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Evidence behind Aerosol Generating Procedures and Risk of Transmission of COVID-19 to Dentists: A Systematic Review

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Received: August 27, 2020; **Published:** September 30, 2020

Abstract

Objectives: Dental aerosol and splatter pose risk of cross infection even from a distance in dental settings. In order to reduce the fallow time between aerosol generating procedures (AGPs) in dental settings and safe time during dental procedures the aim of our review is to gather the urgently needed data relevant for the provision of routine dental care and provide evidence based recommendations.

Data Sources: A literature search was performed on PubMed, Web of Science and Scopus databases. All the abstracts and titles of studies were evaluated and that mentions dental AGPs and COVID-19 studies were included.

Data Selection: Peer-reviewed articles, which included clinical, demographical, observational and cohort studies from January, 2002 until July, 2020. Data synthesis 2 categories were developed, 8 studies that provided the evidence for the aerosol contamination of personal protective equipment (PPE) and the 6 randomized controlled trials were included that revealed the reduction of the AGPs in dental settings.

Conclusion: COVID-19 pandemic has brought several changes in dentistry therefore, recommendations regarding understanding of the characteristics of aerosol generation within dental environment and investigation of effectiveness of aerosol and droplet control measures and environmental precautions will identify the strategies for mitigating the effect of SARS COV-2.

Keywords: *Aerosol Generating Procedures; Dentistry; COVID-19; Mitigation; Evidence; UK Guidelines*

Introduction

Across the globe, spread of COVID-19 outbreak has made it the most challenging public health issue and emergency. Dentistry has been classed as the most high-risk profession of aerosols production via AGPs. COVID-19 spread where has no evidence of spread and assumed to be predominantly transmitted via direct contact and droplets, guidelines to safely practice dentistry and correct use of controlled precautionary measure is the way out in order to reduce the risk of transmission [1-3]. Aerosols are the particles which are less than 50 nm in diameter and the smallest of them are up to size of 0.5 to 10 μm [4]. Such small diameter of particles can remain in air for extended period of time before they get settled on to the surface or able to enter in to the respiratory tract small passages and therefore transmits infections at its greatest potential. Splatter however, is more than 50 um in diameter and they have ballistic manner behavior. It is known that the greatest threat comes from aerosols in dentistry [5,6]. Aerosols generating procedures (AGPs) can be defined as the any medical procedure associated with patient care that results in the production of aerosols that is, airborne particles [7,8]. On the qualitative and quantitative analysis of dental aerosols it is difficult to understand the composition and make up of dental aerosols however, it is supposed to have components coming from plaque, saliva, blood, nasopharyngeal secretions, components of tooth and any of the material used

while carrying out the dental procedure such as, air abrasion or abrasives [6,9,10]. The three potential sources of airborne contamination during any dental treatment is through saliva, dental instruments and respiratory sources and dental unit waterlines (DUWL) are the cause of spread through the organisms on dental instrumentation.

UK national guidelines for dentists to practice under this pandemic

Due to the rich diversity of subspecialties to deliver the dental care the guidance of the dental profession has been developed to meet the varied needs by keeping the safe delivery of dental care and mitigation of virus is in the dental environment by keeping the dental team safe. However, there will be no guidance that can eliminate the risk but it does provides a framework for the identification and mitigation of the major risks in dental profession and the patients and dental team that might be exposed. For different subspecialties different guidelines were made such as from FGDP, BSO, BES, BDA, CDO, BMOS can be seen in table 1 [11]. Nevertheless, it is being acknowledged by the Nation's guidance that the list they provide is not exhaustive and also states that' Not all dental procedure have been covered' [12].

