CLINICAL RESEARCH

To Drill or Not to Drill: Management of Endodontic Emergencies and In-Process Patients during the COVID-19 Pandemic

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ABSTRACT

Introduction: Dental professionals are at high risk of contracting coronavirus disease 2019 (COVID-19) infection because of their scope of practice with aerosol-generating procedures. Recommendation by the Centers for Disease Control and Prevention to suspend elective dental procedures and avoid aerosol-generating procedures posed significant challenges in the management of patients presenting with endodontic emergencies and uncertainty of outcomes for endodontic procedures initiated, but not completed, before shutdown. The purpose of this study was to evaluate the success of palliative care on endodontic emergencies during the COVID-19 pandemic and to evaluate the stability of teeth with long-term $Ca(OH)_2$ placement because of delays in treatment completion. **Methods:** Patients presenting for endodontic emergencies during COVID-19 Shelter-in-Place orders received palliative care, including pharmacologic therapy and/or non–aerosol-generating procedural interventions. Part I of the study evaluated the effectiveness of palliative care, and need for aerosol-generating procedures or extractions was quantified. Part II of the study evaluated survivability and rate of adverse events for teeth that received partial or full root canal debridement and placement of calcium hydroxide before shutdown. **Results:** Part I: Twenty-one patients presented with endodontic emergencies in 25 teeth during statewide shutdown. At a follow-up rate of 96%, 83% of endodontic emergencies required no further treatment or intervention after palliative care. Part II: Thirty-one teeth had received partial or full root canal debridement before statewide shutdown. Mean time to complete treatment was 13 weeks. At a recall rate of 100%, 77% of teeth did not experience any adverse events due to delays in treatment completion. The most common adverse event was a fractured provisional restoration (13%), followed by painful and/or infectious flare-up (6.4%), which were managed appropriately and therefore seemed successful. Only 1 tooth was fractured and nonrestorable (3%), leading to a failed outcome of tooth extraction. The remaining 4 outcome failures (13%) were due to patient unwillingness to undergo school-mandated COVID testing or patient unwillingness to continue treatment because of perceived risk of COVID infection.
Conclusions: Palliative care for management of endodontic emergencies is a successful option when aerosol-generating procedures are restricted. This treatment approach may be considered in an effort to reduce risk of transmission of COVID-19 infection during subsequent shutdowns. Prolonged $Ca(OH)_2$ medicament because of COVID-19 related delays in treatment completion appeared to have minimal effect on survival of teeth. *(J Endod 2020;■:1–11.)*

KEY WORDS

Aerosol-generating procedure; COVID-19; endodontic emergencies; long-term calcium hydroxide; palliative care

SIGNIFICANCE

Palliative care for management of endodontic emergencies is a successful option when aerosol-generating procedures are restricted.

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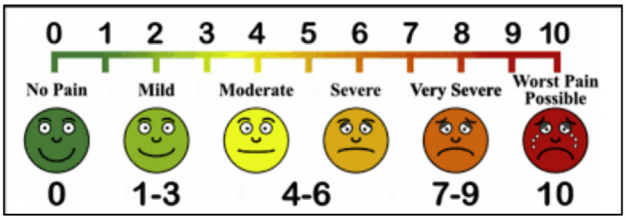
Assessment of a True Emergency

(Circle Patient's Response wherever appropriate)

1) Are you in pain?

Yes *or* ***No***

2) What is your level of pain on a scale of 0-10?



3) When did the pain begin?

……

4) Do you have a dental abscess (Are your gums and/or face swollen?)

Yes *or* ***No***

- If ***Yes***, when did you first notice the swelling?

……

5) Do you have a fever?

Yes *or* ***No***

6) Are you having any trouble swallowing?

Yes *or* ***No***

7) Are you having any trouble opening your mouth?

Yes *or* ***No***

8) Did you experience any trauma?

Yes *or* ***No***

- Please describe the trauma

……

FIGURE 1 – Assessment of a true emergency.

