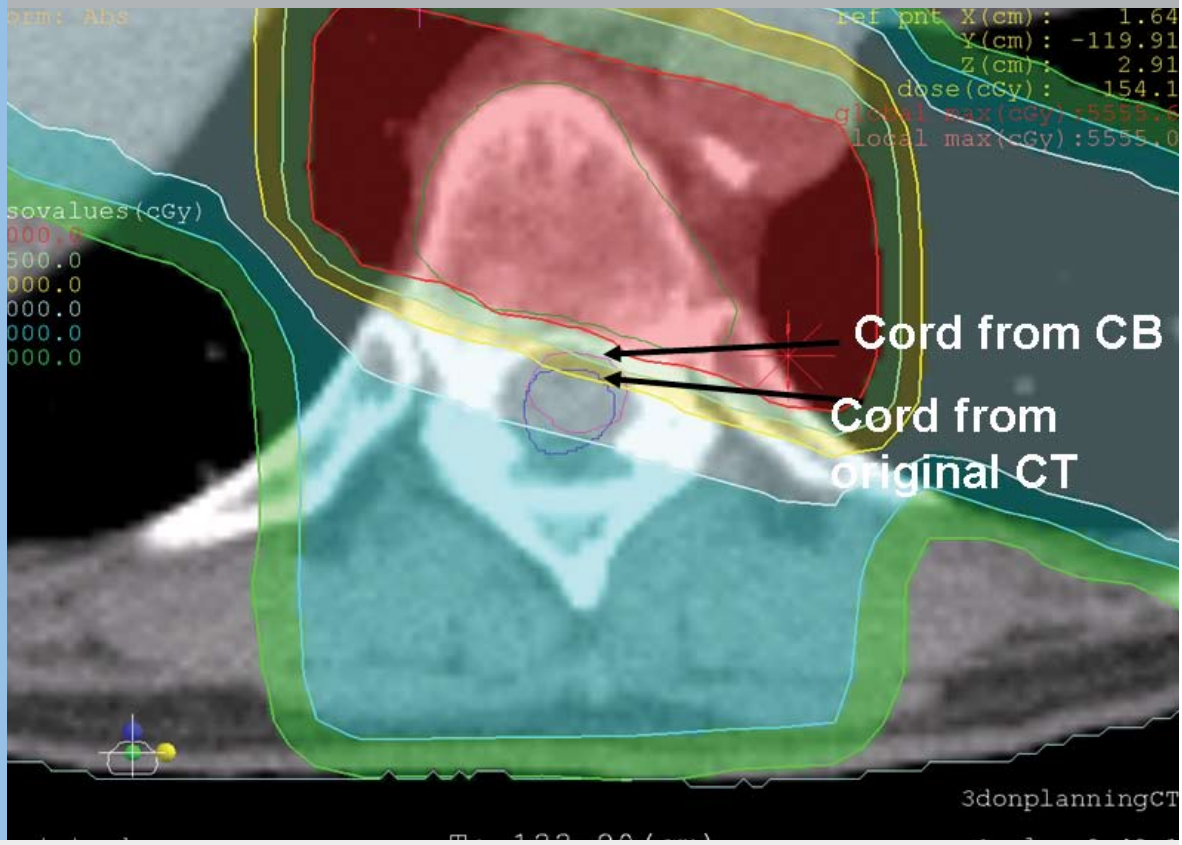
Elekta Synergy®

3D VolumeView™ imaging with spine fusion

Institution: **Jefferson Medical College, Thomas Jefferson University Hospital, Philadelphia, PA**

Purpose: To determine the residual error for cone beam (CB) CT to planning CT fusion for patients treated for spinal metastases. To determine if adaptive planning could improve the treatment delivery accuracy for this population of patients.



