	–3	–6.98 %	122	9.44 %
30–39 years	42	11.83 %	63	14.03 %	56	11.48 %	14	33.33 %	161	12.46 %
40–49 years	63	17.75 %	67	14.92 %	76	15.57 %	13	20.63 %	206	15.94 %
50–59 years	119	33.52 %	118	26.28 %	134	27.46 %	15	12.61 %	371	28.72 %
60–69 years	56	15.77 %	115	25.61 %	122	25.00 %	66	117.86 %	293	22.68 %
70–79 years	5	1.41 %	22	4.90 %	24	4.92 %	19	380 %	51	3.95 %
80–89 years	5	1.41 %	5	1.11 %	6	1.23 %	1	20 %	16	1.24 %
<b>Specialty distribution (number and proportion)</b>										
Postgraduate year training program for dentists (PGYD)	10	2.82 %	18	4.01 %	21	4.30 %	11	110 %	49	3.79 %
Oral and maxillofacial surgery	37	10.42 %	46	10.24 %	124	25.41 %	87	235.14 %	207	16.02 %
Orthodontics	10	2.82 %	10	2.23 %	10	2.05 %	0	0	30	2.32 %
Pediatric dentistry	1	0.28 %	6	1.34 %	13	2.66 %	12	1200 %	20	1.55 %
Endodontics	9	2.54 %	4	0.89 %	4	0.82 %	–5	–55.56 %	17	1.32 %
Prosthodontics	17	4.79 %	13	2.90 %	24	4.92 %	7	41.18 %	54	4.18 %
Operative dentistry	18	5.07 %	9	2.00 %	20	4.10 %	2	11.11 %	47	3.64 %
Periodontics	41	11.55 %	41	9.13 %	35	7.17 %	–6	–14.63 %	117	9.06 %
Family dentistry	212	59.72 %	302	67.26 %	237	48.57 %	25	11.79 %	751	58.13 %

<sup>a</sup> The increased number and growth rate in 2022 compared to 2020.

30-39-year (161, 12.46 %) age groups. For the increased number and growth rate in 2022 compared to 2020, the 60-69-year age group had the highest increased number of patients' visits (66, 117.86 %), while the 70-79-year age group had the highest growth rate (19, 380 %). In addition, among different patient groups from various dental specialty departments, family dentistry had the highest number of patients' visits (751, 58.13 %), followed in a descending order by oral and maxillofacial surgery (207, 16.02 %), periodontics (117, 9.06 %), and prosthodontics (54, 4.18 %). Of different dental specialty departments, oral and maxillofacial surgery had the highest increased number of patients' visits (87, 235.14 %), while pediatric dentistry had the highest growth rate (12, 1200 %).

### The number of irradiations for dental CBCT in the surveyed hospital from 2020 to 2022

Based on different inspection purposes, it should be noted that the patients might receive more than two dental CBCT irradiations in one visit. During the COVID-19 pandemic, the number of irradiations for the usage of dental CBCT increased from 403 in 2020 to 505 in 2021 and further to 548 in 2022 with a growth rate of 35.98 %, while the growth rates compared to the previous year were 25.31 % in 2021 and 8.51 % in 2022, respectively (Table 2). During the three years of the pandemic, there were a total of 1456 irradiations for dental CBCT with an average of 40.44 irradiations per month. Of the 1456 irradiations, the most commonly

**Table 2** The number of irradiations for the usage of dental cone-beam computed tomography (CBCT) in the surveyed hospital during the COVID-19 pandemic (from 2020 to 2022).

