의학물리. 제4권 2호 1993

Measurement of Dose Distribution in Small Fields of NEC LINAC 6 MVX Using Films and Tissue Equivalent Phantoms

Tae-Suk Suh, Dong-Rak Choi, Bo-Young Choe, Sei-Chul Yoon, Hong-Seok Jang, Il-Bong Choi, Moon-Chan Kim, Yong-Whee Bahk, Kyung Sub Shin

Department of Radiology and Neurosurgery*, Catholic University Medical College, Seoul, Korea

ABSTRACT

The purpose of this paper is to develop a simple system to measure dose distribution in small fields of NEC LINAC 6 MVX using film and solid water instead of ion chamber and water phantom. Specific quantities measured include percent depth dose (PDD), off-axis ratio (OAR). We produced square fields of 1 to 3cm in perimeter in 1cm steps measured at SAD of 80cm. The PDD and OAR measured by film was compared with measurement made with ion chamber. We calculated the TMR from the basic PDD data using the conversion formula. The trends of our measured beam data and philips LINAC are similar each other. The measurement for the small field using film and solid water was simple. Hand-made film phantom was especially useful to measure OARs for the stereotactic radiosurgery.

INTRODUCTION

The measurment of small beam is prerequisite for the treatment of stereotactic radiosurgery. The concept of LINAC-based radiosurgery were described in many literatures.[1-6] The measurement data for tissue maximum ratio (TMR) and off-axis ratio (OAR) are the main measured factor for dose model routinely used in radiosurgery. These measurement are identified as basic beam data. Early work on small beam measurement included two main parts. The first part was to determine the detector system for the small beam measurement. The second part was to formulate basic beam data from the limited measurement. Various detectors have been tested and utilized for the samll beam measurement.[7,8] The effort to formulate the percent depth dose, output factor, and beam profile was made for the normal rectangular collimator size.[9-11]

Most beam measurements in radiation therapy are based on ion chamber with water phantom. The size of small fields, less than 30 mm in diameter, presents problems in two ways : (1) the absence of lateral electronic equilibrium due to the finite size of ion chamber, (2) large dose gradient across the small field. To minimize these effect and achieve high resolution,

keyword : small field, radiosurgery, beam measurement

** 이 논문은 1993년도 한국학술 진흥재단의 공모과제 연구비에 의하여 연구 되었음.

a small detector such as film, diode or TLD is essential.

The purpose of this work is to describe the dose measurement for these small x-ray beams simply by using film and solid water phantom.

MATERIALS AND METHODS

The measurement for the small field was performed using film and solid water phantom (Victoreen white solid water). Instead of using cylindrical collimator, we utilized built-in recta-ngular collimator in this study. We produced square fields of 1 to 3 cm in perimeter in 1 cm steps, measured at SAD of 80 cm. To measure the beam we used the film phantom, which was sandwitched by solid water phantom.

The position of gantry was rotated into 90 degree. The height and lateral length of turn-table was adjusted to match the center of the beam and laser line with the top line of the film. SSD was 78.5 cm (1.5 cm buildup for 6 MVX). Figure 1 shows the configuration of our measurement setup. Kodak XV-2 film were used to detect the beam. The optical densities of the films were obtained with optical densitometer, then converted to dose by a calibration curve measured for the film batch used(Fig. 2).