Accuracy study

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3D VolumeView™ imaging with spine fusion

Authors: A Harrison, G Bednarz, J Galvin

Methods and materials

3D volume imaging using Elekta Synergy® VolumeView™ makes it possible to evaluate the accuracy of the rigid body-based patient position correction in cases where there is an organ deformation. This can be important in high dose per fraction treatment of spinal column lesions.

Data sets for 14 patients were reviewed. These patients were immobilized using either a stereotactic body frame (six patients) or a full head- and-neck mask (eight patients). The fusion region-of-interest (ROI) enclosed three to four vertebra and the spinal canal misalignment on fused data sets was quantified using the spinal canal edge as a surrogate for the cord position.

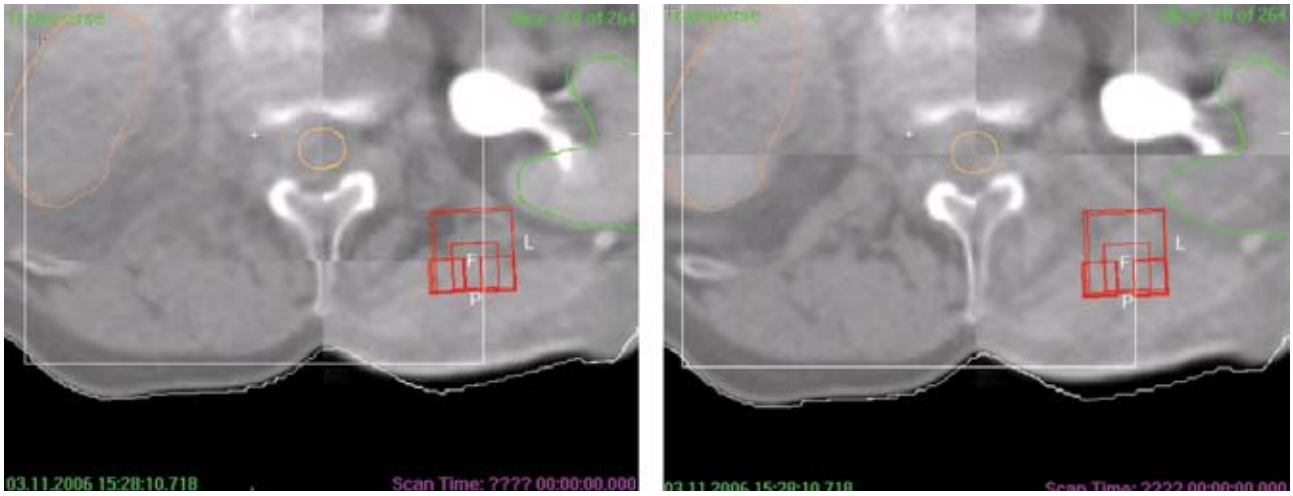
Three types of adaptive plans were developed to assess changes in the dose to critical structures and determine the feasibility of using interactive planning adjustments. The plans were 3DCRT , aperture-based IMRT and beamlet-based IMRT.

Patient no.	Site	ROI size	No. of scans analysed	Date*	Maximum spinal canal misalignment for fusion type/mm	
					Bone	Grey levels
1	T-spine	4 vert	10/13, 10/19	10/30/06	Good agreement	Good agreement
2	T-spine	4 vert.	11/20, 11/30		Good agreement	Good agreement
3	L-spine	4 vert	11/3, 11/14		Good agreement	~1.5mm, ~2.0mm
4	T-spine	4 vert	9/27, 10/5		Good agreement	Good agreement
5	T-spine	4 vert	11/26, 12/8		Good agreement	Good agreement
6	C-spine	4 vert	11/6, 12/6		~1.0mm, <1.0mm	~1.0mm, <1.5mm
7	C-spine	4 vert	11/27, 12/13		~4.0mm, reg? 1.5mm	~1.5mm, <1.0mm
8	C-spine	3-vert.	12/29, 1/10		Poor agreement	Good agreement
9	CT-spine	4 vert	12/15, 1/30		Poor agreement	Good agreement
10	T-spine	4 vert	1/8, 1/11		Good agreement	Good agreement
11	C-spine	4 vert	9 scans, 3/20		N/a ~1.5mm	Good ~3.5mm
12	C-spine	3 vert.	3/14, 3/21		Poor agreement	Good ~2.5mm
13	C-spine	3 vert.	3/14, 3/20		~1.5mm good	Good agreement
14	C-spine	4 vert	4 scans		Poor agreement	Good <1.0mm agreement