Specific guidelines	During AGP procedures	Measures and techniques
FGDP	**3-5 high AGE risk** Tooth polishing, ultrasonic scalers for periodontal procedures, cementation of crown or bridge, intra-oral radiography, 3-in-1 syringe, direct restoration of a tooth, extraction of tooth, endodontic procedures, surgical implant placements, repair of retained implant prosthesis, removable prosthodontics, intraoral photography.	FFP2/FFP3, gown and visor, Fluid resistant Surgical mask (FRSM).
	1-2 high or low AGE risk Oral hygiene instructions, extra oral radiography, extra oral photography, non- surgical extraction, fissure sealants, minimally invasive restoration, periodontal procedures using high volume suction, hand excavation and dressing for endodontic procedures, adjustment and repair of removable prosthesis, provisional restoration, intraoral radiography without the cough reflex.	FRSM, eye protection.
CDO	All AGPs.	Disposable, gloves, fluid repellent gown, Face and eye Protection, FFP3 Respirator
BES	Cellulitis, irreversible pulpitis with acute dental pain, tooth fracture, painful dental abscess, dental trauma due to intrusion, avulsion or lateral luxation injury, temporary dressing replacement in patients with acute pain for endodontic access cavity.	Fill face visor with FFP3, dental loupes or microscope with FFP3, surgical sleeving of all headpieces, rubber dam isolation, 1% hydrogen peroxide before each appointment, high volume aspiration
BOS	Band off, band off Quadhelixes, RME, TPA +/- Nance, orthognathic post op, broken bonded retainers/URA/functional appliance, wires digging in mouth.	Slow piece handpiece, High volume aspiration, FRSM
BAOMS	Benign tumours, endosseous implants, surgical removal of teeth, TMJ replacement, craniofacial surgery, secondary reconstruction for trauma.	PPE, avoidance of piezoelectric saw, use self- drilling and tapping screw system, povidone and iodine skin prep, HEPA filtration

Table 1: *Specific AGP measures and techniques guidelines from FGDP, CDO, BES, BOS, BAOMS for dentists [11].*

Full understanding of AGPs will allow the clinicians to have risk assessment of procedure, patient and clinic and to identify the possible danger of virus transmission. Therefore, once the understanding of AGPs risk, viral transmission and is scientifically more fully understood it is expected to modify the current guidelines. The systematic review presents the aerosols review produced in dental procedures that will facilitate each clinician to make a reliable and valid judgment in order to see the risks involved while carrying out any dental procedure. Antigen testing, antibody development and the subsequent vaccine production will ultimately reduce the AGPs concern in the routine dental practices and the learned lessons from COVID-19 will uplift the dental clinical practice and will not damage it.

Objectives of the Study

1. To examine the effective methods of reducing the effect of AGPs-airflow patterns.

2. To evaluate the evidenced based literature for dental aerosols and effective or inconsistent standards to practice dentistry.

Methodology

Protocols

The protocol followed the recommendations according to Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines.

Eligibility criteria

We included peer-reviewed articles, which included clinical, demographical, observational and cohort studies. The language of articles were set to English, and we included the publications from January 1, 2002 until July, 2020.

Information sources and search strategy

We did the systematic review search by using Web of Science, PubMed and Scopus. The following search terms were used: Combination of free words and MESH terms: "dentist" AND "COVID-19" OR "SARS-CoV-2" OR "coronavirus-19", and AND "COVID-19" OR "SARSCoV-2" OR "coronavirus-19" AND 'Novel coronavirus' AND 'Bio aerosols' AND 'Aerosol generating procedures' AND 'personal protective equipment' OR 'PPE'AND dental aerosols AND 'face mask' OR 'FFP2' OR 'FFP3'.

Study selection

The initial search strategy was screened by the title and abstract. By following the inclusion and exclusion criteria the full text articles, performed on human subjects. The dates starting from 2002-2020; the date starting from 2002 was chosen as the start point because this was when the first SARS outbreak was encountered in the world by World Health Organization (WHO).

Focused question

A focused question was constructed according to the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines. The focused question was: 'Are the current guidelines to practice dentistry post- COVID-19 situation, has thoroughly been evidenced to implement safer practice?'.

