COMPARATIVE STUDY ON SURFACE CONTAMINATION DURING DENTAL TREATMENTS GENERATING AEROSOLS

Balcoș Carina[1], Livia Bobu[1], Irina Bamboi[1], Anca Rapis[1], Ramona Feier[2], Dana Baciu[2], Irina Grădinaru[1], Georgiana Macovei[1], Loredana Hurjui[1], Vlad Danilă[1,*], Adina Armencia[1,*], Iulia Săveanu[1]

[1]University of Medicine and Pharmacy Grigore T. Popa Iasi, Faculty of Dentistry
[2]Dimitrie Cantemir University, Dental Medicine Faculty, Târgu Mureș

Correspondent authors: Adina Armencia – oanaarmencia@yahoo.com ,
Vlad Dănilă – danila_vlad@yahoo.com
*All authors have equal contribution

Abstract

Most dental procedures that use handpieces, turbines, US scalers, airflow, and air abrasion tend to produce aerosols in which the patient's oral fluids are also entrained, with consequences on the health of the medical staff and other patients. Oral fluids are highly contaminated with microorganisms. **The aim** of the study was to assess the degree of surface contamination in relation to certain variables of the aerosol-generating dental maneuvers. **Material and methods**: 2 operators performed 5 simulations of 10 min each for treatments with US scaler, turbine, and contra-angle with spray cooling system. The evaluation of the contaminated surfaces was carried out by measuring the colored surface, in cm, on the paper sheet that was placed on the mannequin, starting from the oral cavity of the mannequin. The measurements were made in all 4 directions (right, left, superior, inferior) to see which part of the operative field is more prone to contamination. Statistical analysis of the collected data was carried out using the SPSS 26.0. **Result:** Dental turbine operations will produce a significant number of aerosols, the most of them in the form of droplets, spanning regions up to 60 cm. US scaling produced less aerosols than the other activities, with the least contaminated surface. Statistics have proven that the observed differences are different (p=0.000). **Conclusions:** The surfaces were contaminated by all three aerosol-producing dental procedures at various and equivalent distances. The turbine produced a greater amount of aerosols, especially in the form of droplets, that exceeded the maximum contamination zone with an area of 1m

Keywords: aerosols, dental office, dental instruments, contamination

Introduction

By exposing employees and patients to a variety of harmful and infectious substances carried by droplets and aerosols produced during dental treatments, dental clinic surroundings raise the risk of cross-infection (1-3). Because of how small they are, aerosols may float in the air for a very long time before settling on surrounding objects.75% of these particles land on surfaces (water, air, or surfaces) with a diameter of 2 m (meters) or more distant from the patient's position (4,5). Oral fluids are highly populated with bacteria, mostly aerobic bacteria (streptococci and staphylococci), and viruses from which they can spread to the environment by aerosols (2,7). In addition to bacteria, there is a considerable likelihood that aerosols also include viruses, blood, and supra- and subgingival plaque in most dental procedures that use handpieces, turbines, US scalers, airflow, and air abrasion to remove material from the surgical site. These materials are aerosolized (3,7,8), by the rotating action of the instrument or by water sprays and combined actions with compressed air this situation favoring the appearance of respiratory diseases (10,11).

Dental offices with high levels of air pollution have been related to an increase in the incidence of respiratory disorders among dentists. After a dental operation, aerosols continue to circulate in the air for a while, raising the risk of airway infection. Droplets that evaporate leave behind incredibly small particles that can harbor

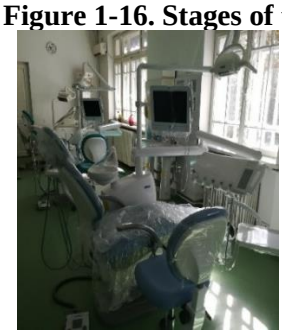
microorganisms or viruses and cause diseases like TB and SARS (12). Dental clinics must adopt more tight infection control, starting in dentistry schools, due to the increased prevalence of these infections. By regularly inspecting the contaminated environment, the quality and safety of medical acts can be increased (13). Due to these factors, the study's goal was to assess the degree of surface contamination in relation to certain variables of the aerosol-generating dental maneuvers.

