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New Fiduciary Plate and Orientation Marker for High Energy Radiation Therapy

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Purpose: A new fiduciary plate and orientation marker have been devised to assist the quality assurance (QA) procedures for port films in radiation therapy department. The plate is used in conjunction with the film/cassette combination during weekly QA procedures, at Seoul National University Hospital (SNUH), in order to verify treatment fields in high energy radiation therapy.

Materials and Methods: A new fiduciary plate was fabricated using an acrylic plate, cerrobend, standard blocking tray and mercury. The acrylic plate had the dimension of 1×25×25 cm, with two fiduciary markers. The plate was rigidly attached onto the standard blocking tray, thus making it easier to set the fiduciary plate to the center of the radiation field of the linear accelerator. The plate had two 2-mm vertical and horizontal lines, with the minor scales in 2-cm steps. The orientation marker was a small mercury filled disk, which was inserted into the plate.

Results: The geometrical structure of the lines in the plate makes it easier to correlate two different images between the simulation and port films. The marker clearly indicated the orientation of the film, for example, the anterior, posterior, left, right and various oblique orientations, without the placement of a conventional orientation marker. Also, the new orientation marker could easily be applied to the simulator by placing the small orientation marker onto the image intensifier or in front of the film/cassette holder.

Conclusions: The new fiduciary plate appears to be useful in verifying the treatment fields, and the new orientation marker makes the film orientation simple, which is expected to lower the block fabrication errors.

Key Words: Port film, Quality assurance (QA), Fiduciary plate, Orientation marker

Introduction

Radiation treatment planning is very important procedure in two aspects. For tumor control, first, the homogeneous dose should be given to the target volume. Second, normal tissues around the target volume should be spared as much as possible. But, in fact, there are several kinds of errors in radiation treatment procedure that cannot satisfy these treatment goals. Errors can be schematically divided into two groups: (a) Errors on dose scale or dose level, which are related to previous steps such as the calibration of the treatment unit, dose measurements, treatment planning, etc. (b) Errors implying a distortion of dose distribution, which includes deviation in set-up parameters as the field sizes, gantry and collimator angle, position of the shielding blocks, etc. and also malposition of the patient.[1] Radiation portal film is an important mechanism for assuring geometric accuracy of radiation therapy delivery. Through the procedures of the comparison of port films with simulation films, the accuracy of patient set-up can be ascertained regularly. To reduce these errors, more frequent use of verification film was used[2] and electronic portal imaging devices to the linear accelerator are developed.[3]

Also, generally, conventional orientation marker, which is made of lead, is located on the area of film/ cassette. But

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conventional orientation marker has some disadvantages as follows: (a) artificial human error of placing a wrong orientation marker, (b) extra-work of making various types of orientation marker. Especially, error of placing the wrong orientation marker leads to the wrong fabrication of the shielding block and a serious damage to the normal tissues.

To improve the treatment verification and increase the readability of port films, and reduce the chance of wrong fabrication of the shielding block, the fiduciary plate and orientation marker has been made.

Materials and Methods

Blocking slot tray of linear accelerator (Clinac 2100C linear accelerator, Varian, Pola Alto, USA) is used to develop the fiduciary plate in the high energy radiation of 6 and 10 MV photon beam. In order to give fiduciary markers in the film, there are two possible locations in the LINAC for the fiduciary plate: (a) wedge slot, and (b) blocking tray slot. The fiduciary plate inserted in the wedge slot can make possible to execute routinely used double exposure technique. The

