



Research Article

Impact of COVID-19 pandemic on using dental radiography

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ABSTRACT

Objectives: This study aimed to analyze the impact of the COVID-19 pandemic on using dental radiography.

Materials and Methods: This retrospective study included adult patients who applied at 3-time intervals reflecting changes in the course of the COVID-19 pandemic in 2020 (T1-T2-T3). Patients' demographics, the number of radiographic and clinical procedures provided, and radiographic findings were noted during T1-T2-T3.

Results: The frequency of using dental radiography was the lowest at the beginning of the pandemic and significantly increased over time. Using radiography increased when the number of COVID-19 cases increased. The course of the COVID-19 disease did not affect using radiography by dentists. The use of dental radiography in elderly patients was found to be less than in younger patients. Invasive treatments applied to the patients who had radiographs were significantly higher than those who had not at T2 and T3.

Conclusion: This study demonstrated the changes in dental radiographic procedures during the pandemic. It was ordered to avoid intraoral radiography as much as possible due to aerosol production during the COVID-19 pandemic. To make better use of dental radiography, manufacturers should improve extraoral radiography with better image quality with lower radiation doses.

Keywords: COVID-19, Dental radiography, Intraoral radiography, Panoramic radiography, Cone-beam computed tomography

INTRODUCTION

The COVID-19 pandemic affected the world and changed all healthcare services. The dental practice had a higher risk of cross-infection compared to many medical disciplines due to droplets and aerosols.^[1] Infection control protocols were published in dentistry and oral maxillofacial radiology applications specific to COVID-19 disease.^[2-4] It was ordered that intraoral radiography should not be used as much as possible due to aerosol production, and extraoral radiographs should be preferred instead of it.^[1,5] While the use of radiography may be needed in the diagnosis and treatment planning of urgent cases,^[2,6] the limited use of intraoral radiography makes it difficult to reveal the clinical problem. The basic principle in the imaging request is to clarify that clinical evaluation is insufficient for definitive diagnosis and treatment planning.

Articles presenting a strategy for the practice of oral and maxillofacial radiology during the COVID-19 pandemic are very limited^[2-4] and clinical data on changes in radiographic procedures were not presented.

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The purpose of our study was to analyze using dental radiography by evaluating and comparing the frequency of radiographs of patients admitted to a university dental hospital and the characteristics of the patients during the COVID-19 pandemic time points reflecting changes in the course of the disease in 2020.

MATERIALS AND METHODS

This study was approved by the Ethics Committee of Ankara Yıldırım Beyazıt University (2021–68). We planned a retrospective study that included adult patients who applied to Ankara Yıldırım Beyazıt University Faculty of Dentistry.

We collected data at three different time intervals. These periods were:

- T1: The 3 days of the month when the first official COVID-19 case was announced in Turkey, several restrictions were started, and when our hospital's adaptation process begins to improve (March 23–25, 2020).
- T2: The 3 days of the month when the number of cases decreased in Turkey and the restrictions were eased with gradual normalization (June 1–3, 2020).
- T3: The 3 days of the month when the number of COVID-19 cases increased again (second peak in Turkey) and tighter restrictions started (November 1–3, 2020).

The data of the study group were obtained from electronic hospital records. Patients with inadequate radiographic image quality and patients under the age of 15 were excluded from the study. Patients with a full diagnostic record were included in this study.

Patients' age and sex and dental clinical and radiographic procedures provided (on the day of their application to the hospital at T1, T2, and T3) were noted and their panoramic, intraoral, and Cone-beam computed tomography (CBCT) radiographs were examined. Each image was evaluated after blinding each reviewer from the other. Radiographic findings were evaluated according to eight subcategories: Caries (primary/secondary), pulp-related caries, periapical infectious lesion, periodontal disease, pericoronitis, crown/cusp/root fracture, impacted teeth, and others (such as cyst, tumor, jaw fracture, periimplantitis, and temporomandibular disorder findings). For this study, common causes of dental urgency^[7] were considered when creating these categories. The radiographic diagnosis was made by the consensus of three dentomaxillofacial radiologists (EYK, ZBA, and B.Ç).

The dental clinical procedures included invasive dental procedures (aerosol and/or non-aerosol generating) and non-invasive procedures (prescription/advise/no dental procedure). We did not categorize dental treatments as aerosol and/or non-aerosol generating because the procedures that produce aerosols were not clear.^[8,9] The items

of invasive treatments provided were classified into six main treatment areas: Restorative, endodontic, surgical prosthetic, periodontal treatments, and other surgical procedures. Orthodontic urgencies were not included in the study because we cannot see the records of orthodontics and pedodontics clinics in the electronic hospital software program.

Statistical analysis

Data were analyzed with Chi-square and Kruskal–Wallis H test using SPSS Version 21 (IBM Corp, Armonk, NY) statistical program. The significance level was determined as $P < 0.05$.