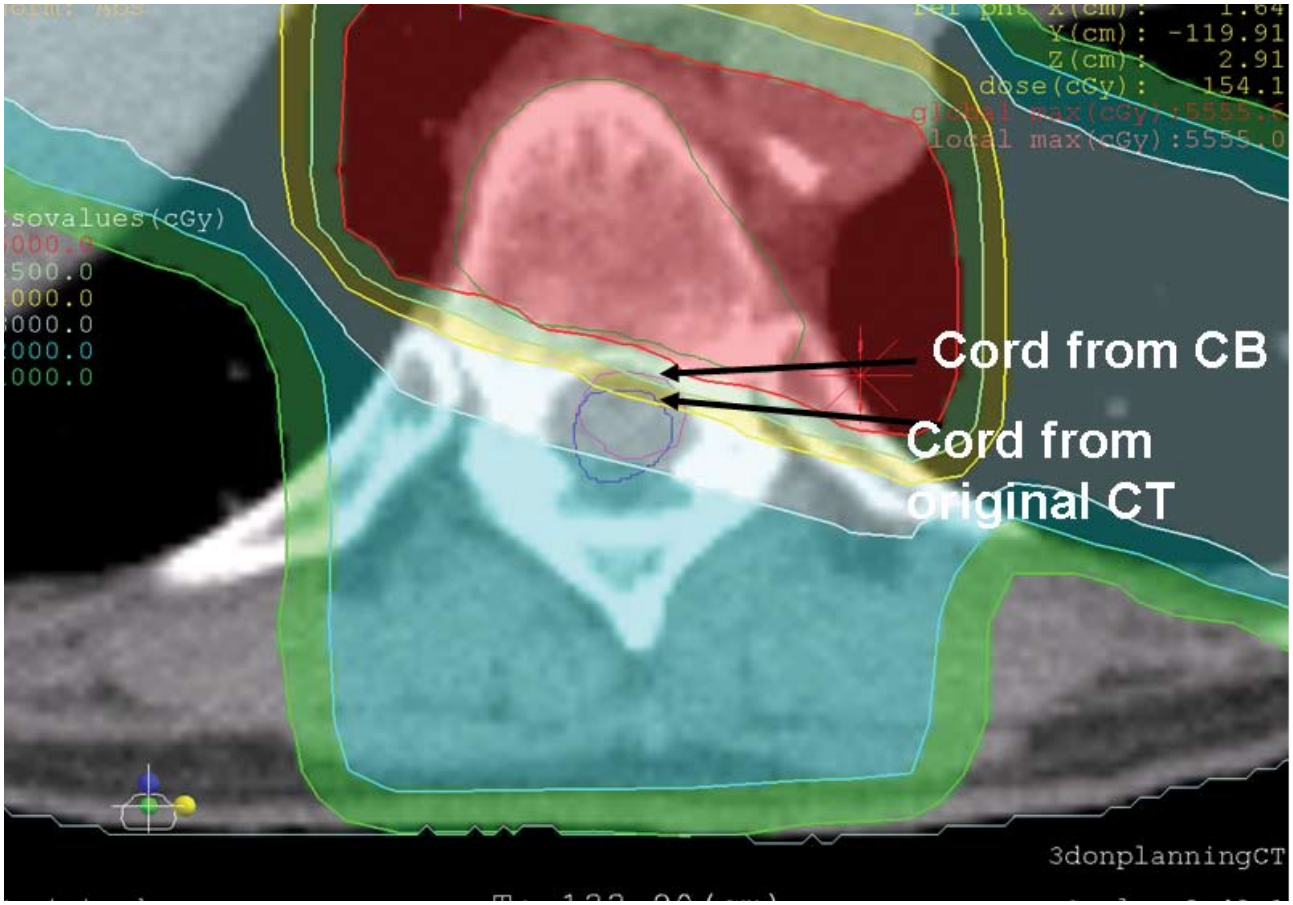
** Usually the beginning of treatment, mid-point and end*