Material and methods

Dental procedures performed with rotary instruments are considered to be highly contaminating because the compressed air that passes through the tubing of the handpieces (turbine, contra-angle, airflow, US scaling piece) generates a large amount of aerosols that cover/move over a very large surface (metres).

The contaminated surfaces that followed US scaling, the turbine, and the contra-angle withsray cooling system were monitored by our investigation. A mannequin and the dental treatment equipment (turbine, contra-angle with water cooling system, and scaling handpiece) were utilized to conduct the research. The photographs below show several stages of the experiment's setup.

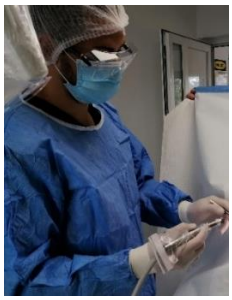
Figure 1-16. Stages of the experiment preparation.



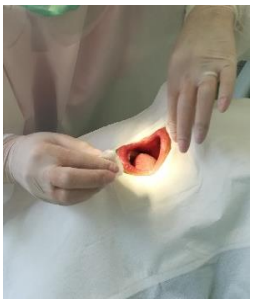
1. Isolation of the dental unit

2.Preparation of the solution used fo coolin with with red food coloring.

3.Setting the scaling device with US, turbine and contra-angle

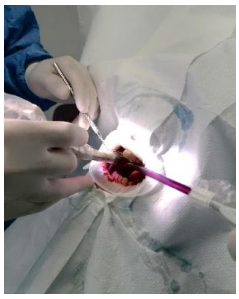


4.Operator's protective equipment

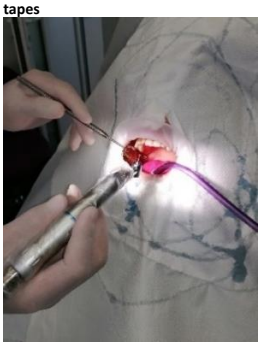


5-6. Isolation of the patient with a paper field fixed around the oral cavity with adhesive tapes

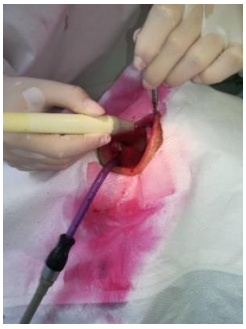
7. Performing US scaling



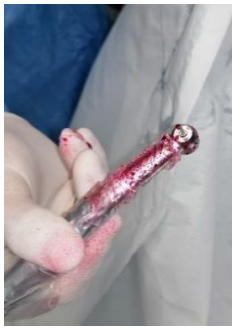
8. Simulating the treatment with the help of turbine with spray cooling system



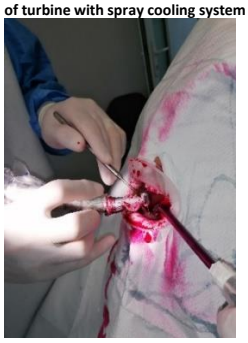
9. Simulating the treatment with the help of contra angle with spray cooling system



10.Evaluation of the contamination of the scaling handpiece



11.Evaluation of the contamination of the dental turbine



12.Evaluation of the contamination of the contra-angle handpiece

13.Evaluation of the contaminated surface after US scaling

14.Evaluation of the contaminated surface after using dental turbine

15.Evaluation of the contaminated surface after using dental contra-angle

16.Evaluation of the contaminated surface on medical staff

For each individual job, 5 simulations of 10 min each were made, the jobs being done by 2 operators to simulate the diversity in manual work.

The evaluation of the contaminated surfaces was carried out by measuring the colored surface, in cm, on the paper sheet that was placed on the mannequin, starting from the oral cavity of the mannequin. The measurements were made in all 4 directions (right, left, superior, inferior) to see which part of the operative field is more prone to contamination.

The statistical analysis of the collected data was carried out using the SPSS 26.0 program for Windows. Student's T-test for determining the differences between the 3 types of aerosol-generating maneuver. The value of p was set at 0.05.

Result

In the case of scaling with US, it was observed that the surface contaminated with droplets/aerosols varied between a minimum of 7 cm and a maximum of 28 cm. Regarding the contaminated surface on the left side of the patient, higher values were recorded, the minimum value recorded being 17 cm, and the maximum 25 cm (tab.1, fig.13).

