Elekta Synergy® S with HexaPOD™

Combined accuracy of HexaPOD™ and Elekta Synergy® S with 3D X-ray volume imaging

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Purpose: Today, radiation doses can be delivered with a very high degree of precision, using Elekta Synergy® S. However, temporal changes in the patient's anatomy and patient set-up errors may result in blurring of the planned dose distribution. Image feedback can be utilized to improve the efficacy of the treatment by detecting and correcting changes in the set-up prior to treatment.

The aim of this study was to scrutinize the positioning accuracy and reproducibility for clinical use of the HexaPOD™ treatment couch in combination with Elekta Synergy® S using 3D VolumeView™ imaging.

Accuracy Study

ELEKTA

Combined accuracy of HexaPOD™ and Elekta Synergy® S with 3D X-ray volume imaging

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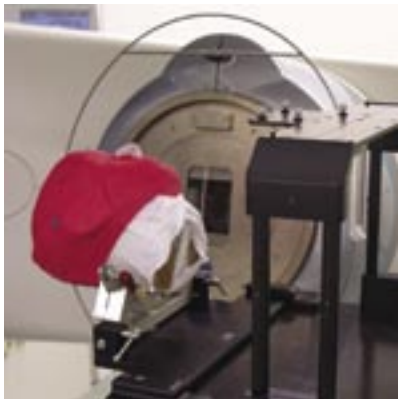
HexaPOD™
The HexaPOD™ treatment couch is mounted on the base of a standard Elekta table. Movement of the table is controlled by iGuide™ software and executed by means of six robotic legs. The HexaPOD™, allows six degrees of freedom, three translational and three rotational. The maximum range of translations are ±3cm in X and Y, ±4cm in Z direction, and ±3° around U, V and W (roll, pitch and yaw) respectively.

Elekta Synergy® S
Elekta Synergy® S is a state-of-the-art digital linear accelerator, equipped with an integrated solution for high resolution, three dimensional images of the patient's soft tissues taken in the treatment position at the time of treatment.

Method

The head of the Alderson phantom was used as a virtual test patient. A scotch cast mask was wrapped around the phantom and the entire arrangement was fixated in the stereotactic system. A planning computer tomography (CT) image-based plan was exported to Elekta Synergy® S to be used as a reference.



The HexaPOD™, attached to the Elekta table, was tested in repeated experiments in different dimensions and with varying degrees of manual control. Firstly we examined the stability of the X-ray volume imaging (XVI) system. Here we focused more on how movement of system components, such as the imaging panel and kV source, affected accuracy and also the reproducibility of the results from bone and grey scale image registration. This was done by acquiring a series of Elekta VolumeView™ cone beam CT scans with and without retracting the imaging panel or kV source between each image acquisition, and then comparing the positional errors of the bone and grey scale matching during image registration. In addition, we tested whether the XVI software was able to determine sub-millimeter displacements between the reference image and the Elekta VolumeView™ image.

Secondly we examined the accuracy of various degrees of translations by defined displacements of the isocenter in the reference treatment plan. An Elekta VolumeView™ image was taken and both grey and bone value matching techniques were used to detect this displacement. Then the HexaPOD™ was moved using the results from the grey scale registration. An additional Elekta VolumeView™ image was taken in the new position and a further image registration performed to investigate the accuracy of the corrections with the HexaPOD™.

This prompted us to examine the accuracy of the rotational displacements determined by X-ray volume imaging following image registration. This we did using iGUIDE™ to rotate the table by various degrees, acquiring an Elekta VolumeView™ image, then using bone and grey scale image registration.

Finally, we applied both translational and rotational errors and investigated how precisely they could be corrected with HexaPOD™.

Results

Elekta Synergy® S delivery and imaging system was found to be extremely stable and movements of components had no significant influence on this stability (see table 1). The grey value registration was able to correctly detect image displacements down to 0.1mm in both axial and longitudinal direction (the reference CT had 3mm slices). In addition the grey value match was found to be more reproducible than bone matching as an image registration tool.

		Bone		Grey value	
		Translational errors (mm) x, y, z	Rotational errors (°) u, v, w	Translational errors (mm) x, y, z	Rotational errors (°) u, v, w
Mean of the standard deviation	Protocol 1a	0.13	0.08	0.04	0.02
	Protocol 1b	0.16	0.23	0.04	0.01
	Protocol 1c	0.16	0.09	0.06	0.01

Table 1: errors resulting from protocol 1a) repeat cone beam CTs b) kV source arm retracted and pulled out again and c) kV panel retracted and pulled out again.

There was no significant difference in the positioning accuracy between translational corrections only and rotational corrections only. Of course, typical patient set-up errors are corrected by using both translational and rotation combined. The following table (table 2) demonstrates the accuracy seen when using HexaPOD™ and Elekta Synergy® S and using a combination of translational and rotational corrections.

	Bone		Grey value	
	Translational errors (mm) x, y, z	Rotational errors (°) u, v, w	Translational errors (mm) x, y, z	Rotational errors (°) u, v, w
Mean	0.04	0.01	0.08	-0.05
STD	0.13	0.40	0.10	0.16
Max ABS	0.30	0.90	0.20	0.30
Accuracy	0.11	0.29	0.11	0.12

Table 2: summarized repositioning errors resulting from multiple translations and multiple rotations

Conclusion

The system and matching procedures are very stable. Translational and rotational position errors can be corrected very precisely. The use of HexaPOD™ enhances the efficacy of Elekta Synergy® S.

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