Results

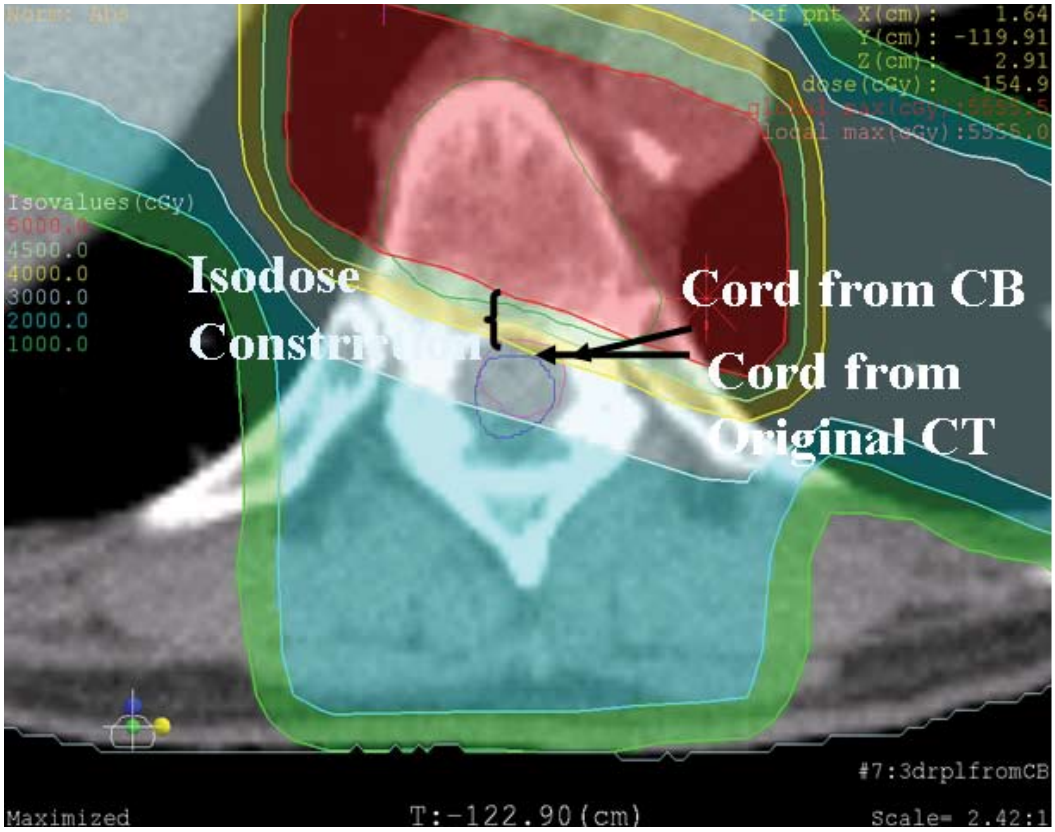
Example of VolumeView™ to CT fusion using bone and grey values auto-fusion. Below left, patient no. 3 bone registration mid-slice. Below right, patient no. 3, grey volume registration mid-slice.

