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ASSESSMENT OF DOSIMETRIC INDICES FOR FIELD-IN-FIELD AND TANGENTIAL WEDGE TECHNIQUES IN INTACT BREAST TREATMENT

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Abstract

The aim of this study is to analyses tangential wedged beam and field in field technique doses using the parameters of homogeneity index, conformity index, coverage index and dose-volume histogram for target volume. The volume of healthy tissues within the irradiated volume investigated on both side lungs and heart doses of left and right beast.

***Material and methods**: 10 patients treated with intact breast cancer. All plans were created/generated: a standard tangential plan with tangential wedges beam compared with Field in Field (FIF) plan. Three indices were used: the dose Homogeneity index (DHI), Conformity index (CI), and Coverage index. Calculation was also measured of bilateral lungs and heart.*

***Results** Dose homogeneity index was significantly lower for FIF in DHI, 0.12 than for the wedges DHI=0.17. all the results of FIF is better than tangential wedges beam.*

***Conclusion**: In this study, the field-in-field method was assessed both clinically and dosimetrically for patients with breast cancer. During the dosimetry analysis we concluded that the FIF approach is a fast and effective technique that may be applied to breast radiation. And concluded that the treatment method of field in field is better than tangential wedged beam.*

INTRODUCTION

External beam radiotherapy (EBRT) is an essential component of local treatment for early-stage breast cancer, particularly following breast-conserving surgery[1]. Numerous randomized clinical trials have demonstrated that breast-conserving surgery followed by irradiation provides survival outcomes equivalent to those of mastectomy, establishing this combined approach as the standard of care. Conventional tangential photon beam irradiation continues to be widely used to treat the intact breast postoperatively, targeting residual microscopic disease and reducing the risk of local recurrence. Anatomically, the breast consists of 15–20 lobes arranged radially, each containing lobules that terminate in alveoli responsible for milk secretion[2]. These drain into lactiferous ducts that converge at the nipple. Fatty and fibrous connective tissues occupy the interlobular spaces, with Cooper's ligaments supporting the glandular tissue and maintaining breast structure[3]. The breast lies atop the pectoralis major muscle,

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separated by the retromammary space, which is a key plane in reconstructive surgery[4]. Lymphatic drainage proceeds primarily through axillary, supraclavicular, and internal mammary lymph node chains. Breast cancer develops when abnormal epithelial cells proliferate uncontrollably, forming malignant tumors capable of invading local structures and spreading through lymphatic or vascular pathways to distant organs. Several biological and metabolic factors influence breast cancer risk. Epidemiological data indicate that higher birth weight is associated with an increased risk of breast cancer later in life, whereas lower birth weights correspond with lower risk[5]. Additionally, metabolic markers such as fasting glucose levels, insulin resistance, and insulin-like growth factors (IGFs) have been implicated in breast carcinogenesis, suggesting an interplay between metabolic dysregulation and tumor initiation[6]. Accurate staging of breast cancer—ranging from Stage 0, or ductal carcinoma in situ, to Stage IV metastatic disease—is essential for determining optimal treatment strategies and prognosis, and is based on tumor size, lymph node involvement, and distant metastasis. Diagnostic evaluation relies on a combination of imaging modalities[7]. Mammography remains the primary screening tool for women over 40 and is also used when assessing suspicious breast findings. Ultrasound assists in differentiating solid masses from cystic lesions, while computed tomography (CT) may be employed to evaluate metastatic spread or to guide deep-seated biopsies when necessary. Treatment approaches for breast cancer integrate surgery, systemic therapy, and radiotherapy. Surgical options include breast-conserving surgery and mastectomy, chosen based on tumor characteristics and patient preferences. Chemotherapy
may be administered after surgery (adjuvant) to eradicate micro metastatic disease or before surgery (neoadjuvant) to shrink tumors, improve respectability, and provide real-time insight into tumor responsiveness. Neoadjuvant therapy is particularly beneficial in cases of large tumors, multiple lymph node involvement, or aggressive subtypes such as triple-negative or HER2- positive disease. EBRT plays a pivotal role by delivering high-energy photons from a linear accelerator, enabling precise targeting of residual tumor cells while minimizing exposure to adjacent healthy tissues. Modern radiotherapy techniques such as three-dimensional conformal radiotherapy (3D-CRT) and intensity-modulated radiotherapy (IMRT) enhance dose conformity and reduce treatment-related toxicity. CT-based imaging is central to the treatment planning process, allowing detailed delineation of target volumes and organs at risk, complemented by tools such as beam's-eye-view (BEV) visualization and digitally reconstructed radiographs (DRRs)[8]. Dosimetric evaluation using dose–volume histograms (DVHs) provides quantitative assessment of dose distribution within the target and surrounding tissues[9]. Quality assessment of radiotherapy plans commonly involves metrics such as the Homogeneity Index (HI), which measures uniformity of dose within the target volume, the Conformity Index (CI), which evaluates how closely the prescribed isodose volume matches the target, and the Coverage Factor (CF), which assesses the adequacy of minimum dose delivered to the target[10]. These indices are critical for optimizing treatment plans to achieve therapeutic effectiveness while minimizing complications. Collectively, advancements in imaging, treatment planning, and delivery techniques have significantly improved the precision and safety of radiotherapy, reinforcing its vital role in the comprehensive management of breast cancer[11, 12].

