

COVID-19 dent guard and movable room for dentists practice with design solution for air cleaning in natural ventilation

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ABSTRACT

Virus could dependently spread in the air rising human infection. The global awareness issues by COVID-19 of the virus at average size about 0.125 μm smaller than dust led to the lung disorder. Thus, the social distancing between humans is recommended for a minimum of 2 meters to lessen droplets infection. Therefore, dentist job is unavoidable to contact in high risk in respiration area. Thus, an outright dent guard is promptly designed to reduce water spreading with a plastic-covered shield for temporary solution that is required to be analysed its effectiveness for human health protection. The shield has distributing over hospitals and healthcare. A monitoring particle spreading inside dent guard by using computational fluid dynamics (CFD) simulation demonstrates a dental guard size 0.50 m. \times 0.60 m. for virus dilution for health protection and position for accumulation a particle flow in the building on capable dent guard for design solution in this crisis.

KEYWORDS

COVID-19, dent guard, virus dilution, air cleaning, CFD

INTRODUCTION

Coronavirus disease or COVID-19 has formed new lifestyle of human wearing marks for protection from virus infection to others. Restricted area is announced with permission for avoid spreading disease. Despite, dentist job is unavoidable to connect near respiration area. Tooth scaling and root planing is prohibited when lockdown, the treatment for dentists' service during COVID-19 pandemic situation. Besides, the treatment is recommended to be clean within two to six months to avoid risk of decay, gum disease, bleeding in tooth. How dentists and patients could securely in contact during the dental practices. Regarding to DEN1019, the ease down situation is possible for general dental check-up but not the practices of tooth scaling and root planning. Furthermore, the COVID-19 situation trends to continue more than six months since late 2019 until current.

When the COVID-19 healing situation was announced 1st lock down where both national and international

states are closed in dental services for health protection. Health service is unable to be performed with dramatically increase of infected people. Due to the immediate lockdown cause inconvenience for people, it would be better to find solution for both patient and dentists to continue common situation. Regarding to dentists' interviews, the major of dental services with risk of virus diffusion are filling, scaling and root planning, prosthodontic treatment, endodontic treatment, and oral surgery. Furthermore, the situation in Thailand, the dental service on scaling is prohibited until the COVID situation is relieved by the Bureau of Dental Health, Thailand (the Bureau of Dental Health, 2020). Thus, the weapon for treatments are supported in various choices (SCG, 2020) to distribute for all provinces of Thailand including rural area. The dent guard is designed for protection water spreading with clear non-reflected plastic shield.

Respiration rate in breathing contacting as the first risk of infection can be likely enjoy exchange on virus at nose and mouth area for taken into human body. (WHO World Health Organization, 2020). The women and men are averaged with breath rates on human body and metabolic rates. On observation of Medical report found an acrylic box at its form and slope might be investigated and overall droplet dispersion between three acrylics are modelled in boxes (3.3%–19.0%), plastic sheet (2.8%), and no coverage technique (26.3%) during tracheal extubation. Besides, using open door is recommended (Laosuwan, P., Earsakul, A., Pannangpetch, P. & Sereeyotin, n.d.). In Thailand, the state of supporting for COVID situation for population and medical field to be able to work consistency. Architects and designers are launching two methods: fast and quick. First, the fast method is group of medical teams on rural area with van and medical check-up and secondly the acrylic box is built for protection of virus from patient to dentists. However, the design is widely spreading and non-testing with effects from particle flow from both patient and dentists. The particles is illustrated for invisible substances such as dust, virus, radon etc. Those particles with size of 0.06 to 0.14 μm where is larger than some dust and gas particles from 50 to 200 nanometres. (Dentsplysirona, 2020).. To investigate the

risk on virus spreading, the tool of computational fluid dynamics (CFD) simulation is beneficial to evaluate for air distribution and particle movement.

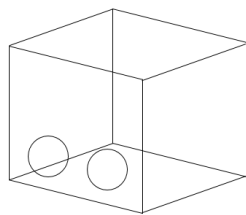
The motivation of research is a solution for possible to perform the dental practices in scaling. Thus, this study is avoiding directly contact with demonstration on two methods by dent guard and movable room for design solution during COVID-19 situation for health protection assessment that can be requirement of design guideline for rural development.

METHODOLOGY

This study is mentioned in current two solutions on dent guard and movable room as design in below;

Dent guard

The plastic box of dent guard is outreach design solution to practice in tooth scaling. The model of air cleaning is demonstrated of size 0.50 m. × 0.60 m. with two openings of 0.25 m. diameters as circle shapes. The simple model for dent guard for dental operation is with opening for hand in figure 1. illustrated with a clear non-reflected plastic-covered shield.