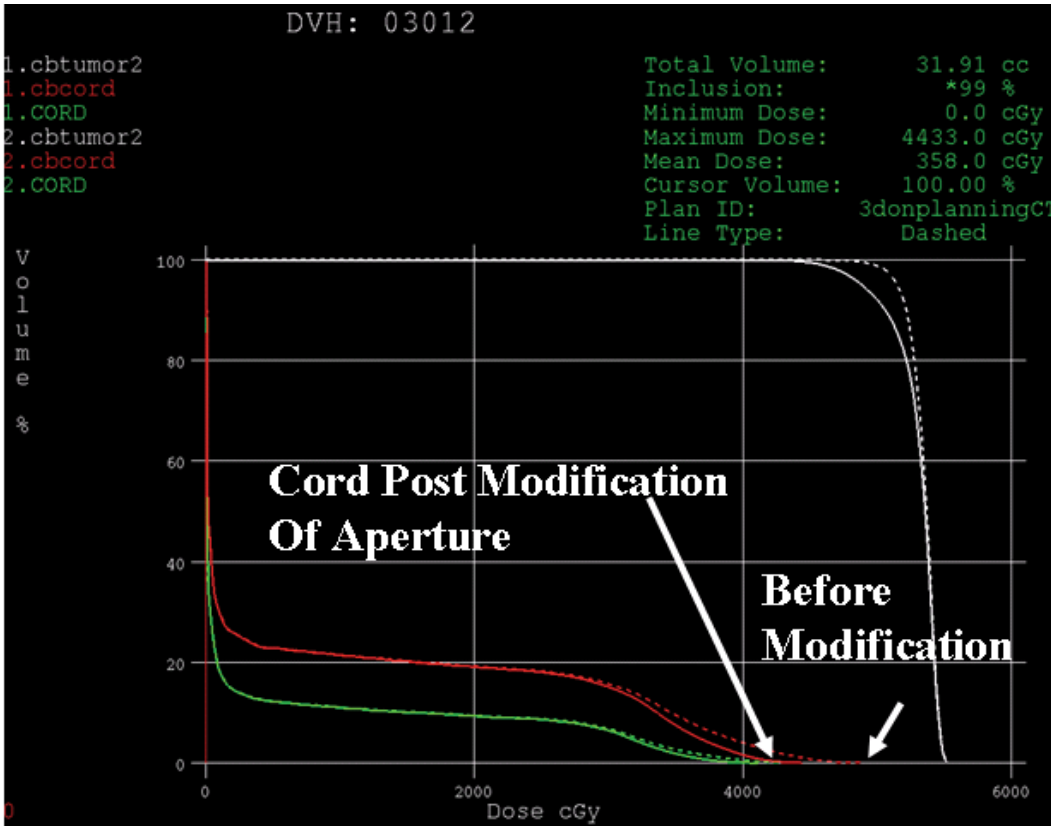


After assessing the magnitude of spinal cord positioning variation, the 3DCRT treatment plan was recalculated to show the resulting dose difference (see following figure):