The World Health Organization declared coronavirus disease 2019 (COVID-19) as a pandemic on March 11, 2020. Shortly after, countries began to lock down their societies, shutting businesses and nonessential services. In the United States, elective dental procedures were suspended and aerosol-generating procedures were to be avoided according to the Centers for Disease Control and Prevention (CDC)[1]. Governor Abbot's orders of "Shelter-in-Place" were then enforced in the state of Texas, and the State Board of Dental Examiners adopted the CDC's recommended guidelines for all dentists[1]. This led to challenges in management of patients presenting with emergencies as well as anxiety among dentists for all in-process pending procedures started before statewide shutdown. Collectively, the global spread of severe acute respiratory syndrome–associated coronavirus 2 (SARS-CoV-2) has wreaked havoc on provision and delivery of dental care worldwide[2].

An estimated two thirds of all dental emergencies are endodontic in nature[3,4], with patients primarily seeking emergency care for a painful tooth[3–5]. In addition, according to Nationwide Emergency Department Sample, approximately 302,507 patients make hospital emergency room visits each year for mouth abscess/facial cellulitis in the United States[6]. During a critical time such as the COVID-19 pandemic, this poses a serious burden on hospital resources. During statewide shutdown, dental professionals were therefore required to work as frontline healthcare workers to help limit hospital resources being needed for management of COVID-19–affected individuals.

It is well-recognized that minor oral surgical, restorative, periodontal, as well as endodontic procedures produce aerosol and splatter contamination that exceeds permissible limits[7–10]. Moreover, Index of Microbial Contamination reveals that endodontic procedures generate significantly greater aerosol-produced colony-forming units compared with restorative procedures[10]. In addition, endodontic procedures disperse aerosols as far as 2 m or 6 feet from the patient's head[10]. Finally, SARS-CoV-2 is estimated to stay aerosolized for 3–16 hours after dispersion[11–13]. Dental professionals, especially endodontists, are therefore at higher

COVID-19 Screening Questionnaire

Patient Name: _____ Temperature: _____

1) In the past 14 days, have you or any household member traveled outside of San Antonio?
Yes: Where and Date of return _____
No

2) In the past 7 days, have you or any household member had any contact with a COVID-19 patient?
Yes
No

3) Have you or any household member had history of exposure to COVID-19 biologic material?
Yes
No

4) Have you had any history of fever in the past 14 days?
Yes
No

5) Have you had any respiratory illness such as cough or difficulty breathing in the last 14 days, unexplained muscle aches or nausea, sore throat, diarrhea or recent loss of taste or smell?
Yes
No

6) Do you have uncontrollable dental or oral pain, infection, swelling, bleeding or trauma to your mouth?
Yes
No

FIGURE 2 – COVID-19 screening questionnaire.

risk for nosocomial infection and transmission of SARS-CoV-2, in particular, because of aerosol-generating procedures[12,14,15].

Recommendations for non–aerosol-generating interventions have been made[15] to mitigate and protect dental healthcare providers. These include pharmacologic management for pain and infections as well as procedures that do not require a handpiece such as incision and drainage and nonsurgical extractions. However, the success of palliative care for endodontic emergencies has not been determined in the face of a pandemic. Moreover, data on outcome of teeth with long-term calcium hydroxide ($Ca(OH)_2$) because of delayed completion of endodontic treatment are lacking. Therefore, the present study aimed to evaluate success of palliative care on endodontic emergencies presented at the Endodontic clinic at University of Texas Health Science Center at San Antonio and stability (survival) of teeth with long-term $Ca(OH)_2$ placement before statewide shutdown.

MATERIALS AND METHODS

Part I: Management of Endodontic Emergencies

All records of patients presenting for endodontic emergencies to the Endodontic clinic at the University of Texas Health Science Center San Antonio between March 23, 2020 and May 20, 2020 (COVID-19 Shelter-in-Place) were assessed. During the COVID-19 statewide Shelter-in-Place, all patients reporting pain level of 7/10 on visual analogue pain scale or a "Yes" response to any of the questions on the "Assessment of a True Emergency" (Fig. 1) were included in the analysis. All patients were seen in person, and no use of teledentistry was performed. Only patients with a "No" response to the COVID-19 screening questionnaire and body temperature between 97°F and 99°F (Fig. 2) were seen in the clinic.

