The Evaluation of RPM Change in X-Smart According to Power Source ; Endodontic Wireless Electronic Motor

Se-Hee Park[1], Dong-Bin Jeong[2], Kyung-Mo Cho[1], Jin-Woo Kim[1]

[1]Department of Conservative Dentistry, College of Dentistry, Gangneung-Wonju National University, Gangneung
[2]Department of Information Statistics, College of Natural Sciences, Gangneung-Wonju National University, Gangneung

The purpose of this study was to evaluate RPM maintenance in X-Smart according to the power supplied by the AC adapter and rechargeable battery. Five new X-Smart were used in this study. A handpiece with rubber disk which has reflective tape was mounted on the vice. To measure the RPM, a non-contact type digital tachometer was used. RPM measurements were recorded every 5 minutes to 180 minutes and repeated 3 times per motor from each power source. To evaluate a difference of the RPM changes, two-way repeated measures were performed using SPSS™ 14.0. All tests were conducted at the 95 percent confidence level. There was no significant difference in the RPM change between the power sources. Continuous use of X-Smart with a rechargeable battery for up to 180 minutes could be safely used as an endodontic wireless motor with a reliable RPM maintenance.

Key words: Rotational speed, RPM, X-Smart, Electronic motor

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INTRODUCTION

During root canal preparation procedures, the potential for instrument separation of nickel-titanium (NiTi) rotary files is always present. It is very rapid, unpredictable, and gives a great deal of stress for the practitioner.[1] Several studies have evaluated the influence of various factors on the separation of endodontic NiTi rotary instruments.[28] Many factors such as rotational speed,[6,7,9] torque,[7,9-11] cyclic fatigue,[2,10,12-14] instrument design,[15-17] instrumentation technique[16,17] and operator experience[5-7,9] can influence the incidence of deformation and fracture of NiTi rotary instruments.

Rotational speed is an important parameter that can influence the incidence of instrument

Correspondence to : Se-Hee Park, DDS,PhD
Department of Conservative Dentistry College of Dentistry Gangneung-Wonju National University
123 Jibyun-dong, Gangneung, 210-702, Republic of Korea
Tel: +82-33-640-2760, H.P: +82-10-4847-7952, Fax: +82-33-640-3103, E-mail: drendo@gwnu.ac.kr
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deformation and separation. Rotary NiTi instruments require constant speed to prevent stress fracture.[18] Although it may sometimes be possible to operate these NiTi instruments with an air-driven handpiece, it is highly recommended that an electric handpiece be used, because the rotational speed can be maintained more evenly and at the right RPM.[18] When the rotational speed is changed in the canal, accumulated internal stress can lead the NiTi instruments to failure.

The X-Smart (Dentsply Maillefer, Ballaigues, Switzerland) motor is widely used with the NiTi rotary instruments. This motor has adjustable rotational speed and torque limits by the manufacturer and varying from 120 to 800 rpm, 0.6 to 5.2 Ncm. It can be used both as a wire motor power supplied by the AC adapter and wireless motor power supplied by the rechargeable battery. Rechargeable battery is a power source of the wireless motor. The output of the rechargeable battery has variations like that of air pressure in an air-driven motor. And a drop in air pressure can lead to a decrease of rotational speed. When the rotational speed is decreased, the instrument may become less active, and the operator may tend to force the instrument into the canal, leading to deformation and separation.[19] The RPM maintenance of wireless motors in endodontics with NiTi rotary instruments has not been evaluated.

Therefore the purpose of this study was to evaluate RPM maintenance in X-Smart endodontic motors according to the power supplied by the AC adapter and rechargeable battery.

MATERIAL AND METHODS

Five new X-Smart were used in this study. A handpiece with a 16:1 reduction ratio was attached to the motor. To measure the RPM, rubber wheel disk which have reflective tape on the upper surface was connected to the handpiece which was gripped with vice. A non-contact type digital tachometer, TM-5000 (Line Seiki Co., Tokyo, Japan) was used for measuring the RPM of handpiece. The TM-5000 and handpiece which was attached to the motor were both mounted on the vice for same distance and position.

Output of the electronic motor was adjusted equally to 300 rpm of rotational speed, 1.0 Ncm of torque value and without auto-reverse option. RPM measurements were recorded every 5 minutes to 180 minutes and three tests were performed at each power source. The rotational speed of the motor handpiece was calibrated before each test. The actual RPM values were recorded.