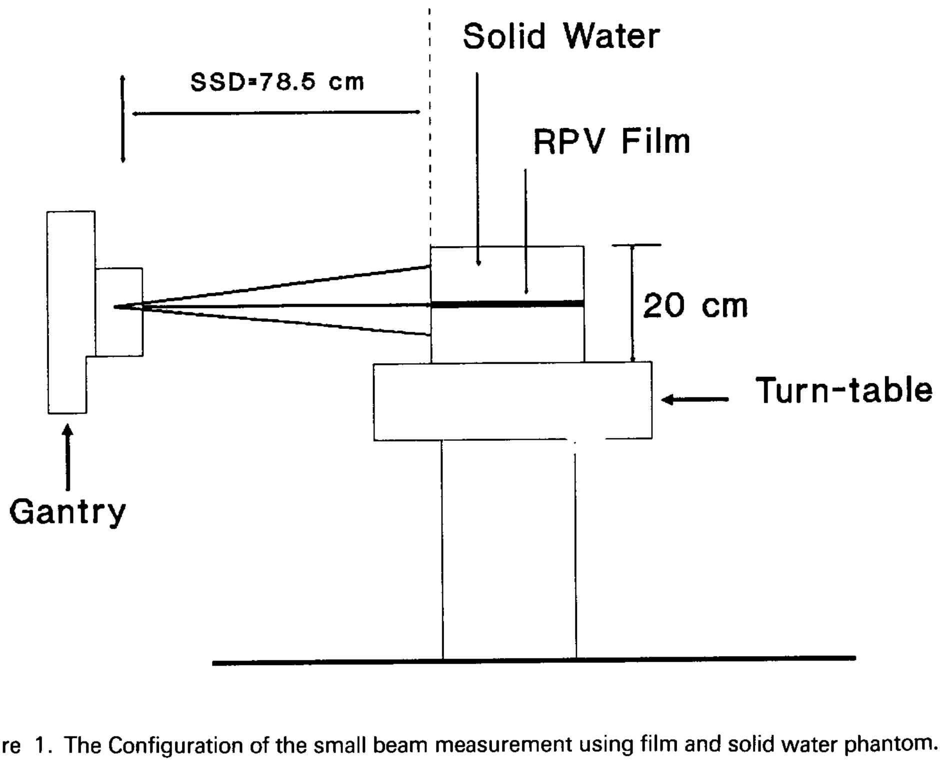


Figure 1. The Configuration of the small beam measurement using film and solid water phantom.

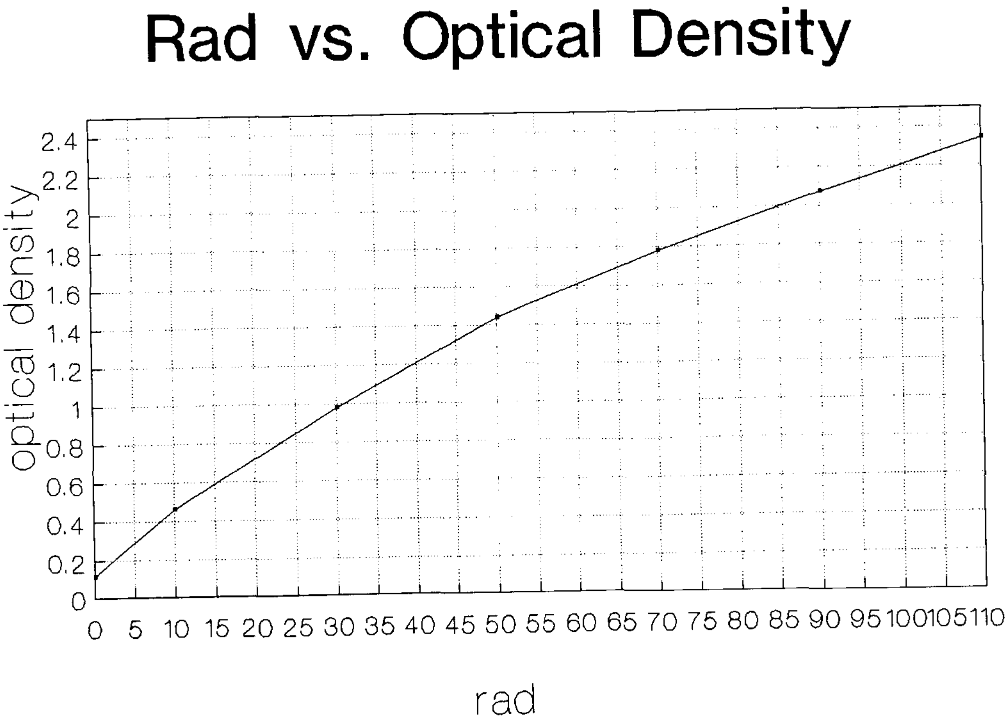


Figure 2. Calibration curve measured for the film batch used (dose vs. optical density)

