ORIGINAL ARTICLE

Evaluation of Presence and Amount of Moisture in Dry Air of Three Way Syringes in Dental Teaching Hospitals and Private Clinics: A Cross-Sectional Study

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OBJECTIVE: This study aimed to assess the amount of moisture present in the TWS of dental units in dental teaching hospitals (DTH) and private clinics (PC) across Karachi.

METHODOLOGY: A total of 285 dental units were included in the study out of which 250 belonged to DTH and 35 to PC. Gushing was initially performed on hand to remove visible moisture from the TWS. The number of gushes required to remove visible moisture were recorded and the moisture-sensing device was used to assess the amount of invisible moisture in dry-air released from the TWS. SPSS v 22 was used to compare data of DTH and PC with the help of Mann Whitney U test. The pre- and post-exposure humidity of the sensing chamber was analyzed through Wilcoxon signed rank test. p value of < 0.05 was considered as significant.

RESULTS: The power of the study was found to be > 99%. The moisture was present in 77.6% of the TWS in DTH and 37.1% in PC (p <0.001). Significantly higher number of hand gushes were required in DTH to eliminate the visible moisture as compared to PC (p= 0.022). Similarly, TWS in DTH were seen to liberate significantly increased amount of invisible moisture as compared to PC (p-value<0.001).

CONCLUSION: Alarmingly high number of three-way syringes of dental units in dental teaching hospitals had moisture. This moisture can jeopardize restorative treatment and may expose patient to lethal microbes.

KEYWORDS: Three way syringe; Restorative; Moisture; Resin Composite; Contamination

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INTRODUCTION

The predictability of restorative dental treatment is dependent on several elements including operators' skill, the type of material, the environment, and the patient factors.[1,2] One environmental factor that is often overlooked, is the condition of dental operating unit machinery. The faults in the devices may unknowingly impact the quality of dental treatment negatively. One such flaw is the presence of water or oil in the dry air of three-way syringe (TWS) attached to the dental units. The uncontrolled and contaminated moisture can affect the bonding procedure negatively, put the health of the patient at risk, and corrode the dental instruments and equipment.[3,4]

Resin composite is a technique-sensitive, widely used restorative dental material. It is preferred by the dental professionals and the patients for a variety of direct and indirect restorative procedures due to favorable esthetics, conservation of tooth structure, bonding, high strength, cost effectiveness, and absence of mercury content.[5,6] However,

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the resin composite is a moisture sensitive material and requires several steps to be performed judiciously during restoration of a tooth structure.[7,8] The most crucial step while doing a resin composite restoration is the bonding procedure. It determines the quality of adhesion of the composite material to the dental substrate.[9] The bonding procedure includes etching, washing and drying of the tooth structure followed by application and air-thinning of primer or bonding agent with simultaneous evaporation of the solvent.[8] A complete drying evident by a frosty appearance is especially important when enamel substrate is used for bonding.[10] On the other hand, for bonding of dentin substrate, wet bonding without absolute drying is recommended for successful bonding.[11] Even so, wet bonding requires the air thinning step.

During bonding, the drying of tooth structure and air-thinning of the adhesive are conveniently done with the help of TWS attached to the dental unit.[12,13] However, there is a chance that a seemingly dry air may hold a minute amount of invisible moisture that may escape through the TWS tip and coat the dried tooth, or the adhesive. The excess moisture may result in immediate or delayed failure of composite restorations due to inadequate formation of the hybrid layer. The failure is often detected as a secondary caries.[1,14] The latter, if undetected or untreated, may cause irreversible inflammation of the pulp that would require an exhaustive treatment.[15-17] On the other hand, the impact of small amount of undetected or invisible moisture on composite restoration is yet to be determined.

The visible moisture could be easily observed when dry air is sprayed through TWS. Whereas, the invisible moisture in the gushed air is not readily visible and can only be detected with the help of moisture detecting device. To the best of our knowledge, the presence and amount of visible and invisible moisture in the dry air of TWS has not been assessed till date. Therefore, the aim of our study was to assess the amount of moisture present in the TWS attached to the dental units in Dental Teaching Hospitals (DTH) and Private Dental Clinics (PC) across Karachi.

