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Fighting Airborne Spread of COVID-19: An Innovative, Economical and Effective High Vacuum Extra Oral Dental Suction System (HVEDS) for Dental Practices

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Abstract

COVID-19 pandemic has led to a great deal of commentary about the airborne spread of the disease. It is of special concern for the dentists as most of the dental procedures generate significant amount of aerosols and droplets. Given such high risk and inevitable aerosol production in dentistry, special precautions and protective measures to ensure safe delivery of dental treatment is directed. To ensure negligence free dental practice, in addition to the standard protective procedures and measures, high vacuum extra oral dental suction system is a mandated dental armamentarium. Most commercially available vacuum aspirators are pricey and require special units with which they can work. In a country like Pakistan, where expensive armamentarium is neither available, nor easily affordable, we present an economical yet effective, high volume extra oral dental suction system for the dental offices which does not require heavy monetary investment. An in-house alternate to the commercially available extra oral aspirator is introduced here. We devised a make-shift extra oral aerosol aspirator which can be effortlessly assembled with the materials easily available around dental offices. When tried in use, the aerosol and spatter was eliminated through the cone-shaped oil key and collected into the collection bin as observed visually.

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The equipment, due to its high vacuum suction capability sucks the aerosol and splatter from the working area to the collection cone. Post COVID-19, we can expect a lot of changes in the infection control practices and guidelines. The use of extra oral vacuum aspiration along with the conventional protocol has been recommended to protect both the dental staff and the patients as the high vacuum extra oral aspirator may offer the way to reduce the generated aerosol particulate.

Keywords: High volume extra oral suction; aerosol; Dental setting; infection prevention; SARS-Cov-2; clinical dentistry.

1. Introduction

SARS-Cov-2 has changed the world order since its emergence and has affected nearly everyone across the globe. As the virus spreads mainly via droplet transmission and direct contact [1], preventive measures have been mandated, updated and strictly implemented worldwide. Despite the world coming to a halt due to the unprecedented global risk, the world is adjusting to the 'new normal' and working its way to keep the life going [2]. Dentists are the most at-risk profession as they cater to oral procedures which produce aerosol and droplets. The only solution is meticulous personal protection. Clinical dentistry risks the dentist, dental assistant, and the patient as well. Despite the measures, the aerosols containing viruses can stay in the surroundings for quite some time and might even become the source of re-inoculation [3]. The potential hazard of droplet/aerosol transmission in clinical dentistry warrants that we implement special precautions to avoid critical negligence in dental practice [3,4]. The use of extra oral vacuum aspiration along with the conventional protocol has been recommended to protect both the dental staff and the patients [5]. Extra oral suction systems are high airflow vacuum suction systems that forage the aerosols and droplets surrounding the patient's mouth and trap the droplets and spatter for safe waste disposal. In a country like Pakistan, where expensive armamentarium is neither available, nor easily affordable [2], we present an economical yet effective, high volume extra oral dental suction system (HVEDS) for the dental offices.

2. HVEDS equipment

High volume extra oral aspirators have been available since a while now for the use in dental offices. Most commercially available extra oral aspirators are expensive and require specific requirements of a dental unit to be functional. We devised an in-house make-shift extra oral aerosol aspirator which can be easily assembled with the materials described below. A vacuum carbon motor of 750 Watts was used. The air outlet was connected to the dental unit with a PVC pipe connected into a waste disposer. It can be connected to the dental unit's drainage system as well. Another flexible PVC pipe (1ft. ¾ pipe) was used and a 6inch oil key was clamped at one of its ends to act as an aerosol collecting unit, as shown in Figure 1.

Figure 1: High vacuum extra oral dental suction system (HVEDS)

The flexible pipe allows it to be easily manipulated by the assistant and place it at the desired position, demonstrated in Figure 2.

Figure 2: HVEDS in function

We recommend placing it at a distance of 4inch from the patient's oral cavity. An electrical power switch was fitted in a convenient position to allow turning on and off the system. The engineering working model of the equipment is shown in Figure 3.