The means of the actual RPM values and the amount of RPM changes generated by each of the five motors at the different power source were determined and analyzed using analysis of variance and the Student T test. To evaluate a difference of the RPM changes, two-way Repeated Measures were performed using SPSS^{TM} 14.0 (SPSS Inc., Chicago, IL, USA). All tests were conducted at 95 percent confidence level.

RESULTS

The means of the actual RPM values and the amount of RPM changes generated by each of the five motors at the different power source are shown in Table I. For each power source, and for the five motors, the actual RPM values obtained with the different motors were significantly lower than the RPM preset and claimed by the manufacturer ($p < 0.05$).

The actual RPM values by each of the five motors at battery mode and AC adapter mode are shown in Fig. 1. For each power source, there were

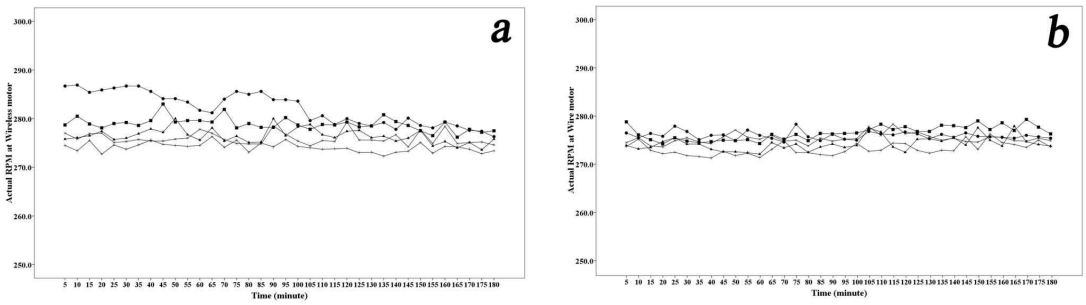

Fig. 1. Graphic shows actual RPM values by each five motors. (A) Power supplied from rechargeable battery, and (B) power supplied from AC adapter.

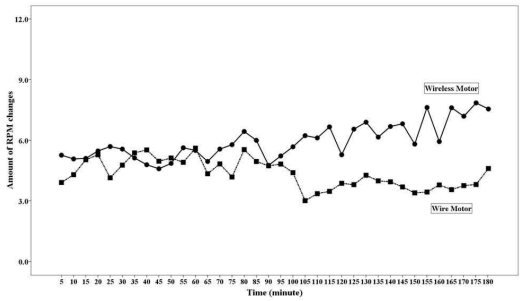

Fig. 2. Graphic shows amount of RPM changes between the power sources

no significant differences among the five motors ($p > 0.05$). The amount of RPM changes between the power sources are shown in Fig. 2. There was no significant difference between battery and AC adapter mode ($p > 0.05$).

DISCUSSION

Recently, NiTi engine driven rotary instruments have become a mainstay for not only endodontists but also general practitioners. Among the various motors, wireless electronic motors are becoming popular to dentists. Because they are relatively inexpensive, have lighter weight than traditional goods, and dentists can use them easily due to their wireless feature. Wireless electronic motors use the rechargeable battery for power source. The output of rechargeable batteries can be changed depending on use, residual capacity of batteries, temperature and whether the batteries are new or old. If there is a change in the output of batteries, wireless electronic motors can have a tendency of RPM change, resulting in different motion and unexpected RPM change. Unexpected RPM change

Table I. Mean of actual RPM values and amount of RPM changes (RPM set=300).

Power source	Rechargeable Battery	AC adapter
Actual RPM	277.4 ± 3.3287	275.4 ± 2.2894
Amount of RPM changes	5.9± 5.4863	4.3 ± 2.7

may accumulate stress to the inside of instruments and it can be a critical factor for leading to instrument failure.

Berutti et al.[20] said that the auto-reverse function at low torque may result in unnecessarily stored stress thus reducing the instrument's useful life. Bahia et al.[21] found that an accumulation of internal stress did not produce unfavorable changes in the superelastic properties of NiTi but will eventually lead to fatigue failure of the instruments.

Recent studies about rotational speed for the frequency of instruments failure showed different results. Some authors have reported that higher speeds reduce the period of time required to reach the maximum number of cycles before fracture.[7,8,22-25] Other authors have reported that the rotational speed of instruments did not seem to influence the frequency of file fracture.[9,26] However, there are no studies on RPM maintenance in the electronic motors for either wired or wireless motors. This is the first comprehensive study to evaluate the changes of rotational speed in endodontic motors.

