RESEARCH PRESENTATION

Research Presentation & Study Overview

Dosimetric and Radiobiological Comparison of 3DCRT and IMRT for Post-Operative Breast Cancer

PRESENTED BY

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M.Phil. Physics (Medical Physics) | CGPA 3.50 / 4.00

ACADEMIC INSTITUTION

The Islamia University of Bahawalpur

M.Phil. Supervisor: Dr. Muhammad Arshad Javid

Academic background and relevant research experience

A physics foundation supported by radiotherapy planning, dosimetry, imaging and research experience.

EDUCATION

M.Phil. Physics (Medical Physics) | 2024-2026

The Islamia University of Bahawalpur • CGPA 3.50 / 4.00

B.S. Physics | 2019-2024

Emerson College, Bahauddin Zakariya University • CGPA 3.40 / 4.00

RELEVANT EXPERIENCE

Research Intern | BINO | Jul 2025-Jan 2026

Radiotherapy workflow, Eclipse TPS, dosimetry and QA, CT image quality, DRLs, DICOM/PACS and IndoQCT.

Physics Lecturer | Punjab College | Jul 2024-Nov 2026

Teaching physics, preparing learning material and assessing student progress.

RESEARCH AND TECHNICAL TOOLKIT

Treatment planning	Eclipse TPS • 3DCRT • IMRT
Biological modelling	RadBioMod • EUD • TCP • NTCP
Data analysis	SPSS • Python • C++
Imaging and QA	CT image quality • DRLs • DICOM/PACS

RELEVANT PROFESSIONAL DEVELOPMENT

IAEA training in quality control and dosimetry and Diagnostic Reference Levels in medical imaging; Medical Physics summer course focused on CT image quality and optimization.

RESEARCH OUTPUT

M.Phil. study on 3DCRT versus IMRT for post-operative breast cancer; manuscript listed as under review in the CV.

Clinical background and the research problem

Post-operative breast radiotherapy requires a balance between target coverage and normal-tissue protection.

CLINICAL CONTEXT

Radiotherapy after surgery is used to control residual microscopic disease and reduce the risk of local or regional recurrence.

STUDY PRESCRIPTION

40 Gy in 15 fractions. Both treatment techniques were evaluated for the same clinical setting.

PLANNING CHALLENGE

The breast target is close to organs at risk, especially the heart and ipsilateral lung. Dose distribution must be assessed across both target and healthy tissues.

OVERALL AIM

To compare 3DCRT and IMRT for post-operative breast cancer using dosimetric and model-based radiobiological outcomes.

RESEARCH QUESTION

How do 3DCRT and IMRT differ in target dose distribution, organ-at-risk exposure and predicted biological effect when both plans are generated for the same patients?

TARGET COVERAGE | HEART SPARING | LUNG SPARING | BIOLOGICAL EFFECT

3DCRT and IMRT: two planning strategies

Both techniques use a linear accelerator, but differ in how beam geometry and intensity are planned.

3D CONFORMAL RADIOTHERAPY

Forward planning

Planner chooses the beam arrangement; the treatment-planning system calculates the resulting dose distribution.

- Multiple fixed radiation beams
- Multileaf collimator (MLC) shapes each field to the target
- Wedges or field-in-field may improve dose homogeneity
- Beam angles, field size and weighting are selected by the planner

Intensity within each field is generally not modulated.

INTENSITY-MODULATED RADIOTHERAPY

Inverse planning

Planner specifies dose objectives and organ constraints; computer optimization determines intensity patterns.

- Multiple beam directions
- MLCs create variable beam intensity across the field
- Optimization balances target objectives and OAR constraints
- Can produce highly conformal dose distributions

Intensity is deliberately modulated during optimization.

Key planning distinction: 3DCRT = choose beam geometry; IMRT = optimize fluence against dose objectives.

Paired study design and treatment-planning workflow

Thirty patients were planned with both techniques, enabling within-patient comparison.

