Development of Electronic Portal Imaging Device and Treatment Position Verification for Fractionated Stereotatic Radiotherapy

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ABSTRACT

The video based electronic portal imaging device (EPID), which could display the portal image in near real time, was implemented to verify treatment position error in FSRT(Fractionated Stereotatic Radiation Therapy) instead of a portal film. Also, Developed FSRT system was composed of the stereotactic frame, frame mounting system and collimator cones.

The verification of treatment position is very crucial in special therapies like FSRT. In general, the FSRT uses high dpse rate at small field size for treating small intracranial lesions. To evaluate quantitative positioning errors in FSRT, we used the first FSRT image as reference image and obtained the second FSRT image that was moved 2mm intentionally and detected intracranial contours after image processing. The generated 2mm error could be verified by overlapping only contours of two images. Through this study, the radiation treatment efficiency could be improved by performing precise radiation therapy with a developed video based EPID and FSRT.

Keywords : EPID, FSRT, RT, setup error

1. INTRODUCTION

It is very important to verify setup errors in cancer therapy by using high energy radiation and to perform the precise radiation therapy. The FSRT techniques intend to deliver a highly focused radiation distribution to the target volume and to minimize the dose to surrounding normal tissues during treatment. In linac-based FSRT, Precise alignment to the localized target volume is a necessity for radiosurgery. After the alignment has been accomplished, the accuracy of the alignment of the radiation distribution in FSRT should be verified prior to treatment. Usually, portal film has been used for alignment errors. In this study, we used the digital EPID system[1], which was consisted of a metal/fluorescent screen, 45°mirror, camera and image grabber was implemented as a verification tool to check setup errors in FSRT .

To estimate the developed FSRT system, the isocenter accuracy of gantry, couch and collimator were performed and a total of inaccuracy was less than ±1mm[2].

To evaluate quantitative positioning errors in FSRT, we got the first FSRT image in first treatment day as reference image and compared this first FSRT image with other FSRT images in next day. So, It was important to setup accurately at first time. We used the basis point plate having 5 points for making reference markers on digital images.

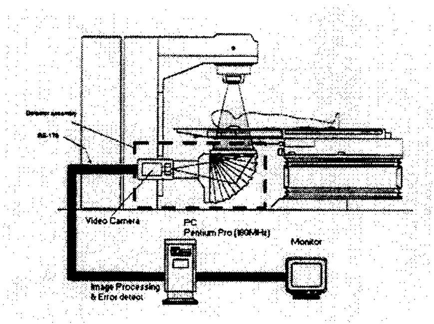

Fig. 1 Schematic diagram of the portal image System

Among 5points, there was an isocenter marker on FSRT treatment image by double exposure method. We could easily know how much errors were generated in FSRT by users. Setup error could be displayed after processing these images by edge detection method to analyze quantitative positioning errors.

2. SYSTEM CONFIGURATION

2.1 EPID system

This System was consisted of a metal plate and fluorescent screen combination, 45^0 mirror, CCD camera and image grabber. The metal plate serves two purposes to stop all secondary electrons produced in the body of the patient, and to convert incident photons into secondary electrons that will then form an image in the fluorescent screen. The metal plate has a thickness of tungsten 1.09 gm/cm^2. The distance between a target and the detector is 139cm and the size of the detector is 340x430mm. A mirror angled at 45^0 send light to CCD camera that has newvicon 1-inch image tube S-4078.

The image grabber is a video signal digitizer with 8-bit ADC operating at 15MHz. The digitized portal image signal was processed with made program in Pentium-3 PC.

2.2 FSRT system

The FSRT system was made up of Head fixation frame, collimator system and frame mounting system. Head fixation frame was composed of a milled duralumin and was placed to the couch. The frame immobilized patient head by using the dental bite. There are 8 step diameter collimators from 15mm to 60mm in collimator system. And also, we developed the frame mounting system that was fixed to couch floor and could be used to evaluate the isocenteric accuracy of gantry, couch and collimator in Q.A procedure. The new head fixation frame and frame mounting system were non-invasive, accurately replaceable, easy to use, very light and well tolerable. The major advantage of using this frame mounting system is complete access to any point in the patients cranium, especially posterior direction.

3. EXPERIMENT METHODS

3.1 Experiment Methods

The MEVATRON linear accelerator (siemens, 6MV) was used for experiment. Head test phantom was installed on FSRT head frame after fixing by facemask. Digital portal image with EPID system was acquired at 90^0 of gantry after finishing head phantom setup. The basis point plate was installed on EPID detector as showing in Fig. 2. We irradiated 8cGy for image acquirement with 25mm collimator cone and also obtained a same image with 20x20cm^2 field after removing this 25mm collimator cone. Two images were overlayed for estimating the treatment position against open field image. Continuously, We moved the FSRT frame artificially ±1mm and ±2mm in the direction of x and y axis and acquired images. Fig.2 shows the experimental scene for verification of FSRT treatment.

