대한치과재료학회지 42(1) : 29~33, 2015

치과용 고속 에어터빈 핸드피스의 Suck-back 현상에 대한 측정 방법*

전영준[1], 임중연[1], 김경남[2], 김양수**[3]

동국대학교 공과대학 기계로봇에너지공학과[1], 연세대학교 치과대학 치과생체재료공학교실 및 연구소[2], ㈜두나미스덴탈[3]

A testing methodology for suck-back behavior of high-speed air-turbine dental handpiece*

Ying-Jun Quan[1], Joong-Yeon Lim[1], Kyoung-Nam Kim[2], Yang-Soo Kim[3]**

Department of Mechanical, Robotics, and Energy Engineering, Dongguk University, Seoul, Korea[1], Department and Research Institute of Dental Biomaterials and Bioengineering, Yonsei University College of Dentistry, Seoul, Korea[2], Dunamis Dental Co. Ltd., Seoul, Korea[3]

(Received: Feb. 23, 2015; Revised: Mar. 16, 2015; Accepted: Mar. 16, 2015)

DOI : http://dx.doi.org/10.14815/kjdm.2015.42.1.29

ABSTRACT

치과용 고속 에어터빈 핸드피스는 압축공기를 이용하여 핸드피스 헤드 내부의 임펠러를 구동시키는 치아 절삭에 사용되는 치과용 의료기기이다. 압축공기의 유동특성에 따른 압력 변화로 인하여 고속 치과용 에어터빈 핸드피스는 사용 중 기체 흡입 현상이 발생하는데 이런 현상을 에어터빈 핸드피스의 suck-back 현상이라고 한다. Suck-back 현상 때문에 치료 시 환자 구강 내의 혈액, 박테리아 등 유해물질이 핸드피스의 내부로 흡입되는데 치과용 에어티빈 핸드피스는 일회용 의료기기가 아니므로 여러 환자들한테 사용될 때 설령 소독하더라도 교차감염(cross-infection)의 위험이 발생하게 된다. 하지만 suck-back 현상에 대해 평가하는 연구가 아직 많이 부족한 상태이다. 연구에서는 suck-back을 방지할 수 있는 기능으로 설계된 상용화 된 5개 제품의 핸드피스에 대해 특별히 제작된 측정 장치를 이용하여 suck-back 성능을 평가하였다. 실험은 측정하려는 5사 제품의 구동 시 최대 압력, 정지 순간의 최소 압력을 측정하고 suck-back 현상이 지속되는 시간을 측정하였다. 실험 결과 A사 제품은 최소 압력이 0 bar로써 suck-back 현상이 발생하지 않았다. 반면 기타 4사의 제품은 suck-back 현상이 발생하였는데 그 중 B사 제품은 평균값 -0.00bar(-0.01bar부터 0bar 사이의 값), E사 제품은 -0.01(0)bar, C사 제품은 -0.019(0.003)bar, D사 제품은 -0.04(0)bar의 결과를 보였다. 또한 suck-back 현상의 지속 시간은 B사 제품이 1.83초로 가장 오래 유지되었으며 그 다음으로 D사 제품이 1.82초, E사 제품은 1.56초, C사 제품은 1.30초, 그리고 A사 제품은 0초로 가장 짧았다. 실험 결과 본 연구에서 고안한 에어터빈 핸드피스의 suck-back 현상 시험 방법은 정량적으로 측정할 수 있을 것으로 사료되었다.

KEY WORDS: Suck-back, High-speed, air-turbine dental handpiece, Cross-infection, compressed air

INTRODUCTION

High-speed air-turbine dental handpiece is a dental medical device for cutting the teeth. In order to cut the teeth, high speed rotation is required so it is operated at 200,000 ~ 400,000 [RPM] by using compressed air (Dyson and Darvell, 1993a; Dyson and Darvell, 1993b; Leonard and Charlton, 1999). The compressed air drives the impeller inside the head of the handpieces when the power is cut off the impeller stops. But in current devices even when the air supply is cut off, the impeller rotates for a few seconds because of the inertia. During the inertial rotation, as the external air pressure is higher than internal pressure air will be sucked into the head of the air turbine in the handpiece. This

* 이 연구는 2009년 지식경제부 기술표준원의 연구비(과제번호 B0011454)에 의해 수행됨.