	2020		2021		2022		Increased number and growth rate <sup>a</sup>		Overall	
Number of irradiations of the whole year	403		505		548		145		35.98 %	
Number of irradiations per month	33.58		42.08		45.67		-		40.44	
Growth rate compared to the previous year	-		25.31 %		8.51 %		-		-	
<b>Distribution of scan pattern (number and proportion)<sup>b</sup></b>										
D mode (8 cm × 8 cm)	373	92.56 %	478	94.65 %	484	88.32 %	111	29.76 %	1335	91.69 %
D mode (5 cm × 6 cm)	0	0	2	0.40 %	13	2.37 %	13	-	15	1.03 %
D mode (5 cm × 7 cm)	0	0	1	0.20 %	16	2.92 %	16	-	17	1.17 %
I mode (8 cm × 8 cm)	30	7.44 %	24	4.75 %	35	6.39 %	5	16.67 %	89	6.11 %
<b>Distribution of inspection purpose (number and proportion)</b>										
Preoperative and intraoperative assessment of dental implants	156	38.71 %	192	38.02 %	236	43.07 %	80	51.28 %	584	40.11 %
Postoperative assessment of dental implants	133	33.00 %	198	39.21 %	182	33.21 %	49	36.84 %	513	35.23 %
Postoperative assessment of bone grafting	14	3.47 %	15	2.97 %	22	4.01 %	8	57.14 %	51	3.50 %
Evaluation of impacted teeth	12	2.98 %	10	1.98 %	17	3.10 %	5	41.67 %	39	2.68 %
Evaluation of supernumerary teeth	32	7.94 %	20	3.96 %	29	5.29 %	-3	-9.38 %	81	5.56 %
Assessment of jawbone lesions and condition	6	1.49 %	8	1.58 %	9	1.64 %	3	50 %	23	1.58 %
Assessment of orthodontic treatment	5	1.24 %	4	0.79 %	4	0.73 %	-1	-20 %	13	0.89 %
Assessment of endodontic treatment	29	7.20 %	45	8.91 %	30	5.47 %	1	3.45 %	104	7.14 %
Assessment of dental hard tissue condition	0	0	4	0.79 %	1	0.18 %	1	-	5	0.34 %
Assessment of prosthodontic reconstruction	2	0.50 %	0	0	0	0	-2	-100 %	2	0.14 %
Assessment of periodontal condition	0	0	1	0.20 %	1	0.18 %	1	-	2	0.14 %
Uncertainty	14	3.47 %	8	1.58 %	17	3.10 %	3	21.43 %	39	2.68 %

<sup>a</sup> The increased number and growth rate in 2022 compared to 2020.

<sup>b</sup> This is the scan pattern based on the equipment - Asahi CBCT X-ray Computed Tomography (AZ3000CT).

used scan pattern was the D mode (8 cm × 8 cm; 1335 times or 91.69 %), followed by the I mode (8 cm × 8 cm; 89 times or 6.11 %). Among different inspection purposes, the most common inspection purpose was the preoperative and intraoperative assessment of dental implants (584 times or 40.11 %), followed in a descending order by the postoperative assessment of dental implants (513 times or 35.23 %), assessment of endodontic treatment (104 times or 7.14 %), supernumerary tooth evaluation (81 times or 5.56 %), postoperative assessment of bone grafting (51 times or 3.50 %), and impacted tooth evaluation (39 times or 2.68 %). Among them, the inspection purpose for the preoperative and intraoperative assessment of dental implants had the highest increased number (80 times, 51.28 %), while that for the postoperative assessment of bone grafting had the highest growth rate (8 times, 57.14 %).

### The number of inspection sites for dental CBCT in the surveyed hospital from 2020 to 2022

Based on different inspection sites, it should be noted that one dental CBCT irradiation might involve more than two inspection sites. During the COVID-19 pandemic, the number of inspection sites for the usage of dental CBCT increased from 432 in 2020 to 542 in 2021 and further to 588 in 2022 with a growth rate of 36.11 %, while the growth rates compared to the previous year were 25.46 % in 2021 and 8.49 % in 2022, respectively (Table 3). During the three years of the pandemic, there were a total of 1562 inspection sites for dental CBCT with an average of 43.39 per month. Of the 1562 inspection sites, the most common inspection site was the mandibular posterior region (604

times or 38.67 %), followed in a descending order by the maxillary posterior region (506 times or 32.39 %), the maxillary anterior region (316 times or 20.23 %), the mandibular anterior region (88 times or 5.63 %), and the maxillary bone (22 times or 1.41 %). Among them, the inspection site for the maxillary posterior region had the highest increased number (69 times, 53.91 %), while that for the full mouth had the highest growth rate (5 times, 250 %).