Materials and Methods

DATA STATISTICS

A total of 10 patients with intact breast cancer. All the patients are with different ages, different stages and grades. Their organ of tumor is same with breast (Malignant Neoplasm). They all are with different sides of Breast Cancer and they all are intact breast. Where they all are treated with 2 Gy**.** All cases were diagnosed as malignant breast neoplasms and treated with a prescribed dose of 2 Gy per fraction. The patients' ages ranged from 20 to 61 years. Disease stages varied from Stage I to Stage III, with tumor grades predominantly Grade 2 and Grade 3.

Treatment planning

In this study, we tailoring available radiotherapy resources to meet each patient's specific clinical needs, based on a comprehensive multidimensional assessment. Cancer cell proliferation (Fig.1).

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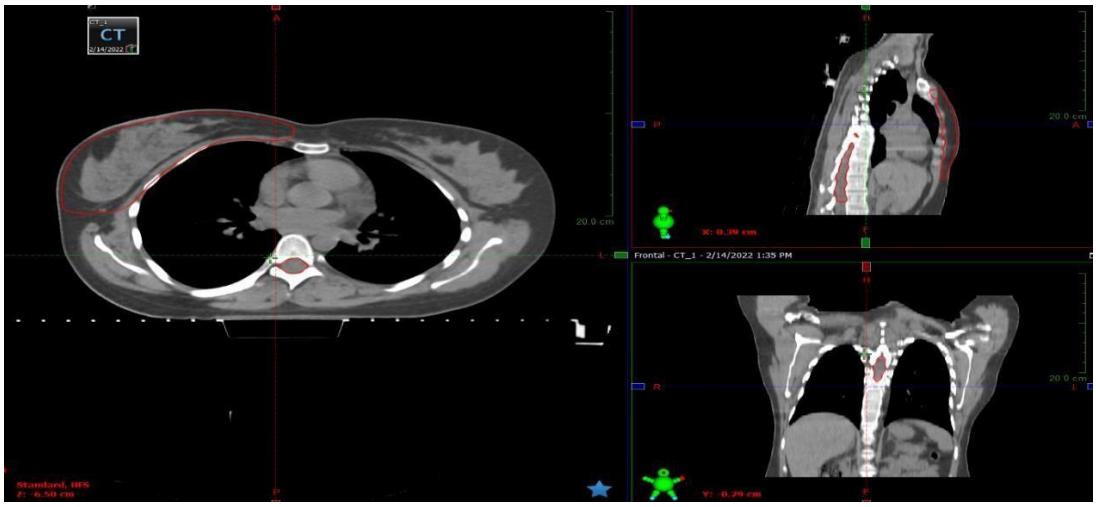


Figure 1. CT-based treatment planning for breast radiotherapy showing axial, sagittal and coronal views used for target delineation and dose planning.