** 교신저자 : 경기도 광명시 하안로 60 광명테크노파크 A동 904호, 김양수
Tel : 02-778-4565, Fax : 02-778-4501, E-mail : yskim@dunamis.co.kr

kind of suction behavioris known as the suck-back phenomenon (Bagga et al., 1984).

Because of the suck-back behavior, the saliva and blood from the oral cavity will be sucked in, this not only contaminates the head of the handpiece but also the coupling, tubing and, some other components. As dental handpiece is not a disposable medical equipment, it is used for more than one patient, hence cross-infection might occur when used for other patients (Artini et al., 2008; Checchi et al., 1998; Dreyer and Hauman , 2001).

One of the way to eliminate or prevent cross infection is by stopping the suck-back which can be achieved by removing the inertial rotation. Thus, many companies have already started or are starting to develop the high-speed air-turbine handpieces with non-suction bearing, labyrinth seals, and other components to prevent or eliminate the suck-back phenomenon. However, it can only reduce the suck-back rather than eliminating it perfectly.

There are several existing technologies to test the suck-back phenomenon (Lewis and Boe, 1992; Masuda et al., 1994; Ozawa et al., 2010). Recent studies have shown that the suck-back phenomenon is obvious because of the inertia of turbine. The testing protocol used in recent research are complex and a common standard procedure is lacking. In this study we've proposed a standardized testing procedure for the suck-back behavior which can be applied for all models currently available in the market.

MATERIALS AND METHOTD

In this study, we've investigated five different models of handpiece made by five different companies which are designed to minimize the suck-back phenomenon (A, Japan; B, Germany; C, Austria; D, Japan and E, Korea). The experiments are performed by using a special testing device which is designed to measure the air pressure of the head periphery of handpiece accurately. In order to maintain consistency in the results, the same air pressure is supplied. The pressure of 0.22~0.25 bar is used.

Fabrication of the testing device

In order to measure the suck-back pressure of the whole handpiece head, a special testing device (Figure 1 and 2) is used which includes an electronic inductive pressure sensor, a small sealing chamber, a check valve and, one display screen which can display air pressure. The specification of the testing device is shown on Table 1.

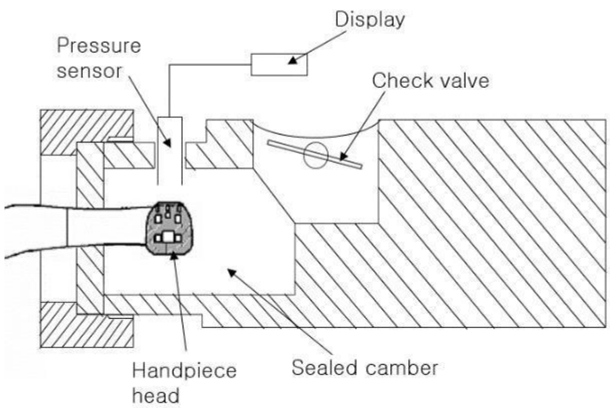

Figure 1. *The structure of suck-back testing device.*

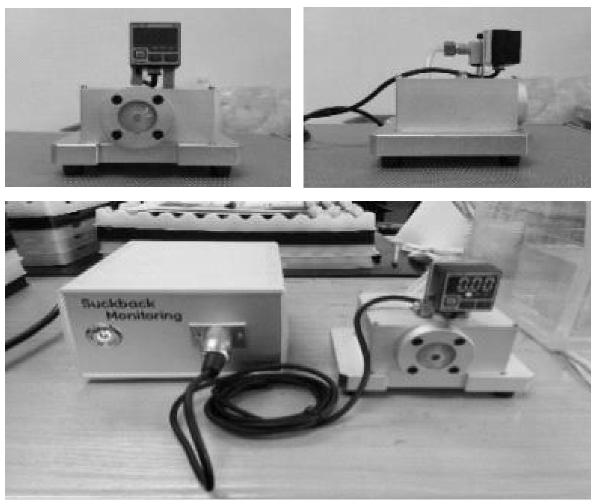

Figure 2. *Model of suck-back experiment device.*

Table 1. Specification of the experiment device

Specification	PSA-1P
Precision	0.01 bar
Measurement range	-0.5~11 bar
Response time	100 ms

Performing the tests

The device should be calibrated before each set of experiment in account to the changing atmospheric pressure.