Dentist treatment 1 (Acrylic box)

Figure 1 CFD set up in dent guard

Movable room

Besides, a plastic covered-moveable room is selected 2.00 m. × 4.00 m. × 2.40 m for isolated treatment. The modular design analysis is to find the best solution on position of openings as in figure 2 for introducing the natural ventilation to improve virus dilution in room.

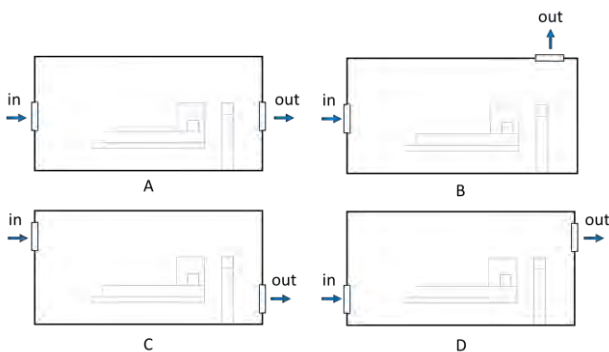


Figure 2 CFD set up in movable room and opening positions

Thus, the CFD setup are modelled as 0.20 m. × 0.20 m. × 0.20 m. as virus sources from head of patient and dentist in figure 3. The models are placed at the height of patient of 0.60 m. as laying position where the height of dentist is set at 1.00 m. as sitting position in figure 4. Thus, the respiration area for patient and dentist is defined at mouth position where the virus likely found.

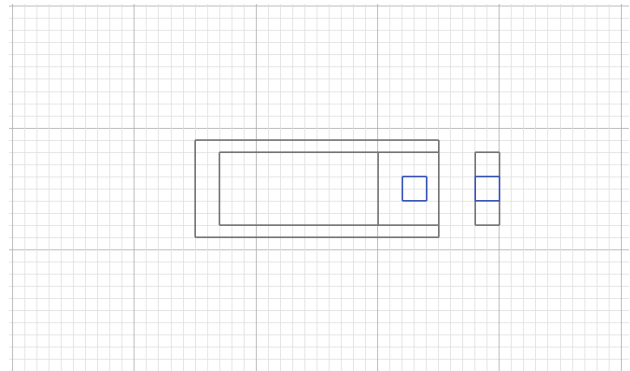


Figure 3 CFD model of dentist and patient distance (plan)

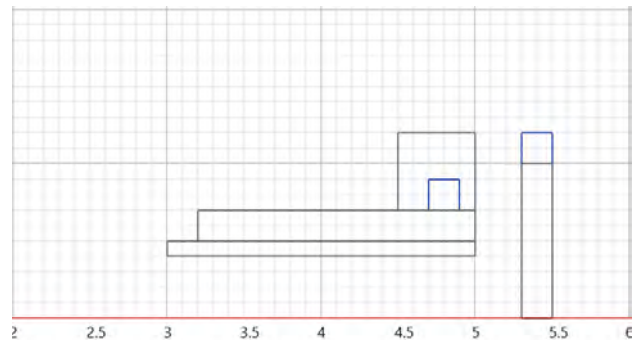


Figure 4. CFD model of dentist and patient distance (section)

Virus flow in dent box

The dent guard and movable room is intended for limited virus spreading from direct contact in figure 5. The current models are illustrated acrylic box in market with two openings for dentist 'hand to do operation services. The considerable point can be at the leakage from two holes that is covered with globes.



Figure 5 Dent guard and movable room (SCG, 2020).

In fact, the tooth scaling is recommended for dental check-up within 2 to 6 months to avoid unhealthy situation. Therefore, it is predicted that the pandemic period may be longer. The high risk of virus as water spreading is required to set a standard for air dilution and reduce air contaminant to solve new lifestyle. Thus, the objective of this study is to find design solution for air cleaning by using natural ventilation for dental practices with dent guard and movable room. The choice depends on treatments. In order to avoid infection for both people, the real practices and procedure in figure 6 are considered especially in the tooth scaling device on three aspects below;

- Tooth devices frequency
- Time practices
- Position

The process of tooth scaling is illustrated in risk area of particle flow and condition on practices periods in tooth scaling. Due to the infection can be connected by droplet and water spreading, the acceleration to is considered with particle speed with its frequency in figure 7 as source from the tooth devices.