Results

The literature search was identified and a total of 516 publications performing the web search from databases PubMed, Web of Science and Scopus (Figure 1). Amongst them 112 were excluded after screening the titles and abstracts. 14 publications were included in this

report. The records screened were 112 and 72 of them were excluded. The full text articles which were assessed for potential eligibility were 40 and the reasons for exclusion of 26 articles were being that it did not fit the inclusion and exclusion criteria and there was no mention of dental aerosols and droplets in head and neck region. The studies included for the qualitative synthesis were 14 and was further categorized into 2 types of evidenced studies. The first category of studies that brought the evidence for the aerosol contamination of 8 PPE studies were included and 6 randomized controlled trails (RCT) were included for methods to reduce AGPs were included.

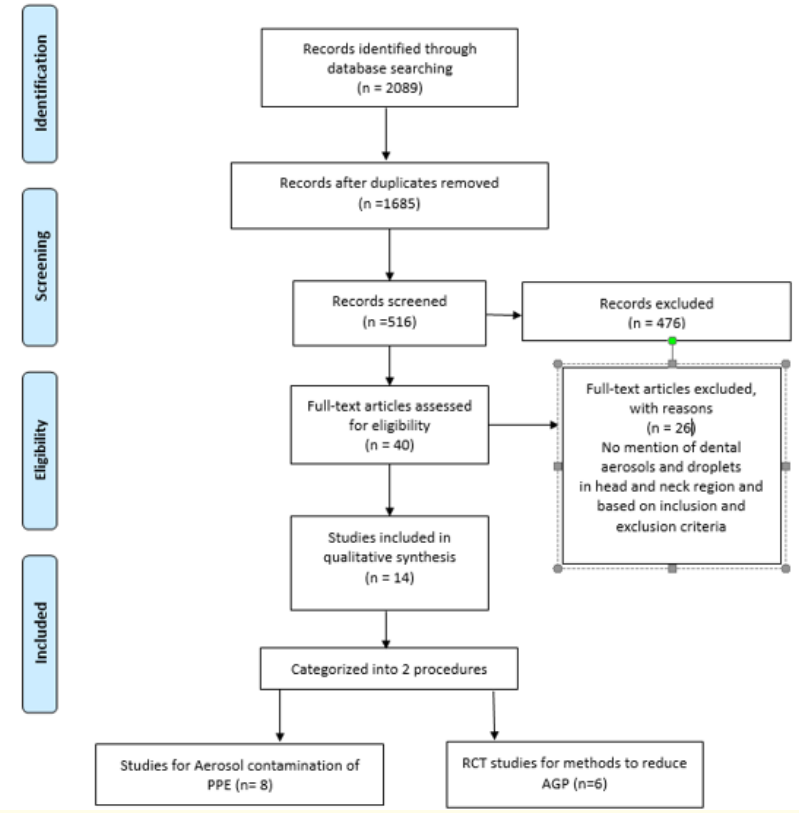

Figure 1: *Search strategy for aerosol generating procedures.*

Study characteristics

There were three studies that revealed the evidence of production of aerosol during the oropharyngeal surgeries and dental procedures within two meters. The studies suggested that with the use of handpieces, high pressure water sprays, surgical procedures has the increased risk of formation of aerosol. Furthermore, the other 3 studies showed the direct clinical evidence of aerosol contamination on PPE during general dental procedures, third molar removal surgery and during head and neck surgeries. Hallier., *et al*. [13] suggested, due to aerosol contamination bacterial growth was seen in performing dental procedures and settings as seen in table 2. Whereas, Ishihama., *et al*. in 2009 [14] and in 2010 [15], revealed direct evidence from aerosols in air samples form blood contamination while performing 3rd molar removal at a distance of 20 cm-76% particles were contaminated with blood and at 100 cm-57%. The indirect clinical evidence was aggregated by 5 studies in which the experimental study conducted by Perdelli., *et al*. [16], amongst others revealed the indirect evidence

of aerosol contamination on PPE during maxillofacial surgery, dental procedures or autopsy experiments by using 132 subjects, where air samples contaminated from haemoglobin were found high in dental operation in comparison to autopsy procedures. The additional 2 studies that presented indirect evidenced results revealing the aerosols contamination on PPE table 2, with high speed instruments can possibly cause blood borne infections on splashes in 90% of cases, 84% of blood splashes of were confirmed and 76% from visor masks [17,18].