Field-in-Field(FIF) Technique

Three female patients with intact breast cancer undergoing pre-surgical radiotherapy were included. Patients were immobilized in the supine position with arms elevated using a thermoplastic system, followed by CT simulation on a 64-slice Philips scanner with 3-mm slices. CT datasets were transferred via DICOM to the TIGRT TPS, where the radiation oncologist contoured GTV, PTV, and OARs according to ICRU guidelines. FIF planning was performed using Varian TPS at INMOL Hospital, Lahore (Fig. 2).

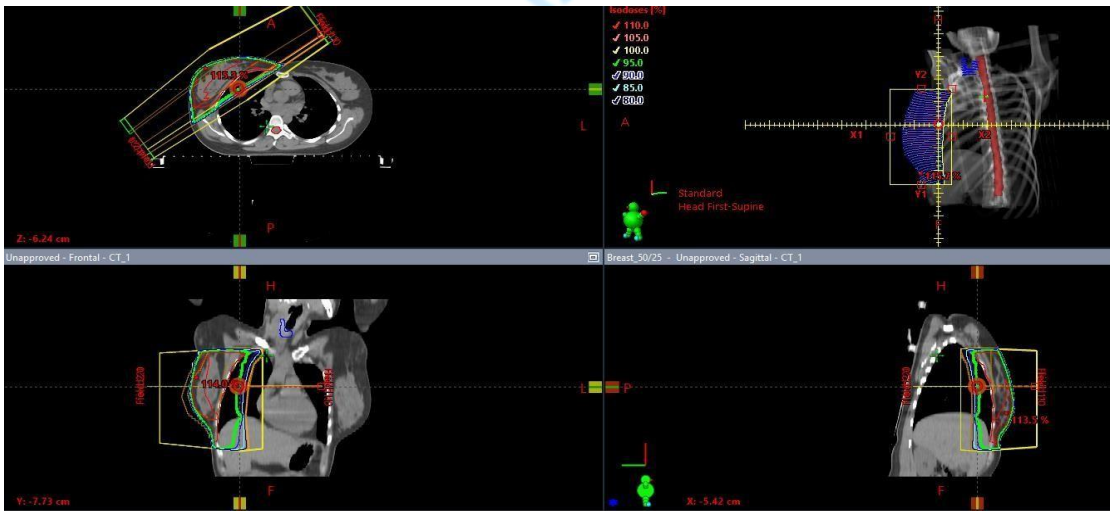


Figure 2. Field-in-Field (FIF) radiotherapy treatment planning workflow.

Wedges

Wedges are widely used across treatment sites, although less common in breast radiotherapy. Varian's Enhanced Dynamic Wedge (EDW) provides wedge angles from 10°–60° by dynamically moving a collimator jaw during beam-on. Asymmetric fields can

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be created by shifting the Y1 jaw, enabling optimized dose distribution. Dosimetric measurements for 6 and 15 MV beams were validated using ionization chambers and Kodak films.

Registration

Cancer registries systematically record cases within defined populations to track disease patterns, monitor trends, support cancer control programs, and provide data for epidemiologic and clinical research. Hospital-based registries collect patient data within a single institution, while special registries focus on specific tumor types.

RT Plan

Treatment planning involves identifying the tumor and OARs, designing beam geometry, and evaluating dose distribution. RT Plan information, stored using DICOM-RT standards, integrates structure sets, dose, beam parameters, and treatment prescriptions on CT images, enabling accurate visualization and execution of therapy (Fig. 3).

