海外派遣研修助成事業による研究の成果

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研究成果 （ 要約：800字 ）

「Simultaneous Analysis of 2D-kV,Cone Beam CT, and MV image Centers for Image-Guided Radiation Therapy Phantom Using Single Setup with Free Software」のタイトルで発表した。今回はHigh scoring posterとして選出され、発表形式は、口述発表と30分のディスカッションが義務付けられている内容であった。渡航前に英語のプレゼンテーションをかなり練習して臨んだので、発表は滞りなく出来た。座長からは、「他のガントリー角度は使用しないのか？」等の質問を受けた。彼らは、我々の開発した方法に興味を示し、私のポスターを写真に撮って記録していた。インド人と中国人の方から多くの質問を受け、30分程ディスカッションした。

全体的なトピックスとしては、Linac-MRIの発表が多く見られた。これは従来の治療計画で使用する画像をCTではなく、MRIを使用することで、治療途中の腫瘍の体積の変化を素早く、また正確に同定することにより、さらに高精度な放射線治療を実現する内容であった。しかし、磁場における光子線の挙動の変化が認められ、さらに放射線の品質管理が重要になることが予想された。

会場には、最新の放射線治療機器や周辺精度管理機器の展示も行われており、日本ではまだ導入されていない装置や、ソフトウェアを実機に触れて体験、またはメーカー担当者から説明を受けることが出来た。Elekta社の新しいQA管理ソフトウェアは、すべての品質管理機器を一元化して、データベース管理し、QAの実施の有無、また許容値に収まっているかを判定できるのは、品質管理者としてとても有意義なツールであると感じた。また当院に導入した国内1号機の3D水ファントム（BeamScan）のエンジニアとも製品についてディスカッションすることが出来た。またAAPM2017においてBeamScanの発表もまだ2演題程度であり、これも当院で精度検証を実施し、新規性の発表としてユーザーに還元出来れば有意義であると感じた。今回の経験を今後の研究に生かしたい。

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Simultaneous analysis of 2D-kV, cone beam CT, and MV image centers for image-guided radiation therapy phantom using single setup with free software

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INTRODUCTION

In recent years, image-guided radiation therapy (IGRT) has become a commonplace radiotherapy method. Confirmation that the center of the image matching system coincides with the center of the irradiation system is very important in IGRT. Center-to-center agreement within a radius of 1 mm was mentioned in a report by the AAPM's Task Group 142. However, the energy used in the relevant system is not given. In our facility, quality assurance (QA) measurements were performed separately on the image collation system and the center of the irradiation system. The Penta-Guide IGRT phantom was used to check the centers of two-dimensional (2D)-kV and cone beam computed tomography (CBCT) images, while an 8 mm tungsten ball bearing (BB) was used to check the centers of MV images. Two QA problems arose from these techniques; the time required for the QA process and the setup errors of each phantom. Commercial QA tools have recently become available but they are very expensive. Additionally, simple and common measurements for CBCT imaging using BBs can be difficult because of the BB-induced afterimages that occur on flat panel detectors.

PURPOSE

We have developed a method for simultaneous analysis of the central axes of 2D-kV images, CBCT images, and MV images for three energies in a single setup using free image analysis software. Here we report our measurement experience and the accuracy of our method when using the Elekta Synergy linear accelerator (linac).

MATERIALS AND METHODS

- Linear accelerator: Synergy (ELEKTA)
- IGRT system: X-ray volume imaging (ELEKTA)
- MV image acquisition: IviewGT (ELEKTA)
- Free image analysis software : ImageJ 1.48v (National Institutes of Health)
- IGRT phantom : Penta-Guide (QUASAR)
- Microsoft Excel 2010 (Microsoft)

(1) 2D-kV and MV images of the IGRT phantom were scanned from four different directions (0°, 90°, 180°, and 270°). The data from the two sets of images were imported into the free image analysis software package. The central coordinates were then input into the Microsoft Excel software tool and graphed.

(2) In the 2D-kV and MV images for three different energies, results for known distances (0.5 mm, 1.0 mm, 2.0 mm, 3.0 mm, 4.0 mm, and 5.0 mm) were verified versus shifts that occurred in the various treatment energy measurement results.

(3) QA of the central axes of 2D-kV, CBCT and MV images that were obtained in Kuki general hospital was performed by varying the treatment energies.

