RSD
Radiology Support Devices, Inc.

ART Phantom with Cadaver Bones

END-TO-END TREATMENT CHAIN VERIFICATION WITH TRUE ANATOMICAL FIDELITY

Building on decades of clinical trust, RSD's ART Phantom with Cadaver Bones incorporates authentic human skeletal material to replicate real tissue density, bone structure, and attenuation characteristics with a fidelity that synthetic substitutes cannot match. The result: QA data your team can trust, from simulation through final delivery.

Engineered as a refined evolution of the Alderson RANDO Phantom and available in inclusive skin tones at no additional cost, our ART Phantom with Cadaver Bones is designed within precise technological constraints and manufactured in full conformance with ICRU-44 standards. It provides integrated testing of the entire treatment planning and delivery chain – from imaging and contouring to dose calculation and plan execution – in a single, streamlined workflow.

Applications

- Organ-specific dosimetry for all dosimeteres (TLD, OSL nanodots, MOSFET, film, Ion chambers, and diodes)
- Standard 3 cm x 3 cm or 1.5 cm x 1.5 cm hole grids for dosimeters
- IMRT organ does distributions

Modalities

- External beams in the 0.04 to 40 MeV
- Intensity-Modulated Radiation Therapy (IMRT)
- Sterotactic Body Radiation Therapy (SBRT)
- Gamma Knife
- CyberKnife
- CT
- Cone Beam CT

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Anatomy

The male ART Phantom represents a 175 cm (5 ft. 9 in.), 73.5 kg (162 lb.) adult male; the female ART Phantom represents a 155 cm (5 ft. 1 in.), 50 kg (110 lb.) adult female. Both phantoms now incorporate authentic cadaver bones, replacing synthetic bone-equivalent inserts with real skeletal material for accurate Hounsfield unit representation and true heterogeneous attenuation.

Each phantom is sectioned transversely into 2.5 cm thick slices. Slices are fitted with interchangeable pins fabricated from bone-equivalent, soft-tissue-equivalent, or lung-tissue-equivalent materials. All pins are replaceable with TLD holder pins to accommodate thermoluminescent dosimetry; holder pins are available as a separate order item.

Slice surfaces are finished with a soft-tissue-equivalent coating, producing glass-smooth interfaces for precise geometric registration between sections. Coatings are selectively removed over the air spaces of the oronasal pharynx, trachea, and stem bronchi to preserve anatomically accurate airway geometry.

Dosimetry holes are drilled in 3 cm × 3 cm or 1.5 cm × 1.5 cm grids at diameters of 5 mm and 7 mm, providing a high-resolution measurement matrix for detailed mapping of three-dimensional dose distributions throughout the phantom volume.

Materials

Soft Tissue: The human body exhibits continuous, small variations in soft-tissue density and attenuation throughout. The ART Phantom's soft-tissue-equivalent material is closely controlled to replicate the mean density of human soft tissues, in conformance with ICRU Report 44 specifications.

Skeleton: This configuration incorporates authentic human cadaver bones, selected and prepared to match the anthropometric dimensions of the phantom's soft-tissue molds. Cadaver bone provides accurate cortical bone density, intact trabecular (spongiosa) microarchitecture, and preserved marrow spaces – material properties that cannot be fully reproduced by synthetic bone-equivalent substitutes.

The use of real skeletal material eliminates discrepancies in Hounsfield unit accuracy, heterogeneous attenuation, and cortical-to-trabecular density gradients that are inherent to polymer moldings, making this configuration the appropriate choice for dosimetric applications requiring the highest anatomical fidelity.

Lungs: Lung volumes are molded from syntactic foam with a specific gravity of 0.30 g/cc, providing a reproducible, low-density tissue-equivalent material consistent with average in vivo lung density.

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TLD Dosimeters & Fittings

All phantoms are shipped with dosimetry holes filled with blank pins. Standard pins are 2.50 cm in length unless otherwise specified.

TLD chip holder pins feature a recess measuring 3.2 × 3.2 × 0.9 mm at one end. TLD rod holder pins are fitted with a 1 mm-diameter cross-drilled hole at the pin center. Pins are also available, configured to accommodate OSLD dosimeters of various types.

Tissue-equivalent plugs are available machined to fit the following detector formats: TLD chips, TLD rods, TLD bars, TLD cubes, MOSFET detectors, LANDAUER® OSL MicroSTAR® holders, and LANDAUER® nanoDot® holders. Holder pins for all detector formats are available separately.

Assembly

ART Phantom slices are secured between aluminum end plates using nylon tie rods with tightening knobs that clamp slices firmly in proper anatomical alignment. Both internal and external assembly configurations are included with the phantom.

The external assembly is designed to facilitate film dosimetry, providing unobstructed slice interfaces for planar dose measurement. The internal assembly is intended for use with TLD or ion chamber dosimetry, supporting point-dose and volumetric measurements within the phantom volume.