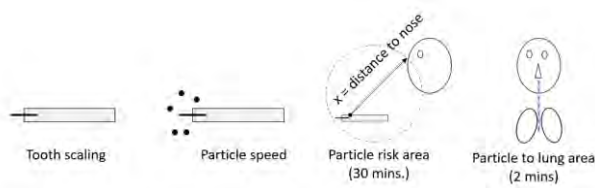


Figure 6 Process for virus spreading in dental service

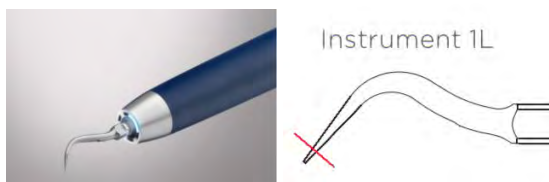


Figure 7 Scaling and diffusion source (Dentsplysirona, 2020)

Thus, the tooth devices frequency is selected with the commercial product, time practices are required by interview dentists for direct contact to patient and the position of contact between both patient and dentist are controlled for real situation on dental services.

Particle flow in CFD setup

The flow is considered indoor room with free-flow of openings in both dent guard and movable room. Where the particle sources are set from the tooth devices. Regarding to current market of devices, the selected commercial products of filling machines, the Piezo-

Electric Crystal is sized at 19.5 cm (L) x 16.2 cm (W) x 8.3 cm (H) with general frequency at 26 KHz - 32 KHz. Meanwhile, the average values of particle sources is considered at 40 kHz . The amount of contaminant is set at the patient mouth where the devices is placed.

Particle set up

The risk conditions are demonstrated in low, medium and high risk for infection. The activities are normal breathing, coughing and tooth scaling. In table 2, the risk scenarios are defined for possibility of higher risk of infection during the dental services periods. Where the amount of particle flow will be accumulated inside the target model within certain periods of interval 30 minutes. The selection on source contaminant is modelled at 20,40, and 80 pieces/square meters (pcs/m³) accordingly. The breathing position are considered at height of 0.6 m. where the distance between patient and dentists is at 0.40 m. Also, the natural ventilation flow is set for freely ventilated through inlet and outlet of movable room.

Table 1. Risk scenarios in dental tooth scaling for CFD models

Risk status	Partial source	Breathing Position (m.)	Source contaminant (pcs/m ³)
Low	Normal breathing	0.6	20
Medium	Coughing	0.6	40
High	Scaling	0.6	80

CFD and configuration setup

The active acrylic box for dent guard and moveable room are calculated with air flow solution. Thus, the configuration is chosen in SIMPLEC and QUICK with transitional analysis setting in calculation of 30 minutes of time as per dental services to be performed. Besides, the k-ε methods and turbulent intensity at 10% are choices as for suitable solution for natural ventilation analysis. The three models of risk situation are compared in results of contaminant and its distribution in room and other results are ;

- Air contaminant
- Distribution
- Dilution
- Natural ventilation and improvement

Calculation period setup

Regarding to dentists ‘interview, the tooth scaling and root planning’s practices is generally operated within 30-32 minutes. Thus, the interval time is calculated for transitional analysis with timing at 30 minutes for total operational time facing with risk situation.

RESULTS AND DISCUSSION

□ *Results for velocity distribution in dent guard*

The trial calculation of CFD in monitoring for inflection between patient and dentist show virus distribution in figure 8. It is found that the density contaminant is likely to be controlled in dent guard. Therefore, the leakage of contaminant in the bottom of dent guard is to be carefully considered.

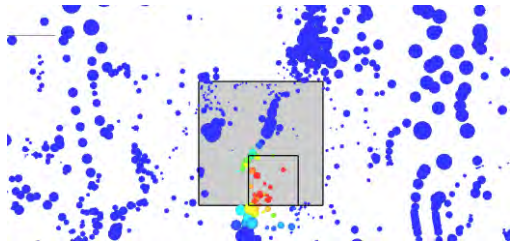


Figure 8 Results in dent guard and particle intensity

□ *Results for velocity distribution in moveable room*

The result for moveable room is investigated with patient inflection the flow distribution in room on the density of contaminant found figure 9,10.