All patients were provided with treatment on the basis of the treatment guidelines outlined in Table 1. Type of intervention (palliative or nonpalliative care) and pulpal and periapical diagnoses were collected for analysis. Palliative care was defined as treatment approaches devoid of aerosol-generating procedures and was divided into procedural intervention and pharmacologic intervention.

All patients were followed up with a telephone questionnaire (Fig. 3) to assess effectiveness of palliative care on endodontic emergencies, length of time until the tooth remained stable after palliative care, and need for additional interventions such as endodontic treatment, extraction, and/or visit to the emergency department or another dental clinic. A successful outcome was defined as tooth was present in the mouth and no further intervention using an aerosol-generating procedure was required. Assessment of restorability and appropriate referral to Oral Maxillofacial Surgery for extraction were considered a successful outcome. Extraction of tooth because of proposed delay in definitive treatment was considered a failed outcome.

Part II: Management of In-Process Treatments

Before March 23rd, 28 patients with 31 teeth were seen in the Endodontic clinic at the University of Texas Health Science Center San Antonio. All patients had received partial or full root canal debridement, followed by placement of $Ca(OH)_2$. Completion of treatment for these patients was delayed because of the statewide shutdown due to the COVID-19 pandemic.

After reopening of clinic operations, patients were scheduled for completion of treatment, with the school-wide mandate of a negative nasopharyngeal COVID test before initiating aerosol-generating procedures. All teeth were assessed for any adverse events due to delay in completion of treatment. Adverse events included loss of provisional restoration, tooth fracture, painful and/or infectious flare-up, the need to present for emergency treatment, extraction, or patient's unwillingness to undergo nasopharyngeal COVID test.

A successful outcome was defined as a tooth that was deemed restorable and obturated to completion.

RESULTS

Part I

A total of 21 patients presented with endodontic emergencies during statewide shutdown. A total of 25 teeth were evaluated and managed for emergencies. Table 2 lists total patient demographics and pulpal and

TABLE 1 - Treatment Guidelines for Various Emergencies

Diagnosis	Primary management	Secondary management
Symptomatic irreversible pulpitis/ symptomatic apical periodontitis	Pain management: First line: • 400–600 mg ibuprofen + 325–500 mg APAP or • naproxen sodium 220 mg + 500 mg APAP (16-18) Second line: • Dexamethasone 0.07–0.09 mg/kg (19) and • Consideration for supplementation with long-acting local anesthetic - bupivacaine for immediate pain relief (20)	Full pulpotomy (21,22)
Acute apical abscess	Intraoral swelling: Incision and drainage • Augmentin 500 mg/clindamycin 300 mg (23) and • 400–600 mg ibuprofen + 325–500 mg APAP (17-19) or Consideration for supplementation with long-acting local anesthetic - bupivacaine for immediate pain relief (20) Extraoral swelling: • Augmentin 500 mg/clindamycin 300 mg (23) and • 400–600 mg ibuprofen + 325–500 mg APAP (17-19)	Call Oral Maxillofacial Surgery for further instructions for a possible referral
Avulsion/luxation	If tooth is replanted, follow pain management protocol: Pain management: dosage dependent on age First line: ibuprofen + APAP (17-19)	If tooth is not reimplanted, replant and follow IADT guidelines (24,25) as best as possible
Tooth fracture resulting in pain	Pain management: dosage dependent on age ibuprofen + APAP (17-19)	Vital pulp therapy (21,22,26)
Trauma involving facial bones, potentially compromising the patient's airway	Refer to Oral Maxillofacial Surgery	
Cellulitis or a diffuse soft tissue bacterial infection with intraoral or extraoral swelling that potentially compromises the patient's airway	Refer to Oral Maxillofacial Surgery	

IADT, International Association for Dental Traumatology.