Breast Attachments

Breast attachments are available in various sizes, contoured to blend realistically with the thorax of both male and female ART Phantoms, and secured with nylon screws. The male chest with breast attachments fitted serves as a large female configuration. Breasts may be sectioned in frontal planes and are available drilled or undrilled for film dosimetry. Sliced breasts accept the full range of tissue-equivalent pins described in the TLD Dosimeters and Fittings section.

Publication References

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Model Numbers

ART Phantom with Cadaver Bones	Male ART	Female ART
UNDRILLED	ART-200XCB	ART-300XCB
3 cm x 3 cm GRID HOLE SPACING	ART-200CB	ART-300CB
1.5 cm x 1.5 cm GRID HOLE SPACING	ART-200ACB	ART-300ACB

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RSD Materials

RSD SOFT TISSUE					
Energy (MeV)	Mean (HU)	Calculated (μ)	μ (ICRU 44)	% Difference	Ratio
00.08	60.30	0.1948	0.1932	0.80%	0.9921
00.10	52.88	0.1797	0.1795	0.15%	0.9985
00.12	57.10	0.1717	0.1709	0.44%	0.9956
00.14	52.95	0.1623	0.1624	0.07%	1.0007
00.20	--	0.1477	0.1439	2.61%	0.9746
00.30	--	0.1245	0.1246	0.04%	1.0004
00.60	--	0.0950	0.0941	1.01%	0.9900
00.80	--	0.0825	0.0826	0.13%	1.0013
01.00	--	0.0744	0.0743	0.18%	0.9982
02.00	--	0.0520	0.0519	0.18%	0.9982
03.00	--	0.0351	0.0357	1.71%	1.0174
06.00	--	0.0288	0.0291	0.88%	1.0088
08.00	--	0.0252	0.0255	0.98%	1.0099
10.00	--	0.0229	0.0232	1.49%	1.0151
15.00	--	0.0203	0.0203	0.15%	0.9985
20.00	--	0.0189	0.0189	0.17%	1.0017

RSD CORTICAL TISSUE					
Energy (MeV)	Mean (HU)	Calculated (μ)	μ (ICRU 44)	% Difference	Ratio
00.08	1365	0.4345	0.4280	1.51%	0.9851
00.10	1048	0.3496	0.3562	1.84%	1.0188
00.12	0977	0.3211	0.3274	1.91%	1.0195
00.14	0902	0.2932	0.2986	1.80%	1.0184
00.20	--	0.2511	0.2513	0.09%	1.0009
00.30	--	0.2155	0.2137	0.84%	0.9916
00.60	--	0.1596	0.1598	0.11%	1.0011
00.80	--	0.1403	0.1402	0.10%	0.9990
01.00	--	0.1274	0.1261	1.06%	0.9895
02.00	--	0.0883	0.0885	0.17%	1.0017
03.00	--	0.0611	0.0625	2.29%	1.0235
06.00	--	0.0512	0.0525	2.46%	1.0253
08.00	--	0.0468	0.0474	1.20%	1.0121
10.00	--	0.0446	0.0444	0.39%	0.9962
15.00	--	0.0410	0.0409	0.16%	0.9984
20.00	--	0.0393	0.0397	1.02%	1.0103

RSD TRABECULAR TISSUE (SPONGIOSA)					
Energy (MeV)	Mean (HU)	Calculated (μ)	μ (ICRU 44)	% Difference	Ratio
00.08	551	0.2849	--	--	--
00.10	515	0.2586	--	--	--
00.12	439	0.2337	--	--	--
00.14	318	0.1541	--	--	--

Soft Tissues: There are unlimited small variations in density and absorption throughout the human body. Phantom soft tissue is closely controlled to have an average density similar to that of these tissues.

Skeletons: RSD skeletons are highly detailed polyner moldings which reproduce the shape, mass density, and attenuation coefficients of cortical bone and spongiosa. RSD's proprietary moldings allow for continuous production, eliminate the restrictions of human skeletal bones (including limited availability, unethical collection of human bone specimens, variable size, and uncertain chemical composition), and avoid the loss of marrow in dried natural skeletons, thereby making RSD skeletons superior to "real bone."

Molds: Molds for RSD cortical bone and spongiosa were made from human skeletons consistent with the sizes of the soft tissue molds.

ICRU 44: RSD skeletons conform closely to the standards established by the International Commission on Radiation Units and Measurements (ICRU Report 44); the mass density is reduced slightly to account for a small decrease in calcium content in older patients.

LINEAR ATTENUATION DATA

- Monte Carlo simulation was used to calculate linear attenuation coefficients as a function of the beam.
- Monte Carlo results were validated with linear attenuation coefficients derived from Hounsfield Unit measurements at discrete energy levels.
- RSD phantom material linear attenuation data were compared to NIST data using ICRU Report 44 compositions of human tissues.
- NIST data was interpolated when necessary.

Materials	Density (g/cc)
RSD Soft Tissue (Opaque)	1.08
RSD Soft Tissue (Trasparent)	1.10
RSD Cortical Bone	1.83
RSD Trabecular Bone	1.17

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