Table 1. The results obtained during scaling with US

	Minimum (cm)	Maximum (cm)	Mean (cm)	SD	P
US scaling, right side	7.00	28.00	17.80	7.87	0.000
US scaling, left side	17.00	25.00	22.10	2.92	0.000
US scaling, upper part	12.00	21.00	15.60	3.16	0.000
US scaling, bottom part	13.00	28.00	22.10	4.48	0.000
US scaling, average value	14.75	22.00	19.40	2.30	

The contaminated surface in the upper part of the mannequin had a minimum recorded value of 12 cm, and the maximum of 21 cm, the values, in general, being lower than those recorded on the left side of the patient. In the lower part, the largest contamination surface was recorded, namely, 28 cm (tab.1, fig.13).

The analysis of the average values recorded and calculated shows us that the lowest average value of the contaminated surfaces was recorded in the upper area (15.6 cm), and the maximum was equal (22.1cm) both for the left side and for the lower part of the operating field (tab.1).

Table 2. The results obtained during treatment with turbine with spray cooling system

	Minimum (cm)	Maximum (cm)	Mean (cm)	SD	P

Turbine with spray cooling system, right side	46.0	61.0	51.20	4.46	0.000
Turbine with spray cooling system, left side	38.00	56.00	46.60	4.97	0.000
Turbine with spray cooling system, upper part	52.00	69.00	60.50	5.81	0.000
Turbine with spray cooling system, lower part	38.00	64.00	48.50	8.64	0.000
Turbine with spray cooling system, average value	46.75	55.50	52.00	2.93	

The use of the cooling turbine determined, as the recorded results show us, a higher surface contamination compared to US descaling. Thus, the contaminated surfaces on the right side varied between 46 cm and 61 cm, while for the left side, the recorded values were lower compared to the right side, varying between the minimum value, 38 cm, and the maximum, 56 cm (tab.2). The highest values were recorded in the upper part of the operative field (oral cavity), varying between the minimum value of 52 cm and the maximum value of 69 cm. The values recorded in the lower part varied between 38 cm as the minimum value and 64 cm as the maximum value. The analysis of the average values shows us that the most contaminated part was the upper one, where the average value was 60.5 cm, and the least contaminated was the left side of the patient, where the average value of the contaminated surface was 46.6 cm. The differences recorded between the average values are statistically significant (p=0.000) (tab. 2, fig. 14).

According to the findings of our investigation, contamination of the surfaces around the mouth cavity occurs after the use of the contra-angle with cooling for several operations. Following the application of the contra-angle with cooling, the distribution of values obtained per patient on the right side revealed a minimum contaminated surface of 28 cm and a maximum of 36 cm. A minimum contaminated surface of 26 cm and a maximum of 36 cm for the left side were noted. In comparison to the right and left sides, the outcomes for the upper and lower sides were better. As a result, the contaminated surface for the top section was 49 cm and for the bottom part, the minimal value was 67 cm was 38 cm and the maximum 66 cm (tab.3. fig.14).

The least contaminated surfaces were the right and left sides, with the most contaminated surfaces being the upper portion, followed by the bottom half, according to the average values computed for the group in which the contra-angle with cooling was utilized. When these average values are compared, they differ statistically significantly (p=0.000) (tab. 3, fig.15).

Table 3. The results obtained during treament with contra-angle with spray cooling system

	Minimum (cm)	Maximum (cm)	Mean (cm)	SD	P
Contra-angle with spray cooling system, right side	28.00	36.00	30.5000	2.75882	.000
Contra-angle with spray cooling system, left side	26.00	36.00	31.1000	3.03498	.000
Contra-angle with spray cooling system, upper part	49.00	66.00	59.3000	4.52278	.000
Contra-angle with spray cooling system, lower part	38.00	64.00	51.2000	8.23003	.000
Contra-angle with spray cooling system, average value	40.00	47.75	43.0500	2.30579	

The magnitude of the surfaces contaminated by various aerosol-generating procedures may be easily seen in fig. 17. In particular in the top section of the working field, dental turbine operations will produce a significant number of aerosols, the most of them in the form of droplets, spanning regions up to 60 cm. The analysis's findings demonstrate that, although being a contaminating process, US scaling produced less aerosols than the other activities, with the least contaminated surface. Statistics have proven that the observed differences are different (p=0.000) (tab. 4).

