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Was the Coronavirus Disease 2019 Pandemic Associated with an Increased Rate of Cracked Teeth?



Ali Nosrat, DDS, MS, MDS,^{*†}
 Peter Yu, BS,[‡] Prashant Verma,
 DDS, MS, FAGD,^{*†§}
 Omid Dianat, DDS, MS, MDS,^{*†}
 Di Wu, PhD,^{‡||} and
 Ashraf F. Fouad, DDS, MS^{||}

ABSTRACT

Introduction: There is lack of data on whether the coronavirus disease 2019 (COVID-19) pandemic was associated with changes in the etiology of pathosis in endodontic patients. The aim of this study was to determine the rate of cracks and other etiologic factors during the period of March 16th to May 31st in 2020 (COVID-19 initial outbreak) and 2021 (COVID-19 ongoing pandemic) compared with figures from the same period in 2019 (pre-COVID era) in 2 endodontists' practices. **Methods:** The etiologies of patients' chief complaints were determined from records of 2440 teeth (740 in 2019, 651 in 2020, and 1049 in 2021). Changes in the proportion of etiologic factors among all 3 periods were analyzed. The association between the rate of cracked teeth and patients' age and sex was determined using a logistic regression model. **Results:** The rates of all etiologies collectively during the studied periods showed a significant change ($P < .0001$). The rate of cracks significantly increased in 2020 (11.8%) ($P = .0001$) and 2021 (8%) ($P = .0018$) compared with 2019 (4.3%). The rate of persistent infections decreased in 2020 (22.3%) ($P = .0013$) and then increased in 2021 (27.5%) ($P = .0153$) compared with 2019 (30%). Cracked teeth were associated with the age group of 40–60 years (odds ratio [OR] = 1.882; 95% confidence interval [CI], 1.063–3.330) in 2020 and with age ranges of 40–60 years (OR = 2.051; 95% CI, 1.120–3.759) and >60 years (OR = 2.038; 95% CI, 1.050–3.956) and male sex (OR = 1.599; 95% CI, 1.019–2.510) in 2021. **Conclusions:** The rate of cracked teeth increased during the initial outbreak of the COVID-19 pandemic and 1 year later. This study provided evidence on the association between the COVID-19 pandemic and changes in the rate and presentation of endodontic etiologic factors. (*J Endod* 2022;48:1241–1247.)

KEY WORDS

Coronavirus disease 2019; cracked tooth; endodontic etiologic factors; external cervical resorption; pandemic; persistent endodontic infection

The coronavirus disease 2019 (COVID-19) pandemic has impacted several aspects of public health including oral health. Several studies showed that the COVID-19 pandemic was associated with less dental visits¹, declined oral health, and increased experience of a toothache². This may have been related to disrupted socioeconomic stature, lack of access to dental practices, and fear of cross-contamination in dental offices during dental visits. Increased pain levels might indicate reduced quality of life for those who deal with toothache³. Previous studies showed prominent changes in the pattern of presentation of endodontic diseases and their diagnoses and treatment in endodontists' practices during the initial outbreak of COVID-19 in 2020⁴ as well as during the ongoing pandemic of COVID-19 1 year later in 2021⁵. These studies showed a significant spike in patients' subjective and objective pain levels during the initial outbreak in 2020. These pain levels mostly returned to normal levels in 2021, except for self-reported pain⁵. Also, these studies showed that the COVID-19 outbreak in 2020 and the ongoing pandemic in 2021 were both associated with an increase in the number of nonsurgical root canal treatments^{4,5}.

SIGNIFICANCE

The impact of the COVID-19 pandemic on the etiologies of endodontic pathoses has not been investigated. This study showed that with the advent of the pandemic, the rates of cracked teeth increased significantly. Endodontists should be aware of indirect impacts of the COVID-19 pandemic on the etiologies of endodontic diseases.