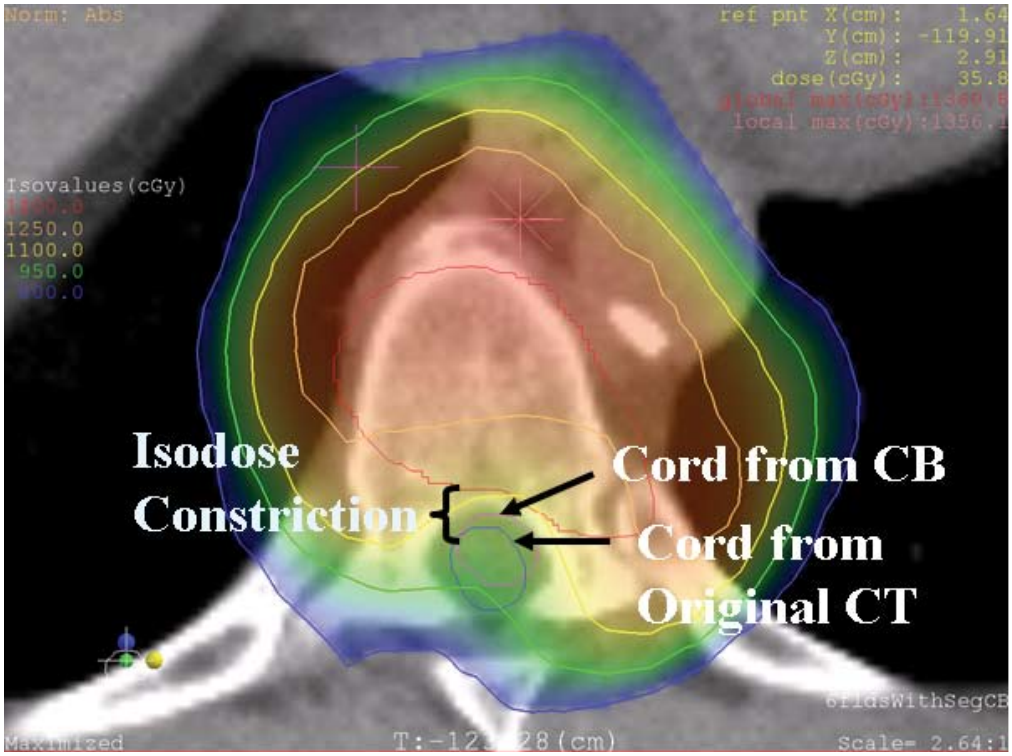


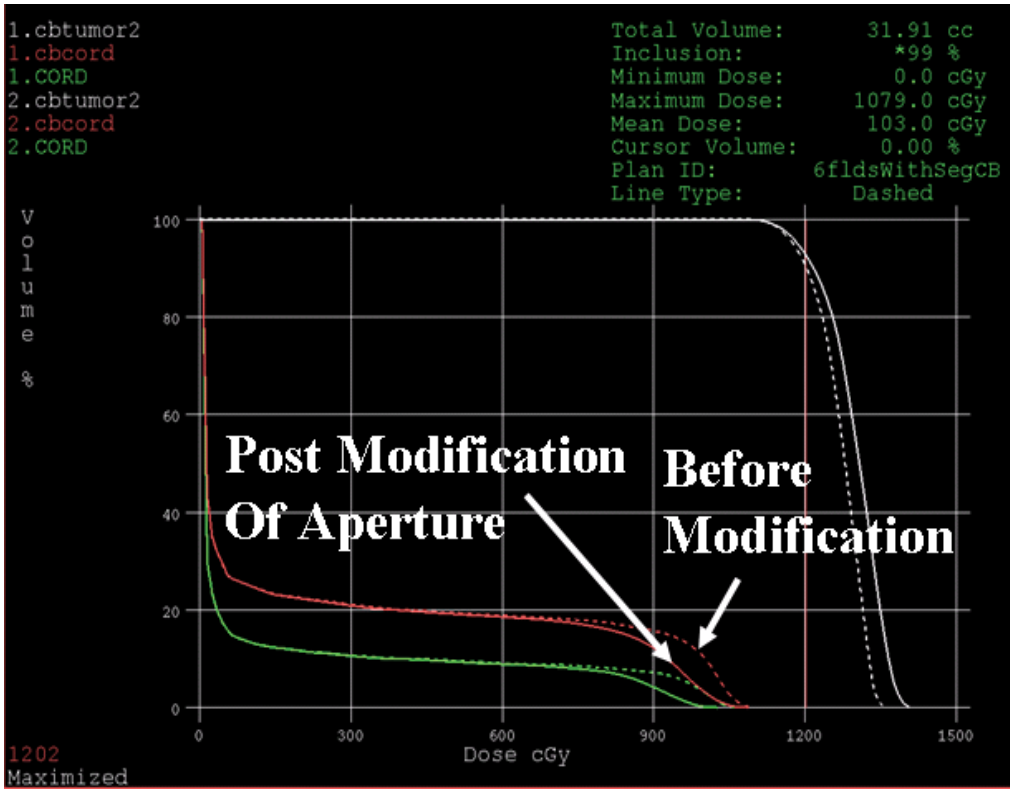
The 3D CRT plan was modified by adjusting the field edge to agree with the spinal cord position as determined by the current 3D VolumeView™ image. This required less than 10 minutes time on the CMS XiO planning system to generate the dose display and corresponding DVH shown below.





