

In the name of God

**Guide to Guidance and confirmation of radiotherapy treatment with
imaging methods course**

instructor/instructors: Dr. Alireza Farajollahi – Dr. Mikaeil Molazadeh

Prerequisite or concurrent unit: New topics in radiotherapy physics, theoretical foundations of image formation

Number of units: 2 **Unit type:** 2 theoretical units **Level:** PhD's degree

Number of sessions: 17

Start and end dates of sessions: According to the educational calendar

Time of sessions per week: According to the educational calendar

Location of in-person sessions: Theoretical (Faculty of Medicine)

General Objective and Introduction to the Course Unit:

General Objective: Familiarizing learners with the basics and technology of treatment confirmation and IGRT.

Specific Objectives: Outline of theoretical and practical topics that learners are expected to be able to explain after completing this course:

1. Reminder: 3D conformal radiotherapy, 2D and 3D imaging, treatment planning, PTV, CTV, GTV
2. The need for treatment verification in radiotherapy
3. Tumor and organ movement, problems caused by it and tracking tumor movement (Tumor tracking)
4. Simulator and CT Simulator
5. Respiratory-correlated CT and 4DCT
6. Use of Fiducial markers
7. Electronical portal imaging systems
8. Image fusion in radiotherapy
9. CT-based methods with X-rays MVCT, kVCT, Cone-beam CT, Fan-beam CT
10. Fluoroscopy-based methods
11. Ultrasound-based methods: BAT and ...
12. MRI-based methods
13. Sensor-based methods
14. Clinical applications of IGRT including adaptive radiotherapy

Educational objectives of the course unit

After completing this course, learners are expected to be able to:

Session	Lesson Topic	Table of Contents
1	Review (Radiation Therapy, Treatment Planning and Imaging)	3D conformal radiotherapy, 2D and 3D imaging, treatment planning, GTV, CTV, PTV, Methods of radiotherapy delivery, Three-dimensional conformal radiation therapy (3D-CRT), Intensity modulated radiotherapy, Volumetric modulated arc therapy (VMAT), Helical tomotherapy
2	Introduction and historical perspective of IGRT	The need for imaging in radiotherapy, 2D image guidance—portal imaging, Kilo voltage planar imaging, Stereoscopic imaging system, Volumetric image guidance, Volumetric imaging with CBCT, Molecular imaging-based guidance—biology-guided radiotherapy, Non-radiological image guidance systems, Ultrasound based image guidance, Magnetic resonance image based image guidance, Surface guided radiotherapy (SGRT), The advantages of IGRT
3	Tumor and organ movement, problems caused by it, and tracking tumor movement (Tumor tracking)	1.Introduction 2. Definition of “set-up error” and how these errors are classified 1.2.1 Systematic and random errors 1.2.2 Gross errors 1.3 Consequences of each type of error and the impact on treatment delivered 1.4 Correction of set-up errors
4	Electronic portal imaging systems	1 Introduction 2 Video camera-based EPID 2.1 The detector 3 Fibre optic-based EPID 3.1 Issues with the fibre optic EPID 4 Liquid ion chamber-based EPID 5 Active-matrix, flat-panel imager (AMFPI)-based EPIDs 5.1 Direct conversion flat-panel imagers 5.2 Indirect conversion EPIDs 5.3 Issues with commercially available AMFPIs 5.4 Ghosting and noise 6 Clinical use of EPID 6.1 General workflow with EPID

		<p>6.2 Use of fiducial markers with EPID</p> <p>6.3 4D radiotherapy using implanted marker tracking with EPID</p> <p>6.4 Errors, on-line and off-line correction strategies</p> <p>6.5 Combining uncertainties to derive planning margins</p> <p>6.6 Correction strategies</p>
5	Image fusion in radiotherapy	<p>1- Principles of Image Reconstruction</p> <p>2- DIR - Feature Space</p> <p>3- Transformation Model</p> <p>4- Applications of DIR in Radiation Oncology</p>
6	Clinical applications of IGRT include adaptive radiotherapy	<p>1-On-line adaptive replanning</p> <p>2- Average anatomy model</p> <p>3- Triggered and scheduled adaptation</p> <p>4- Library of plans</p>
7	On-treatment Verification Concepts (Part 1)	<p>1- Introduction</p> <p>2- Reference Images</p> <p>3- Types of Reference Images:</p> <ul style="list-style-type: none"> 1- Simulator Image 2- DRR Image (Digitally Reconstructed Radiograph) 3- DCR Image (Digital Composite Radiograph) 4- CT Dataset <p>4- Verification Techniques</p> <ul style="list-style-type: none"> 1- MV Imaging 2- kV Imaging 3- Cone Beam CT Scans (CBCT)
8	On-treatment Verification Concepts (Part 2)	<p>5- Imaging time</p> <p>6- Image matching methods:</p> <ul style="list-style-type: none"> 1- Bony Match 2- Fiducial Marker Match 3- Soft Tissue Match <p>7- Image checking and control time:</p> <ul style="list-style-type: none"> 1- On-line Review 2- Off-line Review 3- Review Method

