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An alternative effective method for verifying the multileaf collimator leaves speed by using a digital-video imaging system

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ABSTRACT

We present an alternative effective method for verifying the multileaf collimator (MLC) leaves speed using a digital-video imaging system in daily dynamic conformal radiation therapy (DCRT) and intensity-modulation radiation therapy (IMRT) in achieving increased convenience and shorter treatment times. The horizontal leaves speed measured was within 1.76–2.08 cm/s. The mean full range of traveling time was 20 s. The initial speed-up time was within 1.5–2.0 s, and the slowing-down time was within 2.0–2.5 s. Due to gravity the maximum speed-up effect in the X1 bank was +0.10 cm/s, but the lagging effect in the X2 bank was −0.20 cm/s. This technique offered an alternative method with electronic portal imaging device (EPID), charged coupled device (CCD) or a light field for the measurement of MLC leaves speed. When time taken on the linac was kept to a minimum, the image could be processed off-line.

1. Introduction

Since the development of intensity-modulated radiation therapy and the computer-controlled multileaf collimator system became dynamic, radiation therapy has been launched into the dynamic millennium. The dynamic multileaf collimator "sliding window" technique was one of the methods used to deliver the modulated intensity distributions. To minimize delivery time, it was desirable to move the leaves as quickly as possible. Leaves sequencers typically adjusted each pair of leaves to its maximum speed [1,2].

The use of a dynamic MLC to deliver intensity-modulated beams presents a problem for conventional verification techniques. A study on the use of films for verifying dynamic MLC treatments had been submitted by Bhardwaj et al. [1], Sarkar et al. [3], Chow and Grigorov [4], Chui et al. [5], Wang et al. [6], and Mubata et al. [7], but the task was not only time-consuming but also limited the frequency of use and made patient use impractical. The use of electronic portal image device (EPID) to track MLC leaves during beam delivery has been shown to provide a solution to this problem [8]. Various authors have reported the use of EPID systems as a solution to the problem of dynamic MLC beam verification [8–12] and some have tried to use the kilovoltage-imaging panel equipped on the linac [13].

Due to the limited spatial resolution in the absence of sharp edges, optical distortion, dosimetric non-linearity and fixed-pattern noise, the use of video-based EPID imaging for leaves speed measurement was limited [9,10,14]. Zygmanski et al. [15] proposed that a determination of the maximum leaves speed required DCRT, which resulted in examination of the beam's-eye view (BEV) projections. Evans et al. [8] said that commercially available portal imaging systems could be used to verify dynamic MLC beam delivery and leaves speed with suitable modification.

The stability of leaves speed could affect the intensity profile to be generated. The acceleration and deceleration of the leaves when they moved from one segment to the next might also cause undesirable artifacts in the delivered intensity profile. Thus, to accept the MLC assembly, leaves speed, the maximum speed of leaves and/or carriages should be verified according to Report No. 72 of the AAPM. The individual leaf should move in a continuous and smooth motion over their range of travel. Leaves lagging behind might be an indicator of a problem, which could lead to the failure of MLC, and it should be addressed as soon as possible [2]. They concluded that it was necessary to verify the leaves speed both as the parts of a pretreatment patient and as periodic linear accelerator quality assurance (QA) [9].

According to the Multileaf Collimator System Manual (Siemens Medical System, Inc. Oncology Care Systems Group, Concord, CA, USA, 2000) for leaves speed adjustments, it is mentioned to drive

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the leaves, to monitor them during the process, to verify leaves speed, to adjust leaves, and then to move the leaf one by one to determine whether the speed was acceptable. But it still did not provide any useful method to accurately measure leaves speed.

Digital-video [16,20] and camera images [17] used for linear accelerator quality assurance program and assistant of treatment planning have been used more recently. In this study, an alternative method for quick, efficient and radiation-free leaves speed measurement by using a digital-video image on a Siemens double-focused MLC system in conjunction with a BEAMVIEW (PLUS) EPID was presented and used to measure each leaves speed of the system.