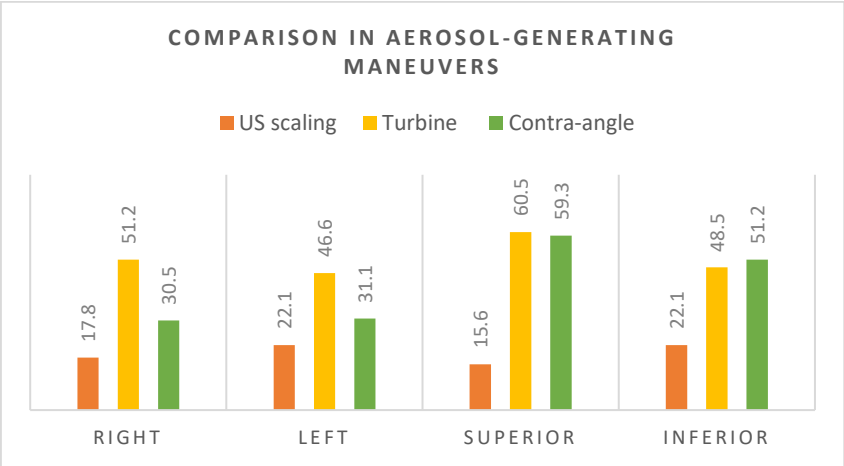


Figure 17. Comparision of mean values in aerosol-generating dental treatments

Table 4. Student's T-test for determining the differences between the 3 types of aerosol-generating dental treatments

	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
US scaling average value	26.66	9	.000	19.40	17.75	21.04
Turbine with cooling average value	56.03	9	.000	52.00	49.90	54.09
Contra-angle with cooling average value	59.04	9	.000	43.05	41.40	44.69

Discussions

Preventing the transmission of infection is a current issue, especially in the case of aerosols or droplets, transmission methods in which the contaminating agent is transmitted over long distances without being visible to the naked eye. This phenomenon becomes even more important as we realize that these aerosols come from the oral cavity, the main source of pathogenic microorganisms in the dental office (14-16).

Due of the many people who are engaged in a medical procedure, including the doctor, nurse, patient, and dental technician, as well as the significant danger of contamination, cross-infection is a phenomenon that occurs more frequently in offices. The oral cavity contains a variety of germs and viruses from the respiratory tract, bacterial plaque, and oral fluids. These microbes can thrive in this unique habitat. Any medical operation has the potential to aerosolize saliva, which might lead to the transfer of bacteria via the air distant from the source. During clinical procedures, skin contamination and

contamination of protective gear are inevitable.

Aerosols and droplets produced by ultrasonic descaling in significant quantities can be scattered far from the source. It was found in an in vitro study done in previous years that aerosols and droplets are still produced even in the absence of the cooling liquid used in an ultrasonic descaling, which will contaminate the surrounding surface if there are liquids in the area where the descaling is done (9).

All patients must be treated as potential sources of contamination since scaling, whether manual or ultrasonic, can harm periodontal tissue and result in bleeding. It has become essential to deploy universal barriers to lessen the danger of infection in light of the introduction of novel, resistant periodontal bacteria. According to our research, the dentist's hands, chest, and face were among the surfaces around the oral cavity that were more or less polluted. The similar outcomes were seen in earlier research (17). The experiments conducted to gauge the dentist's level of contamination revealed that the inner corners of the eyes and the area surrounding the nose were much more polluted than other areas (18). The face mask must be very well adapted to the face, because contaminating agents can overcome this barrier with a filtering effect (19).

In the dental operating volume, ultrasonic scalers produce bacteria aerosols with a maximum CFU count of 300 (9). Barnes et al. showed that, independent of the degree of inflammation, blood was present in the aerosols created when an ultrasonic scaler was used in vivo on teeth with periodontal disease (20). In one investigation, samples from the chest and pockets of the gowns worn by dentistry students were taken using sterile swabs. The samples were subsequently cultured, and the results revealed that the equipment was contaminated with microbes (21)

Numerous studies have shown that using dental tools like ultrasonic scalers and other devices that emit a thin cloud of spray droplets can lead to the production of aerosol bacterial contamination (20, 22,23). According to Miller et al.'s research, rotary tools used in conjunction with air and water sprays during dental operations can result in contamination levels that are higher than those produced by routine procedures. They demonstrated that the size of the aerosols and sprays created by using a turbine and sneezing were comparable (24).