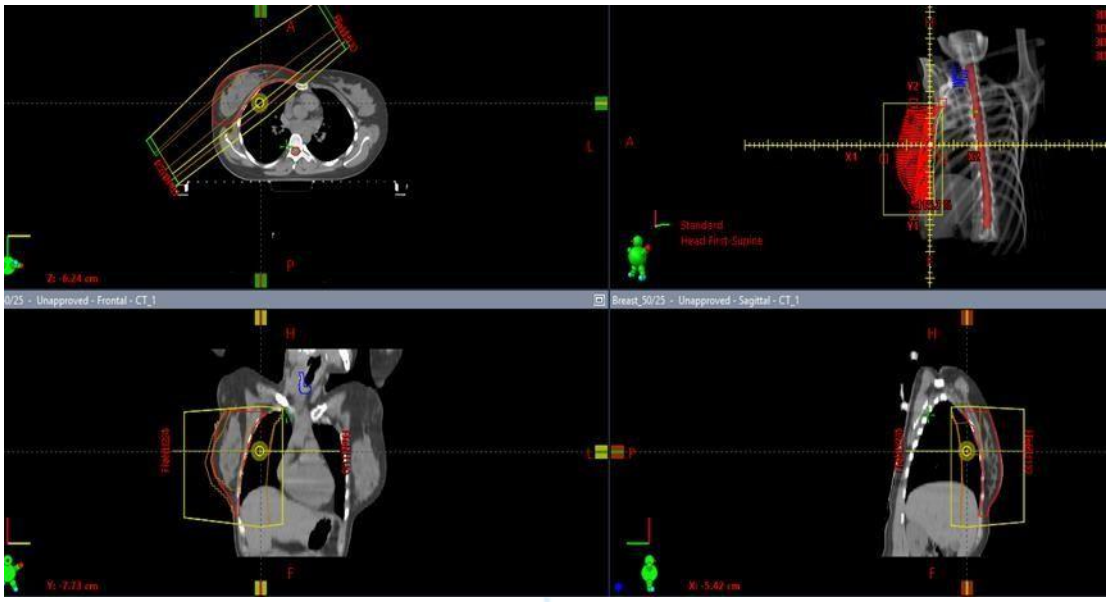


Figure 3. Field-in-Field (FIF) treatment planning technique illustrating beam geometry, subfield creation, and improvement in dose homogeneity.

CT Simulation

CT simulation allows virtual modeling and verification of treatment using 3D CT datasets. Modern systems integrate virtual simulation, DRR generation, and laser guidance to reproduce patient positioning and beam geometry.

Contouring

In this study, Patients with recurrent nodal relapse after curative breast cancer treatment underwent PET/CT for staging. Contouring excluded patients with microscopic disease at planning or prior RNR treatment. Clinical, tumor, and outcome data were obtained from institutional cancer databases.

Before simulation, temporary field borders are marked on the breast or chest wall using anatomical landmarks, supported by radiolucent catheters to aid tangential beam placement. CT images at 1- cm intervals capture the thoracic region in treatment position. Physicians identify glandular breast tissue, IMN regions, and major vessels to refine final PTV and OAR contours, ensuring accurate tangential field design (Fig 4).

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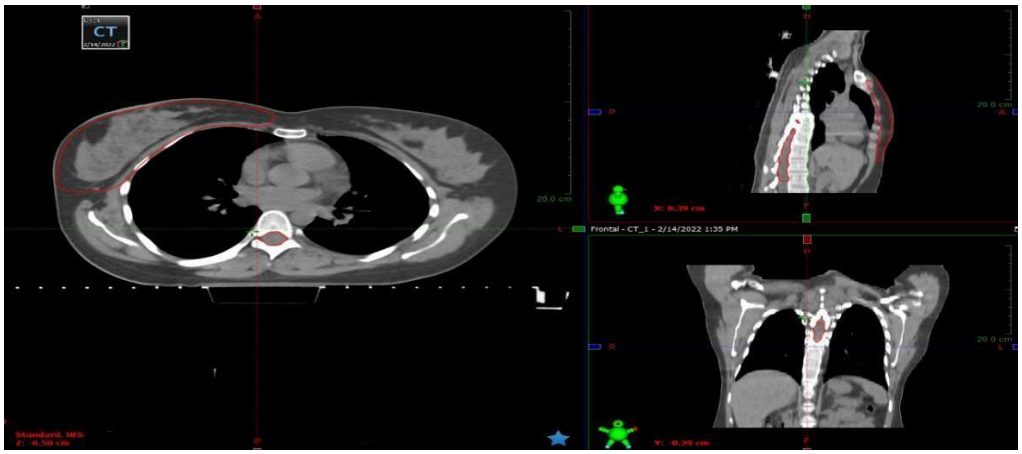


Figure 4. Delineation of target volume and organs at risk (OARs) on planning CT images.