### The usage of dental CBCT for assessment or evaluation of dental implants, impacted teeth, supernumerary teeth, and endodontic treatments in the surveyed hospital from 2020 to 2022

For preoperative, intraoperative and postoperative assessment of dental implants and postoperative assessment of bone grafting, their number of patients' visits for the usage of dental CBCT increased from 266 in 2020 to 352 in 2021 and further to 384 in 2022 with a growth rate of 44.36 %, while the growth rates compared to the previous year were 32.33 % in 2021 and 9.09 % in 2022, respectively (Table 4). During the three years of the pandemic, there were a total of 1002 patients' visits for dental CBCT with an average of 27.83 visits per month. Of the 1002 visits assessed, there were 442 visits by males (44.11 %) and 560 visits by females (55.89 %). The ages of these patients ranged from 15 to 89 years. Among different age groups, the 50-59-year age group had the highest number of patients' visits (323, 32.24 %), followed in a descending order by the 60-69-year (259, 25.85 %), 40-49-year (173, 17.27 %), and 30-39-year (120, 11.98 %) age groups. For the increased number and growth rate in 2022 compared to 2020, the 60-69-year age

**Table 3** The number of inspection sites for the usage of dental cone-beam computed tomography (CBCT) in the surveyed hospital during the COVID-19 pandemic (from 2020 to 2022).

	2020		2021		2022		Increased number and growth rate <sup>a</sup>		Overall	
Number of inspection sites of the whole year	432		542		588		156	36.11 %	1562	
Number of inspection sites per month	36		45.17		49		-		43.39	
Growth rate compared to the previous year	-		25.46 %		8.49 %		-		-	
<b>Distribution of inspection sites (number and proportion)</b>										
Maxillary anterior region	95	21.99 %	100	18.45 %	121	20.58 %	26	27.37 %	316	20.23 %
Maxillary posterior region	128	29.63 %	181	33.39 %	197	33.50 %	69	53.91 %	506	32.39 %
Mandibular anterior region	19	4.40 %	32	5.90 %	37	6.29 %	18	94.74 %	88	5.63 %
Mandibular posterior region	169	39.12 %	214	39.48 %	221	37.59 %	52	30.77 %	604	38.67 %
Maxillary bone	13	3.01 %	7	1.29 %	2	0.34 %	-11	-84.62 %	22	1.41 %
Mandibular bone	4	0.93 %	3	0.55 %	0	0	-4	-100 %	7	0.45 %
Full mouth	2	0.46 %	4	0.74 %	7	1.19 %	5	250 %	13	0.83 %
Uncertainty	2	0.46 %	1	0.18 %	3	0.51 %	1	50 %	6	0.38 %

<sup>a</sup> The increased number and growth rate in 2022 compared to 2020.



**Table 4** The usage of dental cone-beam computed tomography (CBCT) for the assessment related to dental implants in the surveyed hospital during the COVID-19 pandemic (from 2020 to 2022).

