RTsafe
personalized
confidence

PseudoPatient ™

Next Generation SRS Phantoms
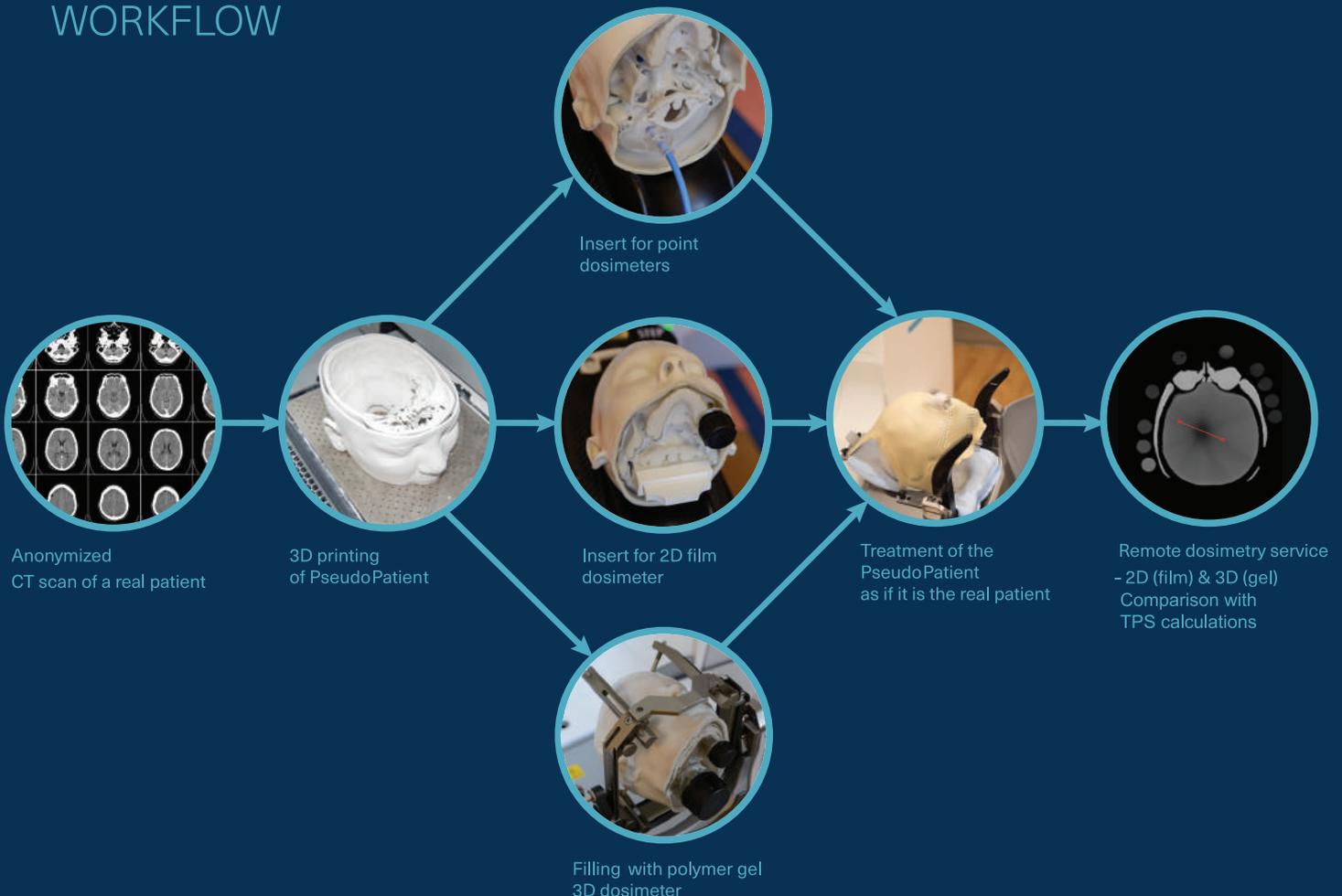Introducing truly personalized QA in radiation oncology