Results and Discussion

We evaluated the quantifying dose homogeneity by the drawing plan of different patients. This is a ratio between the maximum doses in the target volume the reference isodose. The goal of irradiation therapy delivery is to deliver 100% of the recommended dose to the treatment area in a uniform manner.

The value of homogeneity index was calculated for different patients by the comparison of field in field and wedges. Following are the results of homogeneity index.

$$DHI = \frac{D5\% - D95\%}{DP} \quad \text{Equation (1)}$$

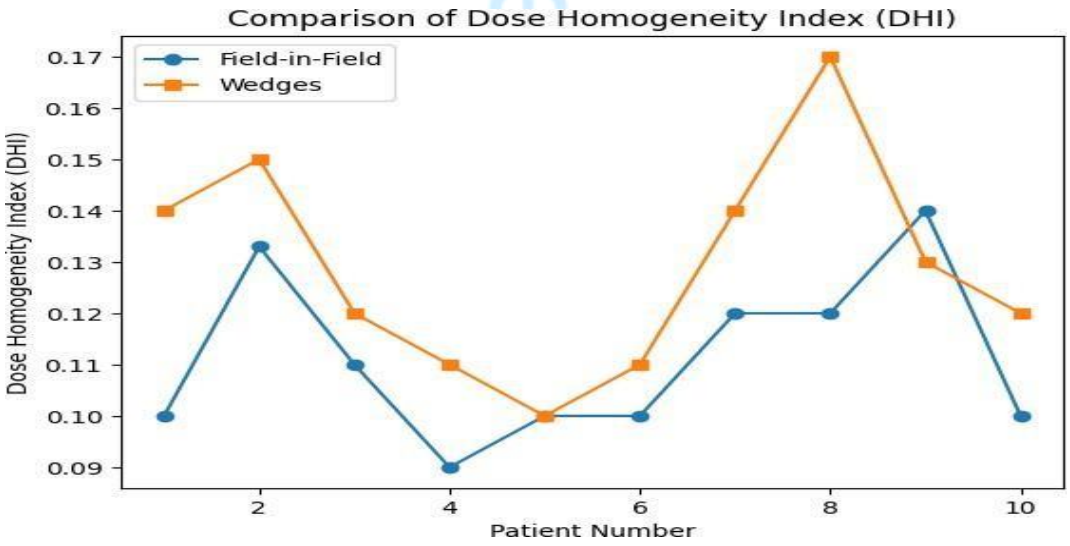


Figure 5. Patient-wise variation of dose homogeneity index (DHI) for Field-in-Field (FIF) and Wedge techniques.

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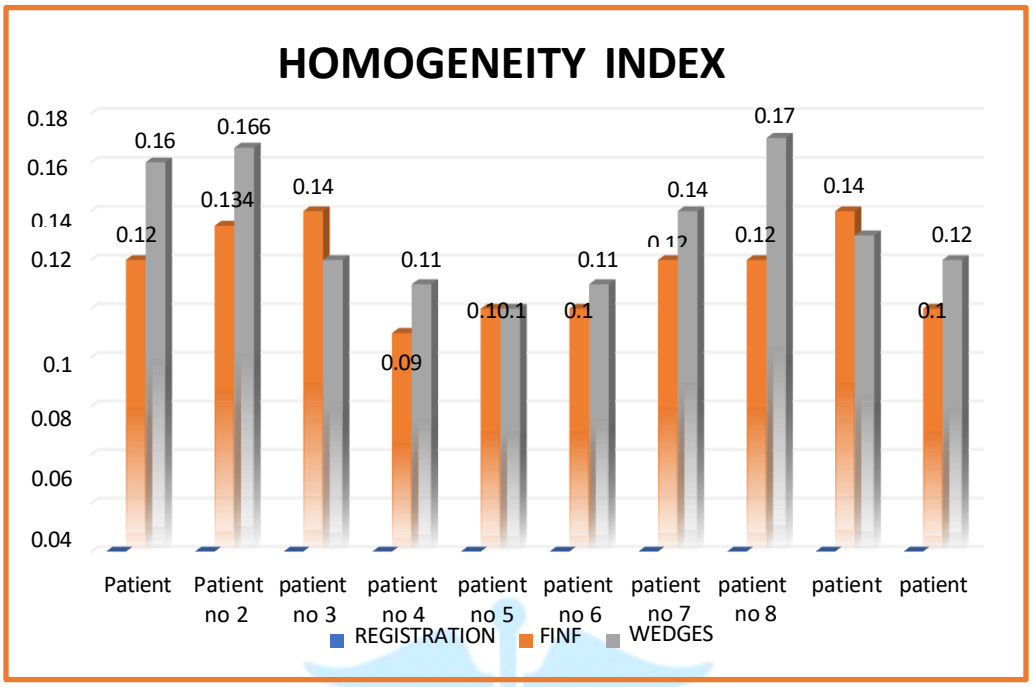