Study /year	Design and settings of the study	Groups for study	No of study subjects	Outcomes of the study	Evidence directness	Inference
Perdelli., *et al*. 2008 [10]	Experimental study	Maxillofacial surgery, dental procedures or autopsy experiments	132	Haemoglobin concentration were found in air samples of autopsy room and dental cubicles	Indirect	Air samples contaminated from haemoglobin were found high in dental operation in comparison to autopsy procedures
AL-Eid., *et al*. 2018 [11]	Cross sectional study	Patients came for third molar removal surgery	30	Mask, gown and visor blood contamination	Indirect	Blood contamination was existent for 73% for gowns, 87% for eye wear and 100% for gloves and masks
Hallier., *et al*. 2018 [12]	Cross sectional study	General dental procedures	8	Due to aerosol contamination bacterial growth was seen and sample was collected from dental chair	Direct	Dental examination, extraction of tooth, cavity preparation, ultrasonic scaling produces aerosols that generate bacterial colonies
Ishihama., *et al*. 2008 [13]	Cross sectional study	Patients came for third molar removal surgery	25	Mask, gown and visor blood contamination	Indirect	Oral procedures with high speed instruments can possibly cause blood borne infections on splashes in 90% of cases, 84% of blood splashes of were confirmed and 76% from visor masks
Ishihama., *et al*. 2008 [13]	Cross sectional study	Patients came for third molar removal surgery	100	Aerosols in air samples form blood contamination	Direct	High speed instruments generate blood aerosols at a distance of 20 cm-76% particles were contaminated with blood and at 100 cm- 57%
Ishihama., *et al*. 2010 [14]	Cross sectional study	Head and neck surgeries	54	Air conduction filter or aerosols contaminated from blood	Direct	High speed rotating instruments or usage of electrocautery results in aerolization of blood

Doremalen., *et al*. 2020 [15]	Experimental	SARS-CoV-2 and SARS-CoV-1 culture infected applied on cardboard, copper, plastic and stainless steel	10 experimental conditions	SARS-CoV-2 was stable on stainless steel and plastic up to 72 hours than on cardboard and copper SARS-CoV-1 had also the longest viability on plastic and stainless steel. Only the difference was seen on cardboard, only SARS-CoV-2half-life was longer than SARS-CoV-1	Indirect*	SARS-CoV-2 and SARS-CoV-1 had similar stability under experimental conditions and both remains viable in aerosolsup to hours and on surfaces for days that's depends on the shedding of inoculum.

Table 2: *Aerosol contamination on PPE during dental care provision.*

The evidence gathered on effective methods of reducing the effect of AGPs in dentistry can be seen in table 3 shows (RCTs) and experimental and the outcome of studies. The RCTs conducted by Valdes., *et al*. suggested the effectiveness of Pre-procedural mouth wash evaluation and the reduction of viable bacteria was seen with mouthwashes after ultrasonic scaling [19]. Timmerman., *et al*. during 17 treatment sessions in 6 patients, determined the atmospheric microbial contamination by using piezoelectric ultrasonic scaler during periodontal treatment along with conventional dental suction (CDS) and high volume evacuation (HVE), the results showed that only limited microbial contamination was produced [20]. A pilot RCT was conducted by Wu., *et al*. to check the efficacy of N95 or FFP2 and Totobobo mask comparing the particle count, in 22 healthy volunteers the results showed the reduction in airborne particle in N95 masks (145 - 200) than for Totobobo masks 83 - 184) therefore, N95 masks were recommended [21]. Furthermore, the RCTs conducted by Maclntyre., *et al*. [22,23] assessed 1441 and 1669 HCWs where they compared the medical masks and N95 fit tested and non-fit tested the outcomes revealed that infections rate was double for medical masks than for N95 and no significant difference was seen with fit testing or without fit testing however, low fit test failure was seen and continuous use of N95 was better than intermittent wearing of N95 or medical mask. In a double blinded study conducted by David., *et al*. they identified the Methicillin-resistant Staphylococcus aureus (MRSA) prevalence in restorative dental care the outcome of the study revealed that efficacy of PPE precautions decreases the MRSA prevalence in aerosols [24] (Table 3).