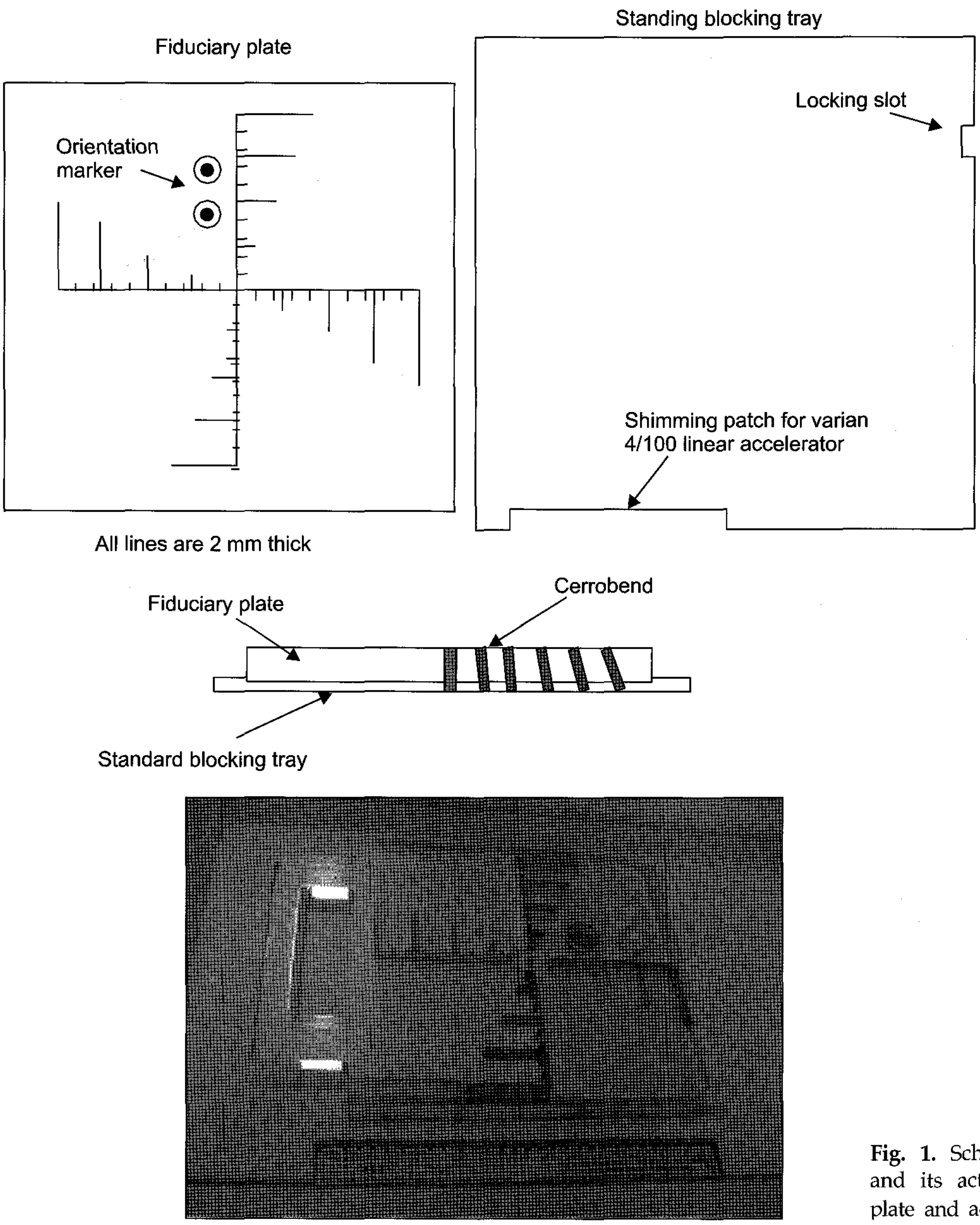

Fig. 1. Schematic diagram (above) and its actual picture of fiduciary plate and accessories (below).

disadvantage of using the wedge slot is that it is difficult to fabricate the fiduciary plate because of (a) sharp divergent angles due to shorter source-to-tray distance and (b) tight metal slots. Therefore, the blocking tray slot has been chosen to place the fiduciary plates. Also, the wedge slot can be a reasonable choice. There are several parameters that affect the imaging quality of port films: patient's thickness or type of diseases, given radiation source, source-to-film distance or patient-to-film distance, types of materials of fiduciary marker, and processor conditions.