In locations where aerosol-producing equipment was in use, airborne bacterial counts increased by a factor of four (25). The ultrasonic scalers' aerosols contain a lot of microorganisms, which makes it feasible for viruses and bacteria to propagate through them. Traditional thinking is that the bacteria causing the bacterial contamination in the dental office are nonpathogenic (26). Studies have found a correlation between the usage of ultrasonic scalers and a rise in the frequency of respiratory illnesses (27,28). There is growing worry about aerosol pollution and worse air quality in dental offices due to the reported recurrence of bacterial illnesses and the existence of other pathogenic organisms with the potential for airborne transmission.

After a procedure, aerosols can linger in the air for a very long period. According to earlier research, the maximum aerosol concentration vanishes 10–30 minutes after scaling (29). Due to the possibility of aerosol contamination, it is advised that the doctor and nurse delay removing their protective gear following the procedure.

When HEPA filters or UV lamps are used to purify the air in the ventilation system, there is also a chance that aerosols may enter the system and the infection will spread to wide surfaces (23). Because they have a potent fungicidal, virucidal, and bactericidal action by denaturing proteins and the DNA chain, UV lamps that produce

light between 250 and 265 nm are useful for air decontamination (30).

However, these technologies are expensive. It is therefore recommended to use the surgical aspirator for aspiration during US scaling as it increases the aerosol reduction rate by 93-96% (31).

Conclusions

The surfaces were polluted by all three aerosol-producing dental procedures at various and equivalent distances. In comparison to both operations using the contra-angle with cooling and the US scaler, when the turbine was used, it produced a greater amount of aerosols, especially in the form of droplets, that exceeded the maximum contamination zone with an area of 1m, with the differences recorded between the average values of the contaminated surfaces being statistically significant. To lessen the possibility of infection, both the patient and the medical personnel must wear protective equipment.

References

1. Yogeshwari Swaminathan, Julie Toby Thomas. "Aerosol"-A Prospective Contaminant of Dental Environment; IOSR Journal of Dental and MedicalSciences (IOSR-JDMS) e-ISSN: 2279-0853, pISSN: 2279-0861, 2013; 11(2): 45-50.
2. Rosiline James, Amit Mani; Dental Aerosols: A Silent Hazard in Dentistry; International Journal of Science and Research (IJSR) ISSN (Online): 2319- 7064 Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391.
3. Eye protection for patients and professionals; Dental Nursing Octobe, 2012; 8(10).
4. Stephen K. Harrel, D.D.S.; JOHN Molinari, Ph.D.; Aerosols and splatter in dentistry; A brief review of the literature and infection control implications; JADA, April 2004; 135.
5. Sruthy Prathap, Prathap M S; Aerosol Contamination – A Hazard to Dentists, 1(6).
6. Jessica L. Holloman, BSDH; Sally M. Mauriello RDH, EdD; Roland R. Arnold, PhD; Luiz A. Pimenta, DDS, PhD; The Effect of the Isolite Suction on Aerosols and Splatter During Ultrasonic Scaling; The Journal of Dental Hygiene, 2014; 88(5): 321.
7. Akanksha Singh, Shiva Manjunath RG, Deepak Singla, Hirak S Bhattacharya, Arijit Sarkar, Neeraj Chandra; Aerosol, a health hazard during ultrasonic scaling: A clinico-microbiological study; Indian J Dent Res, 2016; 27: 160-2.
8. Anshul Sawhney, Sanjay Venugopal, Girish Bab u R.J., Aarti Ga rg Melwin Mathew, Manoj YadavYadav Yadav, Bharat Gupta, Shas hank Tripathi; Aerosols How Dangerous They Are in Clinical Practice; Journal of Clinical and Diagnostic Research, 2015; 9(4): ZC52-ZC57.
9. Rucha Bhatkhande, Abhijit Misal; Microbial Aerosols: An Inconspicuous Health Hazard from a Dentist‟s Perspective; International Journal of Oral Health and Medical Research | ISSN 2395-7387, 2017; 3(6).
10. Catherine Bowden Milejczak; Optimum Travel Distance of Dental Aerosols in the Dental Hygiene Practice; Journal of Dental Hygiene, 2005; 79(4).
11. H.R. Veenaa, S. Mahanteshab, Preethi. Josepha, Sudhir R. Patila, Suvarna H. Patilc; Dissemination of aerosol and splatter during ultrasonic scaling: A pilot study; 1876-0341/© 2014 King Saud Bin Abdulaziz University for Health Sciences. Published by Elsevier Limited.
12. Harrel SK, Molinari J. Aerosols and splatter in dentistry. A brief review of the literature and infection control implications. J Am Dent Assoc 2004;135(4):429—37.
13. Rautemaa R, Nordberg A, Wuolijoki-Saaristo K, Meurman JH. Bacterial aerosols n dental practice — a potential hospital infection problem? J Hosp Infect 2006; 64:76—81
14. Ciurcanu, OE; Forna, DA; Scutariu, MM. Implementation of methods of loco-regional anesthesia in dental surgery. Romanian Journal Of Oral Rehabilitation Oct-dec 2017, 9 (4), pp.120-127
15. Ciurcanu, O; Ciupilan, C; Forna, DA; Scutariu, MM. Particularities of the dental treatment strategy in geriatric patients. Romanian Journal Of Oral Rehabilitation Jan-mar 2018, 10 (1), pp.108-113

