Characterization of a MOSkin detector for in vivo skin dose measurements during interventional radiology procedures

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Purpose: The MOSkin is a MOSFET detector designed especially for skin dose measurements. This detector has been characterized for various factors affecting its response for megavoltage photon beams and has been used for patient dose measurements during radiotherapy procedures. However, the characteristics of this detector in kilovoltage photon beams and low dose ranges have not been studied. The purpose of this study was to characterize the MOSkin detector to determine its suitability for in vivo entrance skin dose measurements during interventional radiology procedures.

Methods: The calibration and reproducibility of the MOSkin detector and its dependency on different radiation beam qualities were carried out using RQR standard radiation qualities in free-in-air geometry. Studies of the other characterization parameters, such as the dose linearity and dependency on exposure angle, field size, frame rate, depth-dose, and source-to-surface distance (SSD), were carried out using a solid water phantom under a clinical x-ray unit.

Results: The MOSkin detector showed good reproducibility (94%) and dose linearity (99%) for the dose range of 2 to 213 cGy. The sensitivity did not significantly change with the variation of SSD (±0%), field size (±1%), frame rate (±3%), or beam energy (±4%). The detector angular dependence was within ±3% over 360° and the dose recorded by the MOSkin detector in different depths of a solid water phantom was in good agreement with the Markus parallel plate ionization chamber to within ±3%. The detector is reliable when exposed to different field sizes, SSDs, depths in solid water, dose rates, frame rates, and radiation incident angles within a clinical x-ray beam. The MOSkin detector with water equivalent depth equal to 0.07 mm is a suitable detector for in vivo skin dosimetry during interventional radiology procedures. © 2015 American Association of Physicists in Medicine. [http://dx.doi.org/10.1118/1.4918576]

Key words: MOSFET detector, MOSkin, skin dose monitoring, skin dosimetry, interventional radiology, in vivo dosimetry

1. INTRODUCTION

According to the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) report, 3.6 × 10⁸ diagnostic radiology x-ray examinations are performed worldwide annually, with this number increasing every year.¹ Until the late 1980s, diagnostic procedures were characterized as low dose radiation procedures and were only linked with stochastic risks. Since the 1980s, fluoroscopically guided interventional procedures have become widespread and have been used effectively to diagnose and treat numerous vascular and cardiac diseases. Although interventional procedures provide enormous advantages over invasive surgical procedures, long periods of radiation exposure may increase the risk of deterministic effects in patients, thus causing radiation-induced skin injuries.²–⁷

The US Food and Drug Administration (FDA),⁸ the World Health Organization (WHO),⁹ the International Commission on Radiological Protection (ICRP),¹⁰ and the International Atomic Energy Agency (IAEA)¹¹ have all expressed concerns regarding patient skin dose. They have also issued guidance on the prevention of skin injuries in high dose interventional procedures. In order to prevent severe radiation injuries, it is important to evaluate the entrance skin dose (ESD) of patients during long irradiation periods. To address these issues, several radiation dose tracking systems have been developed and are available for purchase. The Patient Exposure Monitoring Network (PEMNET®) System (Clinical Microsystems, Inc., Arlington, VA) was designed to calculate and display the real-time exposure rate and subsequently the patient’s ESD based on the exposure parameters and the patient geometry information.¹² The PEMNET®, however, does not differentiate the