METHODOLOGY

The present study was a multi-center analytical cross-sectional study. The ethical approval of the study was taken from Institutional Review Board (Ref no.: EC/25/19). The study followed STROBE (STrengthening the Reporting of Observational studies in Epidemiology) guidelines. The TWS attached to dental units of Operative/Restorative Dentistry departments of the teaching hospitals and private dental clinics were included in the study. The Exclusion criteria consisted of non-working units, defective TWS, dental units that were not used at least once per day, and the colleges/clinics that did not give permission to collect the data. Furthermore, the TWS that produced visible moisture even after 5 hand-gushes prior to start of testing of dry air were also excluded.

An electronic device was assembled to detect and measure the amount of residual moisture present in the dry-air gush of TWS. It consisted of an LCD to display the numerical readings and two DHT-22 sensors. One sensor was fixed inside (internal sensor) a hollow chamber (sensing chamber) opened from one side to facilitate gushing of air inside with the help of TWS tip and simultaneously maintain the humidity for a brief period of time. The sensing chamber was designed to simulate the oral cavity. A second sensor was placed outside (external) the sensing chamber and exposed to the environment for detection of the environmental moisture (Figure 1).

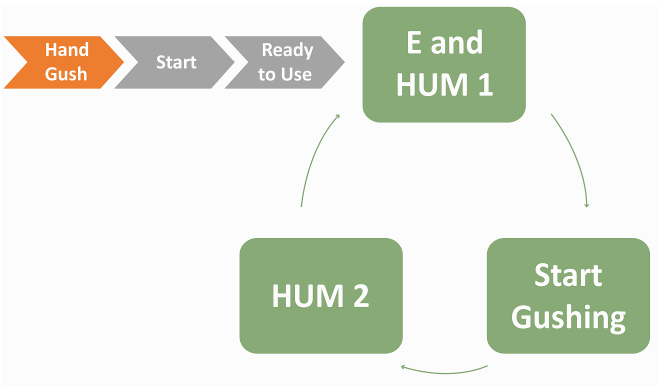
Figure 1: Moisture sensing device. a, circuit and internal components of the device; b, Cone or internal sensing chamber with moisture sensor (white); c, LCD to show the readings

The detection of residual or invisible moisture was based on a differential logic. The device dis-played two humidity readings on the screen with the help of embedded regular averaging. It was designed smart enough to guide the operator about the readiness of the sensors, specifically when to gush the dry air in the cavity and when to stop. The mechanism of action of the device was based on the principle that a constant gush of air for few seconds results in reduction of humidity inside the sensing chamber, indicating a dry-enough air. The operator was trained to use the device for a week by the Engineers who designed the device. The device was tested with the help of a pilot study consisting of 40 TWS

Written permission was obtained from various dental colleges of Karachi for data collection. TWS of 285 dental units were included from 7 DTH (n= 250) and 23 PC (n= 35) across Karachi. The data of the study was obtained by using convenience sampling method from 1st October 2020 to 31st March 2021. A maximum of five gushes (10 seconds/gush) for each TWS were done on the gloved hand to eliminate visible moisture before the start of the testing. The device was then started and the initial humidity reading inside the sensing chamber before gushing (HUM 1) on the internal sensor was noted. The dry air from the TWS was then gushed on the internal sensor (HUM 2;

10 seconds/gush) and the reading was noted. With this, the first cycle was completed. After 20 seconds, the HUM 2 was reverted back to HUM 1 with the restoration of original humidity inside the sensing cavity. The cycle was repeated 5 times on each TWS (Figure 2). The following formula was used to calculate the difference between pre- and post-exposure humidity: HUM3 = HUM2 - HUM1

Figure 2: Process of Detecting Visible (Orange) and Invisible (Grey and Green) Moisture



The positive HUM 3 values (value > 0) indicated the presence of moisture while values ≤ 0 indicated the absence of the moisture. All values of HUM 3 below zero were adjusted to 0 during analysis (to denote absence of moisture). Out of five HUM 3 readings, highest positive value was included in the analysis if majority of the HUM 3 readings were positive. On the other hand, a value of "0" was included in analysis If the majority of the readings were 0 or below. These final values were pooled using Microsoft Excel and analyzed.

