Evaluation of Eclipse AAA Dose Calculation Accuracy In The Presence of A Titanium Spinal Fixation Device

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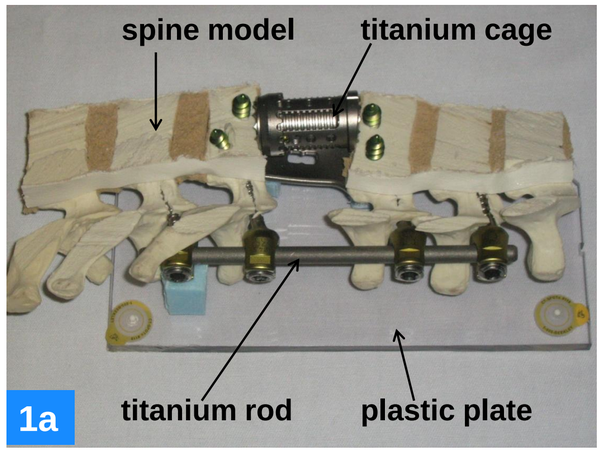
Purpose

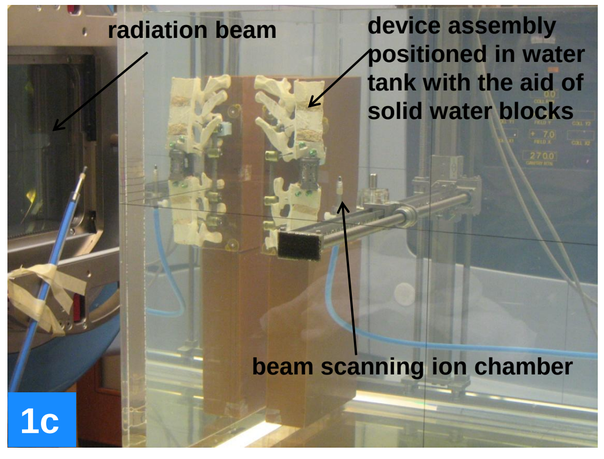
Metallic spinal fixation devices are usually implanted following surgical removal of spine tumors. In radiation therapy that generally follows, it is important to correct for their effects on dose calculation in neighboring target volume and spinal cord. This study was to evaluate the accuracy of Eclipse's AAA 8.9 dose calculation algorithm in the presence of a titanium spinal fixation device.

Methods and Materials

A titanium spinal fixation device was mounted on a spine model and immobilized to a rigid plastic plate (Fig. 1a). In Eclipse, 3D model of the device assembly was reconstructed from its CT images and placed inside a virtual water phantom. Beams of 6 MV on a Varian machine were designed to simulate the posterior and lateral irradiation of the spine implanted with the titanium fixation device (Fig. 1b). Relative electron density of the titanium device was chosen to be 4.0.

The simulated irradiation geometries were reproduced physically with the device assembly placed in water tanks. Dose outputs and relative dose distributions around the device were measured using ion chambers, 2%NanoDot OSLDs and MapCheck (Fig.1c-1d). The measurements were then compared with Eclipse's predictions.





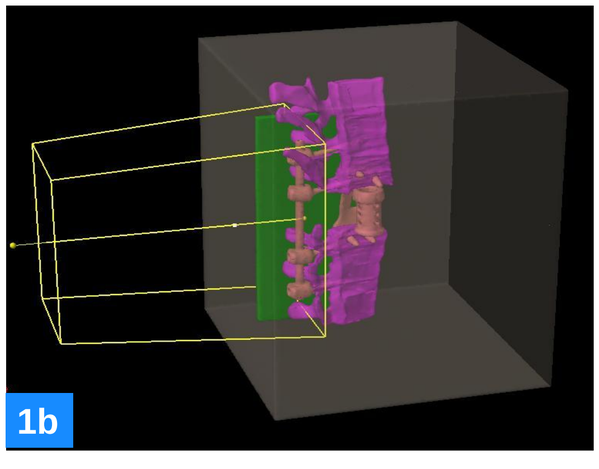


Figure 1a. The titanium device assembly; **1b**. Posterior irradiation of spine implanted with the device inside a virtual water phantom box was simulated in Eclipse; **1c**. The posterior spine irradiation geometry was reproduced in a water tank for dose output and PDD/profile measurement using a PTW PinPoint 3D ion chamber; **1d**. Dose outputs at selected locations (number label) were measured using NanoDot OSLDs.

Results

In the posterior spine irradiation setup, dose measurements were made for open fields with field sizes 10x15 and 5x7 cm^2 respectively. The dose output measurements agreed with Eclipse's predictions within 2.5% (Table 1). Agreements on PDDs were better than 1%. Agreements on profiles were most within 3% while max discrepancy was up to 5%(Fig. 2).