Telephone Questionnaire
1) Are you still in pain?
2) Do you still have swelling?
3) Is the tooth still present?
4) Did the intervention help alleviate the pain?

FIGURE 3 – Follow-up telephone questionnaire.

periapical diagnoses. Table 2 lists patient sex, tooth number, pulpal and periapical diagnoses, procedural and pharmacologic interventions, and outcome for each patient. As noted in Table 3, all patients were managed conservatively without using any aerosol-generating procedures at first visit.

The most common presenting endodontic pulpal diagnosis was symptomatic irreversible pulpitis (44%), followed by pulp necrosis (24%) and previously treated (24%). The most common periapical diagnosis was symptomatic apical periodontitis (80%), followed by acute apical abscess (20%). A total of 5 teeth (20%) were deemed nonrestorable and appropriately referred for extraction.

One patient with 1 tooth was lost to follow-up, providing a follow-up rate of 96%. Of the remaining 20 patients who were followed up, 16 patients (80%) with 20 teeth (83%) reported no need for further intervention, and emergency was managed with pertinent recommendations using non–aerosol-generating procedures. Four patients (20%) with 4 teeth (17%) reported the need to seek further treatment or intervention. Of these, 2 patients resorted to seek extraction of the offending tooth because of the proposed delay in definitive treatment. One patient reported being in pain with 1 tooth throughout the shutdown but did not seek further intervention. Finally, 1 patient required intervention with an aerosol-generating procedure (definitive pulpotomy) because of lack of reduction in pain with the prescribed pharmacologic recommendations.

Part II

A total of 31 teeth in 28 patients had received partial or full root canal debridement before statewide shutdown due to COVID-19 pandemic. Table 4 lists total patient demographics and pulpal and periapical diagnoses, and Table 5 lists patient sex, age, pulpal and periapical diagnoses, time to treatment completion, adverse events, and treatment outcome. Mean time to complete treatment was 13.2 weeks. All patients were followed up, giving a follow-up rate of 100%. Twenty-four teeth (77%) did not experience any adverse events because of delays in treatment completion. Among the 7 patients (25%) who experienced adverse events, the most common adverse event was a fractured provisional restoration (4 teeth, 13%), which occurred exclusively in premolars and molars (Table 5). Painful and/or infectious flare-up occurred in 2 teeth (6%), specifically in 1 vital premolar and 1 necrotic molar with a sinus tract (Table 5). Between the 2 patients who experienced interappointment pain, one patient was prescribed 3 tablets of 6 mg dexamethasone to manage interappointment pain twice, and the other did not report pain to the provider until returning back for completion of treatment. The remaining adverse event observed was a fractured, nonrestorable molar (1 tooth, 3%). Despite the 23% incidence of adverse events in individual teeth, only 1 adverse event (3%) led to a failed outcome of tooth extraction.

Two outcome failures (6%) occurred in pediatric patients (ages 11 and 14 years) because of patient's and/or parent's unwillingness to undergo school-mandated nasopharyngeal COVID testing. Thus, treatment could not be completed, resulting in outcome failure. One patient sought continuation of treatment in private practice, and the other patient was stable and wished to resume care when school-wide COVID testing requirements are no longer enforced. Two additional outcome failures (6%) occurred in relatively older patients, aged 52 and 74 years, who wished to postpone treatment because of perceived risk of COVID infection by continuing treatment. Both patients are stable, without pain, and elected to continue treatment after the COVID-19 pandemic. Aside from patient-related issues with COVID-19 testing or perceived risk of COVID infection, only 1 tooth out of 31 teeth (3%) experienced an outcome failure because of delayed treatment that led to tooth extraction.

