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Effect of the amount of battery charge on tube voltage in different hand-held dental x-ray systems

Eun-Kyung Kim

Department of Oral and Maxillofacial Radiology, Dankook University College of Dentistry, Cheonan, Korea

ABSTRACT

Purpose : Hand-held dental x-ray system is a self contained x-ray machine designed to perform intraoral radiography with one or two hands. The issue about its usage as general dental radiography is still in dispute. The aim of the present study was to assess the relationship between the amount of battery charge and the tube voltage in different hand-held dental x-ray systems.

Materials and Methods : Seven hand-held dental x-ray units were used for the study. Tube voltage was measured with Unfors ThinX RAD (Unfors Instruments AB, Billdal, Sweden) for 3 consecutive exposures at the different amount of battery charge of each unit. The average and the deviation percentage of measured kV from indicated kV of each unit were calculated.

Results : Tube voltage of only 1 unit was 70 kV (indicated by manufacturer) and those of the others were 60 kV. Tube voltage deviation percentage from the indicated kV at the fully charged battery was from 2.5% to −5.5% and from −0.8% to −10.0% at the lowest charged battery.

Conclusion : Tube voltages of all units decreased as the residual amount of the battery charge decreased. It is suggested that the performance test for hand-held x-ray system should be performed for the minimum residual charged battery as well as the full charged one. Persistent battery charging is suggested to maintain the proper tube voltage of the hand-held portable x-ray system. (***Imaging Sci Dent 2012; 42 : 1-4***)

KEY WORDS : Radiography, Dental; Occupational Exposure; Radiation, Ionizing; Radiation Protection

Introduction

Hand-held x-ray system means x-ray equipment that is designed to be hand-held during operation while portable x-ray equipment designed to be hand-carried.[1] Two terms in the literature have been somewhat confused. Hand-held dental x-ray system is a self contained x-ray machine designed to be held in one or two hands to perform intraoral radiography. It was first developed by Kevex X-Ray Corporation in USA in 1993 for the military field use.[2] Currently, there are several kinds of hand-held dental x-ray systems on the market. Since they are easy to adjust for limited patients, they can be conveniently used in certain circumstances such as nursing homes, temporary health clinics, and forensic investigations in the field. However, since the operator adjoins the x-ray source assembly, hand-held x-ray system raises concerns about increased operator exposure due to x-ray leakage and backscatter radiation.[3,4]

Some manufacturers have received Food and Drug Administration (FDA) approval in the United States for clinical use. Some states in the USA permitted its usage for routine dental radiography in dental clinics with very strict requirement. For example, it must be equipped with a permanently attached backscatter shield of 0.25 mm Pb equivalent.[5-7] Operators must wear the personal dosimeter on the hand while holding the beam limiting devices.[5] Storage and security procedures shall be developed and implemented to assure that the system is secured against

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Correspondence to : Prof. Eun-Kyung Kim
Department of Oral and Maxillofacial Radiology, Dankook University College of Dentistry, 119 Dandae-ro, Dongnam-gu, Cheonan, Chungnam 330-714, Korea
Tel) 82-41-550-1924, Fax) 82-41-556-7127, E-mail) ekkim@dankook.ac.kr

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unauthorized use. Unsafe procedure would be abandoned when it not under the control and constant surveillance of the registrant.[5] It should be reported to the Authority within 72 hours if it is lost or stolen.[6] Besides, it shall meet the requirements for dental radiation-generating equipment such as kVp accuracy within plus or minus 10% of the indicated value, source-skin distance (SSD) not less than 18 cm if operable above 50 kVp.[5]

Although several states of USA permitted to use the handheld dental x-ray device for general dental radiography as stated above, other states of USA, Canada, and the European Union do not have the regulation specifically for this device. Hand holding of the x-ray tube housing is prohibited in the countries. The issue about its usage as general dental radiography is still in dispute.

Hand-held dental x-ray system is wireless and battery-operated. It can be assumed that the kV of this system might decrease as the amount of the battery charge decreases. Few studies on the effect of the remaining battery life on the tube voltage have been found in the literature. The aim of the present study was to assess the effect of the amount of battery charge on the tube voltage in different hand-held dental x-ray systems.