Figure 6. Patient-wise comparison of homogeneity index (HI) values for Field-in-Field (FIF) and Wedge radiotherapy techniques.

We investigated the conformity index of one indicates that the (PTV) is well covered and that unnecessary irradiation is kept to a minimum. After the planning treatment done I noted my result value of conformity index, its correct value is close to one and I have write my values by the calculation of reference isodose volume and target volume.

$$CI = \frac{VRI}{TV} \quad \text{(Equation 2)}$$

Conformity index RTOG= VRI / TV

VRI= REFERENCE ISODOSE VOLUME, TV = TARGET volume

Table 1: Readings of conformity index

No of Patient	Field in field	Wedges
Patient no 1	CI = 1.37	CI = 1.52
Patient no 2	CI = 1.03	CI = 1.41
Patient no 3	CI = 1.17	CI = 1.44
Patient no 4	CI = 1.34	CI = 1.35
Patient no 5	CI = 1.36	CI = 1.47

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Patient no 6	CI = 1.15	CI = 1.20
Patient no 7	CI = 1.34	CI = 1.39
Patient no 8	CI = 1.24	CI = 1.41
Patient no 9	CI = 1.13	CI = 1.40
Patient no 10	CI = 1.18	CI = 1.22

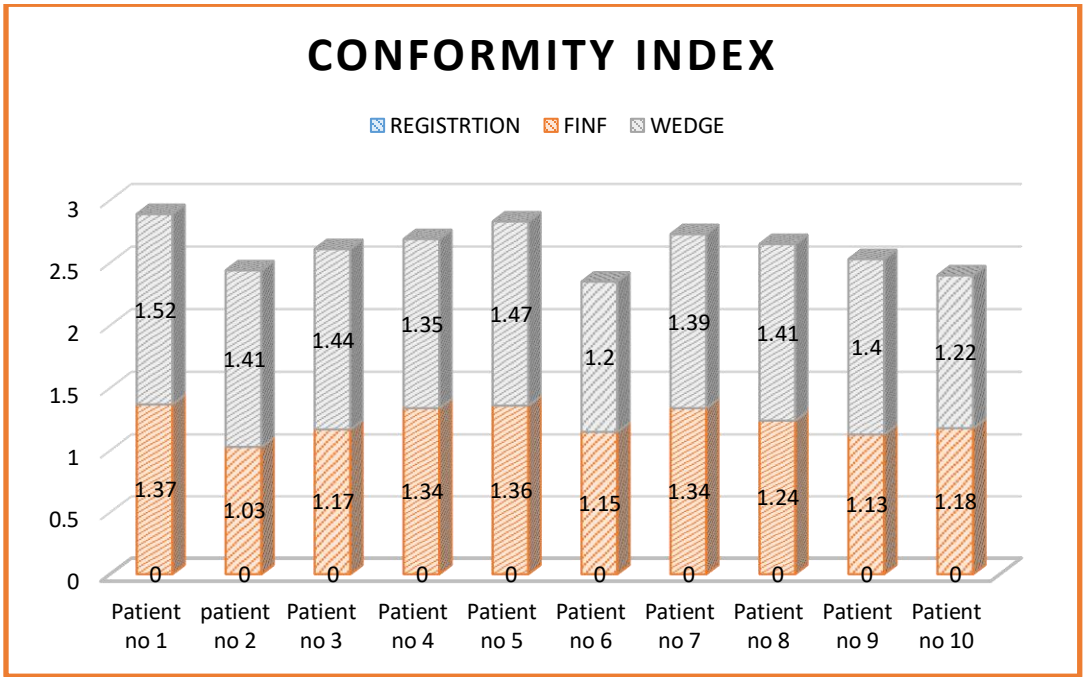


Figure 7. Bar chart showing patient-wise conformity index (CI) comparison between Field-in-Field (FIF) and Wedge techniques.