TABLE 2 - Patient Demographics and Tooth Information for Patients Presenting for Emergencies

Temperature at screening	Range, 97°F–98.4°F; mean, 97.5°F
Sex	
Male	3
Female	18
Age (y)	
Average	42
Range	8–71
Teeth	
Anterior	3
Bicuspid	4
Molar	17
Pulpal diagnoses	
Reversible pulpitis	0
Asymptomatic irreversible pulpitis	0
Symptomatic irreversible pulpitis	11
Pulp necrosis	6
Previously initiated	1
Previously treated	7
Periapical diagnoses	
Normal	0
Asymptomatic apical periodontitis	0
Symptomatic apical periodontitis	20
Acute apical abscess	5
Chronic apical abscess	0

DISCUSSION

With more than 300,000 cases in March 2020 to now more than 11 million cases in July 2020, the COVID-19 pandemic is unlikely to end soon[27]. Several states may be faced with a second cycle of business shutdowns, forcing dentistry to adapt to the ever-changing situation. Because of the increased occupational risk associated with COVID-19

TABLE 3 - Patient Age, Sex, Tooth Type, Pulpal and Periapical Diagnoses, Procedural and Pharmacologic Intervention, and Outcome for Each Patient Attending for Endodontic Emergencies

Tooth no.	Sex	Age (y)	Pulpal diagnosis	Periradicular diagnosis	Procedural intervention	Pharmacologic intervention	Outcome	Success/failure
19	F	13	PN	AAA	First visit: incision and drainage	First visit: 400 mg ibuprofen & 325 mg APAP	Intraoral swelling and pain resolved, and no further interventions were required	Success
18	F	63	SIP	SAP		First visit: 400 mg ibuprofen & 325 mg APAP	Patient had tooth extracted shortly after because of pain and concerns of waiting for definitive treatment	Failure
31	M	21	PN PN	SAP AAA	Fourth visit: incision and drainage	First visit: 400 mg ibuprofen + 500 mg amoxicillin Second visit: 6 mg dexamethasone Third visit: 6 mg dexamethasone Fourth visit: 400 mg ibuprofen + 500 mg amoxicillin	Intraoral swelling and pain resolved after fourth visit, and no further interventions were required	Success
18	F	30	PI	SAP		First visit: 400 mg ibuprofen & 325 mg APAP	Pain resolved, and no further interventions were required	Success
12	F	40	PN	AAA		First visit: 400 mg ibuprofen & 325 mg APAP	Lost to follow-up	No response
19	F	44	PT	SAP	First visit: referred to Oral surgery		Extraction	Success
8	F	62	PT	SAP	First visit: referred to Oral surgery		Extraction	Success
10	F	62	PT	SAP	First visit: referred to Oral surgery		Extraction	Success
4	F	66	PT	AAA	First visit: incision and drainage	First visit: 875 mg augmentin	Intraoral swelling resolved, and no further interventions were required	Success
28	F	71	PN	SAP			Tooth extracted by general dentist, deemed unrestorable	Success
19	F	61	PN	AAA	First visit: incision and drainage	First visit: 600 mg ibuprofen & 500 mg APAP	Pain resolved, and no further interventions were required	Success
3	F	71	PN	AAA	Incision and drainage	First visit: 600 mg ibuprofen, 500 mg APAP, & 675 mg augmentin	Pain resolved, and no further interventions were required	Success
30	F	45	SIP	SAP	First visit: long-acting anesthetic- 0.5% Marcaine	First visit: 600 mg ibuprofen & 325 mg APAP	Pain resolved, and no further interventions were required	Success
19	F	38	SIP	SAP	Hand excavation of caries + calcium hydroxide dressing	First visit: 6 mg dexamethasone	Pain resolved, and no further interventions were required	Success

(*continued on next page*)