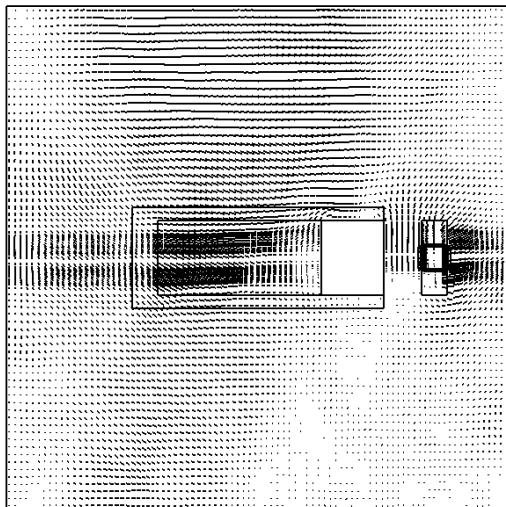


Figure 9 Results in diffusion for normal situation 1

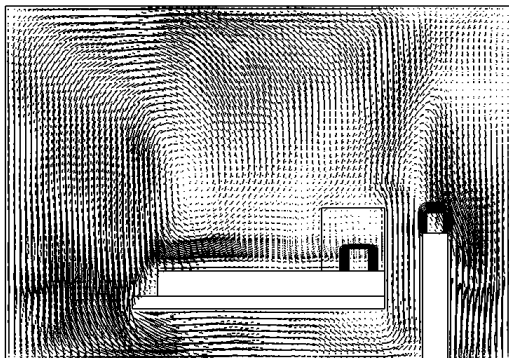
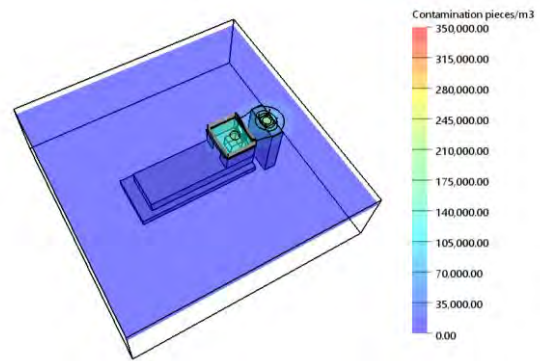


Figure 10 Results in diffusion for normal situation 2

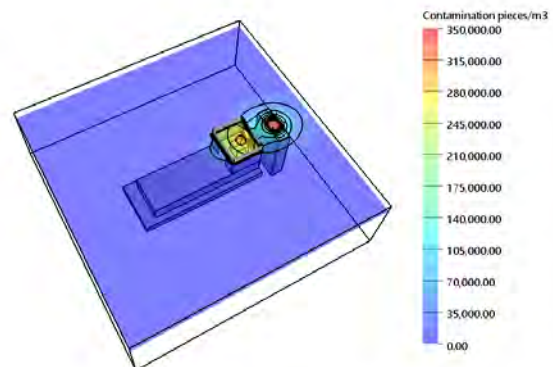
Moreover, the position of nose and mouth is 0.6 m. at patient and at 1.00 m. of dentist found contradict direction on flow when the model is calculated with both patient and dentist are distribution virus sources in the ideal of separation of virus diffusion from others to others.

□ *Results for dilution*

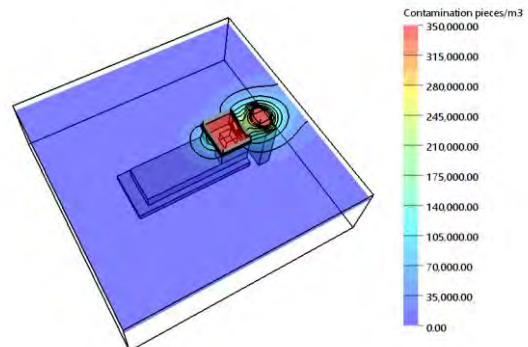
Air cleaning and virus dilution is considered in three scenarios in low, mid and high risk with the consistency amount of particle flow from the target sources at patient with the tooth devices. The movable room are monitored in figure 11 illustrated position of virus distribution in room.



Low contaminant



Mid contaminant



High contaminant

Figure 11 Results in low, mid and high risk diffusion

Besides, the risk in three scenarios on normal breathing, coughing and working period on tooth scaling of devices are illustrated in section and monitored at the near respiration area in figure 12 found the possible of contaminant can be effects to each other and the amount that can control inside the dent guard. Regarding to the results, the proposed of reduction is required for further studies.