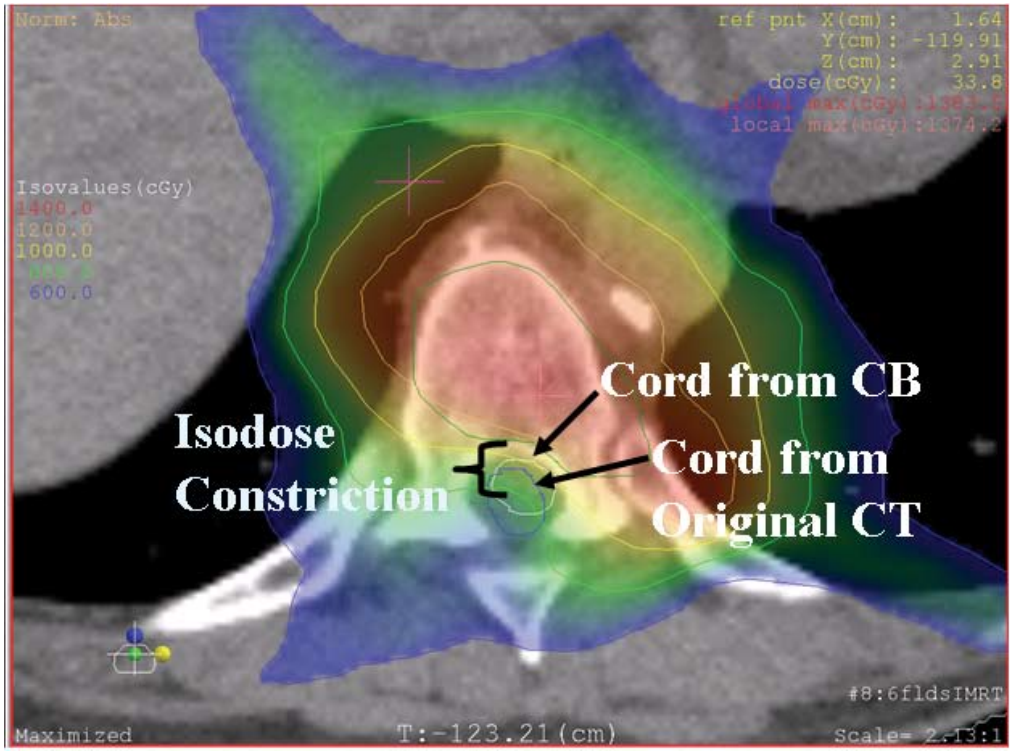
An aperture-based IMRT plan (field within a field) was generated for the same case, and adjusted according to the 3D VolumeView™ spinal cord difference. This adjustment and calculation required 20 minutes.