TABLE 3 - Continued

Tooth no.	Sex	Age (y)	Pulpal diagnosis	Periradicular diagnosis	Procedural intervention	Pharmacologic intervention	Outcome	Success/failure
12	F	68	PT	SAP		First visit: 600 mg ibuprofen & 500 mg APAP	Pain resolved, and no further interventions were required	Success
2	M	16	SIP	SAP		First visit: 600 mg ibuprofen & 500 mg APAP	Patient reported prolonged pain	Failure
7	M	16	SIP	SAP		First visit: 600 mg ibuprofen & 500 mg APAP	Pain resolved, and no further interventions were required	Success
14	F	16	SIP	SAP	First visit: referred to Oral surgery	First visit: 600 mg ibuprofen and 4 mg dexamethasone (IM)	Extraction	Success
3	F	8	PN	SAP		First visit: 400 mg ibuprofen & 325 mg APAP	Pain resolved, and no further interventions were required	Success
31	M	64	PT	SAP		First visit: 400 mg ibuprofen & 325 mg APAP	Extraction	Success
2	M	64	PT	SAP		First visit: 400 mg ibuprofen & 325 mg APAP	Pain resolved, and no further interventions were required	Success
18	F	43	SIP	SAP		First visit: naproxen sodium 220 mg & 500 mg APAP	Patient pain did not resolve; after 5 days patient requested tooth be extracted	Failure
30	F	29	SIP	SAP		First visit: naproxen sodium 220 mg & 500 mg APAP	Pain resolved, and no further interventions were required	Success
29	F	29	SIP	SAP		First visit: naproxen sodium 220 mg & 500 mg APAP	Pain resolved, and no further interventions were required	Success
15	F	17	SIP	SAP		First visit: 400 mg ibuprofen & 325 mg APAP	Symptoms did not resolve; patient required pulpotomy	Failure

AAA- acute apical abscess; IM-intramuscular; PI, previously initiated; PN-pulp necrosis; PT-previously treated; SAP-symptomatic apical periodontitis; SIP-symptomatic irreversible pulpitis.

infection and dentistry[12,14,15,28], the present retrospective study investigated the effectiveness of conservative management (non–aerosol-generating procedures) on management of endodontic emergencies as well as outcome of long-term $Ca(OH)_2$ because of delayed completion of treatment during the COVID-19 shutdown at Endodontics clinic at the University of Texas Health Science Center San Antonio. Specifically, this study aimed to assess the effectiveness of palliative care for endodontic emergencies and the effect of delayed endodontic treatment on survivability of teeth with long-term $Ca(OH)_2$. We hope that findings from this study will aid clinicians in making treatment decisions during potential future shutdowns of clinic operations. To our knowledge, a pragmatic clinical study evaluating these aims is lacking.

For Part I of the study, the most common pulpal diagnosis of endodontic emergencies was symptomatic irreversible pulpitis, followed by pulpal necrosis. The most common periapical diagnosis was symptomatic apical periodontitis, followed by acute apical abscesses. These findings were comparable to a study from Wuhan, China[29], which analyzed the characteristics of endodontic emergencies during the coronavirus disease outbreak. There were a higher percentage of female patients (86%) who reported with painful emergencies than

TABLE 4 - Patient Demographics and Tooth Information

Sex	
Male	11
Female	17
Age (y)	
Average	40
Range	11–87
Teeth	
Anterior	10
Bicuspid	6
Molar	15
Pulpal diagnoses	
Reversible pulpitis	4
Asymptomatic irreversible pulpitis	1
Symptomatic irreversible pulpitis	5
Pulp necrosis	10
Previously initiated	2
Previously treated	9
Periapical diagnoses	
Normal	4
Asymptomatic apical periodontitis	5
Symptomatic apical periodontitis	15
Acute apical abscess	1
Chronic apical abscess	6

male patients (14%). This is consistent with previous reports demonstrating that painful pulpitis is sexually dimorphic in nature[3,30], and that women are more likely to seek medical attention than men when in pain[31].