From the *Division of Endodontics, Department of Advanced Oral Sciences and Therapeutics, School of Dentistry, University of Maryland Baltimore, Baltimore, Maryland; †Private Practice, Centreville Endodontics, Centreville, Virginia; ‡Department of Biostatistics, University of North Carolina, Chapel Hill, North Carolina; §Private Practice, Capitol Endodontics, Washington, DC; ||Division of Craniofacial Health Sciences, Adams School of Dentistry, University of North Carolina, Chapel Hill, North Carolina; and ¶Department of Endodontics, School of Dentistry, The University of Alabama at Birmingham, Birmingham, Alabama

Address requests for reprints to Dr Ashraf F. Fouad, Department of Endodontics, School of Dentistry, The University of Alabama at Birmingham, 1919 Seventh Avenue South, Room 610, Birmingham, AL 35294.

E-mail address: afouad@uab.edu
 0099-2399/\$ - see front matter

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The changes reported in patients' pain symptoms and treatment procedures in previous studies may be associated with multiple reasons including changes in the patients' psychological factors, reluctance to visit the dentist or endodontist until pain arises, a general negative attitude toward dental visits¹, or unidentified changes in the etiology of endodontic pathoses. There is a lack of data on how the COVID-19 pandemic has changed the incidence of different disease etiologies in patients in need of endodontic treatments. A national poll by the Health Policy Institute (HPI) of the American Dental Association was done in October 2021 asking practicing dentists about their observation on the incidence of cracked teeth. A majority (62.9%) of the respondents ($n = 1461$ dentists) reported an increase in the incidence of cracked teeth in their practices⁶. However, these survey data were based on the dentists' opinions rather than objective data from their practices.

Cracked teeth represent a special etiologic factor that is worth studying in relationship to COVID-19. It is generally recognized that cracks are caused by bruxism, clenching, thermal cycling of food, or habitual chewing on hard food or objects⁷. These patient habits may have been increased during the pandemic as a result of increased anxiety or depressive symptoms⁸. Cracks are more common in males and progress slowly, resulting in tooth fracture in about 3% of cases and other signs of progression in about 14% within 1 year⁹. It has been shown that cracks represent about 10% of all cases referred to endodontists for treatment and that 20% to 29% of cracked teeth that have reversible pulpitis on presentation will eventually require root canal treatment within 6 months to 2 years^{10,11}.

The aims of this observational study were to determine the rate of cracks and all other etiologic factors for endodontic pathosis (Table 1) during the initial outbreak of COVID-19 in 2020 as well as during the ongoing pandemic of COVID-19 in 2021 compared with that during the same period in 2019 (pre-COVID era). Also, the rates of these etiologic factors were compared during the period of the initial outbreak in 2020 with the same period of the ongoing COVID-19 pandemic in 2021.

MATERIALS AND METHODS

The present study builds on the data collected throughout the 2 previous studies^{4,5}. The study protocol was reviewed by the Institutional Review Board (IRB) at the University of Alabama at Birmingham and received an IRB exempt approval (IRB-

300006461). The guidelines for Strengthening the Reporting of Observational Studies in Epidemiology¹² were followed.

This study was conducted on data collected from 2 private endodontic practices in Northern Virginia and Washington, DC. Both practices stayed fully operational throughout the outbreak of COVID-19 in 2020 (March 16–May 31), known as the lockdown phase in the United States, and thereafter during the COVID-19 pandemic in 2021. The 2 offices share the same group of endodontists who alternate working in these offices and had the same overall administrative and clinical staffing throughout the study periods. The data collected in this study are from those patients who visited the 2 offices from March 16th to May 31st in 2019 (pre-COVID-19 era), 2020 (initial COVID-19 outbreak), and 2021 (ongoing COVID-19 pandemic). The 3 periods were independent with no patient overlaps.