The statistical analysis was performed using Statistical Package for Social Sciences (SPSS) version 21.0. Mean, standard deviation (SD), median and interquartile range (IQR) were reported to de-scribe continuous variables such as number of gushes and amount of moisture content. Frequencies and percentages were reported to describe categorical variable like presence or absence of moisture. Chi-square test was applied to check the association between TWS and presence or absence of moisture. Assumption of normality of continuous variables was checked using Shapiro-Wilk test. Mann Whitney U test and Wilcoxon signed rank test were used to check the mean differences in amount of moisture between and within the groups. p-value of < 0.05 were considered as statistically significant.

RESULTS

Power of the study was calculated using PASS version 11 by including the mean amount of moisture present in the TWS from the results of the current study (DTH: n= 250, mean=1.67, SD ±2.86; PC: n=35, mean=0.36, SD ±0.55), 95% confidence interval and 0.05 significance level. The calculated power of the study was found to be > 99%, thereby justifying the sample size of the study. The analysis of presence or absence of visible moisture during hand-gushing revealed a statistically significant difference (p= 0.022) between DTH group and PC group. On an average, 1.9 gushes were required to remove the visible moisture from TWS in DTH as opposed to 1.5 gushes in PC (Table 1).

Table 1: Pre-and post-test analysis of moisture present in three-way syringes (n= 285)

Setting	Median (IQR)	Mean ± SD (Range)	p- value
Mean number of gushes required to eliminate visible moisture before testing			
DTH (n= 250)	2 (1)	1.92 ± 1.00 (1 – 5)	0.022*
PC (n= 35)	1 (1)	1.54 ± 0.78 (1 – 4)	
Mean amount of invisible moisture present in three-way syringe			
DTH (n= 250)	0.60 (1.52)	1.67 ± 2.86 (0 - 19.2)	<0.001*
PC (n= 35)	0 (0.80)	0.36 ± 0.55 (0 - 2.2)	

*Significant value; SD, Standard Deviation; IQR, Inter-Quartile Range; DTH, Dental Teaching Hospitals; PC, Private Clinics

The descriptive statistics showed that out of 250 TWS of DTH, moisture was present (reading > 0) in 194 (77.6%) TWS. On the other hand, out of 35 TWS of PC, only 13 (37.1%) TWS had moisture. TWS of DTH (1.67 ± 2.86) had significantly greater amount of moisture as compared to PC (0.36 ± 0.55; p<0.001) (Table 1). The intragroup analysis revealed a significant difference (p < 0.001) between pre-(66.37) and post-gush (67.74) humidity within sensing chamber of the moisture sensing device in the DTH setting. To the contrary, no significant difference (p= 0.694) in this regard was found in the PC setting (Table 2).

Table 2: Comparison of intra-group pre-gush and post-gush humidity inside the sensing chamber (n= 285)

Setting	n	Pre-gush		Post-gush		p- value
		Median (IQR)	Mean ± SD	Median (IQR)	Mean ± SD	
DTH	250	65.00 (20.05)	66.37 ± 12.84	66.50 (20.50)	67.74 ± 12.58	< 0.001*
PC	35	55.00 (13.00)	56.19 ± 8.84	54.30 (13.30)	56.04 ± 8.88	0.694

*Significant value; SD, Standard Deviation; IQR, Inter-Quartile Range; DTH, Dental Teaching Hospitals; PC, Private Clinics

DISCUSSION

The bonding and associated longevity of resin restorations is a complex process contingent on the formation of the hybrid layer between the resin tags and collagen fibrils.[18] Aberrations in the bonding process may result due to various reasons that include hydrolytic instability of hydrophobic methacrylate monomers, interaction of resins with excess moisture, below par resin penetration, incompetence of bonding resins to entirely replace the loosely bound water in the collagen matrix, and degradation of collagen by proteinases.[18,19] Interestingly, the common denominator in all these circumstances is water. The maximum amount of permissible moisture, in the presence of which no detrimental effects are expected for bonded restorations has not been reported. Our study was first to report the presence and amount of visible and invisible moisture present in TWS of dental units in DTH and PC.