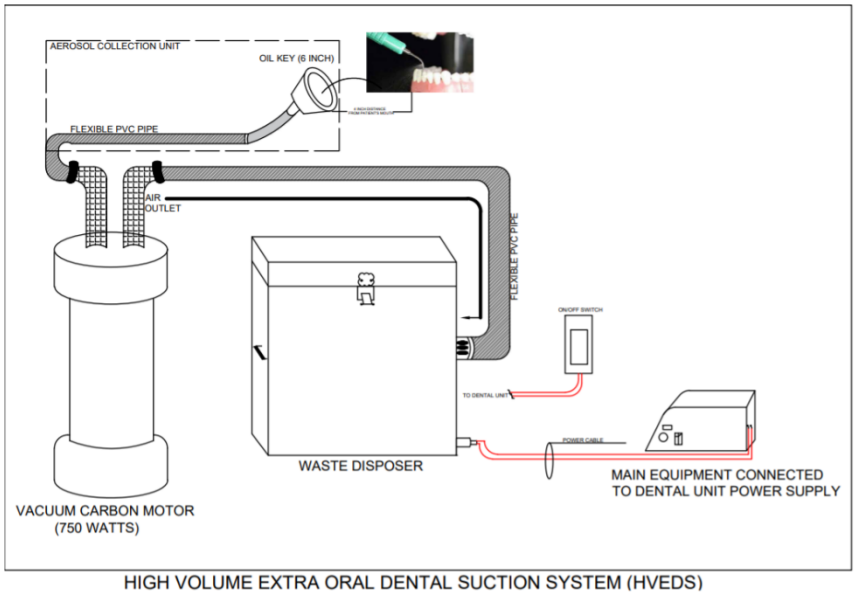

Figure 3: Engineering work model of the equipment

In this study, we incorporated visual droplet detection method, particularly suitable for spatter and aerosol to identify efficacy of the equipment. When tried in use, the aerosol and spatter was eliminated through the cone-shaped oil key and collected into the collection bin, shown in Figure 4.

Figure 4: Aerosols getting accumulated in the aspirator

After use, the entire system and the collection unit is disinfected with the standard disinfectant [Alkyldimethyl benzyl ammonium chloride and Didecyl dimethyl ammonium chloride] to eliminate contaminants and infectious microorganisms.

3. Discussion

SARS-Cov-2 or COVID-19, since it's emergence in December 2019, has continued to reform the "normal" measures and routine as were known prior. It has impacted several countries, with Pakistan also categorizing under severely affected countries [6]. COVID-19 continues to be a global threat and unfortunately the number of cases is increasing at an alarming rate. The life-threatening virus is transmitted via one-to-one contact, and airborne means including droplets and aerosols [7,8]. The potential for these airborne particles to transmit infection from an infected patient to the dental personnel or from the dental team to the patient is a serious hazard and warrants prime attention. Clinical dentistry caters to the procedures that produce profuse amount of aerosols and droplets [9]. This aerosolized cloud is a combination of substances from within the oral cavity; plaque, calculus, saliva, blood, filling material, tooth structure and from the dental unit waterline [9]. The splatter and droplet transmission to the mid face of the dentist and the dental assistant, as well as the nasal area of the patient holds the most risk of inoculation [10]. Furthermore, periodontal treatment has a relatively higher chance of droplet infection transmission compared to restorative procedures [11]. One of the studies [12] demonstrated the highest risk of particle transmission when Ultrasonic and sonic instrumentation were used during a non-surgical procedure, followed by air polishing system, triple syringe usage and high-speed handpiece aerosol production. Another study [13] demonstrated that ultrasonic instrumentation can transmit 100,000 microbes /ft^3 which can last from 35 minutes to 17hours given improper air current is present. Since Dental personnel and the patients are most exposed to these dangers, Occupational Safety and Health Act (OSHA) released a report on "Guidance on preparing workplaces for COVID-19" [14]. They have categorized occupational risks as very high, high, medium and low risk strata and Dentistry, because of the inevitable aerosol production falls into the category of very high risk. With dentistry being the profession at the most risk of contamination from aerosol and spatter, armamentarium to ensure safe dental practice is the need of the hour. Bacteria and viruses in the mouth and respiratory niches are dislodged during a dental procedure and become aerosol contaminants that may potentially infect other people. All of the oral fluids such as Saliva, blood and gingival fluid should be considered infective [15]. The standard precautions against the aerosols being face masks, and dental shields might still expose dental personnel to the dental aerosol. Bentley and his colleagues [16] demonstrated that infectious aerosol passes through the single layered face masks and rendered dental face shields as much inferior to the facemask because they lack the peripheral fit. Therefore, this mandates additional precautionary measures to mitigate inhalable aerosol and spatter emission, especially in these unprecedented times[14]. The use of extra oral dental suction was not widespread pre-pandemic. Numerous studies have tested their efficacy in experimental simulatory conditions and demonstrated efficient spatter reduction [15,17]. The current equipment is in lieu with the work of Teanpaisan and his colleagues [15], who used a modified extra oral vacuum aspirator (EOVA). The authors demonstrated the efficacy of their equipment by comparing the bacterial load with and without the usage of EOVA. The results showed promising and statistically significant reduction when the extra oral aspirator was used. In another study by Nobuo Motegi and his colleagues [18], the incorporation of the extra oral suction along with the intra oral suction demonstrated significant reduction in bacterial colony forming units (CFU) in comparison to when the intra oral suction was used without the extra oral suction. Hence favoring the installation of an extra oral vacuum suction for the reduction of aerosol and spatter contamination. In a very recent study by Chavis S and his colleagues [19], the extra oral suction unit