Upon patient arrival, the endodontists collected data regarding the patient's chief complaint and dental history. A series of clinical examinations were performed to determine the etiology of the chief complaint. The examinations included percussion, palpation, the bite test, thermal and electric pulp tests, periodontal probing, and assessment of mobility. A periapical radiograph of the tooth/teeth was taken using the XCP paralleling device (Dentsply Sirona, Charlotte, NC) and Carestream digital sensors (Carestream Dental, Atlanta, GA). The endodontist made a pulpal and periapical diagnosis with confirmed etiology associated with the patient's chief complaint. An electronic chart was created for each patient in secure electronic record software (PBS Endo Enterprise; PBS Endo, Cedar Park, TX), and all clinical and radiographic findings, etiologies, and treatment options were recorded in the patient's chart. After treatment, the endodontist documented all findings and details of the procedures in their notes as well as in their reports to the referring dentists if there were any. These notes documented the prognosis and expected outcome based on the etiology, clinical, and radiographic findings. If the patient only received an evaluation without treatment (eg, in cases with nonendodontic pain or a nonrestorable tooth), the endodontist documented the clinical and radiographic findings, etiology, diagnosis, and the reason(s) why an endodontic treatment was not recommended/performed. All notes and reports were recorded in the patient's electronic chart. Unlike the previous 2 studies, the tooth associated with the patient's chief complaint was the unit of analysis not the patient visit.

Data Collection and Statistical Analyses

The electronic charts of all eligible patients were reviewed, and demographic data of age and sex as well as the etiologies of chief complaints were collected. A list of etiologies and their definitions are presented in Table 1.

The strategy for statistical analyses was as follows: the chi-square test of independence was performed to determine whether there was a significant change in the rate of all etiologies in 3 periods together as well as for each etiology in the 3 years (Table 2). For those etiologies that showed a significant change in the 3 periods, a year-to-year comparison was performed using the chi-square test to determine when the significant change happened. Because of multiple testing in this model, the Benjamini-Hochberg method was used for "multiple testing adjustments," and q values were calculated (Table 2).

A scatterplot of patients based on age and the rate of cracked teeth was prepared to visually determine if cracks happened with higher frequency in a specific age range. A logistic regression model was used to examine the association between the rate of cracked teeth, age ranges, and sex simultaneously in each year. The significance level was set at $< .05$. Analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC).

RESULTS

The etiology of endodontic complaints/diseases was assessed in 2440 teeth (740 in 2019, 651 in 2020, and 1049 in 2021). It was rare for a patient to be seen for more than 1 tooth. The proportional distribution of etiologic factors based on the period of assessment is presented in Figure 1. The etiologic factors of abrasion, attrition, congenital anomaly, dentinal hypersensitivity, nonendodontic bony lesion, and unknown were not analyzed because of the low number of occurrences (Table 2).

The chi-square test of independence on the rate of all etiologies during the studied periods showed a significant change ($P < .0001$). The results of comparisons on each etiologic factor in all 3 periods are shown in Table 2. After adjusting for multiple testing, 2 variables of cracks ($P < .0001$) and persistent infection ($P = .0049$) showed a significant association with the 3 years overall (Table 2). External cervical resorption (ECR) initially showed a significant change in the analysis ($P = .0415$), but after adjusting for multiple testing, the changes were not significant ($q = .138$) (Table 2).