	2020		2021		2022		Increased number and growth rate <sup>a</sup>		Overall	
<b>Assessment related to dental implants</b>										
Number of patients' visits of the whole year	266		352		384		118		44.36 %	
Number of patients' visits per month	22.17		29.33		32		-		27.83	
Growth rate compared to the previous year	-		32.33 %		9.09 %		-		-	
<b>Gender distribution (number and proportion)</b>										
Male	116	43.61 %	157	44.60 %	169	44.01 %	53	45.69 %	442	44.11 %
Female	150	56.39 %	195	55.40 %	215	55.99 %	65	43.33 %	560	55.89 %
<b>Age distribution (number and proportion)</b>										
Age range (years)	21–89		19–88		15–89				15–89	
0–9 years	0	0	0	0	0	0	0	-	0	0
10–19 years	0	0	2	0.57 %	1	0.26 %	1	-	3	0.30 %
20–29 years	19	7.14 %	28	7.95 %	22	5.73 %	3	15.79 %	69	6.89 %
30–39 years	30	11.28 %	47	13.35 %	43	11.20 %	13	43.33 %	120	11.98 %
40–49 years	53	19.92 %	54	15.34 %	66	17.19 %	13	24.53 %	173	17.27 %
50–59 years	110	41.35 %	96	27.27 %	117	30.47 %	7	6.36 %	323	32.24 %
60–69 years	47	17.67 %	104	29.55 %	108	28.13 %	61	129.79 %	259	25.85 %
70–79 years	3	1.13 %	18	5.11 %	22	5.73 %	19	633.33 %	43	4.29 %
80–89 years	4	1.50 %	3	0.85 %	5	1.30 %	1	25 %	12	1.20 %

<sup>a</sup> The increased number and growth rate in 2022 compared to 2020.

group had the highest increased number (61, 129.79 %), while the 70-79-year age group had the highest growth rate (19, 633.33 %).

For impacted tooth evaluation, the number of patients' visits for the usage of dental CBCT increased from 8 in 2020 to 9 in 2021 and further to 16 in 2022 with a growth rate of 100 %, while the growth rates compared to the previous year were 12.5 % in 2021 and 77.78 % in 2022, respectively (Table 5). During the three years of the pandemic, there were a total of 33 patients' visits for dental CBCT with an average of 0.92 visits per month. Of the 33 visits, there were 8 visits by males (24.24 %) and 25 visits by females (75.76 %). The ages of these patients ranged from 8 to 59 years. Among the different age groups, the 20-29-year age group had the highest number of patients' visits (14, 42.42 %), followed in a descending order by the 30-39-year (8, 24.24 %) and 10-19-year (6, 18.18 %) age groups.

For supernumerary tooth evaluation, the number of patients' visits for the usage of dental CBCT decreased from 28 in 2020 to 20 in 2021 and further increased to 28 in 2022 (Table 6). During the three years of the pandemic, there were a total of 76 patients' visits for dental CBCT with an average of 2.11 visits per month. Of the 76 visits, there were 44 visits by males (57.89 %) and 32 visits by females (42.11 %). The ages of these patients ranged from 4 to 68 years. Among the different age groups, the 0-9-year age group had the highest number of patients' visits (35, 46.05 %), followed in a descending order by the 20-29-year (17, 22.37 %) and 10-19-year (16, 21.05 %) age groups.

For assessment of endodontic treatment, the number of patients' visits for the usage of dental CBCT increased from

28 in 2020 to 43 in 2021 and further decreased to 29 in 2022 (Table 7). During the three years of the pandemic, there were a total of 100 patients' visits for dental CBCT with an average of 2.78 visits per month. Of the 100 visits, there were 51 visits by males (51 %) and 49 visits by females (49 %). The ages of these patients ranged from 23 to 85 years. Among the different age groups, the 50-59-year age group had the highest number of patients' visits (29, 29 %), followed in a descending order by the 60-69-year (22, 22 %) and 40-49-year (19, 19 %) age groups.

## Discussion

Since the global outbreak of COVID-19 at the end of 2019, till October 18, 2023, there have been 771,407,825 confirmed cases of COVID-19 globally, including 6,972,152 deaths reported to WHO.<sup>6</sup> In Taiwan, from the global outbreak of COVID-19 to April 2020, there were only a few local confirmed cases. Then, from May 2020 to November 2020, there was even none of the new local confirmed case. However, from December 2020, the number of new local confirmed cases gradually increased. By May 2021, the pandemic broke out greatly in Taiwan. At the end of 2022, there have been 8,847,360 confirmed cases, including 14,056 deaths reported by Taiwan Centers for Disease Control (CDC), also causing unprecedented impact and tension throughout Taiwan.<sup>7</sup>

Although the global pandemic has slightly ceased with its downward trend since 2023, during the three years of the pandemic (from 2020 to 2022), there were still great differences in the level of the pandemic in various countries

**Table 5** The usage of dental cone-beam computed tomography (CBCT) for the evaluation of impacted teeth in the surveyed hospital during the COVID-19 pandemic (from 2020 to 2022).