RESULTS

1. The development of our method

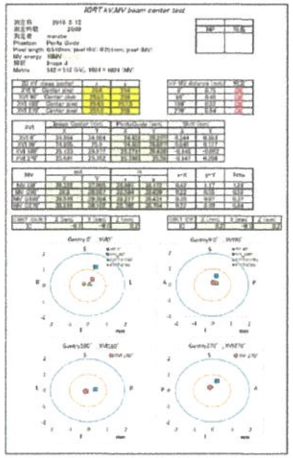
① Open data file and set scale
・1 pixel was assigned a size of 0.518 mm.

② Trim and set rescale
・Image center 100×100 pixel array was trimmed and interpolated linearly to produce a 5000×5000 pixel array.

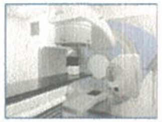
③ Threshold center sphere
・A center sphere was detected using an appropriate threshold value.

④ Binary coded processing
・The center sphere alone was detected by binary coded processing.

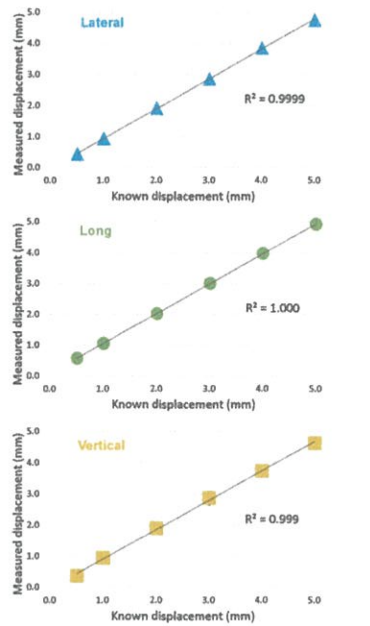
⑤ Measure coordinates of the center sphere
・The center sphere coordinates were measured using the particle analysis function in the free software.



- The sequence above shows the procedure for detection of the center of a 2D-kV image using the IGRT phantom and free software. The analysis time was short because of the macro procedure available in the free software.
- A center obtained from MV image analysis was used as the center of the MV field (5 × 5cm²) and the center of the IGRT phantom.
- An analysis result for the center of a CBCT image was used for the XVI system.
- The results of this QA process are shown on the left. We were able to quantify whether each center position was in or out of tolerance.
- The errors between the centers of the 2D-kV, CBCT and MV images were evaluated visually.

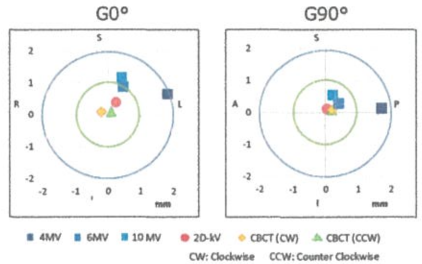


2. The accuracy of our method

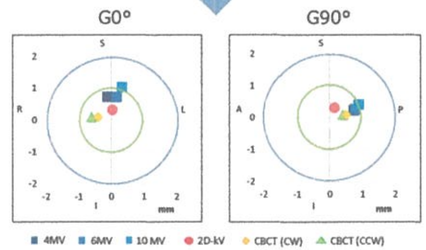


The total shift errors when compared with those at the 4 MV level, expressed here as the mean ± standard deviation (maximum), were −0.001 ± 0.111 (0.116) mm at 6 MV and 0.053 ± 0.077 (0.152) mm at 10 MV.

3. The experience in our linac



At 6 MV and 10 MV, the errors were within tolerable limits. However, the error at 4 MV exceeded 1 mm.



The figure above shows the recalculated results after adjustment of our linac. At 4 MV, the errors were now within tolerable limits.

CONCLUSIONS

Our method enabled simultaneous high-accuracy analysis of the central axes of 2D-kV, CBCT, and MV images. In our facility, the irradiation center of the 4 MV images was unacceptable because of a malfunction in the secondary steering adjustment. While we had previously checked the flatness and symmetry of each energy profile using a semiconductor detector over a period of a month, we could not find any error on the 4 MV beam center axis. However, the developed method could typically locate the error easily.

The central axis for the MV images also varies depending on the type of treatment energy that is used. The developed QA method can show these energy-dependent differences in detail while simultaneously showing the central axes of 2D-kV and CBCT images.

REFERENCES

Klein *et al.*: Task Group 142 Report: QA of Medical Accelerators, Medical Physics, Vol. 36, No. 9, September 2009.

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