Year-to-year chi-square analyses showed that the rate of cracks significantly

TABLE 1 - A List of Etiologic Factors and Their Definitions

Etiologic factor	Definition
Abrasion	The pathologic wearing away of structure of the tooth through unusual or abnormal mechanical processes, which resulted in pulpal involvement, mainly in the cervical area
Attrition	The physiological wearing away of structure of the tooth during normal use or parafunctional habits, which resulted in pulpal involvement, mainly through the incisal edge in anterior teeth
Caries	When caries was the only explanation for the endodontic pathosis
Congenital anomalies	Dens invaginatus, dens evaginatus, and palatal groove
Crack	Coronal cracks in teeth with/without previous restoration without previous endodontic treatment that caused pulpal/periapical pathoses; cracks were detected with/without dye staining under microscope magnification (Zeiss PICO; Carl Zeiss, Jena, Germany) and usually extended mesiodistally, including 1 or both marginal ridges
Dentinal hypersensitivity	When the patient complained about cold sensitivity and the source of sensitivity was associated with exposed root/crown dentin with/without gingival recession
External cervical resorption	An external resorption with a point of entry in the periodontal ligament in the cervical area extending into the crown/root determined using 2-dimensional as well as 3-dimensional (cone-beam computed tomography) radiographic imaging
Nonendodontic bony lesion	When the patient presented with a periapical radiolucent lesion of the jaws with/without symptoms that did not have an endodontic origin
Nonendodontic pain	When the pain could not be reproduced during the examinations, and it could be classified as nonendodontic pain, such as myofascial pain, pain from the temporomandibular joint, etc; the type/quality of nonendodontic pain and/or associated factors were not collected/analyzed
None	When the patient presented with a “history” of a complaint that did not exist at the time of the visit and no endodontic disease could be detected
Periodontal	When the patient’s chief complaint was associated with periodontal disease, such as periodontal or gingival abscesses
Persistent infection	Teeth with failed previous root canal treatment without a crown or root fracture as the cause of failure; the reason for failure (missed canals, coronal leakage, recurrent caries, faulty restoration, etc) was not included in the data collection/analysis
Restorative	When endodontic disease was a sequela of a restoration, including all types of direct or indirect restorations and partial- or full-crown coverages, on teeth without previous endodontic treatment
Trauma	Mainly in anterior teeth, with history of an impact trauma; this category included short-term as well as long-term consequences of dental trauma
Vertical root fracture	A vertical crack in the root of previously treated teeth; vertical root fracture was detected through direct observation (ie, surgical access) or indirect observation by finding an isolated deep (≥ 7 mm) pocket associated with vertical bone loss and increased mobility in the absence of other explanatory etiologies for failure
Unknown	When the etiology of the patient’s chief complaint could not be detected or the data on etiology were missing

The definitions are adopted from *Glossary of Endodontic Terms* published by the American Association of Endodontists in 2020.

increased in 2020 ($P = .0001$) and 2021 ($P = .0018$) compared with 2019 (Table 2, Fig. 1). However, the rate of cracks was significantly reduced in 2021 compared with 2020 ($P = .0089$). The number of teeth with persistent infection reduced in 2020 compared with 2019 ($P = .0013$) and then increased in

2021 compared with 2020 ($P = .0153$) (Table 2, Fig. 1).

The average age of patients with cracked teeth was 53.2 ± 12.9 , 49.7 ± 13.1 , and 52.1 ± 13.5 years in 2019, 2020, and 2021, respectively. An age-based scatterplot of patients with cracked teeth showed that

most of these patients were 40–60 years of age (Fig. 2A). Patients were then divided into 3 age groups: <40, 40–60, and >60 years (Fig. 2B). Logistic regression analyses showed that there was no association between cracked teeth, age groups, and sex in 2019 ($P \geq .05$). Cracked teeth were significantly associated with the age group of 40–60 years (odds ratio [OR] = 1.882; 95% confidence interval [CI], 1.063–3.330) in 2020. There was a significant association between cracked teeth and age ranges of 40–60 years (OR = 2.051; 95% CI, 1.120–3.759), >60 years (OR = 2.038; 95% CI, 1.050–3.956), and male sex (OR = 1.599; 95% CI, 1.019–2.510) in 2021. The results of logistic regression analyses are shown in Table 3.

DISCUSSION

Previous studies have shown that the initial outbreak of COVID-19 and its persistent pandemic impacted several aspects of oral public health. However, there was an unanswered question about whether the pandemic has impacted the pattern and incidence of dental and endodontic pathoses. As far as the authors of this article are aware, this is the first report addressing the association between the COVID-19 pandemic and changes in the etiology of endodontic pathoses, specifically the rate of cracked teeth. The present study showed that the initial COVID-19 outbreak was associated with a significant increase in the rate of cracked teeth. One year later, the rate was still significantly elevated compared to prepandemic levels but significantly less than at the initial outbreak. The study is unique because of its design, which includes the same periods in 3 successive years (prepandemic [2019], initial outbreak [2020], and ongoing pandemic [2021]), which revealed an association between changes in the rate of different etiologies and the time periods. It is also exceptional because of the large sample size of 2440 teeth included.