RESULTS

The PDD were obtained by dividing the dose by maximum depth dose(i. e. at d=1.5 cm for 6 MVX-ray). The PDD are given in figure 3. Since the film measurement of TMR is a little complicate, we calculated the TMR from the basic PDD data using the conversion formula[12] :

$$TMR(w,\ d) = (\frac{PDD(SDD,\ w_m, d)}{100})\ (\frac{BSF(W_m)}{BSF\ (W)})\ (\frac{SSD + d}{SSD + d_m})^2 \qquad (1)$$

Since the variation of back scateer factor (BSF) is small over the small change of field size, equation (1) cna be approximated into following equation by ignoring the BSF term for small fields.[13]

$$TMR(w,\ d) = (\frac{PDD(SDD,\ w_m, d)}{100})\ (\frac{SSD + d}{SSD + d_m})^2 \qquad (2)$$

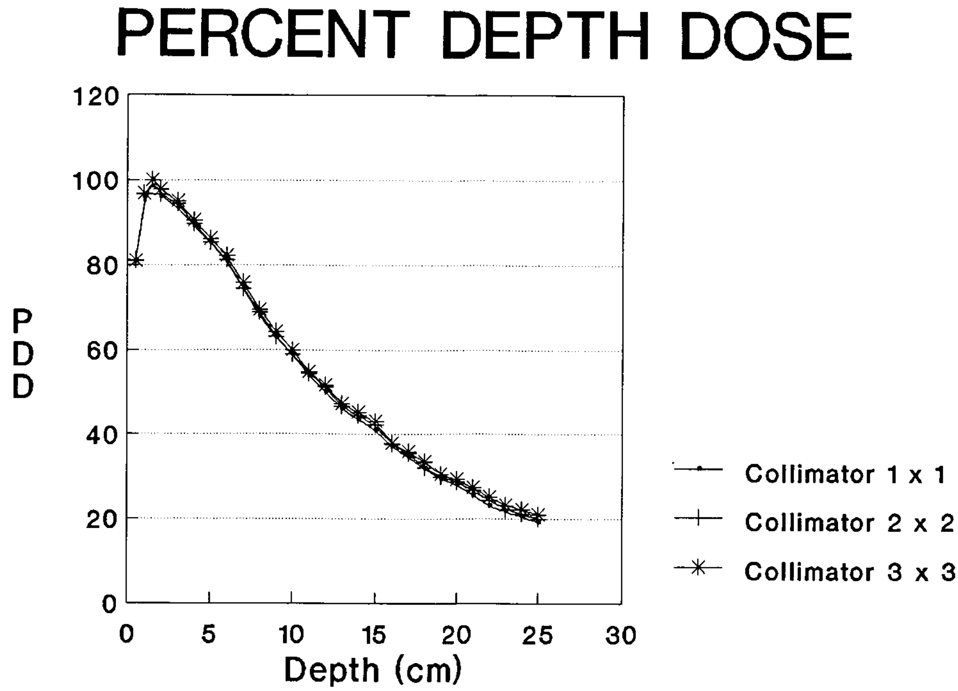


Figure 3. Percent depth dose for NEC 6 MeV X-ray.

