

Supplementary Material

1 SUPPLEMENTARY DATA

Suppl. 1A: List of the most dominating elemental components and densities for reference human tissues as determined by Woodard and White (1986).

Tissue surrogate	C [% _m]	O [% _m]	$H[\%_m]$	N [$\%_m$]	Ca [% _m]	Mg [$\%_m$]	$Cl[\%_m]$	P [% _m]	Density [g/cm ³]
Adipose tissue 1	51.7	35.5	11.2	1.3	-	-	0.1	-	0.97
Mammary gland 2	33.2	52.7	10.6	3.0	-	-	0.1	0.1	1.02
Muscle – skeletal 3	11.2	74.5	10.2	3.0	-	-	0.1	0.2	1.05
Liver 2	13.9	71.6	10.2	3.0	0.1	-	0.2	0.2	1.06
Skeleton – spongiosa	40.4	36.7	8.5	2.8	7.4	0.1	0.2	3.4	1.18
Skeleton – cortical	15.5	43.5	3.4	4.2	22.5	0.2	-	10.3	1.92



Suppl. 1B: a) shows an example picture of a cuboid and cylindrical material sample for the printed material Though 2000 (TGH). b) the CT scan of the CIRS phantom including the different samples; the green circle

represents the area of one selected sample (in this case TGH) that was used to extract the CT number (CTN) distribution c) the CTN distribution corresponding to the green circle illustrated in b). d) shows pictures of all sample types and materials where the bottom row (from left to right) shows the fused deposition modelling (FDM), stereolithography (SLA) and selective laser sintering (SLS) pieces and the top row shows the resin-based materials.

Suppl. 1C: Mass and Volume of 3D-printed and epoxy-based samples over time. The one year / six months follow-up time was due to beam-time availability. The abbreviations for the resin mixtures refer to the ratios of epoxy resin (ER), bone meal (BM) and polyproplyene powder (PE) as in ER:BM:PE. This data was collected shortly before consistency measurements of water equivalent thickness (WET) were performed. Systematic uncertainty is assumed to be 0.1 g and 1 ml.

	m _{initial} [g]	m _{12 months} [g]	V _{initial} [ml]	V _{12 months} [ml]
HIPS	22.2	22.2	24.8	24.8
ABS	26.4	26.4	24.7	24.7
ELA	26.3	26.2	24.1	24.0
NY-FDM	26.7	26.7	24.9	25.0
PLA	29.2	29.2	25.9	25.8
WR	29.2	29.3	24.9	25.0
TGH	29.4	29.5	24.8	24.8
DUR	42.7	42.7	25.2	25.2
NY-12	24.3	24.3	24.9	24.8
Resin mixtures	m _{initial} [g]	m _{6 months} [g]	V _{initial} [ml]	V _{6 months} [ml]
1:1:0	32.1	32.1	23.5	23.6
10:9:1	31.8	31.9	24.5	24.6
5:4:1	29.6	29.6	24.2	24.2



Suppl. 1D: a) shows the lateral profile of a 148.2 MeV proton beam 50 mm in front of the distal 80 % depth of the Bragg peak (r_{80}). b) shows the lateral profile after passing through an acrylonitrile butadiene styrene (ABS) sample. The difference of a) and b) is visualized in c), where differences bigger 4 % are only associated with artefacts from the film scans (dust particles, surface scratches, etc.). A second profile in water is provided in d), from which another difference map e) was calculated for qualitative comparison to c).

Suppl. 1E: Stopping power ratio (SPR)_{DirectSPR} and distance to agreement (DTA) values for the DirectSPR measurements of the 3D-printed and epoxy-based samples. Sample mean and one standard deviation (SD) are given.

	SPR _{meas}	SPR _{DirectSPR}	DTA
HIPS	0.91 ± 0.01	0.88 ± 0.04	3.3 ± 4.5
ABS	1.01 ± 0.01	1.03 ± 0.02	0.0 ± 2.2
ELA	1.08 ± 0.01	1.09 ± 0.02	-0.9 ± 2.1
NY-FDM	1.08 ± 0.01	1.09 ± 0.02	-0.9 ± 2.1
PLA	1.09 ± 0.01	1.11 ± 0.02	-1.8 ± 2.1
WR	1.17 ± 0.02	1.16 ± 0.02	0.9 ± 1.9
TGH	1.17 ± 0.02	1.16 ± 0.02	0.9 ± 1.9
DUR	1.52 ± 0.02	1.59 ± 0.03	-4.6 ± 2.2
1:1:0	1.30 ± 0.02	1.34 ± 0.02	0.5 ± 1.8
10:9:1	1.27 ± 0.01	1.27 ± 0.03	0.4 ± 1.8
5:4:1	1.22 ± 0.01	1.23 ± 0.03	-1.1 ± 2.7

REFERENCES

Woodard HQ, White DR. The composition of body tissues. *The British Journal of Radiology* **59** (1986) 1209–1218. doi:10.1259/0007-1285-59-708-1209.