The fiduciary plate is made of acrylic (PMMA, polyethylmetacrylate) plate having two major lines with minor scales of 2 cm. The fiduciary plate has the dimension of 1 cm ×25 cm ×25 cm and contains fiduciary markers. Two lines have divergent angles so that the lines are clearly defined in the port film. The optimum thickness of the lines, defined as the actual thickness at the fiduciary plate, is determined to be 2 mm. The lines are made by filling up the divergent lines with cerrobend. The detailed schematic diagram and its actual picture are shown in Fig. 1. The geometrical structure of the lines in the fiduciary plate is determined by trying to make the scale of the simulation film and the that of the port film as identical as possible, thus making easier to correlate two different images in weekly QA procedure.

The fiduciary plate is attached onto the standard blocking tray, thus making simpler to align the fiduciary plate in the standard blocking tray. The standard blocking tray can be smoothly slided into the locking pin of the treatment head of the linear accelerator by means of the divergent locking slots shown in Fig. 1. The mechanical accuracy of the fiduciary plate is determined to be less than 0.2 mm by exposing star patterns. This tray can be used with other linear accelerator, for example, with Varian Clinac 4/100 linear accelerator by modifying the edge of the tray.

The orientation marker is made by inserting mercury in two circular cylinder with the diameter of 1 cm and 3 cm, and the height of 8 mm each in order to take advantage of the gravity. The height of the cylinder is determined by the atomic number and the physical density of the mercury. Only half of the cylinder is filled up with mercury, thus making possible to indicate the gantry or collimator rotations in the port films. The diagram of the orientation marker and its actual picture are shown in Fig. 2.

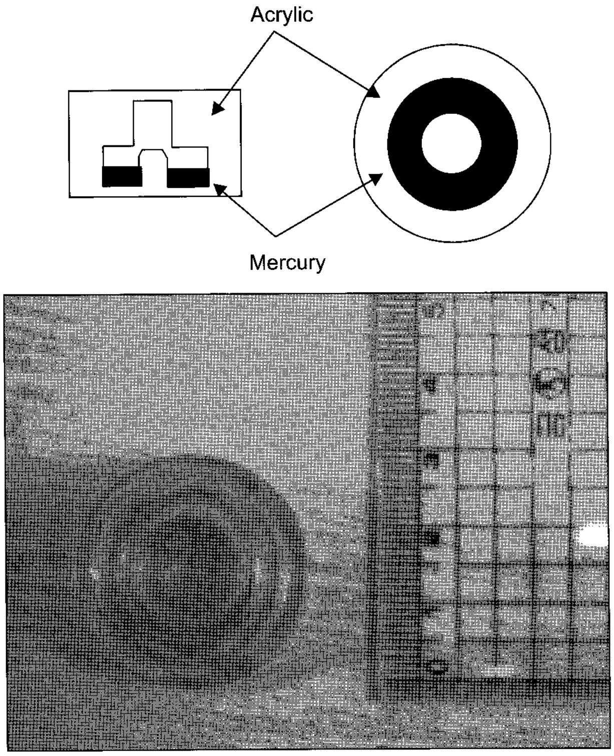

Fig. 2. Schematic diagram (above) and its actual picture of orientation marker (below).

Results

Since the fiduciary plate made the port films similar to simulation films, the field replacement error could be precisely corrected. And since there were lines in fiduciary plate in one direction, normal structures in the port films could be easily compared with those of simulation films. Since the new fiduciary plate contained the mercury-filled orientation marker, the procedure of verification of the port films was easier to radiation oncologists, especially for the verification of the oblique direction of beam. The port films using a new fiduciary plate are shown in Fig. 3.