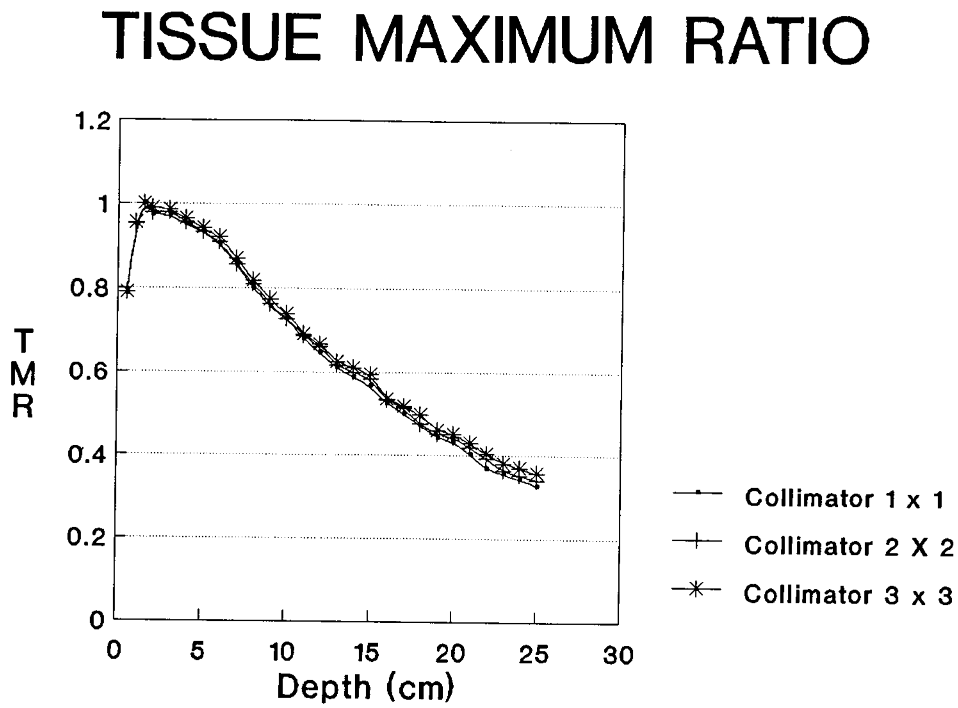


Figure 4. Tissue maximum ratio for NEC 6 MeV X-ray.

TISSUE MAXIMUM RATIO

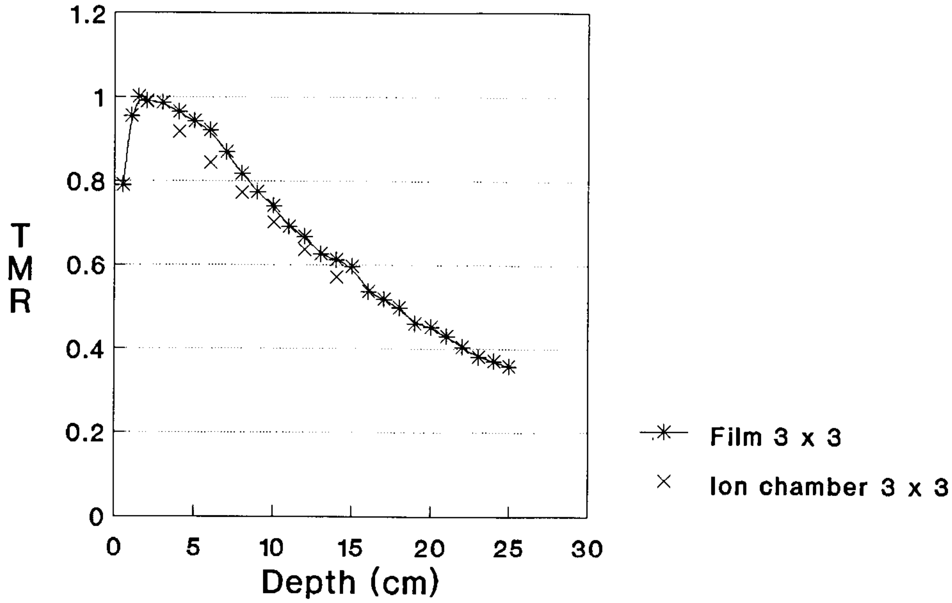


Figure 5. Tissue maximum ratio for NEC 6 MeV X-ray. The points denote the capitec ion chamber measurement and the curve denote the film measurement.