Study/ year	Design of study	Methodology	No of subjects	Outcome of study
Valdes., *et al*. 2017 [19]	RCT	Pre-procedural mouth wash effectiveness was evaluated containing zinc lactate (Zn), cetylpyridinium chloride (CPC) and sodium fluoride (F) and compared with water to see the decrease in viable bacteria after ultrasonic scaler prophylaxis, bacteria was collected from dental office various locations on TSA plates and DNA-DNA Hybridization was performed for the identification of species	60 (15 per group)	Colony-forming units (CFUs) in aerosols made up 70% to 77% less when rinsing with CPC+Zn+F and CHX were used when compared to water which was 61% or 70%. It was concluded that reduction of viable bacteria was seen with mouthwashes after ultrasonic scaling.
Timmerman., *et al*. 2004 [20]	Experimental study	Determination of atmospheric microbial contamination by using piezoelectric ultrasonic scaler during periodontal treatment along with conventional dental suction (CDS) and high volume evacuation (HVE)	17 treatment sessions in 6 patients	The microbial air pollution was detected through cultured plates for 3 and 7 days and the during the 40 min of ultrasonic scaler continuous use with HVE and CDS only limited microbial contamination was produced.

Wu., *et al*. 2010 [21]	Randomised controlled pilot study	To check the efficacy of N95 or FFP2 and Totobobo mask comparing the particle count.	22 healthy volunteers	The airborne particle reduction was seen in N95 masks (145-200) than for Totobobo masks83-184) therefore, N95 masks were recommended.
Macintyre., *et al*. 2011 [22]	Randomized clinical trial	Comparison of medical masks and N95 fit tested and non-fit tested, 4 weeks both masks were worn to see influenza like illness, clinical respiratory illness and laboratory confirmed respiratory virus	1441 HCWs	Infections rate was double for medical masks than for N95 and no significant difference was seen with fit testing or without fit testing however, low fit test failure was seen.
Macintyre., *et al*. 2013 [23]	Randomized clinical trial	Comparison of medical masks and N95 respirators in high risk procedures in HCWs against the clinical respiratory illness and laboratory confirmed respiratory pathogens	1669 HCWs	Continuous use of N95 was better than intermittent wearing of N95 or medical mask
David., *et al*. 2003 [24]	Non-blinded	Methicillin-resistant *Staphylococcus aureus* (MRSA) prevalence in restorative dental care while using handpieces that generate aerosols by taking the cultures swab tests and plates	6	The study showed the efficacy of PPE precautions, such as gowns, gloves, masks, facial shields, hats and glasses, pre procedural 0.12% chlorhexidine mouth wash, surface disinfectant, perioral skin scrubs and high volume evacuation along with the measurement of infection control methods, rubber dam isolation, high speed hand piece, high speed air turbine, hand excavation, there was no increase of MRSA prevalence aerolization was seen.

Table 3: *Evidence for the effective methods of reducing the effect of AGPs in dentistry.*

Discussion

Based on the studies available and the evidence provided above we recommend and emphasize on the mitigating strategies implications for dental environments in order to control the aerosol productions. As the guidelines provided lack the evidence and thorough research is required to implement the measures for dentists. The guidelines and standard operating procedures (SOPs) were provided by different organisations advising that aerosol generating procedures (AGPs) should be avoided unless there is an emergency. The SOPs although inform regarding the practice however, there is limited evidence to the guidance available. So far, numerous authors have used the microbiological studies in order to study the bacterial contamination occurred from the dental procedures from aerosol and splatter, by swabbing of contaminated surfaces, by air sampling by culturing onto the media, this revealed that studies had limitations. Therefore, the lack of evidence regarding aerosol and splatter persistence and distribution is the major barrier for the reintroduction to the routine dental care which has ultimately negatively impacted the care of patients [25-28].