(ESU) installed, uses a flexible spatter collection system placed closed to patient's mouth, and shows less spatter at the dentist's eye level as well as the patient's mouth. The results are consistent with our study results where the flexible collection unit was placed at 4-inch distance from the working area and demonstrated visibly less spatter with the use of HVEDS. Citing the dangers of aerosol contamination, we urged the need to develop an easy, economical yet effective and reliable equipment that would help contain the environmental and personal hazards. We take the liberty to recommend this high vacuum extra oral evacuator for the dental offices and dental setups, especially for the third world countries where there are monetary constraints. High vacuum extra oral dental suction system (HVEDS) will get the businesses and clinics back to work while maintaining safety precautions both for the dental personnel and the patients.

4. Conclusion

Post COVID-19, we can expect a lot of changes in the infection control practices and guidelines. The virus is unfortunately not very easy to eradicate all at once. To continue with work life, we need to implement safety measures which are backed by research and evidence. while we strive to make dental offices safe for both the dental personnel and the patients, it's pivotal that we create indigenous, practical and affordable equipment to help contain the spread of infective aerosol and spatter. Before band-wagoning and jumping to extreme financial and architectural change, it is advised to evaluate the already available practices, armamentarium and methods to mitigate the risk of infection while maintaining practicality.

5. Limitations and future recommendations

The current study has not taken place at a standardized control room where the environmental aerosol production could be mitigated due to resource constraints. It will be promising to evaluate the efficacy of the equipment with a medical grade particle counter, under standard conditions, to quantitatively evaluate the efficacy of the system.

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6. Consent for publication

The demo patient was informed of the project and an informed consent was signed by the patient while assuring that the reproduction of the data would be solely for research purposes.

7. Conflict of interest

The authors declare no conflict of interest

8. Author's contribution

MH conceived the idea of the equipment. AH conducted the working demonstration, wrote the manuscript. HRB and SQ contributed to the manuscript.

References

[1]. Z. Ge, L. Yang, J. Xia, X. Fu and Y. Zhang. "Possible aerosol transmission of COVID-19 and special precautions in dentistry." Journal of Zhejiang University-SCIENCE B, vol. 21, no. 5, pp. 361-368, 2020. Available: 10.1631/jzus.b2010010 [Accessed 21 September 2021].

[2]. R. Watt. "COVID-19 is an opportunity for reform in dentistry." The Lancet, vol. 396, no. 10249, p. 462, 2020. Available: 10.1016/s0140-6736(20)31529-4 [Accessed 21 September 2021].

[3]. W. Kohn, A. Collins, J. Cleveland, J. Harte, K. Eklund and D. Malvitz. "Guidelines for Infection Control in Dental Health-Care Settings --- 2003." Cdc.gov, 2021. [Online]. Available: https://www.cdc.gov/mmwr/preview/mmwrhtml/rr5217a1.htm. [Accessed: 21- Sep- 2021].

[4]. A. Pethani, R. Allana and M. Hussain. "Emerging Challenges and Threats for Dental Health Care Sector Attributable to COVID-19: Tale of a Developing Country." Asia Pacific Journal of Public Health, vol. 32, no. 5, pp. 278-280, 2020. Available: 10.1177/1010539520932708 [Accessed 21 September 2021].

[5]. A. Nulty, C. Lefkaditis, P. Zachrisson, Q. Van Tonder and R. Yar. "A clinical study measuring dental aerosols with and without a high-volume extraction device." British Dental Journal, 2020. Available: 10.1038/s41415-020-2274-3 [Accessed 21 September 2021].