The introduction of hardware and software innovations in medical imaging, treatment planning, radiation dose delivery and advanced approaches in patient positioning have inspired and allowed the use of more complex treatment plans, involving steeper dose gradients better conforming to the number and shapes of targets. However, the increased complexity of contemporary treatment planning and delivery workflows is also associated with minimum spatial and dosimetric uncertainty tolerances. Especially in advanced radiotherapy applications such as intracranial Stereotactic Radiosurgery (SRS) and Stereotactic Radiotherapy (SRT) several tiny brain lesions (of the order of a few millimeters) are often treated simultaneously, delivering high dose levels and steep dose gradients in a single or a few fractions and often involving a single isocenter.

RTsafe is proud to introduce the next generation of dosimetry phantoms in combination with advanced highly accurate remote dosimetry services.

RTsafe offers the **Reference PseudoPatient™** and the **Personalized PseudoPatient™** dosimetry phantoms, built from real patient CT data. More specifically, PseudoPatient™ phantoms are anatomically accurate replicas of patients (including bone inhomogeneities) produced using a 3D printer, while point, 2D and inherently 3D radiation detectors are incorporated. A PseudoPatient™ phantom is treated as if it was the actual patient, reproducing all steps of the treatment chain, including patient imaging, treatment planning, patient immobilization (e.g., stereotactic frame or thermoplastic mask), image guidance, patient positioning and radiation dose delivery. This approach results in a comprehensive End-to-End quality assurance (QA) test and can also serve as:

- **Commissioning and benchmarking of advanced radiotherapy modalities, focusing on SRS and SRT**
- **Truly patient-specific pre-treatment plan verification**
- **Periodic End-to-End QA procedures**
- **Educational and Confidence Building Purposes**
- **Remote or internal audit test**
- **Proton therapy dosimetry**
- **Clinical or academic research**

WORKFLOW

Insert for point dosimeters

Anonymized
CT scan of a real patient

3D printing
of PseudoPatient

Insert for 2D film
dosimeter

Treatment of the
PseudoPatient
as if it is the real patient

Remote dosimetry service
– 2D (film) & 3D (gel)
 Comparison with
 TPS calculations

Filling with polymer gel
3D dosimeter

3D printed PseudoPatient™ phantoms

RTsafe has developed a unique methodology to produce **PseudoPatient™**. Briefly, using a 3D printer, any patient's CT scan can be used to produce their very own anatomically accurate hollow phantom involving all bone structures and external contour of the head. The resulting avatar is properly machined to accommodate any kind of point, 2D or 3D dosimeters, according to the end-user's needs.

Key Features:

- 3D printed bone anatomy with density corresponding to bone equivalent materials

- Accurate replica of any real patient's anatomy

- Can incorporate arbitrary number and type of detectors at positions and orientation designated by the end-user

- Dose measurements for the most complicated treatment plans with arbitrary number of targets

- Comprises all steps of treatment chain: planning-CT, TPS, set-up, image guidance, treatment delivery

- Combined with Remote Dosimetry Services:

- High spatial resolution (of ~1mm^3) 3D relative dosimetry vs TPS calculations

- 1D, 2D, 3D dosimetry vs TPS calculations

- 1D, 2D, 3D Gamma index analysis

- Truly experimental DVH measurements for both targets & OARs & inter-comparison with corresponding TPS DVH calculations. An RTsafe unique feature!

PseudoPatient™ *Prime*
Broadening the spectrum of quality assurance

Complexity of contemporary radiotherapy demands a novel approach in quality assurance. PseudoPatient™ Prime broadens the spectrum of quality assurance through an integrated solution. Comprehensive dosimetry in a true-to-life human anatomy phantom provides an End-to-End evaluation of advanced radiotherapy applications, focusing on stereotactic radiosurgery.