The studies included in our systematic review, gives the overview of the evidence available on the aerosol contamination on PPE during dental care provision and evidence for the effective methods of reducing the effect of AGPs in dentistry. The studies revealed that aerosol and splatter are produced by several dental procedures, they are contaminated with blood or saliva. It is suggested that SARS-COV-2, can

be transmitted through saliva and the virus can remain infectious and viable have for hours in aerosol and for days on surfaces. The transmission of SARS-COV-2 is based on the size of the particles. The viral particles can be aerosolized through dental care procedures, sneeze or cough. The particles can be travelled across far distances up to 20 feet from infected individual. The nuclei of the aerosolized droplet remain in the suspended air even after the patient has left and can contaminate the surface and infect the dentists. The longevity of SARS-COV-2 is various places is different such as it can stay viable on stainless steel and plastic surfaces up to 72 hours, 24 hours on cardboard surfaces, 9 hours on copper surfaces and up to 3 hours in the suspended aerosols. Furthermore, the studies suggested that pre procedural measures and appropriate PPE usage help preventing the spread of virus. The culture tests, bacterial colony formation, the use of mask such N95 and medical masks, comparison of conventional dental suction (CDS) and high volume evacuation (HVE), detection of air pollution, efficacy of PPE precautions, such as gowns, gloves, masks, facial shields, hats and glasses, pre procedural 0.12% chlorhexidine mouth wash, surface disinfectant, perioral skin scrubs and high volume evacuation along with the measurement of infection control methods, rubber dam isolation, high speed hand piece, high speed air turbine, hand excavation evidenced and backed up the guidelines provided.

However, as elimination of the virus from environment at the moment, but we can reduce the viral load by employing different technologies [29-31]. Current evidence shows that there is a threshold viral load which causes illness and low viral dose results in subclinical infection. Reducing the viral load is therefore the best strategy. Currently, dentists try to prevent and control transmission of infection by employing a stratified, multi-layered biological risk strategy that includes use of PPR and environmental precautions such as using air filtration/purification, germicidal UVC, fogging with hypochlorous acid, negative air pressure isolation (with 20 - 30 air changes per hour) room techniques. Pilot studies have shown that “at source” high volume extraction near the mouth during AGPs can be highly effective in controlling the spread of aerosols and droplets. Unfortunately, there is very little evidence to show if these techniques are effective [6,32-34]. Therefore, with the validation of impact of COVID-19 on dentistry and research conduction of bench studies in laboratory with the objective of investigating and identifying strategies for mitigating the effect of SARS COV-2 will help in exploring the aerosol and droplet control measures and environmental precautions in order to commercialize and extend the strategies in to the clinical settings [35].

Future Recommendations

Based on the limited clinical an experimental evidence available there should be further research conducted on the validity of the guidelines, the use of PPE find fallow time and we propose certain recommendations listed below.

Issues concerning new guidelines:

- FFP3- Fit testing, shortage of training individuals.
- FFP3- Designed for the industrial work in order to prevent individuals with any dust particles, hence it was never designed for the dentists [35].
- Indemnity does not cover dentist to fit test their dental team.
- Fear among dentists performing AGPs.
- Uncomfortable PPE makes it difficult to communicate with the patient and dental team.
- Gowns- expensive and to re-use them, the transport is an issue, it is not routine practice for all the dentists.
- HEPA filter may not capture the smallest molecules (0.05 microns); particle size below 10 micron goes into lung.
- Increased follow time, causes the surgery to suffer, reduces the capability of the practice, increased reading list, deep cleaning causes the surgery loaded jobs.