An overall success rate of 83% was noted for cases that were managed conservatively with non–aerosol-generating procedures and pharmacologic management. On average, teeth deemed successful were stable with conservative interventions for 8 weeks. One patient required several rounds of first and second lines of pharmacologic management, with a last visit warranting an incision and drainage procedure. However, because all recommendations were palliative in nature, this case was considered successful. All patients with a periapical diagnosis of acute apical abscess (20%) were successfully managed with incision and drainage with or without antibiotics and pharmacologic intervention for pain management. Forty-one percent of all teeth presented with a pulpal diagnosis of symptomatic irreversible pulpitis and symptomatic apical periodontitis. Of these, 60% were managed appropriately with pharmacologic interventions. Interestingly, all cases deemed unsuccessful were diagnosed with symptomatic irreversible pulpitis and symptomatic apical periodontitis. All 4 patients (3 female, 1 male) were prescribed a combination of nonsteroidal anti-inflammatory drug with acetaminophen (APAP). Two patients resorted to extraction because their pain was unmanaged with the recommended first line of pharmacologic intervention (400 mg ibuprofen with 325 mg APAP and 220 mg naproxen with 500 mg APAP, respectively). It is noteworthy that these patients did not return to clinic for second line of pharmacologic intervention. Therefore, it is unknown whether further pharmacologic interventions would have been beneficial. Nonetheless, because of the COVID-19 pandemic and the pragmatic nature of this clinical study, patient perceptions leading to untimely tooth extractions were considered a failure. A third patient was also managed with 600 mg ibuprofen with 500 mg APAP. Although this patient did not opt for tooth extraction, they reported having "unbearable" pain and did not want to return to clinic until definitive treatment was offered. A fourth patient required definitive pulpotomy because of inadequate pain management with 400 mg ibuprofen with 325 mg APAP. Collectively, findings and success rate of 83% from Part I of the study are encouraging and provide strategies to mitigate the use of aerosol-generating procedures for management of endodontic emergencies.

For Part II of the study, a total of 31 teeth were in an interim treatment phase with $Ca(OH)_2$ placed in all teeth. The most common complication experienced by this cohort of patients was fractured restoration (13%). However, all teeth with this adverse event were deemed restorable and therefore successful. One tooth (3%) was deemed nonrestorable because of tooth fracture and therefore was considered a failure. Previous studies have raised concerns on the use of long-term $Ca(OH)_2$ and its relationship to weakening of teeth[32]. Andreasen et al[32] suggested that fracture strength of teeth dressed with $Ca(OH)_2$ decreased significantly from 2 months, and at 12 months they were 50% of the original strength. The authors concluded $Ca(OH)_2$ should not be used for longer than 30 days. Another study demonstrated that there was a significant decrease in fracture strength from 28 to 84 days with calcium hydroxide[33]. However, results from a third study disagree with these findings and do not demonstrate a detrimental effect of $Ca(OH)_2$ up to 6 months[34]. All patients in this study had an average time of 13.2 weeks in $Ca(OH)_2$, and only 1 tooth was lost because of tooth fracture. However, all studies referenced here are either *in vitro* or *ex vivo* animal models, and the results of our study may differ because of inherent differences in the study models used. However, long-term follow-up on survivability of all teeth included in this study is warranted.

The University of Texas Health Science Center San Antonio Dental School mandated a COVID-19 test before all aerosol-generating procedures. Therefore, refusal to testing was considered a negative outcome and therefore an outcome failure. Six percent of patients refused COVID-19 test. An additional 6% deferred treatment because of perceived COVID-19 infection risk by continuing treatment. The latter were also considered an outcome failure because patient perception in retention or loss of dentition is a key component of a pragmatic clinical study. Collectively, findings from Part II of the study suggest that success of delayed endodontic treatment of teeth with $Ca(OH)_2$ does not lead to significant tooth loss, with a success rate of 84%.