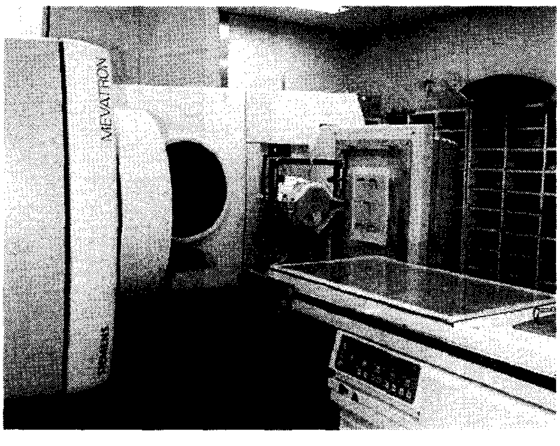

Fig. 2 Experimental scene for position verification in FSRT.

3.2 Procedure for image process

Fig. 3. shows verification procedures for FSRT. The first FSRT image in first treatment day was used as a reference to compare next images. So we should align the patient very accurately in first treatment day. We acquired images by double exposures in the case of 20x20 cm^2 open field and 25mm collimator cone. We could also compare this image with DRR image for verification if you want. We had to relocate the patient if there was something wrong prior to save this image as a reference image for FSRT. We processed the reference image by edge detection to show the boundary of head. With same procedures, we got the second image with open field and compared the treatment position by overlaying two images with contour of head. We should irradiate the rest of radiation after attaching the collimator con if tolerance was within the distance limit.

4. RESULTS

Fig. 4 shows the EPID portal image obtained by double exposure in FSRT. There are 5 markers on image as reference points. The white circle space in the center of the image is treatment area. There is one isocenter marker inside white circle treatment area made by basis point plate. So, It is possible to verify the target position by comparing the treatment area with isocenter marker.

We processed the 25mm cone image by using logarithm image processing for enhancement of dim image. We moved only head by 2mm intentionally in the x-direction for test purpose. Fig. 5 shows the verification image on treatment position error by edge detection in FSRT after overlaying reference image and moved image. We could know that there was no change in head frame contour and only difference in head because we moved only head part. In this study, the radiation treatment efficiency could be improved by performing precise radiation therapy with a developed video based EPID and FSRT in near real time.

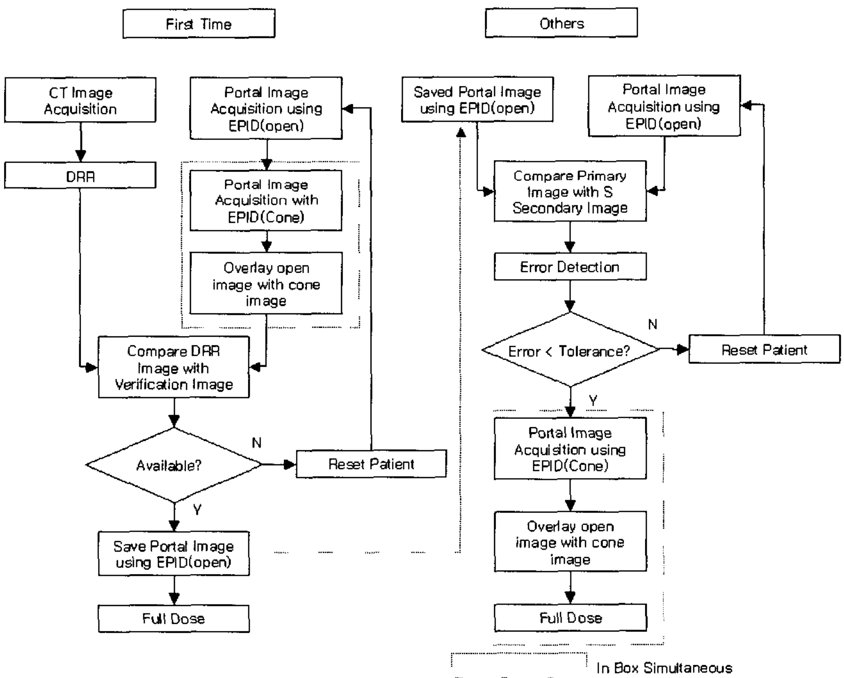

Fig. 3 The algorithm for treatment position verification in FSRT.

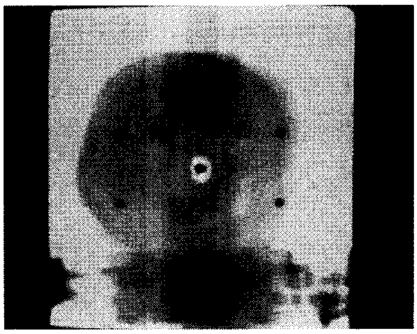

Fig. 4 The EPID portal image acquired by double exposure in FSRT.

Fig. 5 The verification image on treatment position error by edge detection in FSRT.

5. REFERENCES

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