The results of this research show that COVID-19 had a significant impact on the dental health of the studied population in specific areas but not others. There were no changes related to the prevalence of caries or restorative dental work. The increase in the rate of cracked teeth may be an indirect consequence of the pandemic (ie, because of altered socioeconomic status² or increased stress levels⁵) or a more direct impact on oral health, specifically related to temporomandibular joint disorders (TMDs)¹³. As shown in the Health Policy Institute poll by the American Dental Association⁶, the majority of dentists in the United States reported seeing

TABLE 2 - Chi-Square Analyses on the Rate of All Etiologies Associated with Patients' Chief Complaint in the 3 Time Periods

Etiology	2019			2020			2021			P value			q value		
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	Overall	2019/2020	2019/2021	2020/2021	Overall	2019/2020	2019/2021	2020/2021	
Abrasion	0 (0)	1 (0.1)	0 (0)	1 (0.1)	0 (0)	0 (0)	ND								
Attrition	2 (0.2)	1 (0.1)	2 (0.2)	1 (0.1)	2 (0.2)	2 (0.2)	ND								
Caries	128 (17.3)	133 (20.5)	208 (20)	133 (20.5)	208 (20)	208 (20)	.269								
Congenital anomaly	3 (0.4)	2 (0.3)	4 (0.4)	2 (0.3)	4 (0.4)	4 (0.4)	ND								
Crack	32 (4.3)	77 (11.8)	84 (8)	77 (11.8)	84 (8)	84 (8)	<.0001	.0001	.0018	.0089	.0001	.001	.018	.05	
Dental hypersensitivity	3 (0.4)	1 (0.1)	0 (0)	1 (0.1)	0 (0)	0 (0)	ND								
External cervical resorption	12 (1.6)	4 (0.6)	23 (2.2)	4 (0.6)	23 (2.2)	23 (2.2)	.0415	.0788	.3905	.0114	.138				
Nonendodontic bony lesion	2 (0.2)	2 (0.3)	3 (0.3)	2 (0.3)	3 (0.3)	3 (0.3)	ND								
Nonendodontic pain	7 (0.9)	7 (1)	16 (1.5)	7 (1)	16 (1.5)	16 (1.5)	.5033								
None	14 (1.9)	16 (2.4)	21 (2)	16 (2.4)	21 (2)	21 (2)	.7364								
Periodontal	4 (0.5)	10 (1.5)	9 (0.9)	10 (1.5)	9 (0.9)	9 (0.9)	.1483								
Persistent infection	221 (30)	145 (22.3)	289 (27.5)	145 (22.3)	289 (27.5)	289 (27.5)	.0049	.0013	.2855	.0153	.024	.006	.47	.05	
Restorative	258 (34.7)	207 (31.8)	341 (32.5)	207 (31.8)	341 (32.5)	341 (32.5)	.4268								
Trauma	15 (2)	16 (2.4)	15 (1.4)	16 (2.4)	15 (1.4)	15 (1.4)	.2997								
Vertical root fracture	31 (4)	23 (3.5)	31 (2.9)	23 (3.5)	31 (2.9)	31 (2.9)	.3731								
Unknown	8 (1)	6 (0.9)	3 (0.3)	6 (0.9)	3 (0.3)	3 (0.3)	ND								
Total	740 (100)	651 (100)	1049 (100)	651 (100)	1049 (100)	1049 (100)									

ND, not determined because of low incidence. Significant differences at $P < .05$ are highlighted in bold. The Benjamini-Hochberg method was used for multiple testing adjustments for those etiologies that showed significant changes. q values were calculated after multiple testing adjustments. External cervical resorption initially showed a significant change in the analyses, but after adjustment for multiple testing, the changes were not significant. "Tooth" was the unit of analysis.

higher numbers of patients with bruxism and TMDs. Other studies have shown increased stress levels among the public^{8,13,14}, increased self-reported bruxism¹⁵, increased prevalence of sleep disorders¹⁶, and exacerbation of symptoms in TMD patients¹³ after the outbreak of COVID-19. The increase in the rate of cracked teeth shown in the present study may be associated with increased stress, bruxism, parafunctional habits, and other depressive symptoms that were brought on by the pandemic. Further clinical studies are recommended to investigate these associations.