Confidence through 3D dosimetry

- 3D spatial accuracy evaluation
- Remote 3D gel dosimetry service
- Multi-level comparison with TPS calculations

True-to-life human anatomy

- Based on an actual patient's CT scan
- Realistic bone and soft tissue contrast in MR and CT imaging
- Bone and tissue equivalent materials

End-to-End QA in stereotactic radiosurgery

- Easy setup and treatment as it is the real patient
- Evaluation of the whole treatment chain
- Point, 2D, and 3D dosimetry. CT/MR imaging QA

Imaging and dosimetry inserts available

- Variable Ion Chamber Position Dosimetry kit
- Film Dosimetry kit
- * Gel Dosimetry kit
- * CT-MR co-registration accuracy & imaging assessment insert
- MR-related geometric distortions evaluation insert
- Winston-Lutz insert with central and offset targets

PseudoPatient™ *Prime* phantom can be combined with RTsafe's Remote 2D & 3D dosimetry services

Intended for

- End-to-End QA in SRS Applications
- Commissioning and Benchmarking
- Periodic Quality Assurance
- Confidence Building & Training
- * Remote or Internal Audit Tests
- * Clinical or Academic Research

Reference PseudoPatient™ for SRS/SRT

Based on real patient CT scan, RTsafe has developed high-fidelity **Reference PseudoPatient™** 3D printed head phantoms of realistic anatomy (including bone inhomogeneities), enabling users to perform benchmarking procedures and End-to-End QA testing for their SRS/SRT treatment protocols. A Reference PseudoPatient™ phantom is treated as if it was the actual patient, reproducing all steps of the treatment chain, including patient imaging, treatment planning, patient immobilization (e.g., stereotactic frame or thermoplastic mask), image guidance, patient positioning and radiation dose delivery.

The Reference PseudoPatient™ phantoms are unique in that 3D reconstruction of cranial bone anatomy is true-to-life reproduction of patient anatomy, also allowing for the simulation of the actual challenging clinical workflow.

Two models of Reference PseudoPatient™ phantoms are available:

Reference PseudoPatient™ GL: Single use head phantom filled with 3D polymer gel dosimeter as a tissue equivalent material. Polymer gel dosimetry using RTsafe VIP gel-filled phantoms is a QA method which yields full 3D high spatial resolution and accurate relative dose measurement. Dose read-out is performed using MRI.

Reference PseudoPatient™ MI: Reusable multi-insert head phantom which can be filled with water as a tissue equivalent material. The phantom is properly machined to accommodate two interchangeable inserts for point dosimeters at specific locations within the brain and a film holder located at a central coronal plane. Absolute real-time point and 2D film dose measurements can be performed by the end-user.


Reference PseudoPatient™ phantoms are accompanied by the RTsafe-provided multi-target SRS package modeling a reference set of seven targets and organs at risk (OARs) for a realistic multiple metastases case. Alternatively, feel free to create your own set of targets and OARs, simulating a challenging SRS/SRT case.

Advantages: Compared to the Personalized PseudoPatient™, there is no need to select and anonymize the CT scan of one of your patients. Dosimetric analysis of 2D and 3D measurements can be performed by RTsafe as remote dosimetry services. Results are compared with corresponding TPS calculations.

Reference PseudoPatient™ for SBRT

Meeting TG-51 dosimetric requirements, RTsafe 3D printed Reference PseudoPatient™ phantoms for SBRT are uniquely constructed to enable highly accurate dosimetric analysis and QA evaluation of challenging spine radiosurgery cases. RTsafe Reference PseudoPatient™ SBRT phantoms are an ideal choice for QA, building confidence and ensuring patient safety in hypofractionated treatments. **Reference PseudoPatient™ SBRT** phantoms are properly machined to accommodate two (2) point dosimeters (i.e., ion chambers, dosimetry diodes etc.) into the spinal cord and the spinal bone.