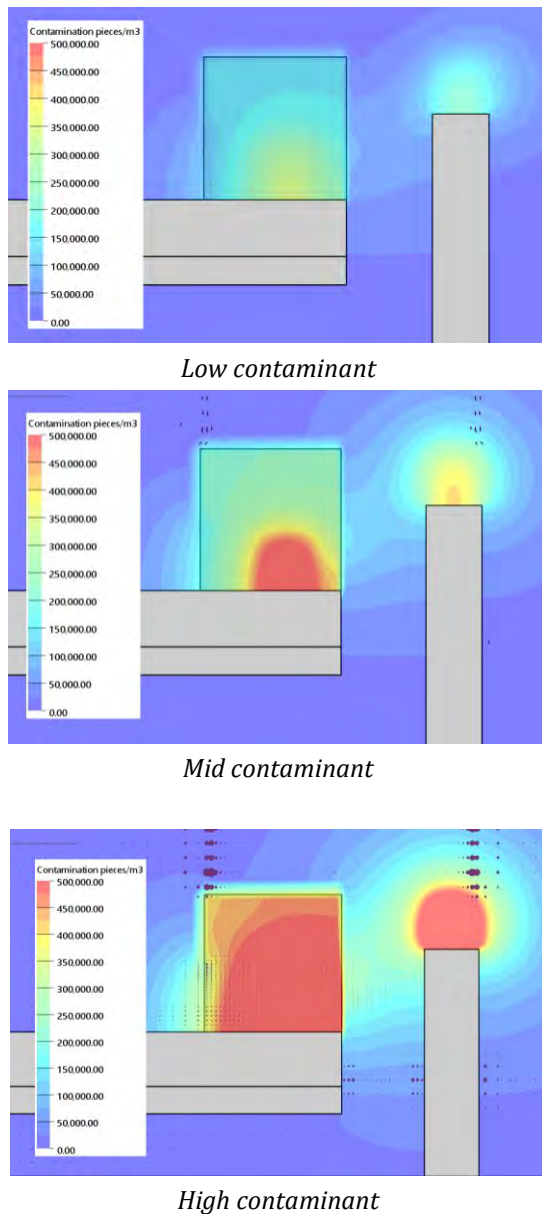


Figure 12 Results in low, mid and high contaminant at mouth

- Discussion for virus dilution in air cleaning process
The demonstration two methods: dent guard and movable room aims for design solution in use of natural ventilation. After 30 minutes in CFD calculation for real condition, the CFD results are compared in three positions that are 1) respiration

the possible accumulation on contaminants are from approximately from 60k to 300k on pieces/m³. Regarding to acceptable contaminant, the WHO for indoor air pollutant found for respiratory virus-induced for primary human nasal epithelial of virus and bacteria's from 3160 to 84,000 µg/m³ (WHO World Health Organization, 2010) where the low contaminant test case found 67,708 pieces/m³ at the space between breathing area of dentist and patient. The minimum, average and maximum of contaminant are summarized in below; In figure 12, the results found the highest accumulated contaminant is in patient respiratory area, followed by dentist area and dent guard as in target volume in pieces/m³. The further studies as expansion from this research will be continued as entitle below;

Dent guard

The illustration of particle flow inside dent guard and leakage of particle shall be performed. The simulation of hole is required to be re-design and re-calculated.

Movable room

The movable room and its position of opening for introducing of natural ventilation on each location in Thailand base on weather data. That relation to the current situation use of the movable room is including in rural area for all provinces in Thailand. This can be a supporting the dental staffs to low risk of infection.

CONCLUSIONS

Dental services sensitively prohibit tooth scaling due to the risk of virus diffusion Dent guard is outreach solution for supporting dentist and patient on protection from spreading especially in tooth scaling. The diffusion control of COVID-19 disease is limited with social-distancing not higher than two meters avoiding infection from breathing. Therefore, the dental practice is prohibited for long period until current. Thus, to continue in dental practices, the virus spreading and room is required dental extra-prevention. In current, the dent guard is designed as a plastic box with opening and movable room. Moreover, the virus control for rural development area with medical check-up is necessary to support with the moveable room. The design protections for health in both patient and dentists to avoid infection from virus in air. The invisible particle is selected case of tooth scaling and its working periods of working at 30 to 32 minutes for dental service for CFD calculation, the number of particle flow and the acceptable range for human are discussed for efficient of the dent guard. The virus accumulated during operation can be found approximate 67,708 pieces/m³ of contaminants

calculated from CFD simulation for normal breathing condition. This study is monitoring situation of using dent guard in low, mid and high risk for cases of normal breathing, coaching and scaling for decision in improvement methods for indoor air. Further studies in moveable room and particle flor behaviour in CFD modelling would be likely to investigate in case studies.

ACKNOWLEDGEMENT

The author would like to address special thanks to dentists from Chonburi province in Thailand on working process during COVID-19 situation for technical information and interview.

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