We calculated the Coverage index (ratio of minimum dose within target volume to prescribed dose). Prescribed dose PD is minimum dose to tumor volume. If target volume is completely covered by 90% of prescription Iso-dose, then plan is considered per Protocol. after the planning treatment done, we observed that calculated value of coverage index was close to one and I have done my calculation by the calculation of ratio of minimum dose divided by prescribed dose.

$$Coverage = \frac{\boldsymbol{Dmin}}{\boldsymbol{DP}}$$

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The coverage index values for both Field-in-Field and Wedge techniques were evaluated for all patients to assess dose coverage uniformity. For Patients 1 to 3,

lower coverage index values were observed, ranging from 0.70 to 0.87 for the Field-in-Field technique and from 0.73 to 0.84 for the Wedge technique. In contrast, Patients 4 to 6 demonstrated higher coverage index values, exceeding 1.25 for both techniques, indicating improved target coverage. Comparable values were observed for Patient 7 using both

techniques (0.80). For Patients 8 and 9, the Wedge technique
showed slightly higher coverage index values compared to the Field-in-Field technique. Overall, both techniques provided similar coverage performance, with marginally higher coverage indices observed for the Wedge technique in some cases.

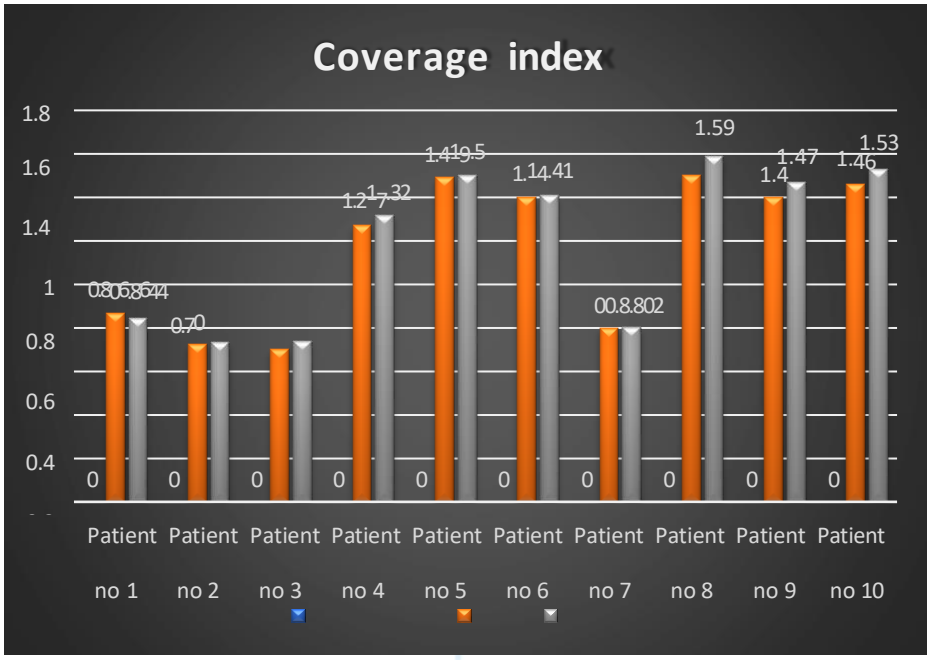


Figure 8. Patient-wise comparison of coverage index (CI) values for Field-in-Field (FiF) and Wedge radiotherapy techniques.