<p>9</p>	<p>Volumetric Radiological Image Guidance Systems (Part 1)</p>	<p>1- Introduction: 1- Development of CT scanners 2- CT reconstruction 3- Fan beam reconstruction 2- On-rail CT – (in-room CT): 1- Workflow of CT on-rails IGRT system 2- Uncertainties in CT on-rails system 3- Clinical applications and benefits of CT on-rails IGRT system</p>
<p>10</p>	<p>Volumetric Radiological Image Guidance Systems (Part 2)</p>	<p>3- Tomotherapy: 1- MVCT IGRT in Tomotherapy 2- MVCT Imaging System in Tomotherapy 3- kV CT in Tomotherapy 4- IGRT Workflow with Tomotherapy 4- Image Guidance Based on CBCT: 1- CBCT Image Reconstruction 2- MV CBCT 3- Development of MV CBCT Systems 5- Halcyon Unit IGRT Workflow with Halcyon Unit</p>
<p>11</p>	<p>Volumetric Radiological Image Guidance Systems (Part 3)</p>	<p>6- IGRT based on kV CBCT: 1- Halcyon unit with kV CBCT 2- Vero 4D IGRT system and kV fluoroscopy 3- Sidhart II IGRT system 4- C_Arm Based CBCT system 5- Bow-tie filters 6- Extended longitudinal FOV image guidance 7- Respiratory correlated CBCT (4D CBCT) 8- 4D CBCT reconstruction 9- Streaking artifact reduction 10- Image quality with number of projections 7- Image reconstruction: Clinical applications of 3D image guidance: - ART</p>

<p>12</p>	<p>Ultrasound for Image Guidance in External Beam Radiotherapy (Part 1)</p>	<p>1- Introduction 2- Physics of Ultra-Sound (US) Imaging 3- US Frequency 4- Scan Modes 5- US Imaging Techniques: 1- Transrectal US (TRUS) Imaging 2- TASU Imaging 3- TBUS Imaging 6- Three-dimensional (3D) US Imaging</p>
<p>13</p>	<p>Ultrasound for Image Guidance in External Beam Radiotherapy (Part 2)</p>	<p>7- US-based commercial IGRT systems: 1- BAT system 2- Sonarray 3- Clarity system 8- Workflow for inter-fraction and intra-fraction ultrasound imaging 1- Inter-fraction imaging 2- Intra-fraction imaging 3- Organ motion estimation techniques with 4D US 9- Commissioning and quality assurance of US-based IGRT system: 1- Lasers 2- System calibration 3- Phantom offset test 4- Laser offset test 5- Optical system stability test 6- Image quality and stability test 7- End-to-End test 10- Advantages of US IGRT system 11- Challenges in using US system for IGRT</p>
<p>14</p>	<p>Magnetic resonance imaging-guided radiotherapy: MRIgRT (Part 1)</p>	<p>1- MRI Physics: 1- Pure Magnetic Field Generation and Hydrogen Protons 2- Precession 3- Radiofrequency (RF) Energy and Resonance 4- T1 Relaxation Time 5- T2 Relaxation Time 6- Repetition Time (TR) and Echo Time (TE) 7- MR Pulse Sequence</p>

<p>15</p>	<p>Magnetic resonance imaging-guided radiotherapy: MRIgRT (Part 2)</p>	<p>2- Challenges in integrating MRI with linac for image guidance</p> <ul style="list-style-type: none"> 1- Effect of magnetic field on linac 2- Electron focusing effect (EFE) 3- Electron return effect (ERE) 4- Effect on MR image due to linac 5- MR linac orientation <p>3- MRIgRT systems:</p> <ul style="list-style-type: none"> 1- ViewRay MR-linac 2- Unity MRIgRT system 3- Aurora-RT MR linac 4- Australian MRI-linac program 5- Sequential system with MR guidance
<p>16</p>	<p>Optical surface scanning (optical sensors): Surface-guided radiotherapy (SGRT)</p>	<ul style="list-style-type: none"> 1- Scientific logic of surface guidance and sensors 2- Clinical SGRT systems Registration with reference surface 3- Align RT system: <ul style="list-style-type: none"> 1- Align RT performance 2- AlignRT system calibration and quality assurance 4- Catalyst/Sentinel system <ul style="list-style-type: none"> 1- Sentinel system 2- Catalyst system 3- Catalyst and Sentinel system quality assurance 5- SGRT advantages 6- Limitations of surface tracking systems <ul style="list-style-type: none"> 1- Sensitivity to external factors 2- System latency 3- Relationship between surface and internal anatomy
<p>17</p>	<p>End of semester exam</p>	<p>End of semester exam</p>