According to the manufacturer, the X-Smart with rechargeable battery can be used up to 5 hours, if fully charged. Petka[27] said that 10 minutes is needed for root canal preparation in a single-visit endodontic therapy. Generally in South Korea, about 15 to 18 patients are treated by a dentist in one day. To evaluate the changes of output in a day, we measured the rotational speed of motors during 180 minutes.

To measure the RPM, a non-contact type digital tachometer, TM-5000 was used for measuring the RPM of handpiece. It has a 0.1 rpm resolution and the margin of error is plus or minus 0.001%. Non-contact type tachometer needs the reflective tape to gather the lights from the photoelectric part. Therefore, the reflective tape was attached on the upper surface as near as possible to the outer edge of the rubber wheel disk and the disk was connected to the handpiece.

In the pilot test, we found a tendency for motor stoppage because of overheating. Therefore we had cooling periods of 5 minutes after 20 minutes continuous using of the motor. To minimize the error of RPM measuring, the rotational speed was recorded after 5 minutes later from re-starting.

X-Smart has a calibration function and it is to decrease fluctuation in the rotational speed of the motor handpiece and the difference in torque by the contra angle.[28] To minimize this fluctuation, we had a calibration of the rotational speed of the motor handpiece before each test.

Interestingly, the actual RPM values were significantly lower than the RPM set on the motor and there was a little change in the rotational speed. These results were in agreement with another study that showed similar significant variations in devices used with Tri Auto AX.[29]

Kobayashi et al.[29] said that the change of rotational speed 240 to 280 rpm was observed during usual preparation procedure when using the engine driven with rechargeable battery and it is a negligible little change.

Five motors at the same power source show the similarity in changes of rotational speed during 180 minutes. The amount of speed changes has no significant difference between the power sources. But there was a possibility of significant difference in the amount of rotational speed after 90 minutes. Therefore statistical analysis after 90 minutes was done but there was no significant difference, too.

In conclusion, there was no difference in changes of rotational speed between the power supplied by the AC adapter and rechargeable battery. Up to the 180 minutes continuous using of X-Smart with rechargeable battery could be safely used as an

endodontic wireless electronic motor with a reliable RPM maintenance and without concern about file separation due to stress fracture.

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근관치료용 무선전기모터인 X-Smart의 전원의 종류에 따른 RPM 변화의 평가

[1]강릉원주대학교 치과대학 치의학과
[2]강릉원주대학교 자연과학대학 정보통계학과

박세희[1] · 정동빈[2] · 조경모[1] · 김진우[1]

본 연구의 목적은 근관치료용 무선전기모터인 X-Smart의 지속적인 사용 시, 배터리전원과 AC 어댑터 전원일 때의 RPM의 유지를 평가하고자 하였다. X-Smart (Dentsply Maillefer, Ballaigues, Switzerland) 신품 5대를 사용하였다. 본체에 연결한 핸드피스를 바이스에 고정하고, RPM의 측정을 위한 반사지를 붙인 Disk를 장착하였다. 비접촉식 RPM측정기인 TM-5000을 사용하여 RPM을 측정하였다. 배터리 전원시의 RPM과 AC 어댑터 전원시의 RPM을 5분마다 180분에 걸쳐 측정하였고 각 전기모터마다 3회씩 반복하였다. SPSS™ 14.0을 이용하여 2요인 반복측정분석을 통해 각 전원별 전기모터에 따른 RPM 변화량과 전원의 종류에 따른 RPM 변화량의 상관관계를 95% 유의 수준에서 비교하였다. 전원의 종류와 관계없이 같은 전원에서 각 기기별 RPM 변화량은 유의한 차이를 보이지 않았고, 전원의 종류에 따른 RPM 변화량의 차이는 90분 이후의 측정치에서 점진적으로 증대되는 것이 관찰되어지나 통계학적으로 유의한 차이는 보이지 않았다. 이상의 결과로, 배터리 전원의 무선전기모터로서의 X-Smart를 180분 이내로 연속사용 한다면, 신뢰성 있는 RPM 유지를 얻어 안전한 임상사용이 가능하리라 생각된다.

주요어: 회전속도, RPM, X-Smart, 전기모터

교신저자: 박세희
강원도 강릉시 지변동 123 강릉원주대학교 치과대학 치의학과 치과보존학교실
Tel: +82-33-640-2760, H.P: +82-10-4847-7952, Fax: +82-33-640-3103, E-mail: drendo@gwnu.ac.kr
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