Commissioning of a 3D scanner for digitizing and ordering electron cutouts using 3D printed phantoms

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PURPOSE / OBJECTIVE(s)

- Decimal3D is a 3-dimensional scanning system developed by .Decimal (Sanford, FL)
- The system utilizes a stereoscopic camera and iPad® (Apple Inc., Cupertino CA) to generate a 3D object of the patient with a texture map
- The scanner generates a digital rendering of the patient's treatment area and allows the user to contour the treatment field
- The patient rendering is placed in the coordinate system of the linac, enabling the user to set the gantry, table, and collimator settings
- The Decimal3D application generates the appropriate electron cutout and allows the user to order the block
- There is no task group or comprehensive vendor instructions for implementation of this device and it is up to the user to validate and commission for clinical use
- In reviewing potential failure modes, the following were identified as needed at the time of commissioning: cutout scale, coordinate system (gantry, couch, collimator), digitization, and ordering process

AIMS

- Design and implement a simple, customizable phantom for commissioning of the Decimal3D scanner
- Perform verification tests to determine the accuracy of the electron cutout shape in comparison to the designed contour
- Validate the beam geometry coordinate system generated by the scanner

MATERIAL & METHODS

- A thorax phantom and a set of 3D printed phantoms were used to define regions of interest (ROIs) representing intended treatment fields
- Printed phantoms consisted of a fixed base with a removable template surface. The angle of the template surface with respect to the base could be adjusted such that the surface would be *en face* to different combinations of couch and gantry angles (Figure 1)
- ROIs were drawn on the template surfaces and ranged from simple circles to complex shapes

MATERIAL & METHODS

- Decimal3D was used to generate a rendering of each phantom and ROI, with the ROI digitized as an electron aperture in the Decimal3D software after determining cone size, gantry angle, collimator angle, couch rotation, and SSD
- The procedure from scanning to digitization is outlined in Decimal3D user guide, which was followed for all scans
- Digitized apertures were sent to .decimal for electron cutout fabrication
- Verification consisted of reproducing each phantom setup with planned settings and confirming ROI and light field congruence

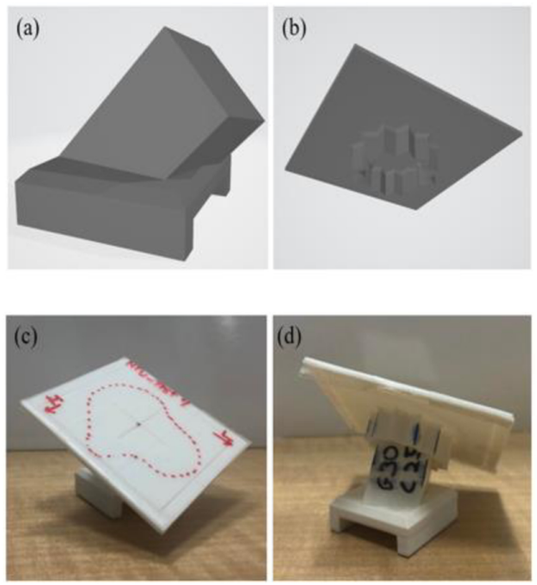

Figure 1: (a and b) CAD rendering and, (c and d) photographs of the 3D printed phantom used for cutout validation

REFERENCES / ACKNOWLEDGEMENTS

.Decimal provided the scanners and apertures used in this work as part of testing the product. The authors would like to thank .decimal for their assistance with the scanner.

RESULTS

- Comparison of light field produced by the electron cutout and the treatment field contour showed good agreement for all cutouts (Figure 2)
- The maximum deviation between light field and contour was 2 mm, which is within clinical tolerance for electron treatments (Table 1)
- Small discrepancies between the light field and the contour may have arisen during the process of tracing the cutout shape on the iPad
- The scanner correctly scaled the apertures for all SSDs tested – ranging from 100 and 120 cm
- All planned couch, gantry, and collimator angles matched those necessary for accurate treatment positioning with SSD tested via magnification

Table 1: Phantom, accelerator settings, and measured difference between the light field and contour

Phantom	Gantry Angle (degrees)	Collimator Angle (degrees)	Couch Rotation (degrees)	SSD (cm)	Max difference (mm)
Thorax	0	0	0	100	< 1
Phantom 1	30	0	25	100	< 1
	30	0	25	120	< 1
	50	15	25	100	2
Phantom 2	31	0	0	100	< 1
	31	0	0	120	< 1
	45	0	345	100	2

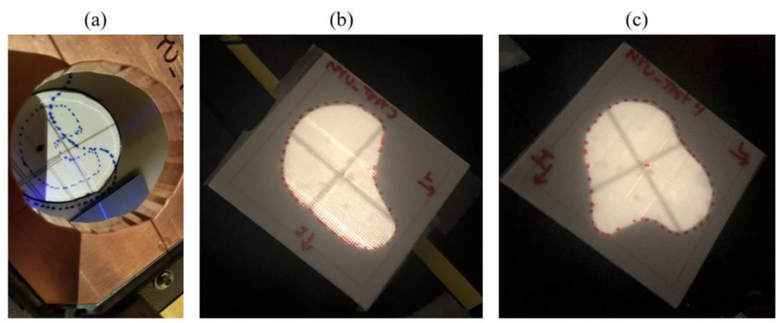

Figure 2: Comparison of light field and contours for the (a) thorax phantom, and (b) and (c) 3D printed phantoms

SUMMARY / CONCLUSION

- Pre-clinical verification of the Decimal3D scanner showed good agreement between the produced cutout and the expected treatment field
- A series of designed phantoms were developed in-house to test the cutout scale, coordinate system, digitization, and ordering. All of these could be utilized by other institutions adopting this technology into clinical practice
- The .decimal software produces accurate apertures that accurately account for gantry, couch and collimator rotations
- The system accurately scales apertures for SSDs over the usual clinical range of 100 to 120 cm
- Some scans were completed outside of the treatment vault and verification tests were performed in the vault in an effort to perform clinical electron simulations without requiring machine time

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