The current study showed that the rate of cracked teeth was significantly increased in the age group of 40–60 years in 2020 and in all males and in patients in the age groups of 40–60 years and older than 60 years in 2021. Studies on the demographics (age and sex) of patients with cracked teeth are scarce. A previous study on 2858 patients with cracked teeth in the United States reported an average age of 54 for patients with cracked teeth with a higher prevalence in females¹⁷. Another study reported an average age of 56 years for 69 patients diagnosed with cracked teeth¹⁸. The 2 previous studies on the characteristics of patient visits in 2020 and 2021 showed that patients who visited the endodontic offices during the initial outbreak of COVID-19 in 2020 were significantly younger compared with the same period in 2019⁴. This trend reversed in 2021, when the average age of patients was similar to prepandemic levels⁵. Also, male patients had a higher number of visits in 2021⁵. As noted, the present study showed that the rate of cracked teeth was significantly higher among patients aged 40–60 years in 2020 and older than 60 years in 2021 but not in 2019. It also showed a higher rate for cracked teeth in male patients in 2021, which was not observed in 2020 or 2019. In other words, the COVID-19 pandemic might have resulted in a change in the demographic pattern of patients with cracked teeth in that cracks arose earlier in susceptible patients than ordinarily reported and showed a higher rate in male patients at later stages (ie, in 2021). This is a novel finding. Further clinical studies are recommended to explore this important clinical topic.

The present study showed that the number of cases with persistent infection after previous endodontic treatment was significantly reduced in 2020, which then significantly increased in 2021 to return to prepandemic levels in 2019. Our previous studies on the characteristics of patient visits in 2020 during the outbreak of COVID-19 showed that these visits were mainly driven by patients' pain levels. Patients who did not have moderate to severe pain may not have been