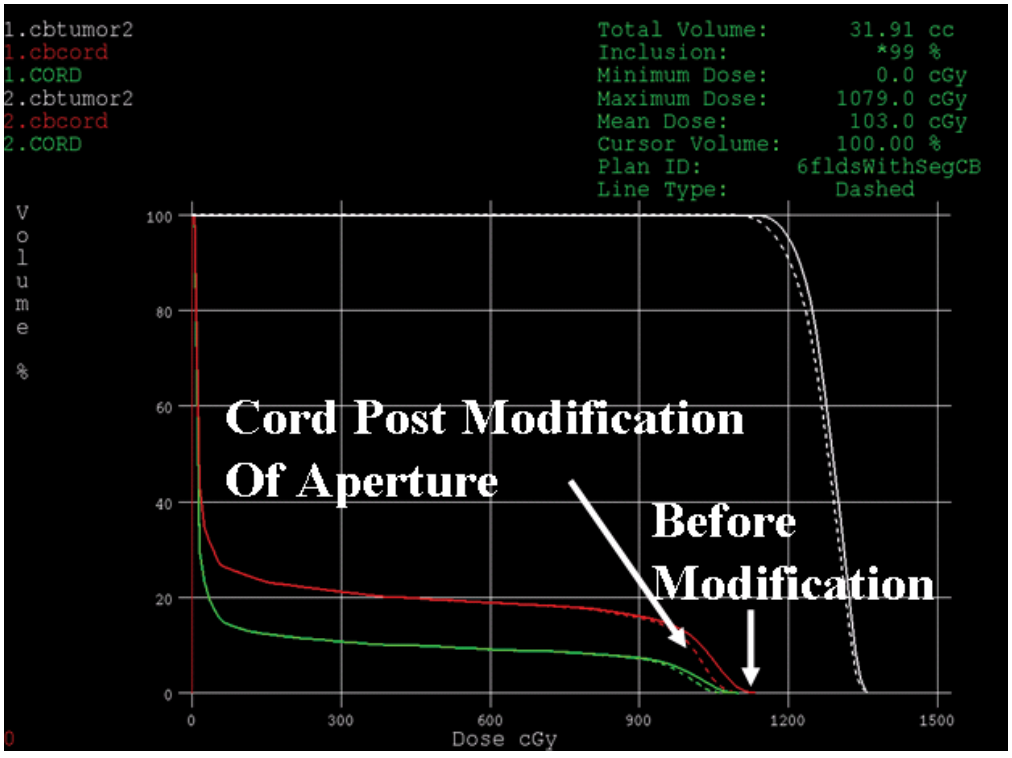




By making minor changes to the leaves along the spinal cord, the dose to this critical structure was reduced to agree with the original dose constraints. This can be seen in the DVH shown above.

A beamlet-based IMRT plan was generated and modified according to the cone beam spinal cord. This re-planning process was the longest as it required repeating the fluence optimization process for the new spinal cord structure. The time for the fluence generation, MLC segmentation and final calculation approached 40 minutes and would require repeating the IMRT QA process.





Results

In the majority of analyzed VolumeView™ images the registration resulted in a very good cord alignment when the ROI extended over three to four vertebrae, which was the assumed extent of the spinal lesion plus margins. Nine of 39 scans reviewed showed spinal cord misalignment within the treatment region. The maximum difference, in the range of 3mm, was observed between the planning CT and VolumeView cords. The fusion quality and cord misalignment got progressively worse when more than 4 vertebra were included in the ROI.

Based on the analysis of cord dose volume histograms, the use of adaptive planning (see the example) would result in substantial decrease in cord doses for cases where there was more than 2mm cord shift.

Conclusions

Elekta Synergy® VolumeView™ imaging could be used effectively to achieve high positioning accuracy for the patients treated for spinal metastases. For a low percentage of cases, the rigid body registration and position correction did not account for small changes in spine curvature. Simple adaptive correction schemes can be applied to further protect the cord without the need for the treatment plan re-optimization.The adaptive planning was feasible for 3D and aperture-based IMRT plans but would create time and QA issues for beamlet-based IMRT cases.

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Corporate Head Office, Stockholm, Sweden Tel +46 8 587 254 00 Fax +46 8 587 255 00 info@elekta.com

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North America,
Atlanta, GA
Tel +1 770 300 9725
Fax +1 770 448 6338
info.america@elekta.com

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Tel +44 1293 654068
Fax +44 1293 654655
info.europe@elekta.com

Japan,
Kobe
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Fax +81 78 271 7823
info.japan@elekta.com

China,
Beijing
Tel +86 10 8012 5012
Fax +86 10 8012 5000
info.china@elekta.com

Asia-Pacific,
Hong Kong, SAR China
Tel +852 2891 2208
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info.asia@elekta.com