16. Esanu, I; Constantin, I; Forna DA; Mihai, C. The Role of Chemical Factors in the Diabetes and the Prediabetes that Leads to Polimorfe Oro -Maxilo-Facial Alterations in Malformative Syndrome REVISTA DE CHIMIE Jun 2019, 70 (6), pp.2112-2117
17. Bentley CD, Burkhart NW, Crawford JJ. Evaluating spatter and aerosol contamination during dental procedures. J Am Dent Assoc 1994; 125:579—84.
18. Netajidanesh F, Khosravi Z, Goroohi H, Badrian H, Savabi O. Risk of contamination of different areas of dentist's face during dental practices. Int J Prev Med 2013;4(5):611—5.
19. Leonas KK, Jones CR. The relationship of fabric properties and bacterial filtration efficiency for selected surgical face masks. J Text Appar Technol Manag 2003;3(2):1—8.
20. Barnes JB, Harrel SK, Rivera-Hidalgo F. Blood contamination of the aerosols produced by in vivo use of ultrasonic scalers. J Periodontol 1998; 69:434-8.
21. Bhat SS, Bhat VS, Rao LV, Mathew RT. A study on microbial contamination of overcoats of dental students. Kerala Dent J 2013; 36:105-10.
22. Bentley CD, Burkhart NW, Crawford JJ. Evaluating spatter and aerosol contamination during dental procedures. J Am Dent Assoc 1994; 125:579-84.
23. Harrel SK, Barnes JB, Rivera-Hidalgo F. Aerosol and splatter contamination from the operative site during ultrasonic scaling. J Am Dent Assoc 1998; 129:1241-9.
24. Miller RL, Micik RE, Abel C, Ryge G. Studies on dental aerobiology. II. Microbial splatter discharged from the oral cavity of dental patients. J Dent Res 1971; 50:621-5.
25. Gehring F. Total bacterial count and the occurrence of Streptococcus mutans and Streptococcus sanguis in the air of various work areas. Dtsch Zahnarztl Z 1976; 31:149-52.
26. Holbrook WP, Muir KF, Macphee IT, Ross PW. Bacteriological investigation of the aerosol from ultrasonic scalers. Br Dent J 1978; 144:245-7.
27. Miller RL, Micik RE. Air pollution and its control in the dental office. Dent Clin North Am 1978; 22:453 76.
28. Allsopp J, Basu MK, Browne RM, Burge PS, Matthews JB. Survey of the use of personal protective equipment and prevalence of work-related symptoms among dental staff. Occup Environ Med 1997; 54:125-34.
29. Bennett AM, Fulford MR, Walker JT, Bradshaw DJ, Martin MV, Marsh PD. Microbial aerosols in general dental practice. Br Dent J 2000;189(12):664—7.
30. Szymanska J. Dental bioaerosol as an occupational hazard in a dentist's workplace. Ann Agric Environ Med 2007; 14:203—7.
31. Aslam AM, Zanman T, Badruddoza M. Practice of dental surgeons about dental splatter and aerosol. City Dent Coll J 2013;10(2):10—6.