The images of orientation marker with different gantry angles are shown in Fig. 4. For example, only 1 cm diameter of circle was shown in the posterior-anterior (PA) films, a ring in anterior-posterior (AP) films, and half circle in right and left films with different orientations. Therefore, there were obvious distinctions between anterior oblique film and posterior oblique film depending upon the position of the half

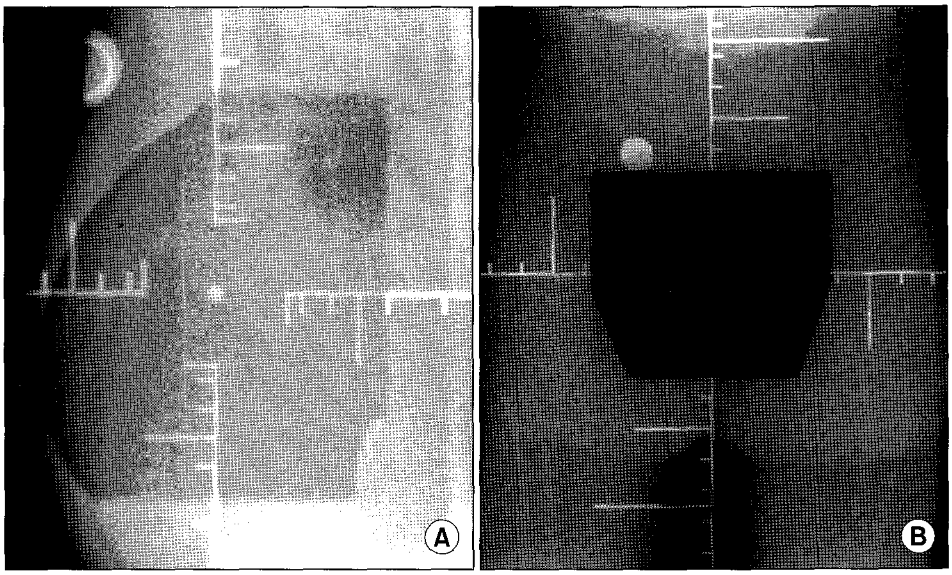

Fig. 3. Port film images using a new fiduciary plate. (A) AP view (B) lateral view.

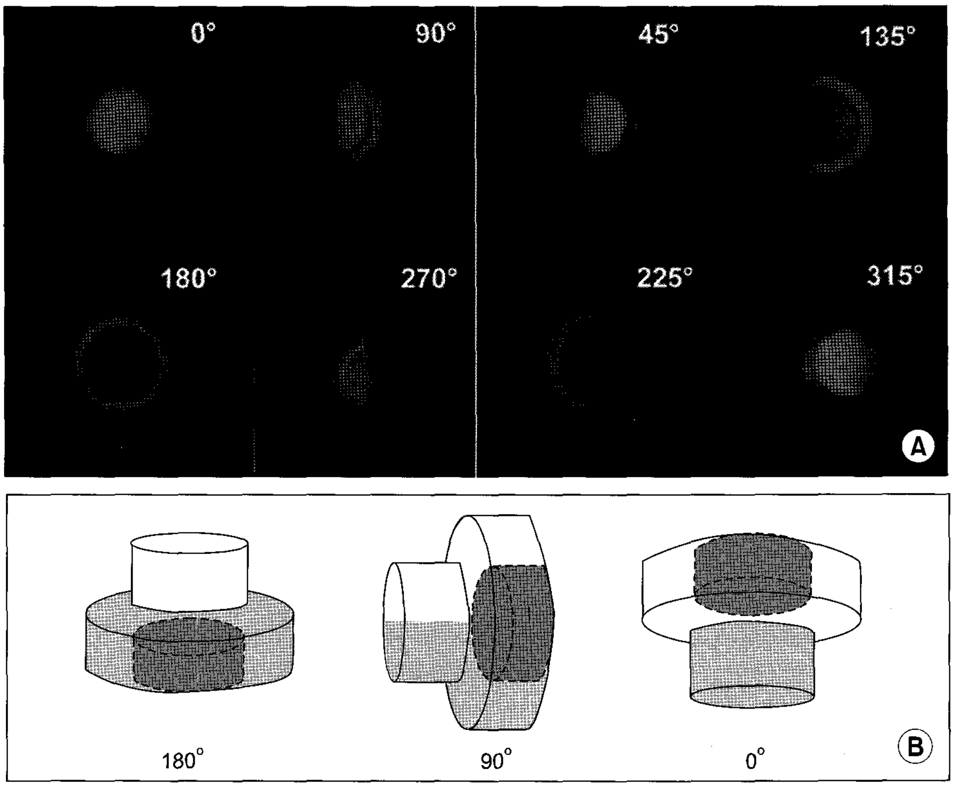

Fig. 4. New orientation marker appearance with different gantry angles (A) and schematic example of various gantry angle.

circle. Also, in the case of oblique fields the collimator rotations were estimated from the film.