As the global expansion of the COVID-19 pandemic continues, it is accompanied by stress on supply chains for personal protective equipment (PPE)[35,36]. The CDC guidelines for dental professionals recommend the use of N95 or other higher quality filtration devices during all aerosol-generating procedures. Because of the high prevalence of endodontic emergencies[3–5], it is most appropriate to manage these emergencies with definitive treatment such as root canal therapy or extraction. However, because of the likelihood for a second shutdown in many regions, a high risk of contraction of COVID-19 for dental professionals, and the shortage of PPE, alternative treatment options are warranted. Our data suggest that palliative care for a short-term duration may be applicable to endodontic practices to minimize aerosol-transmitted COVID-19 infection as well as to conserve critical PPE required by medical frontline hospital workers. It is noteworthy that none of the providers in our study contracted COVID-19 during management of emergency patients. This finding is similar to the study from Wuhan, China[29], where emergencies were managed with aerosol-generating procedures such as pulpotomies and pulpectomies. However, our study included various pulpal and periapical diagnoses and therefore precludes a direct comparison. Moreover, because respiratory droplets and aerosol particles released from coronavirus-infected individuals can range from 10,000–100,000 viral particles without a protective barrier such as a mask on the patient's mouth[37], a consideration for best practices during this pandemic is warranted. Finally, teeth in the interim stage of an endodontic procedure appear to remain stable and therefore restorable for completion after reopening of dental clinics.

Overall, within the limitations of this study such as a small sample size, palliative care for management of endodontic emergencies is a successful interim

TABLE 5 - Patient Demographics, Pulpal and Periapical Diagnoses, Adverse Events, and Treatment Outcomes

Tooth #	Sex	Age (y)	Pulpal diagnosis	Periradicular diagnosis	Time to treatment completion (wk)	Adverse event	Outcome
2	M	18	PN	CAA	14	None	Success
3	F	87	SIP	SAP	13	None	Success
4	F	16	SIP	SAP	13	Pain/flare-up – prescribed 6 mg dexamethasone	Success
5	F	42	RP	SAP	15	Fractured restoration	Success
7	M	17	RP	N	10	None	Success
8	M	17	RP	N	10	None	Success
9	M	17	RP	N	10	None	Success
8	M	14	PT	AAP	N/A	Refused COVID-19 test	Failed
8	F	37	PN	SAP	13	None	Success
8	F	17	PN	AAP	12	None	Success
9	M	23	PN	AAP	13	None	Success
13	F	54	PT	SAP	18	None	Success
14	F	39	SIP	SAP	17	None	Success
14	F	61	PT	SAP	13	None	Success
14	F	17	PN	SAP	12	Fractured restoration	Success
14	F	44	PT	AAP	13	None	Success
19	M	37	PT	SAP	14	None	Success
19	F	41	PT	AAA	14	None	Success
19	F	18	PT	CAA	16	None	Success
19	M	40	PI	CAA	14	Fractured restoration	Success
19	M	11	PI	CAA	N/A	Refused COVID-19 test	Failed
19	F	70	PT	SAP	12	None	Success
19	M	34	PT	AAP	13	None	Success
20	F	64	PN	CAA	12	Fractured restoration	Success
21	M	52	AIP	N	N/A	Deferred treatment due to perceived COVID-19 infection risk	Failed
22	M	16	SIP	SAP	13	None	Success
24	M	16	SIP	SAP	13	None	Success
23	F	74	PN	SAP	N/A	Deferred treatment due to perceived COVID-19 infection risk	Failed
30	F	65	PN	SAP	16	None	Success
31	F	40	PN	SAP	13	Fractured tooth	Failed
31	M	71	PN	CAA	10	Pain/flare-up	Success

AAA, acute apical abscess; AAP, asymptomatic apical periodontitis; AIP, asymptomatic irreversible pulpitits; CAA, chronic apical abscess; PI, previously initiated; PN, pulp necrosis; PT, previously treated; RP, reversible pulpitis; SAP, symptomatic apical periodontitis; SIP, symptomatic irreversible pulpitis.

treatment option when aerosol-generating procedures are restricted. This treatment approach may be considered in an effort to reduce risk of transmission of COVID-19 infection during subsequent shutdowns. Finally, survivability of teeth with long-term $Ca(OH)_2$ does not appear to pose a detrimental effect on tooth loss.

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Biraj Patel: Conceptualization, Methodology, Writing - original draft, Writing - review & editing. **Michael A. Eskander:** Conceptualization, Methodology, Writing - original draft, Writing - review & editing. **Nikita B. Ruparel:** Conceptualization, Methodology, Writing - original draft, Writing - review & editing.

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The authors deny any conflicts of interest related to this study.

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