	2020		2021		2022		Increased number and growth rate <sup>a</sup>		Overall	
<b>Impacted tooth evaluation</b>										
Number of patients' visits of the whole year	8		9		16		8		100 %	
Number of patients' visits per month	0.67		0.75		1.33		-		0.92	
Growth rate compared to the previous year	-		12.5 %		77.78 %		-		-	
<b>Gender distribution (number and proportion)</b>										
Male	2	25 %	2	22.22 %	4	25 %	2	100 %	8	24.24 %
Female	6	75 %	7	77.78 %	12	75 %	6	100 %	25	75.76 %
<b>Age distribution (number and proportion)</b>										
Age range (years)	8–37		11–59		10–52				8–59	
0–9 years	1	12.5 %	0	0	0	0	-1	-100 %	1	3.03 %
10–19 years	2	25 %	2	22.22 %	2	12.5 %	0	0	6	18.18 %
20–29 years	4	50 %	2	22.22 %	8	50 %	4	100 %	14	42.42 %
30–39 years	1	12.5 %	3	33.33 %	4	25 %	3	300 %	8	24.24 %
40–49 years	0	0	1	11.11 %	0	0	0	-	1	3.03 %
50–59 years	0	0	1	11.11 %	2	12.5 %	2	-	3	9.09 %
60–69 years	0	0	0	0	0	0	0	-	0	0
70–79 years	0	0	0	0	0	0	0	-	0	0
80–89 years	0	0	0	0	0	0	0	-	0	0

<sup>a</sup> The increased number and growth rate in 2022 compared to 2020.

**Table 6** The usage of dental cone-beam computed tomography (CBCT) for the evaluation of supernumerary teeth in the surveyed hospital during the COVID-19 pandemic (from 2020 to 2022).

	2020		2021		2022		Increased number and growth rate <sup>a</sup>		Overall	
<b>Supernumerary tooth evaluation</b>										
Number of patients' visits of the whole year	28		20		28		0		0	
Number of patients' visits per month	2.33		1.67		2.33		-		2.11	
Growth rate compared to the previous year	-		-28.57 %		40 %		-		-	
<b>Gender distribution (number and proportion)</b>										
Male	14	50 %	11	55 %	19	67.86 %	5	35.71 %	44	57.89 %
Female	14	50 %	9	45 %	9	32.14 %	-5	-35.71 %	32	42.11 %
<b>Age distribution (number and proportion)</b>										
Age range (years)	6–48		6–68		4–53				4–68	
0–9 years	6	21.43 %	9	45 %	20	71.43 %	14	233.33 %	35	46.05 %
10–19 years	8	28.57 %	4	20 %	4	14.29 %	-4	-50 %	16	21.05 %
20–29 years	9	32.14 %	5	25 %	3	10.71 %	-6	-66.67 %	17	22.37 %
30–39 years	4	14.29 %	1	5 %	0	0	-4	-100 %	5	6.58 %
40–49 years	1	3.57 %	0	0	0	0	-1	-100 %	1	1.32 %
50–59 years	0	0	0	0	1	3.57 %	1	-	1	1.32 %
60–69 years	0	0	1	5 %	0	0	0	-	1	1.32 %
70–79 years	0	0	0	0	0	0	0	-	0	0
80–89 years	0	0	0	0	0	0	0	-	0	0

<sup>a</sup> The increased number and growth rate in 2022 compared to 2020.

**Table 7** The usage of dental cone-beam computed tomography (CBCT) for the assessment of endodontic treatment in the surveyed hospital during the COVID-19 pandemic (from 2020 to 2022).