(1) Verification of the testing device

In order to verify the accuracy of the pressure sensor, a compressed air source of known value (0.22~0.25 bar) is connected to the sealed chamber of testing device by a tube and corresponding reading is noted. Repeat the verification test for at least 5 times. If the reading are within the range the experiment is proceed further.

(2) Test steps

Once the power supply is cut off, the reading for maximum and minimum pressure are taken for a period of five seconds. A high speed camera is employed to record the pressure variation during that period.

In order to obtain the accurate value, the experiment for each model is done 10 times. The average of both maximum and minimum pressures for each models of handpiece are calculated and recorded. For the pressure experiment of the entire handpiece head, ANOVA is used to determine the significance of the difference for each handpieces.

(3) Measurement

As shown in Figure 2, the test setup is done by putting the entire head of the handpiece into the head sealed chamber. The handpiece is put in such a way that it's front face is directed towards the pressure sensor. Once the setup is completed, the handpiece is turned on. The check valve should be opened during the operation, which if closed will cause rise in pressure inside the sealed chamber and results in false reading. A high speed camera with 7 pictures per second is used to capture the instantaneous pressure reading during the whole experiment and pressure graphs based are drawn by the aid of captured data.

RESULT AND DISCCUSION

Verification of the pressure sensor

Table 2. shows the reading of the calibrated testing equipment for a known pressure value. The result shows that the device is calibrated correctly.

Table 2. Verification of the pressure sensor (Unit: bar)

	Resource pressure	Average of testing pressure(ANOVA)	Error (%)
1	0.22	0.22(0.005)	0
2	0.23	0.23(0.008)	0
3	0.24	0.24(0.007)	0
4	0.25	0.25(0.007)	0

Maximum and minimum pressure of entire head of handpiece

Model A has almost no difference of minimum pressure with standard pressure as both of the values are 0. The average of minimum pressure of the entire handpiece head of B is -0.00bar which means the value is between -0.01 bar to 0 (as the precision of the machine is 0.01). For model C and E, the average of minimum value is -0.019 bar and -0.01 bar. The minimum pressure of model D has the lowest value with -0.04 bar (Table 3).

Table 3. The pressure of entire head of handpiece (Unit: bar)

Model	Maximum pressure	Minimum pressure
A	0.45 (±0.020)	0
B	0.42 (±0.030)	-0.00(-0.01~0) (±0.003)
C	0.41 (±0.013)	-0.019 (±0.003)
D	0.415 (±0.008)	-0.04 (±0)
E	0.42 (±0.010)	-0.01 (±0)

Suck-back phenomenon depends on time durations

Figure 3 and Table 4 shows the average pressure values of 10 different iterations. As seen from the minimum pressure data, model A has no suck-back behavior. Model B and D have the longest suck-back duration with 1.83 s and 1.82 s while model E has suck-back time of 1.56 s and model C is 1.30 s.

Suck back phenomenon is a complex function of intake pressure, inertial rotation and many other factors so the handpiece models tested here which are supposed to be zero suck-back devices have residual suck back pressure. One of the reason, as explained by (Ozawa et al., 2010) can be the placement of the location of the suck-back behavior. The 4 out of 5 devices tested here are also tested by Ozawa et al. The test result aggress with their conclusion although their test was done using different method.

The suck-back phenomenon can result in cross contamination even when the external part is disinfected. Thus the disinfection of the internal as well as external part is suggested by various researchers and doctors (Andersen et al., 1999; Checchi et al., 1998; Collins et al., 2003; Montebugnoli and Dolci, 2000).