RESULTS

Patients' demographics

The comparisons of the patients' demographics and distribution of radiographic procedures among the COVID-19 pandemic time points (T1, T2, and T3) are presented in Table 1.

The mean age of the patients was significantly higher at T1 (47.4%) than at T2 (43.3%) and at T3 (43.3%) ($P = 0.0001 < 0.05$). The frequency of male patients was found to be higher than females at T1 and T2, while, found to be lower than for females at T3 ($P = 0.006 < 0.05$).

Radiographic procedures of the patients

The frequency of the patients who had a radiographic procedure was the lowest at T1 and was the highest (46.6%) at T3 [Table 1].

Radiographic procedures of those aged 65 and over

The number of radiographic procedures for patients aged 65 and over was lower than for those aged 64 and below [Table 2].

Radiographic findings

Values for radiographic findings at T1, T2, and T3 are provided in Table 3. Radiographic images of 16 of 767 (2%) patients were normal.

Variables of using CBCT are shown in Table 4. Reported signs related to the CBCT images were limited to the scanning area.

Correlations between treatments and radiography provided

The correlations between provided treatments and radiography at T1, T2, and T3 are presented in Table 5.

There was no significant dependence between providing radiography and dental treatments regarding invasive and

Table 1: Patients' demographics during COVID-19 pandemic and distribution of radiographic procedures.

	T1	T2	T3	Total	P
Age					
Average	47.4	43.3	43.3		0.0001
Median	48	43	42		
Min-max	15-88	15-90	15-93		
Gender (number/%)				Total	
Female	296 (44.4)	458 (49.5)	472 (52.6)	1226 (49.3)	0.006
Male	370 (55.6)	468 (50.5)	425 (47.4)	1263 (50.7)	
Radiographic procedures (number/percent)					
Patients without a radiographic procedure	644 (96.7)	599 (64.7)	479 (53.4)	1722 (69.2)	0.0001
Patients with a radiographic procedure	22 (3.3)	327 (35.3)	418 (46.6)	767 (30.8)	
Total	666 (100)	926 (100)	897 (100)	2489 (100)	
Radiographic technics (number/percent)					
Intraoral	2 (9.1)	4 (1.2)	45 (10.8)	51 (6.6)	0.0001
Panoramic	22 (100)	326 (99.7)	391 (93.5)	739 (96.3)	0.0001
CBCT	0 (0)	1 (0.3)	9 (2.2)	10 (1.3)	0.084

The total number of patients provided radiography is less than the total number of radiographs because some patients had one more radiograph. $P < 0.05$, CBCT: Cone beam computed tomography

Table 2: Correlations of radiography provided (per patient) of the age groups at T1, T2, and T3.

Age groups	Radiography			P
	Without a radiographic procedure (n/%)	With a radiographic procedure (n/%)	Total (n/%)	
		T1		
65 and over	97 (99)	1 (1)	98 (100)	0.141
64 and under	547 (96.3)	21 (3.7)	568 (100)	
		T2		
65 and over	72 (75.8)	23 (24.2)	95 (100)	0.011
64 and under	527 (63.4)	304 (36.6)	831 (100)	
		T3		
65 and over	81 (77.9)	23 (22.1)	104 (100)	0.0001
64 and under	398 (50.2)	395 (49.8)	793 (100)	

n: Number of patients. The total number of patients provided radiography is less than the total number of radiographs because some patients had one more radiograph. $P < 0.05$

Table 3: Radiographic findings of the patients during the pandemic.

	T1		T2		T3		T1+T2+T3		P
	n	%	n	%	N	%	n	%	
Caries	1	4.5	104	31.7	210	50.2	315	41.0	0.0001
Caries related pulp	10	45.5	234	70.9	270	64.6	514	66.8	0.0001
Periapical infectious lesion	10	45.5	124	37.5	101	24.2	235	30.5	0.0001
Periodontal disease	2	9.1	91	27.6	191	45.7	284	36.9	0.0001
Pericoronitis	3	13.6	25	7.6	39	9.3	67	8.7	0.513
Crown-root fracture	4	18.2	93	28.2	119	28.5	216	28.1	0.577
Impacted teeth	3	13.6	72	22.0	101	24.2	176	22.9	0.452
Other diseases	0	0.0	11	3.4	2	0.5	13	1.7	0.008

n: Number of patients. $P < 0.05$

non-invasive procedures at T1 ($P > 0.05$) while invasive treatments applied to the patients who had radiographs

(48% at T2 and 47.6% at T3) were significantly higher than those who did not (28.4% at T2 and 28.2% at T3) ($P < 0.05$).

Table 4: Characteristics of the patients who had CBCT and their radiographic features at post-COVID time intervals.