	2020		2021		2022		Increased number and growth rate <sup>a</sup>		Overall	
<b>Assessment of endodontic treatment</b>										
Number of patients' visits of the whole year	28		43		29		1		3.57 %	
Number of patients' visits per month	2.33		3.58		2.42		-		2.78	
Growth rate compared to the previous year	-		53.57 %		-32.56 %		-		-	
<b>Gender distribution (number and proportion)</b>										
Male	12	42.86 %	22	51.16 %	17	58.62 %	5	41.67 %	51	51 %
Female	16	57.14 %	21	48.84 %	12	41.38 %	-4	-25 %	49	49 %
<b>Age distribution (number and proportion)</b>										
Age range (years)	23–69		26–85		24–71				23–85	
0–9 years	0	0	0	0	0	0	0	-	0	0
10–19 years	0	0	0	0	0	0	0	-	0	0
20–29 years	5	17.86 %	1	2.33 %	3	10.34 %	-2	-40 %	9	9 %
30–39 years	6	21.43 %	6	13.95 %	2	6.90 %	-4	-66.67 %	14	14 %
40–49 years	4	14.29 %	8	18.60 %	7	24.14 %	3	75 %	19	19 %
50–59 years	5	17.86 %	15	34.88 %	9	31.03 %	4	80 %	29	29 %
60–69 years	8	28.57 %	7	16.28 %	7	24.14 %	-1	-12.5 %	22	22 %
70–79 years	0	0	4	9.30 %	1	3.45 %	1	-	5	5 %
80–89 years	0	0	2	4.65 %	0	0	0	-	2	2 %

<sup>a</sup> The increased number and growth rate in 2022 compared to 2020.

and regions around the world. In order to prevent the spread of the pandemic, governments in various countries and regions have closed their public facilities and schools, and restricted people's social activities as measures.<sup>1,2</sup> Through the internet, online meetings or online courses can still allow many social activities and educational activities to continue during the pandemic.<sup>8,9</sup> However, some medical activities that must be face-to-face cannot be completed by the online mode alone. Therefore, it is crucial to maintain the normal operation of medical institutions physically rather than online.

The COVID-19 infection can be spread through droplets transmission, which can be caused by the direct contact through contact with mucous membranes of the mouth, nose, and eyes of the face or by the indirect contact through droplets settling on the objects and then being touched by the hands. Dental practice mainly takes place in the oral cavity. Saliva, blood, secretions or potential bacteria and viruses in the mouth can be easily transmitted through splatter, droplets, and aerosols produced by dental handpieces, ultrasonic scalers, and air-water syringes. Therefore, dental staff and their patients are always at a high risk of exposure to pathogens during the dental procedures.<sup>3,4</sup>

Taiwan CDC announced dental guidelines for COVID-19 infection control in August 2020, and further recommended in another announcement that treatments or examinations for non-urgent medical needs, including teeth scaling and oral examinations, shall be postponed. According to our observation, after the global outbreak of COVID-19 at the end of 2019, many dental patients in Taiwan did voluntarily

postpone their oral treatment plans based on the implementation of independent health management. The dental CBCT is most commonly used for the assessment or evaluation of planned dental treatments (such as assessment for dental implants, prosthodontic reconstruction, orthodontic, endodontic and periodontal treatments, extraction of impacted and supernumerary teeth, and evaluation or surgical treatments of pathological lesions in the oral and maxillofacial regions) rather than temporary dental treatments.

In this study, the number of patients' visits for the dental CBCT usage in the surveyed hospital increased from 355 in 2020 to 449 in 2021 with a growth rate of 26.48 % compared to 2020, and then further increased to 488 in 2022 with a growth rate of 8.69 % compared to 2021. In overall, the growth rate in 2022 was 37.46 % compared to 2020. This finding indicates that in the first year of the global pandemic (2020), more patients voluntarily postpone their oral treatment plans. Although the global pandemic has lasted for three years, new local confirmed patients of COVID-19 increased in Taiwan in December 2020, and the pandemic of Taiwan entered the great outbreak stage in May 2021, this seemed not to affect patients' arrangements for receiving dental treatments and this fact could also be approved by the continued increase in the number of patients' visits for the dental CBCT usage in the surveyed hospital in 2021 and 2022. In Taiwan, due to the effectiveness of pandemic prevention, the execution for dental care could continue uninterruptedly and recover quickly during the pandemic. In addition, from 2020 to 2022 there were 573 visits by male patients (44.35 %) and 719 visits by



female patients (55.65 %) using the dental CBCT for evaluation and treatments of special dental diseases or conditions. It needs further researches to assess whether male and female dental patients have a difference in the decision-making for dental treatments during the pandemic.