Also, the orientation markers could be easily applied to the simulator by placing the small orientation marker onto the image intensifier or the front of the film/cassette holder (Fig. 5).

Discussion

Accurate delivery of the prescribed dose to the tumor is an important factor that determine the success rate of the tumor control in the radiation therapy. Traditionally, to assess the

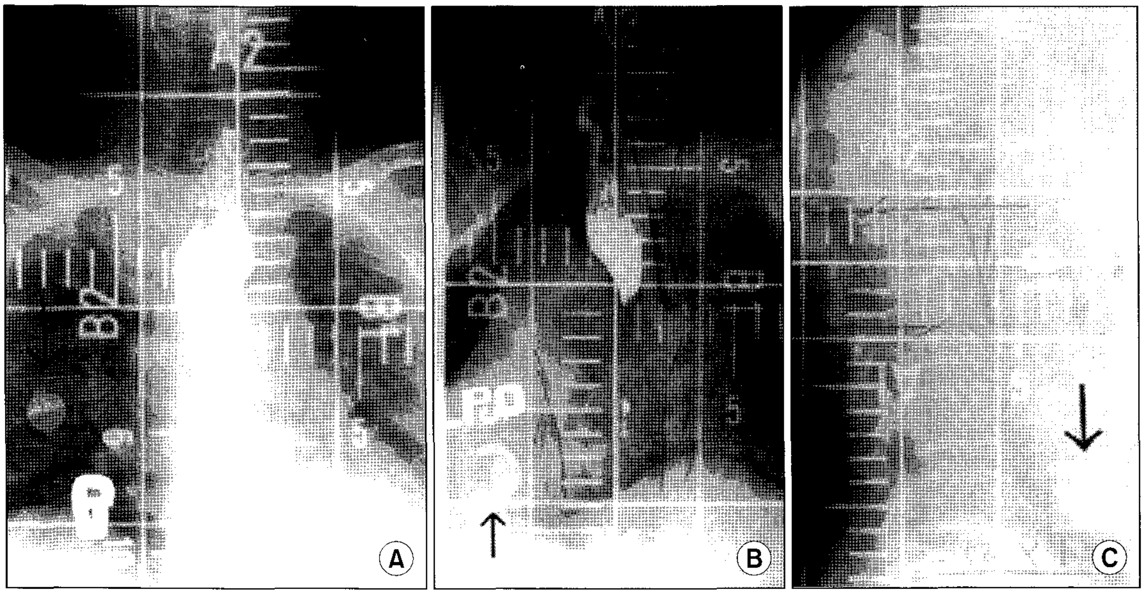

Fig. 5. Orientation marker on simulation films. (A) Anterior view (B) LPO view (C) lateral view 1 cm diameter of circle is shown in the posterior-anterior (PA) films, a ring in anterior-posterior (PA) films (A), and half circle in lateral films (C).

field placement accuracy radiation oncologists have compared port film images with reference to simulation films. A port film can be taken in two ways: localization film and verification film. First, the localization film is used to localize the treatment field by using the film/cassette combination with the radiation of 2~10 cGy. In general, double exposure technique is utilized to give more anatomical information to medical doctors. The advantage of using the localization film is that (a) optimum imaging quality can be achieved by using the standard exposure techniques, and (b) the film includes many anatomical information by using double exposure technique. The disadvantage is that (a) extra work is needed for radiation therapists, (b) it might not include patient's motion during the treatment session, and (c) it increases unnecessary radiation doses to a patient.