Age	Gender	Time interval	Using conventional radiographs prior to CBCT	Radiographic findings of the conventional radiographs	Radiographic findings of the CBCT
27	Female	T2	Panoramic	Other diseases	Other diseases
19	Female	T3	Both panoramic and intraoral	Caries, deep caries, pericoronitis, impacted teeth	Impacted teeth
20	Female	T3	Both panoramic and intraoral	Caries, deep caries, pericoronitis, impacted teeth	Impacted teeth
30	Female	T3	Panoramic	Impacted teeth	Impacted teeth
61	Female	T3	Panoramic	Periodontal disease, impacted teeth	Other diseases
32	Male	T3	Panoramic	Other diseases	Other diseases
47	Male	T3	Panoramic	Periapical infection	Periapical infection
61	Male	T3	Panoramic	Other diseases	Other diseases
50	Male	T3	Panoramic	Other diseases	Other diseases
30	Female	T3	Panoramic	Periodontal disease	Periodontal disease
48	Female	T3	Panoramic	Other diseases	Other diseases

CBCT: Cone beam computed tomography

Table 5: Numbers and distribution of treatments and correlations of invasive and non-invasive treatments radiography provided (per patient) among T1-T2-T3.

	T1		T2		T3		Total		P
	N	%	n	%	n	%	n	%	
Number of the patients provided treatment									
Non-invasive	493	74	599	64.7	563	62.8	1655	66.5	0.0001
Invasive	173	26	327	35.3	334	37.2	834	33.5	
Number of the invasive treatments									
Restorative treatment	2	1.2	59	18.0	45	13.5	106	12.7	0.0001
Endodontic treatment	0	0.0	5	1.5	11	3.3	16	1.9	0.0001
Surgical procedure	11	6.4	168	51.4	206	61.7	385	46.2	0.031
Prosthetic procedure	156	90.2	99	30.3	87	26.0	342	41.0	0.031
Periodontal treatment	5	2.9	4	1.2	1	0.3	10	1.2	0.0001
Other surgical procedures	0	0.0	12	3.7	22	6.6	34	4.1	0.002
Dental treatment	Radiography						Total (n/%)	P	
	Without a radiographic procedure (n/%)		With a radiographic procedure (n/%)						
			T1						
Non-invasive	475 (73.8)		18 (81.8)				493 (74)	0.397	
Invasive	169 (26.2)		4 (18.2)				173 (26)		
Total	644 (100)		22 (100)				666 (100)		
			T2						
Non-invasive	429 (71.6)		170 (52)				599 (64.7)	0.0001	
Invasive	170 (28.4)		157 (48)				327 (35.3)		
Total	599 (100)		327 (100)				926 (100)		
			T3						
Non-invasive	344 (71.8)		219 (52.4)				563 (62.8)	0.0001	
Invasive	135 (28.2)		199 (47.6)				334 (37.2)		
Total	479 (100)		418 (100)				897 (100)		

n: Number of the patients. The total number of the patients provided treatment and radiography is less than the total number of the procedures and radiographs because some patients had one more procedures and radiographs. P<0.05

DISCUSSION

The incidence of patients who had a radiographic procedure was the lowest at the beginning of the pandemic and significantly increased over time. The frequency of patients

who had a radiographic procedure was higher (46.6%) at T3 than at T2. Using radiography increased when the number of COVID-19 cases increased. It can be said that the course of the disease did not affect use of radiography by dentists. It

can be explained as an adaptation of the dentists to the new pandemic conditions.

Intraoral radiography was the most used radiographic technique before the COVID-19 pandemic^[10-14] because it has a lower radiation dose and higher image quality than panoramic radiography. It continues to be superior to other radiographic methods in the diagnosis of proximal caries and endodontic treatment planning.^[15] Although American Dental Association issued interim guidance recommending avoiding or reducing intraoral radiography when the COVID-19 pandemic begins,^[16] MacDonald *et al.*^[2] created a flowchart to guide the prescription of radiographic procedures during the recovery phase of the COVID-19 pandemic. In this flowchart, they recommended that if the patient who needs radiography is infected or suspected infection with COVID-19, only urgent treatment should be performed, and the first imaging method should be panoramic radiography. They suggested providing conventional dental procedures for patients without or suspected COVID-19 infection and the use of conventional radiography including intraoral radiography as the initial imaging modality if the patient does not have a gag reflex. However, these recommendations are prepared to be used in the recovery phase of the COVID-19 outbreak. It cannot be said that the epidemic was in the recovery phase since vaccination was not yet started in Turkey during the periods included in the study. In addition, considering the possibility of people infected with COVID-19 being asymptomatic,^[17] dentists should treat each patient as an infected or suspected case, as a basic principle of contamination prevention.