Point Location	Depth (mm)		Output (cGy/MU)		
	Physical	Equiv.	Eclipse	Measured	Diff
C/A point under cage	125	174	0.5767	0.5722	**0.8%**
Off-axis point under cage	125	145	0.5985	0.6046	**-1.0%**
Inferior cord point	68	76	0.8435	0.8559	**-1.4%**
Superior cord point	61	64	0.8858	0.8827	**0.4%**
Central cord point#1	61	77	0.8849	0.8763	**1.0%**
Central cord point#2	58	74	0.8756	0.8672	**1.0%**

Table 1. Comparison of dose outputs measured by ion chamber in a water tank and predicted by Eclipse's AAA dose calculation algorithm for the 10x15 cm^2 open field in the posterior spine irradiation setup as illustrated in Fig. 1b.

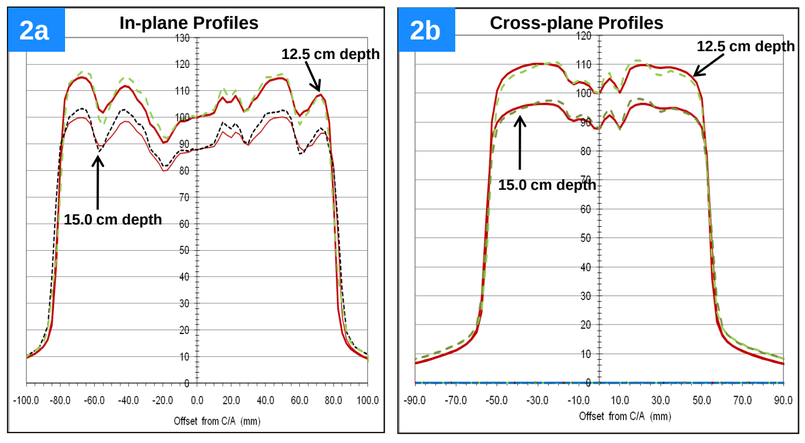


Figure 2. The in-plane (**2a**) and the cross-plane (**2b**) dose profiles at two different depths as measured by ion chamber in a water tank (dash lines) and predicted by Eclipse (solid lines) in the posterior spine irradiation setup. Field size was 10x15 cm^2 and SSD was 95 cm. All profiles were normalized to the C/A point at depth 12.5 cm. The dips on profile curves represent large beam attenuation by the titanium material of the device.

In the lateral spine irradiation setup, dose distributions on a plane below the device assembly were measured using MapCheck for both open and IMRT fields. Agreements between measured and Eclipse-predicted planar doses were better than 95% under the 2mm/2% gamma analysis criteria (Fig. 3a-b).

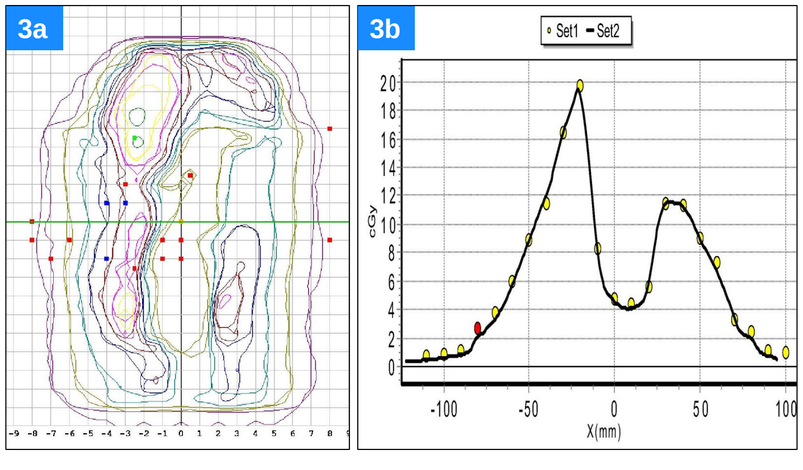


Figure 3a. The isodose lines of an IMRT field as measured by MapCheck were overlaid with the isodose lines predicted by Eclipse in the lateral spine irradiation setup. Gamma analysis showed 95.9% points passed test under the 2%/2mm criteria. The plane of measurement was at depth 10.2 cm. IMRT field SSD was 100 cm; **3b.** Dose profiles across field C/A point on the plane showed a great agreement between the measured (Set1) and Eclipse's prediction (Set2).

Conclusion

Eclipse's AAA 8.9 dose calculation algorithm appears to account for the dosimetric effect of studied titanium spine fixation device reasonably well. Its dose calculation accuracy in the presence of studied device is clinically acceptable.

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