Second, the verification film is used during daily treatment session to verify the treatment field. In general, a verification film (Kodak's X-Omat V-film, Eastern Kodak Company, Rochester, N.Y., U.S.A.) alone is used to take port film in routine treatment sessions. The advantage is that (a) it can include all the patient's motions, and (b) it does not give any extra doses to a patient. The disadvantage is that the imaging quality is quite sensitive to exposure techniques. Port films were rejected most often because of centering errors. Some studies showed that field malposition was most common error recorded about 70% of all errors on average.[4] Malrotation, patient malposition, and block misalignment averaged 14%, 8.5%, 4%, respectively.

Nowadays, electronic portal image devices (EPID) have been widely used in radiation departments to verify treatment field. It has advantage over port film in that treatment images are recorded and digitally stored on computer. Recently, field-only EPI was introduced by Kay et al., reporting its usefulness of specific treatment sites including breast, chest, hip, spine, and large pelvic fields.[5]

Port film has been used to assess field replacement at SNUH, and to improve the treatment verification and increase the readability of port films, a new fiduciary plate has been devised. The geometrical structure of the lines in the fiduciary plate makes it easy to compare the port films with the simulation films. As the lines at the fiduciary plate are made of cerrobend, the thickness of those is determined to be 2 mm. But, if the lines are fabricated by using the lead, thinner (1 mm) lines may be possible and so present the more delicate verification.

Although the gantry angle difference is not discriminated in oblique beam, the orientation marker, indicates the film directions clearly as shown in figure 4. The orientation marker can be applied to both portal films and simulation film. Incidents involving misadministration of prescribed dose was reviewed during 1988 and 1989 in Fox Chase Cancer Center. They reported the incidence of wrong block was 10 (25%) of 54 cases in 1988 and 5 (18%) of 28 cases in 1989 among misadministration types.[6] Although, there was little possibility that block fabrication error occurs, it is very important in that it leads to severe risk to damage to normal tissues. The new orientation marker may decrease the rate of block fabrication error.

Conclusively, the new fiducially plate containing mercury-filled orientation marker may help the radiation oncologist to verify the treatment field, especially oblique fields and the new orientation marker is expected to reduce the wrong fabrication of block.

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국문초록

고에너지 방사선치료의 정도관리를 위한 Fiduciary Plate 및 Orientation Marker의 개발

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목 적: 선형가속기를 이용한 방사선 치료시 치료부위의 확인을 위한 하나의 방법으로 port film이 사용되고 있다. 서울대학병원에서는 port film 촬영 시 기계적 변수를 port film상에 나타내기 위하여 방향성 표시기(orientation marker)를 갖는 fiduciary plate를 개발하였다.

대상 및 방법: Fiduciary plate의 제작에는 아크릴 plate와 cerrobend, 수은이 사용되었다. 아크릴 plate의 크기는 1 cm×25 cm×25 cm로 그 내부에 두 개의 방향성 표시기가 내재되었고, 선형가속기의 blocking tray slot에 삽입이 가능하도록 제작되었다. Plate 내부에는 2 cm 간격으로 2 mm 두께의 수평과 수직으로 만들어진 cerrobend line이 위치해 있고, 방향성 표시기 내부에는 수은으로 채워져 있다.

결 과: 아크릴 plate의 cerrobend line은 simulation films과 port films간의 치료 영역의 비교를 용이하게 한다. 수은을 이용하여 만들어진 방향성 표시기는 납으로 만들어진 일반적인 표시기가 없이도 전후좌우와 다양한 각도로 경사진 방향을 구분할 수 있게 한다. 또한 방향성 표시기는 film/cassette holder에 부착함으로써 simulation 시에도 이용될 수 있다.

결 론: Fiduciary plate는 치료 영역 확인에 유용하고, 수은을 이용한 방향성 표시기내의 혼합액의 기하학적인 모양에 따라 port film의 촬영 parameter를 용이하게 파악할 수 있어 치료과정에서 촬영한 port film 간의 임상정도관리에 유용한 방법이 될 수 있다.

핵심용어: Port film, Quality assurance (QA), Fiduciary plate, Orientation marker