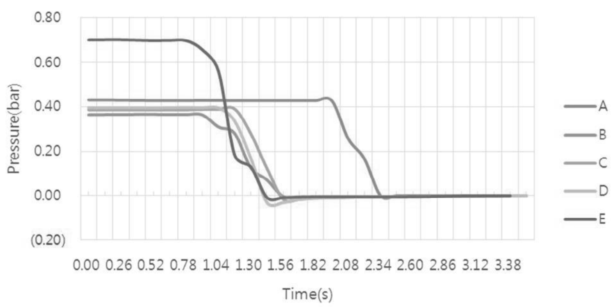

Figure 3. *Average pressures of 5 models depends on time(s).*

Table 4. The pressure depends on suck-back durations (Unit: bar)

Model	Suck-back time (s)	Minimum suck-back pressure (average)	Maximum suck-back pressure (average)
A	0	0	0
B	1.83	-0.01~0.00	
C	1.30	-0.017	-0.001
D	1.82	-0.31	-0.001
e	1.56	-0.01	-0.001

CONCLUSION

The purpose of this study was providing a test methodology to investigate the suck-back phenomenon quantitatively which is a high issue in current dental treatment. In addition, the verification was done to confirm that the proposed methodology shown in this study was correct. The conclusions were as followings:

1. This study showed the suck-back phenomenon of high-speed air-turbine dental handpiece was exist clearly and the efficiency was due to the air pressure change, and also depended on the durations of negative air pressure.
2. The methodology given in this study can investigate the air-turbine dental handpiece quantitatively, so it can be used to compare the performance of different kinds of air-turbine dental handpiece.

REFERENCES

Andersen HK, Fiehn NE, Larsen, T (1999). Effect of steam sterilization inside the turbine chambers of dental turbines. *Oral Surg Oral Med Oral Pathol Oral Radiol Endodont* 87:184–188.

Artini M, Scoarughi GL, Papa R, Dolci G, De Luca M, Orsini G, Selan L (2008). Specific anticross-infection measures may help to prevent viral contamination of dental unit waterlines: A pilot study. *Infection* 36(5):467–471.

Bagga BS, Murphy RA, Anderson AW (1984). Contamination of dental unit cooling water with oral microorganisms and its prevetion. *J Am Dent Assoc* 109:712–716.

Checchi L, Montebugnoli L, Samaritani S (1998). Contamination of the turbine air chamber: a risk of cross infection. *J Clinic Periodontol* 25:607–611.

Kohn WG, Collins AS, Cleveland JL, Harte JA (2003). Guidelines for Infection Control in Dental Health-Care Settings. *J Am Dent Assoc*135:33-47.

Dreyer AG, Hauman CH (2001). Bacterial contamination of dental handpieces. *SADJ* 56(11):510–512.

Dyson JE, Darvell BW (1993a). The development of the dental high-speed air turbine handpiece. Part 1. *Aust Dent J* 38(1):49–58.

Dyson1 JE, Darvell BW (1993b). The development of the dental high-speed air turbine handpiece. Part 2. *Aust Dent J* 38(2):131–143.

Leonard DL, Charlton DG (1999). Performance of high-speed dental handpieces subjected to simulated clinical use and sterilization. *J Am Dent Assoc* 130(9):1301–1311.

Lewis DL, Boe RK (1992). Cross-infection risks associated with current procedures for using high-speed dental handpieces. *J Clin Microbiol* *30*(2):401–406.

Masuda K, Ohta M, Ohsuka S, Matsuyama M, Ashoori M, Usami T, Kaneda T (1994). Bacteriological evaluation of a new air turbine handpiece for preventing cross-contamination in dental procedures. *Nagoya J Med Sci* 57:69–76.

Montebugnoli L, Dolci G (2000). Effectiveness of two devices designed to prevent fluid retraction in a high-speed handpiece. *J Prosthet Dent* 84: 225–228.

Ozawa T, Nakano M, Arai T (2010). In vitro study of anti-suck-back ability by themselves on new high-speed air turbine handpieces. *Dent Mater J* *29*(6):649–654.