Recommendations

- This should be reduced with the evidenced research in which the particles should be quantified after every surgery in order to analyse what might be the best time to restart the next procedure. Therefore, we also need to test/understand HEPA filtration and recommend setting up a small simulation using a HEPA filter to capture concentration using an airflow and bag method. Laboratory test, aerosol testing; flash vaporizing - small droplets. This would measure the capability and efficiency in capturing aerosol droplets.

- Further urgent research is needed in order to provide with the greater understanding of aerosol generation and spread within the clinical setting. Existing methods of aerosol containment, using extraction methods will also be further understood and will enable the design of improved methods of aerosol containment. These new methods would form the basis of the commercialisation of novel extraction technologies. Hence, understanding of the characteristics of aerosol generation within dental environment and investigation of effectiveness of aerosol and droplet control measures and environmental precautions will identify the strategies for mitigating the effect of SARS COV-2.

Conclusion

In the medical literature, the transmission on the airborne spread of SARS is well documented. However, in the dental literature it has been revealed that dental procedures produce the droplets and aerosols which are contaminated with blood and bacteria which shows the potential transmission route. It is also being documented in the literature that the airborne aerosol contamination can be reduced simply and cost-effectively by taking the routine precautions during performing all the dental procedures. There is limited evidence for AGPs to be shown the exact timing and transmission to dentists. Robust and rigorous precautionary approach is necessary to cope up with the risk factors, transmission and safety of dentists until the scientific evidence becomes available. There is a big gap in research and urgent research is required for the quantification of AGPs in dental settings to have reduced fallow time, aerosol transmission and spread of virus. The research is needed to explore the mitigating strategies which may behave as potential aerosol containing device. We hope that research will bring about breakthroughs in dental practice which will benefit the dental patients and dentists in terms of controlling the dental environment from aerosols.

Acknowledgements

We are thankful to Rabia Sannam Khan for helping us with the write-up and compilation of all knowledge on one platform. Cemal brought the idea of this innovative topic and helped in whole paper overseeing. All other authors supported in the compilation of tables, figures and English improvement.

Conflict of Interest

There are no conflicts of interests.

Bibliography

1. Baghizadeh Fini M. "What dentists need to know about COVID-19". *Oral Oncology* 105 (2020): 104741.

2. De Stefani A., *et al*. "COVID-19 outbreak perception in Italian dentists". *International Journal of Environmental Research and Public Health* (2020).

3. Passarelli PC., *et al*. "The impact of the COVID-19 infection in dentistry". *Bulletin of Experimental Biology and Medicine* (2020).

4. Harrel Sk and Molinari J. "Aerosols and splatter in dentistry". *Journal of the American Dental Association* (2004).

5. Szymańska J. "Dental bioaerosol as an occupational hazard in a dentist's workplace". *The Annals of Agricultural and Environmental Medicine* (2007).

6. Long RH., *et al*. "Modifications of emergency dental clinic protocols to combat COVID-19 transmission". *Special Care Dentistry* 40.3 (2020): 219-226.

7. Tagg A. "Aerosol Generating Procedures". Don't Forget the Bubbles (2020).

8. Seto WH. "Airborne transmission and precautions: Facts and myths". *Journal of Hospital Infection* 89.4 (2015): 225-258.

9. Naqvi K., *et al*. "Challenges in providing oral and dental health services in COVID-19 pandemic". *Journal of Pakistan Medical Association* (2020).

10. Wu KY., *et al*. "COVID-19's impact on private practice and academic dentistry in North America". *Oral Diseases* (2020).

11. FGDP(UK) "Notices and Announcements". *Primary Dental Journal* (2019).

12. Gandolfi MG., *et al*. "Coronavirus contamination in dental clinics. New systems and operating devices". *Dent Cadmos* (2020).

13. Hallier C., *et al*. "A pilot study of bioaerosol reduction using an air cleaning system during dental procedures". *British Dental Journal* (2010).

14. Ishihama K., *et al*. "Evidence of aerosolised floating blood mist during oral surgery". *Journal of Hospital Infection* (2009).