Method of providing training

■ Speech ■ Slide ■ Questions and Answers ■ Problem-based learning ■ Practical training

Student evaluation method

Class seminar 10% - Class participation in teaching sessions 5%, Quiz 5%, End of semester written exam in the form of essay/test/short answer/limited answer/fill in the blank/correction/multiplication 80%

Minimum passing score for this course: [According to the curriculum.](#)

Number of hours of absence allowed for this course unit: [According to the approved educational regulations.](#)

Educational resources

1. Khan FM and Gibbons JP, The physics of Radiation Therapy. Philadelphia: Wolters Kluwers Health; Last edition
2. Bourland J. Daniel. Image-Guided radiation Therapy, Boca Raton, Florida: CRC press; Last edition
3. Mayles P, Nahum A, Rosenwald J.C. Handbook of radiotherapy Physics: theory and Practice. New York: Taylor & Francis; Last edition

Educational resources for further study

Related resources from the Internet and university web pages

Learning opportunities

Holding limited conferences in each session, managed by the teacher and presented by the student

Contact information

Course Instructor/Instructors (Phone, Email, etc.):

Dr. Alireza Farajollahi: 04133364660 – farajollahia@tbzmed.ac.ir

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In the name of God

Guide to Internship and clinical skills acquisition in radiotherapy course

instructor/instructors: Dr. Alireza Farajollahi – Dr. Mikaeil Molazadeh

Prerequisite or concurrent unit: New topics in radiotherapy physics

Number of units: 2 **Unit type:** 2 internship units **Level:** PhD's degree

Number of sessions: 9 weeks (2 full days per week)

Start and end dates of sessions: According to the educational calendar

Time of sessions per week: According to the educational calendar

Location of in-person sessions: Radiotherapy Department, Shahid Madani Hospital

General Objective and Introduction to the Course Unit:

General Objective: Acquire essential skills in calculations, dosimetry, treatment planning, quality control, and radiation protection in radiotherapy centers..

Specific Objectives: Outline of theoretical and practical topics that learners are expected to be able to explain after completing this course:

1. Working with simulators and CT simulators
2. Making specific shields for patients
3. Participating in implementing various treatment techniques
4. Designing various treatments
5. Practical work with dosimetry systems
6. Practical work with immobilization methods
7. Practical work with quality control methods of radiotherapy systems
8. Familiarity with the duties of the health physicist in the radiotherapy department

Educational objectives of the course unit

After completing this course, learners are expected to be able to:

Session	Skill	Minimum hours of skill practice to learn			
		View	Assist in performing	Independently perform	Total hours
1	Working with simulators and CT simulators	4	8	0	12
2	Making dedicated photon and electron shields	4	4	4	12
3	Performing treatment techniques (3D conformal, tomotherapy)	8	8	0	16
4	Planning common photon and electron treatments	8	8	4	20
5	Planning 3D conformal treatments	8	4	4	16
6	Planning advanced treatments (tomotherapy and IMRT)	8	4	0	12
7	Performing photon and electron dosimetry (relative and absolute)	8	8	0	16
8	Quality control of accelerators and tomotherapy	8	8	4	16
9	Quality control of simulators	4	2	2	6
10	Patient immobilization methods	2	2	2	6
11	Radiation protection and environmental monitoring	2	1	1	4
12	Introduction to the duties of the health physicist in the radiotherapy department	2	1	1	4

Method of providing training

View Assist in performing Independently perform

Student evaluation method

Practical exam includes: 25% work-based, 25% professor report, 25% log book and 25% lab book

Minimum passing score for this course: [According to the curriculum.](#)

Number of hours of absence allowed for this course unit: [According to the approved educational regulations.](#)

Educational resources

1. Khan FM and Gibbons JP, The physics of Radiation Therapy. Philadelphia: Wolters Kluwers Health; Last edition
2. Khan, F. M., Potish RA. "Treatment Planning in Radiation Oncology". Williams & Wilkins. Last Edition
3. Podgorsak Bourland J. Daniel. Image-Guided radiation Therapy, Boca Raton, Florida: CRC press; Last edition
4. Mayles P, Nahum A, Rosenwald J.C. Handbook of radiotherapy Physics: theory and Practice. Vienna: Taylor & Francis; Last edition
5. Webb S. The physics of three-dimensional radiation therapy: Conformal therapy, radiosurgery and treatment planning, Bristol: IOP Publications; Last Edition.

Educational resources for further study

Related resources from the Internet and university web pages and connections to other radiotherapy centers in the country

Learning opportunities

Participation in training courses of the Iranian Medical Physics Association, the Atomic Energy Organization, and companies selling dosimetry and radiotherapy equipment.

Holding limited conferences in each session, led by an instructor and presented by the student.

Contact information

Course Instructor/Instructors (Phone, Email, etc.):

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