OFF AXIS RATIO

NEC 6MVX

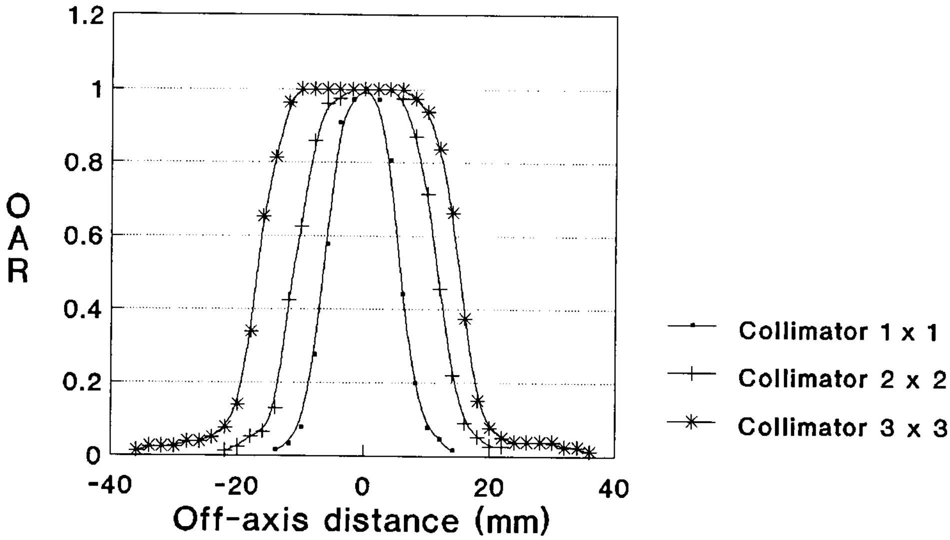
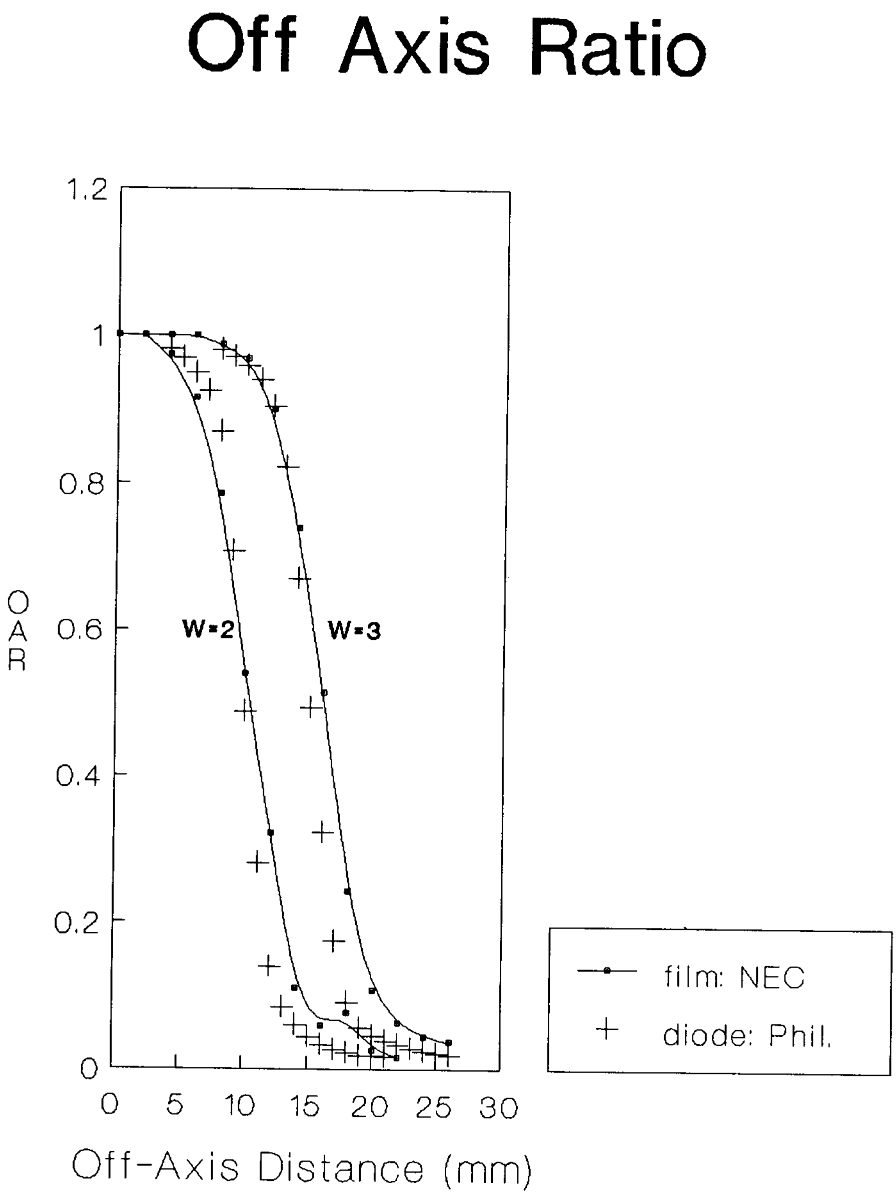