30	15 / 15	40 Gy	15
PATIENTS	LEFT / RIGHT	PRESCRIPTION	FRACTIONS

WORKFLOW

01 — CT simulation
Patient anatomy in treatment position

02 — Contouring
PTV and OARs delineated

03 — Plan generation
3DCRT and IMRT in Eclipse TPS

04 — Dose calculation
40 Gy / 15 fractions

05 — DVH extraction
Target and OAR dose metrics

06 — Bio + statistics
RadBioMod and paired analysis

DOSIMETRIC ENDPOINTS

Dmean • Dmax • V20 • V5 • target coverage • dose homogeneity

STATISTICAL APPROACH

Paired t-test • $p < 0.05$ • Cohen's d effect size

The same patient contributes a 3DCRT plan and an IMRT plan; paired analysis accounts for this design.

EVALUATION FRAMEWORK

From physical dose to predicted biological effect

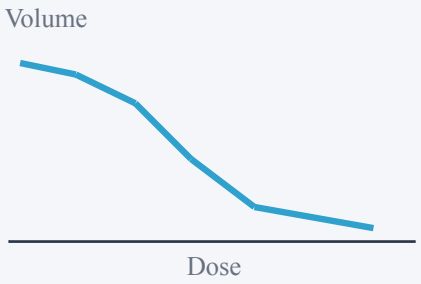
The analysis combines dose-volume information with radiobiological models.

PHYSICAL DOSIMETRY

Gray (Gy) 1 Gy = 1 J/kg of absorbed energy per unit mass.

DOSE-VOLUME HISTOGRAM (DVH)

A DVH summarizes the percentage or volume of a structure receiving a given dose. It supports evaluation of target coverage, homogeneity and OAR sparing.



V20 = % of an organ receiving 20 Gy or more; V5 uses the 5 Gy threshold.

GTV → CTV → PTV

Gross disease • clinical target • planning margin

RADIOBIOLOGICAL ENDPOINTS

EUD — **Equivalent Uniform Dose**
One uniform dose with approximately equivalent biological effect.

TCP — **Tumor Control Probability**
Modelled probability of tumor control.

NTCP — **Normal Tissue Complication Probability**
Modelled probability of a specified normal-tissue complication.

MODEL BASIS

LKB model: n (volume effect), m (slope), TD50 (dose for 50% complication probability).

Linear-quadratic cell survival: $SF = \exp[-(\alpha D + \beta D^2)]$; α/β reflects fraction-size sensitivity.

EUD, TCP and NTCP are model-based estimates, not observed clinical outcomes.

Heart and ipsilateral lung: key dose parameters

Mean ± standard deviation; paired comparison of 3DCRT and IMRT plans.

Parameter	3DCRT	IMRT	p-value
Heart Dmean (Gy)	2.43 ± 0.63	4.31 ± 0.65	<0.0001
Heart V20 (%)	8.66 ± 1.35	3.54 ± 0.66	<0.0001
Heart Dmax (Gy)	40.32 ± 0.69	38.33 ± 0.49	<0.0001
Lung Dmean (Gy)	11.19 ± 0.87	8.79 ± 0.70	<0.0001
Lung V20 (%)	28.20 ± 2.09	22.43 ± 1.90	<0.0001
Lung V5 (%)	68.20 ± 7.39	70.24 ± 7.02	0.4102