Advantages: You can easily perform absolute dose measurements in the spinal cord and spinal bone using your equipment in order to implement a patient-specific QA test. There is no need to select and anonymize the CT scan of one of your patients.
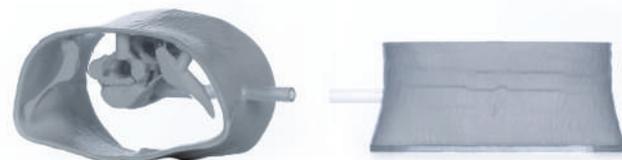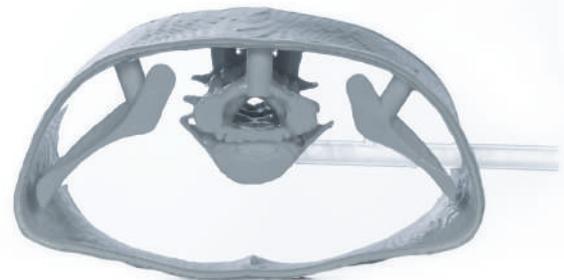
Personalized
PseudoPatient™
for SRS/SRT

Do you need a **PseudoPatient™** head phantom of one of your own SRS/SRT cases for **End-to-End QA** testing?

Would you like to incorporate a **truly patient-specific pre-treatment plan verification** method to the clinical practice of SRS/SRT and IMRT/VMAT treatments for head lesions?

RTsafe offers the **Personalized PseudoPatient™** dosimetry phantoms, built from real patient CT data using highly accurate 3D printing technology. Personalized PseudoPatient™ phantoms are anatomically accurate replicas of patients, properly machined to accommodate any kind and number of point, 2D and inherently 3D dosimeters, according to your needs. Number, location and orientation of detectors are fully customizable.

All you need to do is anonymize the patient's CT scan series and RTstructure DICOM files.

A Personalized PseudoPatient™ phantom is treated as if it was the actual patient, reproducing all steps of the treatment chain, including patient imaging, treatment planning, patient immobilization, image guidance, patient positioning and radiation dose delivery.

Two models of Personalized PseudoPatient™ phantoms can be produced:

Personalized PseudoPatient™ QA: Single use gel-filled (GL) or reusable multi-insert (MI) head phantom. This approach results in a comprehensive End-to-End QA test for demanding clinical cases.

Personalized PseudoPatient™ PV: Single use gel-filled (GL) or multi-insert (MI) head phantom. This approach results in a truly patient-specific pre-treatment plan verification (PV) for each and every patient.

Dosimetric analysis of 2D and 3D measurements can be performed by RTsafe as remote dosimetry services. Results are compared with corresponding TPS calculations.

Remote 3D Dosimetry Services

RTsafe's polymer gel dosimeter, RTgel-100, can be combined with **PseudoPatient™** or any other dosimetry phantom for 3D remote dosimetry services.

3D dosimetry: RTgel-100

RTgel-100 is a unique formulation for 3D polymer gel dosimetry, developed and optimized by RTsafe.

PseudoPatient™ can be filled with RTgel-100, enabling high spatial resolution 3D dosimetry ideal for cases involving multiple targets/OARs and steep dose gradients.

Dose readout is performed by the MRI scanner of your department (or at one of RTsafe's collaborative sites) using specially designed pulse sequences.

RTsafe will analyze the MR images of the irradiated phantom and provide an in-depth multi-level comparison with TPS calculations, incorporated in a detailed 3D dosimetry report. Alternatively, you can use the RTcompare software tool to perform the evaluation.

Key Features:

- 3D dose measurements for the most complicated treatment plans with arbitrary number of targets and OARs
- Dose range up to 35 Gy
- High spatial resolution (of ~1mm^3) 3D relative dosimetry vs TPS calculations
- 1D, 2D, 3D dosimetry vs TPS calculations
- 1D, 2D, 3D Gamma index test comparing measured and calculated distributions

Truly experimental DVH measurements for both targets and OARs and inter-comparison with corresponding TPS calculations.

Remote 2D Dosimetry Services

RTsafe Film Dosimetry Lab can assist you in the implementation of a film dosimetry protocol, offering 2D remote dosimetry services.