Figure 6. Off-axis ratio for 6 MeV-ray. The points denote the Phillips OAR data through diode measurement. and the curve denote the NEC OAR data through film measurement.



measured at SAD=80 and depth 5 cm

The TMRs were obtained by using Eq. (2), and are shown in figure 4. Figure 5 shows similar trends of TMR between the film and captintec ion chamber. The TMR data could be fit to a function of the exponential form.[7,8] The optical densities across the off-axis distance at maximum depth of 1.5 cm (SAD=80) were measured. The dose was obtained through the same conversion procedure as mentioned in PDD.

The OARs were obtained by dividing the off-axis dose by central axis dose at the same depth. Figure 6 shows OAR beam data at d_{max} for various square field sizes. Figure 7 compares NEC OAR beam data with the Phillips 6 MVX OAR beam data (diode measurement). The trends of OAR in both cases are similar each other, and could be fit to modified Cunningham function.[8].

DISCUSSION

Various techniques have been developed to measure the quantities necessary to calculate dose distributions in small fields. Due to the high gradients present at the beam edges and absence of lateral electronic equilibrium on the central axis for the small fields, detector size and positioning were the most important factors in making precise measurement. The present experiment yielded the results concerning measured factors, some of which (OAR) were acceptable, but others (PDD and TMR) were unacceptable. The TMR through film measurement were different from those through ion chamber measurement. The source of error may be from the various factors : film position, inaccuracy of film measurement, back scatter factor ignored, different phantom used, finite size of ion chamber, etc. The NEC OAR data were well represented by Philiips OAR data. When we compare NEC OAR data with Phillips OAR, the beam profile with phillips were seen to be more sharply dropped off.

Although we obtained somewhat rough results in TMR, this experiment was profitable experiment and gave an easy protocol to setup and measure the small beam without complicated measurememt system. In conclusion, better measuring technique, more accurate measurement and experimental verification of the assumptions in the beam model, would give more agreeable results.

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필름 및 tissue equivalent 팬톰을 이용한 NEC LINAC 6 MVX 소조사면에 대한 선량분포 측정

서택석, 최동락, 최보영, 윤세철, 장홍석, 최일봉, 김문찬*, 박용휘, 신경섭

가톨릭대학교 의과대학 방사선과학교실, 신경외과학 교실*

초 록

본 논문의 목적의 NEC LINAC 6 MVX 선의 소조사면에 대한 선량분포를 복잡한 물팬톰 및 ion chamber대신 film 및 고체 물팬톰을 이용하여 간단히 측정하고 분석하는 시스템을 개발하는 데 있다.

단일 선속측정을 위하여 필름과 고체 물팬톰이 이용되었으며, 측정된 데이타는 percent depth dose (PDD), off-axis ratio (OAR) 등을 포함하며, 한변이 1, 2, 3cm의 정사각형 소조사면에 대하여 측정이 이루어 졌다. 또한 Output factor측정은 ion chamber로 측정되었으며, 필름에 의하여 측정된 PDD, OAR 등은 ion chamber측정기로 측정된 값과 비교 검토되었다.

필름으로 부터 측정된 PDD값으로 부터 환산식을 이용하여 tissue maximum ratio (TMR) 값을 얻었으며, 본 실험에서 얻어진 TMR, OAR 값들은 같은 에너지를 나타내는 Philips LINAC의 선량 데이타와 유사한 결과를 보여주었다.

고체 물팬톰 및 필름을 이용한 소조사면 측정은 간편하고도 유용한 방법이었으며, 특히, 자체 개발된 필름팬톰은 뇌정위적 방사선 수술을 위한 OAR 선량을 측정하는 데 유용하였다.