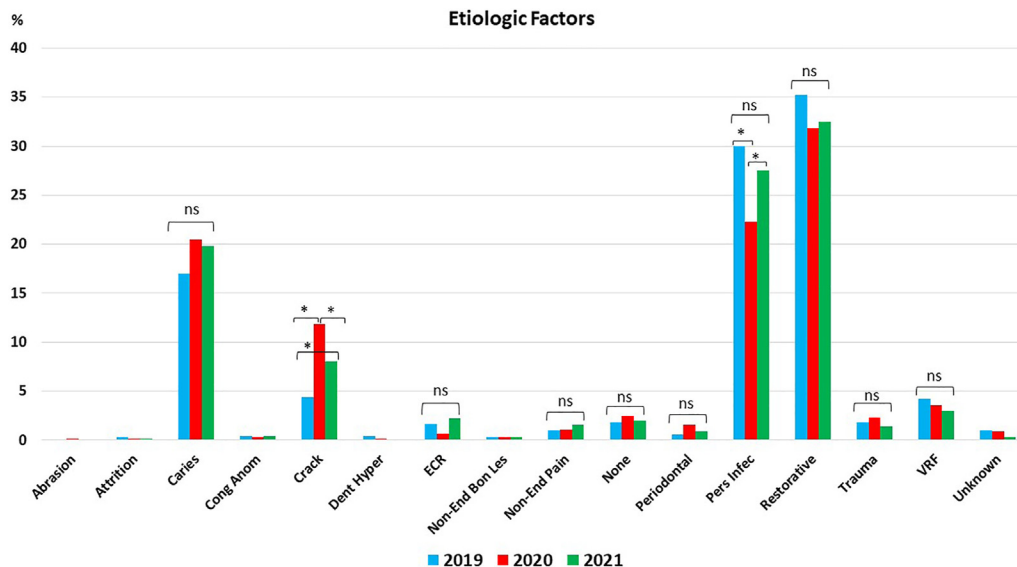


FIGURE 1 – Proportional (percentage) distribution of all etiologic factors based on the period of assessment as well as the results of year-to-year comparisons. Year-to-year comparisons were performed for those etiologic factors that showed significant changes in the overall 3-year comparisons (Table 2). *Significant differences (chi-square, $P < .05$). The tooth was the unit of analyses. ns, not significant; Cong Anom, congenital anomaly; Dent Hyper, dentinal hypersensitivity; Non-End Bon Les, nonendodontic bony lesion; Non-End Pain, nonendodontic pain; Pers Infec, persistent infection; VRF, vertical root fracture. Categories of abrasion, attrition, congenital anomaly, dentinal hypersensitivity, nonendodontic bony lesion, and unknown were not analyzed because of the low number of incidences.

motivated to seek treatment during the pandemic because of a perceived higher risk of COVID-19 transmission in the dental setting. Previous studies showed that periapical lesions associated with root canal-treated

teeth are mainly asymptomatic, and the majority of them (>96%) tended to stay asymptomatic for a long period of time (up to 20 years)¹⁹. Therefore, the reduction in the number of cases presenting with persistent

disease during the initial outbreak of COVID-19 in 2020 may have been related to the fact that most of these patients were asymptomatic. Another reason that could explain the reduction in the number of cases with