15. Ishihama K., *et al*. "Floating aerial blood mists in the operating room". *Journal of Hazardous Materials* (2010).

16. Perdelli F., *et al*. "Evaluation of contamination by blood aerosols produced during various healthcare procedures". *Journal of Hospital Infection* 70 (2008): 174-179.

17. Al-Eid R., *et al*. "Detection of visually imperceptible blood contamination in the oral surgical clinic using forensic luminol blood detection agent". *Journal of International Society of Preventive and Community Dentistry* (2018).

18. Van Doremalen N., *et al*. "Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1". *The New England Journal of Medicine* (2020).

19. Retamal-Valdes B., *et al*. "Effectiveness of a pre-procedural mouthwash in reducing bacteria in dental aerosols: randomized clinical trial". *Brazilian Oral Research* 31 (2017): e21.

20. Timmerman MF., *et al*. "Atmospheric contamination during ultrasonic scaling". *Journal of Clinical Periodontology* (2004).

21. Au SSW., *et al*. "A randomised controlled pilot study to compare filtration factor of a novel non-fit-tested high-efficiency particulate air (HEPA) filtering facemask with a fit-tested N95 mask". *Journal of Hospital Infection* (2010).

22. CR M., *et al*. "A cluster randomized clinical trial comparing fit-tested and non-fit-tested N95 respirators to medical masks to prevent respiratory virus infection in health care workers". *Influenza and Other Respiratory Viruses* 5.3 (2011): 170-179.

23. MacIntyre CR., *et al*. "A randomized clinical trial of three options for N95 respirators and medical masks in health workers". *American Journal of Respiratory and Critical Care Medicine* 187.9 (2013): 960-966.

24. Hall DL. "Methicillin-resistant Staphylococcus aureus and infection control for restorative dental treatment in nursing homes". *Special Care Dentistry Association* 23.3 (2003): 100-107.

25. Wilson NM., *et al*. "Airborne transmission of severe acute respiratory syndrome coronavirus-2 to healthcare workers: a narrative review". *Anaesthesia* 75.8 (2020): 1086-1095.

26. Mick P and Murphy R. "Aerosol-generating otolaryngology procedures and the need for enhanced PPE during the COVID-19 pandemic: A literature review". *Journal Otolaryngology–Head and Neck Surgery* (2020).

27. Howard BE. "High-Risk Aerosol-Generating Procedures in COVID-19: Respiratory Protective Equipment Considerations". *Otolaryngology–Head and Neck Surgery* (2020).

28. Soma M., *et al*. "Operative team checklist for aerosol generating procedures to minimise exposure of healthcare workers to SARS-CoV-2". *International Journal of Pediatric Otorhinolaryngology* (2020): 10075.

29. Sahibzada HA., *et al*. "Outbreak Of Chikungunya Virus In Karachi, Pakistan". *Journal of Ayub Medical College Abbottabad* 30.3 (2018): 486-489.

30. Proffitt E. "What will be the new normal for the dental industry?" *British Dental Journal* (2020): 678-680.

31. Burke FT., *et al*. "Suggestions for Non-Aerosol or Reduced-Aerosol Restorative Dentistry (for as Long as is Necessary) (2020).

32. Harding H., *et al*. "Aerosol-generating procedures and infective risk to healthcare workers from SARS-CoV-2: the limits of the evidence". *Journal of Hospital Infection* 105.4 (2020): 717-725.

33. Heij R., *et al*. "Testing for coverage from personal protective equipment: Public Health England's guidance does not protect healthcare workers from droplet spray". *Anaesthesia* 75.7 (2020): 966-967.

34. Chahal AM., *et al*. "A Rapidly Deployable Negative Pressure Enclosure for Aerosol-Generating Medical Procedures (2020).

35. Day CJ., *et al*. "Aerosols and splatter in dentistry--a neglected menace? *Dent Update* 33.10 (2006): 601-602.

36. Christian J Day., et al. "Aerosols and splatter in dentistry--a neglected menace?". *Dental Update* 33.10 (2006): 601-602, 604-606.

Volume 19 Issue 10 October 2020