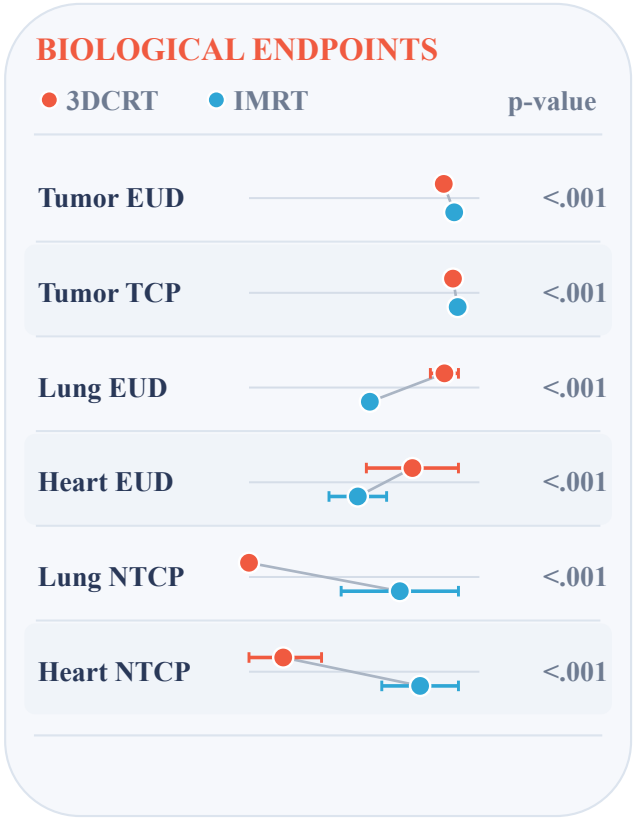
All five significant endpoints above have p < 0.0001.

Radiobiological comparison: EUD, TCP and NTCP

Mean ± standard deviation; reported radiobiological differences were statistically significant ($p < 0.001$).

Endpoint	3DCRT	IMRT	Direction with IMRT
Tumor EUD (Gy)	37.00 ± 0.23	38.98 ± 0.81	Higher
Tumor TCP (%)	95.59 ± 0.45	97.78 ± 0.37	Higher
Lung EUD (Gy)	9.33 ± 0.67	5.77 ± 0.30	Lower
Heart EUD (Gy)	12.99 ± 3.66	8.65 ± 2.29	Lower
Lung NTCP (%)	0.00 ± 0.00	0.18 ± 0.07	Slightly higher
Heart NTCP (%)	0.25 ± 0.28	1.25 ± 0.28	Higher

Both heart and lung NTCP values remained below 2%.



What the combined findings indicate

IMRT improved several selected endpoints, but the overall pattern is a balance of benefits and trade-offs.

NO SIGNIFICANT DIFFERENCE (p > 0.05)

Parameter	p-value	Finding
Lung V5	0.4102	NS
Spinal cord Dmax	0.3630	NS
Body Dmax	0.1313	NS
Contralateral breast Dmean	0.3884	NS

MAIN CONTRIBUTION

- Same-patient paired comparison of 3DCRT and IMRT.
- Combined DVH-based dosimetry with EUD, TCP and NTCP.
- Evaluated the 40 Gy / 15-fraction schedule and quantified technique trade-offs.

PRACTICAL MESSAGE

Plan selection should consider the full DVH and biological profile - not a single dose metric.

INTERPRETATION AND LIMITS

Heart mean dose and both NTCP estimates were higher with IMRT, although absolute NTCP values were low. Modelled TCP/NTCP should be interpreted as predictions, not verified clinical outcomes.

Study cohort: 30 patients. Clinical follow-up validation was not included in the presented analysis.

CONCLUSION AND NEXT STEPS

M.Phil. findings

KEY CONCLUSION

IMRT improved selected high-dose heart/lung metrics and modelled tumor EUD/TCP, while heart mean dose and NTCP were modestly higher.

FUTURE WORK

Advanced dosimetric and radiobiological evaluation of modern radiotherapy techniques for breast cancer.

01	**Expand cohort**	Increase sample size and evaluate patient subgroups.
02	**Compare techniques**	Extend the analysis to VMAT and other advanced approaches.
03	**Personalize planning**	Study patient-specific target and OAR optimization.
04	**Validate models**	Relate EUD/TCP/NTCP predictions to clinical follow-up.

THANK YOU Questions and discussion

Future work may include larger cohorts and clinical validation.