Materials and Methods

Seven hand-held dental x-ray units were used for the present study: 1 unit of Rextar (Poskom Co. Ltd., Goyang, Korea), 1 unit of Anyray (Vatech Co. Ltd., Yongin, Korea), 1 unit of Nomad Pro (Aribex Inc., Orem, USA), 1 unit of Point-X (Bemems Co. Ltd., Seoul, Korea), 1 unit of Prox (Digimed Co., Seoul, Korea), 1 unit of DX 3000 (Dexcowin Co. Ltd., Seoul, Korea) and 1 unit of Port X-II (Genoray Co. Ltd., Seongnam, Korea). All of them are battery-operated. They used various display methods to show the remaining battery amount. Remaining amount of battery charge was displayed as the percentage in Rextar, the remaining number of exposure in Anyray, the number of remaining bars among five bars in Nomad Pro and Point-X, the number of remaining bars among four bars in Prox, and the number of remaining bars among three bars in DX 3000 and Port X-II.

Their specifications described in the manual are shown in Table 1. Tube voltage was measured with Unfors ThinX RAD (Unfors Instruments AB, Billdal, Sweden). Exposure time applied for adult mandibular molar periapical radiography using digital sensor (Vatech Co. Ltd., Yongin, Korea) was used for the measurement of kV of each system. Tube voltage (kV) was measured for 3 consecutive exposures at the different residual battery amount of each unit. The average and deviation percentage of measured kV from indicated kV of each unit was calculated.

Results

The measured tube voltage and deviation percentage of the indicated kV at the different battery charge amount at 7 hand-held dental x-ray units are shown in Tables 2-8. Tube voltages of all units except Rextar were 60 kV. That of Rextar unit was 70 kV. Rextar unit showed 67.0 kV at full charge and 66.5 kV at 40% charge (Table 2). Anyray unit showed 60.5 kV at full charge and 58.0 kV at its lowest charge (Table 3). Nomad Pro unit showed 59.5 kV at full charge and 57.0 kV at its lowest charge (Table 4). Point-X

Table 1. Technical specifications of hand-held dental x-ray systems used in the present study

	Tube voltage (kV)	Tube current (mA)	Focal spot size (mm)	Total filtration (mm Al)	SSD (mm)	Back-scatter shield	Month and year of manufacture	Battery
Rextar	70	2	0.4	1.5	115	No	2011.10	11.1 V Li polymer
Anyray	60	2	0.8	2.0	100	No	2011.4	Rechargeable battery
Nomad Pro	60	2.5	0.4	1.5	200	Permanently attached	2010.8	22.2 V Li polymer
Point-X	60	2	0.8	1.8	100	No	2011.9	22.2 V Li polymer
Prox	60	2	0.8	1.6	100	No	2011.6	24 V Li polymer
DX 3000	60	1	0.8	1.5	100	Optional	2011.3	16.8 V Li polymer
Port-X II	60	2	0.8	1.8	100	No	2011.6	22.2 V Li polymer

Table 2. Tube voltage and deviation % from indicated kV (70 kV) according to different battery charge amount in Rextar unit

Battery charge amount (remaining battery %)	100	90	80	70	60	50	40
Measured kV (deviation % from indicated kV)	67.0 (−4.3)	66.7 (−4.7)	66.8 (−4.6)	66.7 (−4.7)	66.5 (−5.0)	66.8 (−4.6)	66.5 (−5.0)

Table 3. Tube voltage and deviation % from indicated kV (60 kV) according to different battery charge amount in Anyray unit

Battery charge amount (remaining number of times of exposure)	100	90	80	70	60	50	40	30	20
Measured kV (deviation % from indicated kV)	60.5 (0.8)	60.3 (0.5)	59.3 (−1.2)	59.3 (−1.2)	58.2 (−3.0)	58.5 (−2.5)	58.5 (−2.5)	58.5 (−2.5)	58.0 (−3.3)

Table 4. Tube voltage and deviation % from indicated kV (60 kV) according to different battery charge amount in Nomad Pro unit

Battery charge amount	5/5 bars	4/5 bars	3/5 bars	2/5 bars	1/5 bars
Measured kV (deviation % from indicated kV)	59.5 (−0.8)	59.3 (−1.2)	58.5 (−2.5)	58.3 (−2.8)	57.0 (−5.0)

Table 5. Tube voltage and deviation % from indicated kV (60 kV) according to different battery charge amount in Point-X unit