Gushing of dry-air through TWS may consist of imperceptible moisture as highlighted by the current study. This moisture may hypothetically exert various effects. During post-etching drying of the prepared cavity, the unseen moisture may impede the activity of the primer.[4] Likewise, during primer evaporation and air-thinning of bonding resin, the unaccounted moisture may act as a barrier and diluent for the adhesive resin.[4] In both the scenarios, the bonding strength may be adversely affected. In addition, lethal microbes like SARS-CoV-2 may also be transferred to the oral cavity via the unwarranted moisture from the TWS.[20-22]

The results of our study revealed that the humidity inside the sensing chamber was substantially increased after dry-air was gushed within the DTH setting group. Similarly, the presence and amount of moisture in TWS of DTH was significantly greater as compared to PC. These findings suggest that TWS of DTH were leaking excessive moisture in the gushed dry-air. This flaw may be attributed to the increased usage of dental units by multiple operators, and absence of regular maintenance in DTH.[23] The increased and repeated usage may lead to incompetence and leakage in the valves of the TWS. The aged-out, un-monitored, and un-replaced O-rings inside the head assembly of the TWS act as a major reason for the release of water droplets alongside dry-air.[23] Moreover, the absence of regular maintenance of the compressor and its key components such as air-intake filtration, post-compression filtration and drying system may lead to contaminated and moist air.[24] Another reason that may contribute to the production of moisture is the increase in temperature of the compressed air. The increases in temperature holds the water in the vapor form. When the air leaves the compressor and enters the pipeline, it cools down and causes water to condense out. The ideal temperature range for compressed air equipment is from 50 to 85°F (10 to 30°C), above which the functioning of compressor and dryer is critically impaired.[25] Moreover, the amount of resulting moisture is dependent upon the atmospheric conditions. Therefore, it is recommended that the placement and maintenance of the compressor system must be according to the manufacturer`s guidelines.

The current study had few limitations. Firstly, the number of maintenance cycles, age of dental units and compressors were not recorded. Therefore, only an assumption could be made that DTH lacked regular and/or inferior maintenance. Moreover, there was a considerable difference between the number of assessed TWS of DTH and PC. Lastly, no comparison was done between public and private sectors. However, our study was first to highlight the presence of invisible moisture in the TWS across multiple centers. In our study, various lacunae were identified that needs to be filled such as: Does invisible or minute amount of moisture have a negative impact on the bond strength of resin composite? what is the permissible amount of invisible moisture that has no adverse effect on filling materials and instruments? and what are the microbial types and counts present in the seemingly dry air liberated from TWS.?

CONCLUSION

Within the study limitations, it can be concluded that a high number of three-way syringes of the dental teaching hospitals had imperceptible moisture and the amount of this moisture was significantly higher as compared to private clinics. This increased amount of moisture might play a crucial role in failure of restorations, corrosion of instruments, and may pose a health risk to the patient.

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DISCLAIMER

The authors have nothing to disclose

CONFLICT OF INTEREST

None to declare

FUNDING DISCLOSURE

None to declare

AUTHORS CONTRIBUTION

Juzer Shabbir **(JS):** Conceptualization; Ayesha Anis **(AA)**: Data curation; Muhammad Moiz Anis **(MMA):** Formal analysis; Wajiha Saghir **(WS):** Investigation; JS, Tazeen Zehra **(TZ):** Methodology; JS, AA: Resources; MMA: Software; Naheed Najmi **(NN)**: Supervision; JS: Validation; SMH: Project Administration; JS, Syed Masood ul Hasan **(SMH)**, AA: Roles/Writing **-** original draft; JS, TZ: Writing

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