Our findings undoubtedly confirm that the need for CBCT usage in dental procedures covers patients of all ages, and that the usage of CBCT for the dental patients is relatively popular for the assessment or evaluation of various dental procedures, including preoperative, intraoperative and postoperative assessment of dental implants, postoperative assessment of bone grafting, evaluation of impacted teeth and supernumerary teeth, and assessment of the jawbone lesions, orthodontic treatment, endodontic treatment, dental hard tissue condition, prosthodontic reconstruction, and periodontal condition. In addition, in the surveyed hospital, the dentists of various specialties and the trainees of postgraduate year training program for dentists (PGYD) all used CBCT for evaluation of special dental conditions and determination of their subsequent dental treatment procedures. Our findings are enough to reveal that the usage of CBCT has been relatively popular in Taiwan's dental profession. Unlike dental X-ray machines for periapical radiographies, which involve intraoral operations, the dental CBCT operations do not contact the patient's oral cavity, greatly reducing the risk of spread of SARS-CoV-2 or other pathogens to medical radiation technologists. This also demonstrates the potential advantage of using CBCT for the dental patients during the pandemic.

On the other hand, according to Taiwan CDC statistics, among the cumulative deaths from COVID-19 in Taiwan by the end of 2022, deaths of the patients over the age of 60 accounted for more than 90 %, while deaths of the patients over the age of 50 accounted for more than 95 %.<sup>7</sup> In this study, from 2020 to 2022, the 50-59-year age group had the highest number of patients' visits for dental CBCT usage (371, 28.72 %), followed by the 60-69-year age group (293, 22.68 %) in overall. In addition, the 60-69-year age group had the highest increased number of patients' visits (66, 117.86 %), while the 70-79-year age group had the highest growth rate (19, 380 %) in 2022 compared to 2020. The dental CBCT is most commonly used for the assessment of dental implants in dental patients, while most of these patients are elderly. It means that during the long-lasting pandemic, the impact of pandemic factors on the decision-making of dental treatments in elderly patients decreased in 2020. Therefore, the number of their visits to the hospital for dental treatments increased rapidly in 2021 and 2022. This also reflects their confidence in the effectiveness of the pandemic prevention recommended by the government.

Furthermore, our results indicate that the dental CBCT was used mainly for the assessment of dental implants, accounting for 78.85 % (1148 irradiations) of the total 1456 CBCT irradiations, while the inspection site of dental CBCT was dominated by the mandibular posterior region (604/1562 or 38.67 %) and maxillary posterior region (506/1562 or 32.39 %). Among different inspection purposes, their gender distribution and age distribution of patients were also different. This means that different oral diseases or

problems may have different incidence rates and dental treatment determinants among patients of different genders and age groups. For example, in this study, the 20-29-year age group had the highest number of patients' visits (14, 42.42 %) for the impacted tooth evaluation by dental CBCT, while the 0-9-year age group had the highest number of patients' visits (35, 46.05 %) for the supernumerary tooth evaluation by dental CBCT. This gives us an inspiration that the collection and analysis of dental radiography data can contribute to the research of oral epidemiology, just like our previous studies of the supernumerary teeth and odontomas.<sup>10,11</sup>

Therefore, we conclude that during the COVID-19 pandemic, the medical services for dental care and treatments in Taiwan are still maintained normally, and the dental CBCT is also used widely and popularly by the dental patients of all ages, various dental procedures, and various dental specialties.

## Declaration of competing interest

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

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