Battery charge amount	5/5 bars	4/5 bars	3/5 bars	2/5 bars	1/5 bars
Measured kV (deviation % from indicated kV)	59.0 (−1.7)	59.0 (−1.7)	58.0 (−3.3)	58.5 (−2.5)	(no exposure)

Table 6. Tube voltage and deviation % from indicated kV (60 kV) according to different battery charge amount in Prox unit

Battery charge amount	4/4 bars	3/4 bars	2/4 bars	1/4 bars
Measured kV (deviation % from indicated kV)	56.7 (−5.5)	56.3 (−6.2)	54.5 (−9.2)	54.0 (−10.0)

Table 7. Tube voltage and deviation % from indicated kV (60 kV) according to different battery charge amount in DX 3000 unit

Battery charge amount	3/3 bars	2/3 bars	1/3 bars
Measured kV (deviation % from indicated kV)	60.8 (1.3)	58.5 (−2.5)	56.5 (−5.8)

Table 8. Tube voltage and deviation % from indicated kV (60 kV) according to different battery charge amount in Port-X II unit

Battery charge amount	3/3 bars	2/3 bars	1/3 bars
Measured kV (deviation % from indicated kV)	61.5 (2.5)	60.0 (0)	59.5 (−0.8)

unit showed 59.0 kV at full charge and 58.5 kV at its lowest charge which can be measured (Table 5). Prox unit showed 56.7 kV at full charge and 54.0 kV at its lowest charge (Table 6). DX 3000 unit showed 60.8 kV at full charge and 56.5 kV at its lowest charge (Table 7). Port-X II unit showed 61.5 kV at full charge and 59.5 kV at its lowest charge (Table 8).

Discussion

The effect of the remaining amount of battery charge on the tube voltage in 7 hand-held dental x-ray units was evaluated in the present study. Tube voltages of all units decreased as the remaining amount of the battery charge decreased. Tube voltage deviation percentage of the indicated kV was from 2.5% to −5.5% at the full battery charge and from −0.8% to −10.0% at the lowest battery charge. Prox with 60 kV (indicated by manufacturer) showed 54.0 kV (−10.0 deviation % of indicated kV) at the lowest battery charge. According to the regulations about diagnostic x-ray equipments of Korean Food and Drug Administration (KFDA),[8] tube voltage of dental radiographic system should be within ±10% of the indicated kV value. One unit among 7 units examined at the present study did not meet with this regulation at the low battery level. Potential cause of this deviation from the indicated kV might be due to faulty battery or faulty x-ray generator. Other units except the above unit also showed that their kV decreased as the remaining amount of the battery charge decreased although there were some differences in severity.

According to the Korean regulation about safety management of diagnostic x-ray equipments,[9] periodic performance test should be performed every 3 years and reported to the health authorities. However, it is suggested that the interval of the performance test should be shortened in case of battery-operated x-ray system because the life of battery is short and its performance can be rapidly degraded. Also, it is suggested that the performance test for hand-held x-ray system should be performed for the minimum residual charged battery as well as the full charged one. In

case of wall-mounted dental x-ray system, the tube voltage is almost always maintained consistently. In contrast, the inconsistency of tube voltage of hand-held dental x-ray systems could be one of serious considerations for its usage as general dental radiography.

Goren et al[10] reported that Nomad portable system presented risks to the operator and patients that are no greater than with standard dental x-ray units. However, it should be considered that each model of hand-held x-ray units had to be evaluated respectively for safety purposes because the design characteristics could vary significantly from one manufacturer to another.[4]

Especially, most of them except Nomad Pro showed short SSD (10.0-11.5 cm) less than 18 cm and did not offer a permanently attached backscatter shield. Only one model (DX 3000) provided an optional backscatter shield. The author recently carried out the study measuring the operator dose in the same units as the present study and found out the considerable dose difference in different hand-held units. For the safe use of these hand-held dental x-ray systems, the strict permission requirement and an individual performance test are imperative.

In conclusion, the tube voltages of all hand-held dental x-ray units measured in this study decreased as the remaining amount of the battery charge decreased. It is suggested that the performance test for hand-held x-ray system should be performed for the minimum residual charged battery as well as the full charged one. Persistent battery charging is suggested to maintain the proper tube voltage of the hand-held dental x-ray system.

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