2. Materials and methods

A Siemens PRIMUS linac with double focus MLC system (Siemens Oncology Care Systems, Concord, CA) was used. The Siemens MLC assembly consisted of two banks (X1 and X2) of 29 leaves defining collimation along the *X*-axis, with the center 27 leaves 1 cm wide (at 100 cm isocenter) and the outer leaves at each end 6.5 cm wide. According to the Siemens Linac Acceptance Test Procedure (ATP) document (Siemens Oncology Care Systems, Concord, CA), leaves in each bank could travel from +20 cm to −10 cm over the isocenter [13]. The cross-hair reticule was to be inserted in the accessory holder in slot 1 to determine the actual

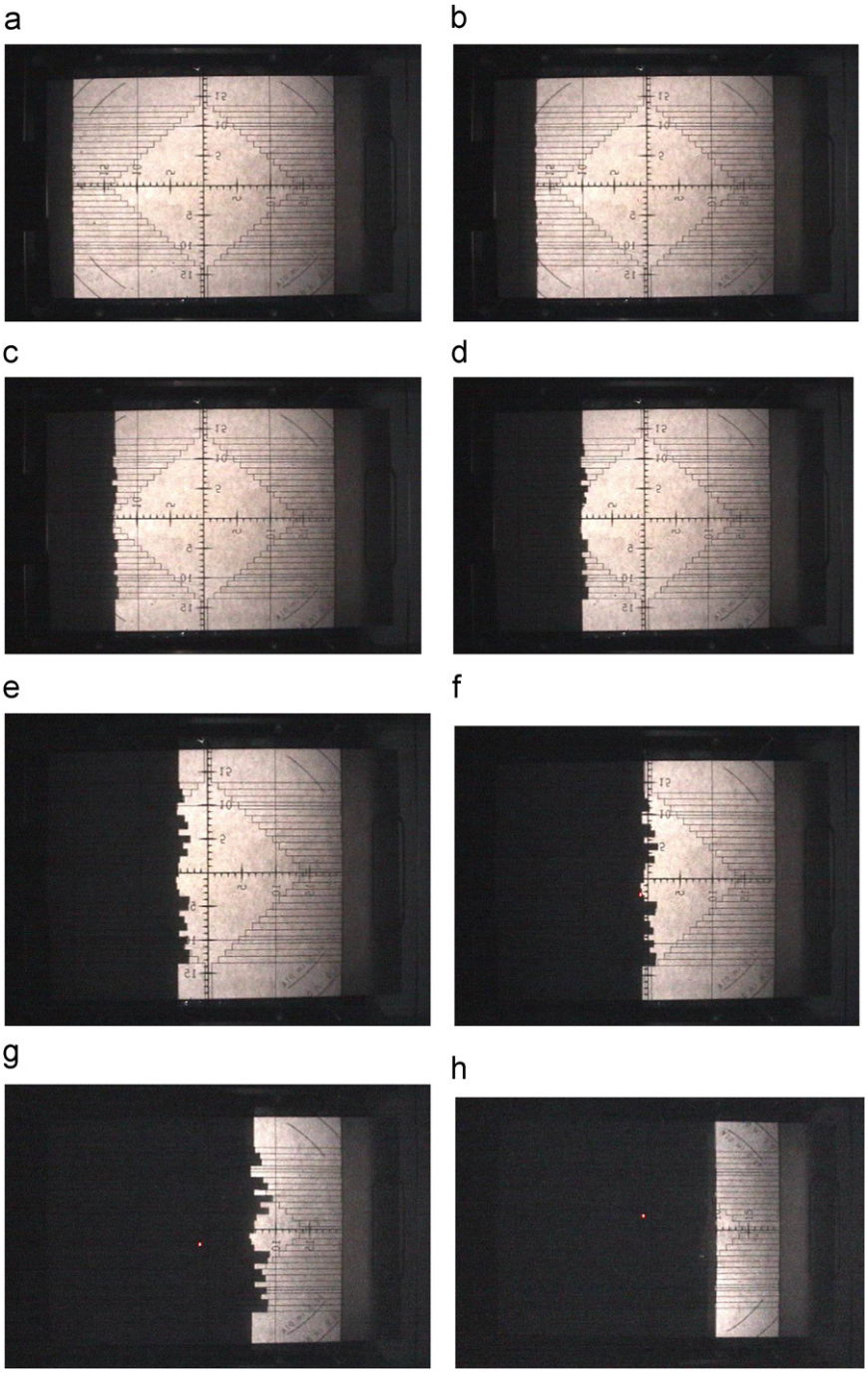

Fig. 1. Images (a)–(h) show the sequence of Simens Primus Linac X1 MLC leaves bank motion images at collimator and gantry angle of 90° with the MLC check tray overlaid onto the leaves shadow.