2D Dosimetry: RADIOCHROMIC FILMS

Combined with a **PseudoPatient™** incorporating a film holder, RTsafe can guide and support in implementing an End-to-End film dosimetry test. If required, commercially available radiochromic film pieces from a calibrated batch and professional flatbed scanner are available for remote dosimetry. Moreover, the RTsafe team can perform the analysis of the 2D measurements, spatially co-register the datasets and provide an in-depth multi-level comparison with TPS calculations, incorporated in a detailed dosimetry report.

Key Features:

- 2D dose measurements for the most complicated treatment plans with arbitrary number of targets and OARs
- Dose calibration range up to 25 Gy, performed in a Secondary Standard Dosimetry Laboratory (SSDL)
- Absolute and relative dose measurements
- Both single and triple channel dosimetry protocols available
- In-plane spatial resolution of ~0.17mm
- Spatial co-registration between 2D measurements and 3D TPS calculations based on fiducial markers
- 1D and 2D dose distributions vs TPS calculations
- 2D Gamma index test comparing measured and calculated distributions

RTcompare software

RTcompare is a DICOM-RT Viewer and Dose Distribution Comparison tool for radiotherapy treatment plans evaluation. The current version supports the inter-comparison of up to three RTdose files of the same patient/case, and produced from either the same or different treatment planning systems. RTcompare allows extraction of comparison metrics that include 1D dose profiles, 2D isodoses, 1D/2D/3D gamma index evaluation, calculation/comparison of Dose Volume Histograms (DVHs) and plan quality metrics.

RTcompare can be used to analyze and compare 3D measured and calculated dose distributions using a **PseudoPatient™** filled with RTgel-100.
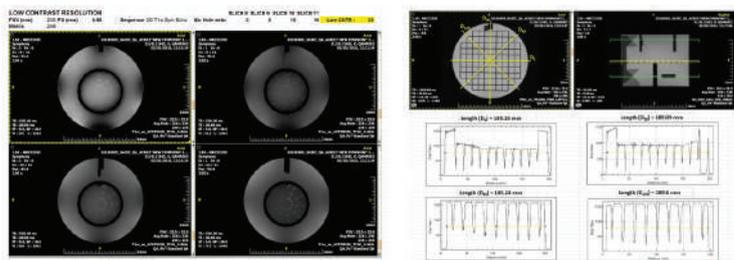
Key Features:

- CT scan dicom viewer
- Structure sets superimposed on CT scan
- Profile and 1D gamma index comparison on arbitrary orientations
- Isoline and 2D gamma index comparison within selected ROIs
- 3D gamma index comparison within selected ROIs
- DVH and plan quality metrics comparison
- Exportable figures
- Fully compatible for 3D analysis of PseudoPatient™ phantom filled with RTgel-100
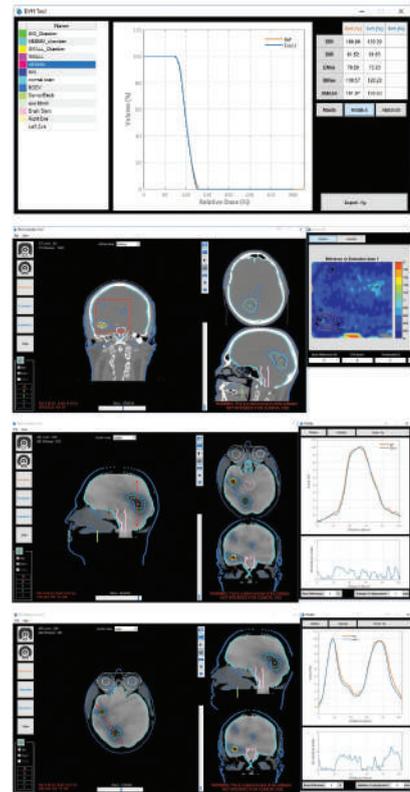
Advanced MRI QA for RT

RTsafe offers advanced MRI QA services using the ACR MR phantom, RTsafe-built MRI-QA hardware and software tools as well as our 20-year experience in the field. Emphasis is given to the Radiotherapy needs. The RTsafe MRI-QA-Lab members can suggest optimizations for your MRI-scanner towards its enhanced performance for RT needs.

RTsafe personalized confidence