Dental panoramic radiography became the star of dental imaging during the COVID-19 pandemic because of its advantages such as having a lower radiation dose compared to full-mouth periapical radiography and CBCT, no gag reflex, and no aerosol formation^[18] but it was difficult to manage urgent treatments using panoramic radiography because it was insufficient to diagnose periapical pathology and pulp-related caries^[15] The main areas of using panoramic radiography are clinical suspicion of teeth with periapical pathology, the presence of partially erupted teeth, clinically evident caries lesions, swelling, and clinically suspected unerupted teeth.^[6]

Recently, conventional panoramic devices have been developed and panoramic machines with extraoral-bitewing functions have been introduced to the market. The extraoral-bitewing function of a panoramic device has an orthogonal view and provides better visualization of the interface contacts of the teeth compared to conventional panoramic radiographs.^[19] The popularity of the extraoral-bitewing function of a panoramic machine increased during the COVID-19 period and it was discussed to replace intraoral radiography^[2,19,20] and suggestions were presented to improve

image quality.^[19] However, according to the results of the previous studies, it was contradictory that it was superior to intraoral radiography for caries diagnosis.^[21-23] Dave *et al.*^[24] implied that avoidance of using intraoral radiography was inappropriate during the pandemic because the advantages of intraoral radiography cannot be ignored.

According to our results, using CBCT did not increase over time. CBCT indication can be summarized as the situations in which conventional radiographic imaging is insufficient for diagnosis and treatment planning. It should not be an alternative to intraoral radiography due to its high radiation dose.^[24] The analyses of our study were consistent with the nature of the use of CBCT.

As shown in studies,^[8,10,25,26] patients mostly apply for dental pulpal or periapical lesions and cellulitis or abscess during the COVID-19 period. The most common radiographic findings were found as caries related pulp (66.8%), caries (41%), periodontal disease (36.9%), and periapical infectious lesion (30.5%) during overall pandemic time points on average in this study. Considering that the radiographic findings also reflect the reasons for admission to the hospital, these results were compatible with other studies.^[8,10,25,26] While our results showed that periodontal disease increased gradually from 9.1% (at T1) to 45.7% (at T3) and caries gradually increased from 4.5% (at T1) to 50.2% (at T3). This may be related to the disruption of dental treatments due to the pandemic and patients' need for these treatments was gradually increasing. We should also point out that, since intraoral radiography was rarely used during the COVID-19 period, the radiographic findings reported in our study were limited by the diagnostic ability of panoramic radiography.

The results of this study demonstrated that non-invasive treatments were higher than invasive treatments. Since no urgent triage clinic was established in our hospital and every applicant was accepted for dental interviews, the number of cases requiring urgent dental treatment was not clear. Although invasive dental treatments increased gradually during the pandemic process, dentists did not use radiography in 28% of patients who underwent invasive treatment. Since it took time for the hospital to establish a suitable environment by taking infection control measures in the early days, the interventions changed over time. Surgical and prosthetic procedures were found as the most common treatments among invasive dental procedures. The number of prosthetic treatments was highest at T1 because, at the beginning of the pandemic, unfinished prosthetic treatments were completed. The surgical treatments increased gradually over periods and most tooth extraction was performed. Restorative treatments (12.7%) and other surgical procedures (4.19%) were rarely performed and endodontic and periodontal treatments were extremely infrequent (fewer than 2%). It was recommended to extract the tooth causing severe pain to reduce the risk of

infection, shorten the treatment period, and minimize re-visits.^[27] Restorative treatments were applied mostly by an excavation of caries using handpieces, and by restoration with temporary fillings or glass ionomer.

The results of the study showed that the dentists avoided the use of radiography in elderly patients and the use of radiography in the aged 65 and over patients was found to be lower than in those aged 64 and under. Measures were taken to ensure that the time spent by the elderly patients who were a high-risk group and had a curfew, in our hospital was as short as possible. The incidence of male patients was found to be higher than females at T1 and T2. In a study evaluating the attitudes of dental patients toward the Mers-A virus, women were found to be more anxious about infection than men.^[28]

Limitations of this retrospective study include a lack of clinical variables because the reasons for patient admission were not included in the hospital's software. The causes for the patients' admission to the hospital should be noted; however, according to the results of our study, 98% of the patients who had radiographs showed radiographic findings of common dental urgency cases.

CONCLUSION

The rate of patients undergoing dental radiography was strikingly the lowest at the beginning of the pandemic. Later, a significant increase was found over time. The course of the COVID-19 disease did not affect using dental radiography because it was higher at the time when the COVID-19 cases increased than when the cases decreased. The use of dental radiography in elderly patients was found to be less than in younger patients during the COVID-19 period. Invasive treatments applied to the patients who had radiographs were significantly higher than those who did not. This study demonstrated the changes in radiographic procedures of dental patients at different times of the COVID-19 pandemic.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

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Conflicts of interest

There are no conflicts of interest.

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