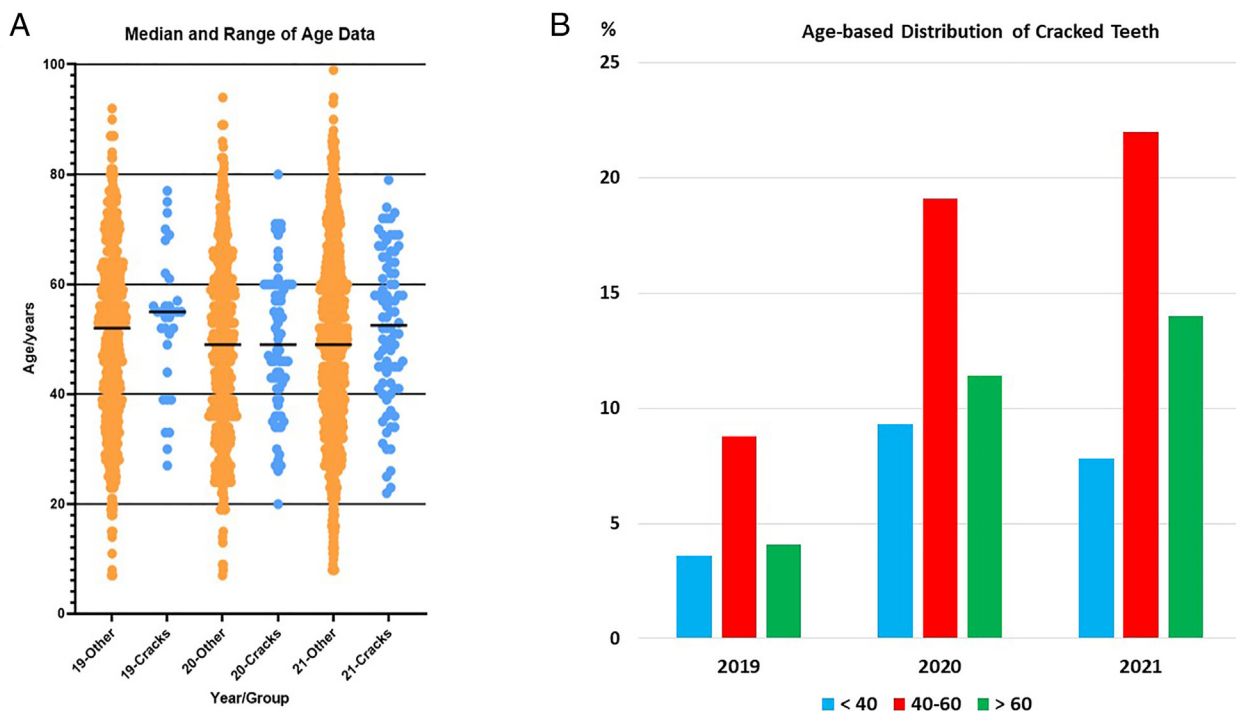


FIGURE 2 – (A) An age-based scatterplot of all patients with or without cracked teeth. The plot shows that most patients with cracked teeth were 40–60 years of age in all 3 years. It also shows how the overall number of cracked teeth increased in 2020 and 2021 compared with 2019. (B) Proportional distribution of cracked teeth based on age groups of <40, 40–60, >60 years. The results of the analyses on the age groups are shown in Table 3.

TABLE 3 - Results of Logistic Regression Analyses on the Association between Cracks, Age Groups, and Sex in 2019, 2020, and 2021

Year	Variable	Coefficient	P value	OR	95% CI
2019	Age 40–60 y	0.4353	.3427	1.545	0.629–3.798
	Age >60 y	0.0508	.9235	1.052	0.373–2.967
	Male	0.6872	.6872	1.158	0.566–2.369
2020	Age 40–60 y	0.6322	.030	1.882	1.063–3.330
	Age >60 y	–0.1751	.65	0.839	0.394–1.788
	Male	0.1654	.5051	1.180	0.725–1.919
2021	Age 40–60 y	0.7185	.02	2.051	1.120–3.759
	Age >60 y	0.7120	.0354	2.038	1.050–3.956
	Male	0.4694	.0413	1.599	1.019–2.510

CI, confidence interval; OR, odds ratio.

Significant differences at $P < .05$ are highlighted in bold. Age group of <40 years and female sex were selected as the reference groups.

persistent disease in 2020 is the nationwide closure of many dental offices during that period. Therefore, patients with asymptomatic disease may not have known about their disease status because they skipped their routine dental radiographic examination.

There are some other unique findings in the current study that have not been reported previously. The initial outbreak of COVID-19 in 2020 and the persistent pandemic in 2021 did not result in a significant change in the rate of caries in the practices studied. Usually, cases with deep primary or recurrent carious lesions and carious pulp exposures are referred to endodontist offices, not those with shallow carious lesions. These deep and extensive lesions take a long time to develop, which may be longer than the period of this study. We also

reported the overall incidence of ECR and vertical root fractures. There is a lack of data regarding the prevalence of ECR^{20,21} and vertical root fractures. It is useful to know the prevalence because these conditions are challenging for endodontists to manage. Teeth with ECR constituted ~0.6%–2.2% of all cases. Teeth with vertical root fracture constituted ~3%–4% of the total cases.

Like other observational studies, the present study has some limitations. The data in this study are limited to 2 endodontist offices located in the Washington, DC and Northern Virginia area and does not represent the entire country. Therefore, the changes observed in the patients could be limited to this area because of its relatively unique geopolitical and economic dynamics. The data could be better

generalized once similar reports from other parts of the country are published. Also, the data collection was performed in certain discrete periods (ie, March 16–May 31) in the 3 years and does not have continuity. In other words, this study compared 3 cross sections of data in these practices. A more applicable model to analyze changes in the rate of etiologies is to assess incidence in a continuous period that stretches from normal times to the period of outbreak and continues into the period of pandemic 1 year after the outbreak. This longitudinal model of data collection was not used in the present study because of limitations in logistics. It is worth noting that the process of data collection was not blinded in this study. Also, it is possible that practitioners became more vigilant about recognizing and treating cracked teeth after the pandemic. However, all diagnoses and treatments were performed several months before the study was designed and conducted. Once the diagnostic data were recorded and the procedures were completed, the data could not be changed. Therefore, the possibility of bias during data collection was minimized.

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