[6]. "WHO Coronavirus (COVID-19) Dashboard", Covid19.who.int, 2021. [Online]. Available: https://covid19.who.int/. [Accessed: 21- Sep- 2021].

[7]. M. Jayaweera, H. Perera, B. Gunawardana and J. Manatunge. "Transmission of COVID-19 virus by droplets and aerosols: A critical review on the unresolved dichotomy." Environmental Research, vol. 188, p. 109819, 2020. Available: 10.1016/j.envres.2020.109819 [Accessed 21 September 2021].

[8]. "Report of the WHO-China Joint Mission on Coronavirus Disease 2019 (COVID-19)." Who.int, 2021. [Online]. Available: https://www.who.int/publications/i/item/report-of-the-who-china-joint-mission-on-coronavirus-disease-2019-(covid-19). [Accessed: 21- Sep- 2021].

[9]. D. Mehta, P. Pulluri and S. Karibasappa. "Aerosol and splatter in Dentistry - An Overview." CODS Journal of Dentistry, vol. 7, no. 1, pp. 28-32, 2015. Available: 10.5005/cods-7-1-28 [Accessed 21 September 2021].

[10]. R. Scott Froum, "COVID-19 and the problem with dental aerosols." Perioimplantadvisory.com, 2021. [Online]. Available: https://www.perioimplantadvisory.com/periodontics/oral-medicine-anesthetics-and-oral-systemic-connection/article/14173521/covid19-and-the-problem-with-dental-aerosols. [Accessed: 21- Sep- 2021].

[11]. G. Williams, N. Pollok, D. Shay and C. Barr. "Laminar Air Purge of Microorganisms in Dental Aerosols: Prophylactic Procedures with the Ultrasonic Scaler." Journal of Dental Research, vol. 49, no. 6, pp. 1498-1504, 1970. Available: 10.1177/00220345700490065701 [Accessed 21 September 2021].

[12]. S. Harrel and J. Molinari. "Aerosols and splatter in dentistry." The Journal of the American Dental Association, vol. 135, no. 4, pp. 429-437, 2004. Available: 10.14219/jada.archive.2004.0207.

[13]. R. Miller. "Characteristics of Blood-Containing Aerosols Generated by Common Powered Dental Instruments." American Industrial Hygiene Association Journal, vol. 56, no. 7, pp. 670-676, 1995. Available: 10.1080/15428119591016683 [Accessed 21 September 2021].

[14]. "Guidance on Preparing Workplaces for COVID-19." 2021. [Online]. Available: https://www.osha.gov/sites/default/files/publications/OSHA3990.pdf. [Accessed: 21- Sep- 2021].

[15]. R. Teanpaisan, M. Taeporamaysamai, P. Rattanachone, N. Poldoung and S. Srisintorn. "The usefulness of the modified extra-oral vacuum aspirator (EOVA) from household vacuum cleaner in reducing bacteria in dental aerosols." International Dental Journal, vol. 51, no. 6, pp. 413-416, 2001. Available: 10.1002/j.1875-595x.2001.tb00853.x [Accessed 21 September 2021].

[16]. C. D. Bentley, N. W. Burkhart, and J. J. Crawford. “Evaluating Spatter And Aerosol Contamination During Dental Procedures.” The Journal of the American Dental Association, vol. 125, no. 5, pp. 579–584, May 1994, doi: 10.14219/jada.archive.1994.0093.

[17]. Junevicius, J. Surna, A. Surna, R. “Effectiveness evaluation of different suction systems.” Stomatologija. vol. 7, no. 2, pp. 52-57, 2005.

[18]. Motegi. N. Ikegami, Y. Chiba, M. Asano, Y. “How much extra-oral suction (EOS) can prevent dental aerosols? Fluid dynamic analysis of aerosols with EOS.” Dent outlook, vol. 115, no. 6, pp. 2010-2016, 2010.

[19]. S. E. Chavis, S. E. Hines, D. Dyalram, N. C. Wilken, and R. N. Dalby. “Can extraoral suction units minimize droplet spatter during a simulated dental procedure?,” The Journal of the American Dental Association, vol. 152, no. 2, pp. 157–165, Feb. 2021, doi: 10.1016/j.adaj.2020.10.010.