The most effective plan of any cancer patient is that when their dose distributed all area of tumor and does not bad effect on other OARs like heart, lungs, bilateral breast e.tc. Ideal and good plan is done when the dose distribution is up to 95% area of effective organ when dose is distributed on 100% area then its excellent plan. In this image dose area is clearly mentioned green line is dose line and my dose is cover 98% area of tumor. All these indices are used to assess the patient dose between the TV. However, even if the dose dispersion is not comparable, the (CI) may be the same in some cases. In this case, the healthy organs dosages the key point is distribution the distinguishes the plans.

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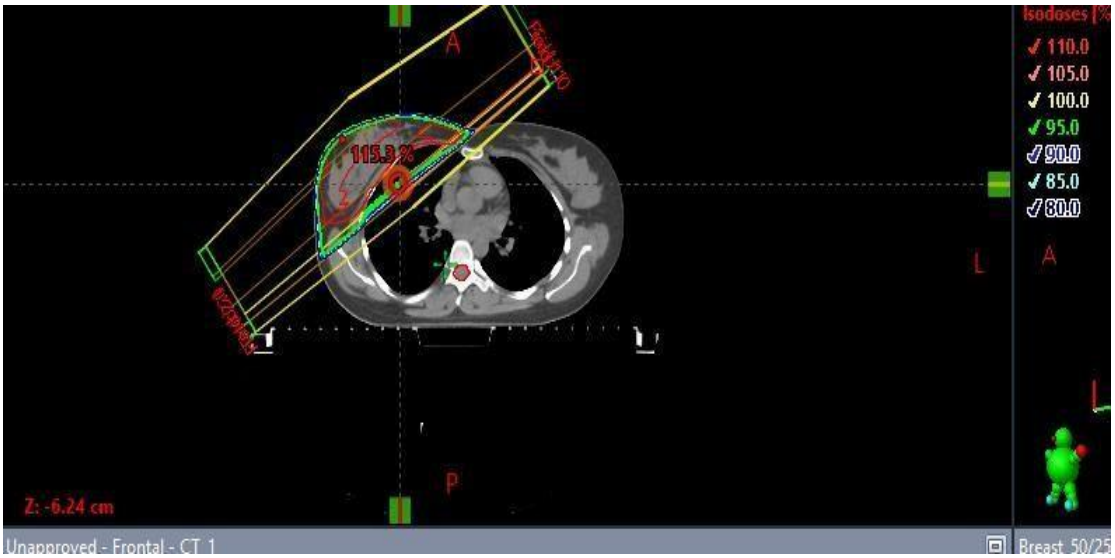


Figure 9. Isodose distribution overlaid on an axial CT image illustrating dose coverage of the target volume and sparing of surrounding organs at risk in tangential breast radiotherapy.

Table 2. Dosimetric comparison between Field-in-Field (FiF) and Wedge plans

Parameter	FiF plans (Mean ± SD)	Wedge plans (Mean ± SD)	p- value
Dose Homogeneity Index (DHI)	0.111 ± 0.015	0.128 ± 0.017	0.002
Conformity Index (CI)	1.23 ± 0.11	1.38 ± 0.14	0.001
Coverage Index	1.42 ± 0.21	1.48 ± 0.19	0.084

The dosimetric comparison between the Field-in-Field (FIF) and Wedges techniques was performed by evaluating doses to organs at risk (OARs), including the left lung, right lung, and heart. All evaluated dose parameters were found to be within clinically acceptable limits for both techniques. For the Field-in-Field technique, the mean dose to the left lung (30%) was 3.81 Gy, while the median dose was 0.21 Gy, indicating that the majority of patients received relatively low lung doses, with a few higher values contributing to the overall mean. The right lung (30%) showed a mean dose of 6.91 Gy with a median of 8.90 Gy, representing moderate dose exposure. The mean heart dose was 2.69 Gy, with a median of 1.02

Gy, reflecting effective cardiac sparing in most patients.

In contrast, the Wedges technique resulted in higher dose values. The mean dose to the left lung (30%) was 5.04 Gy, with a median of 1.17 Gy, while the right lung (30%) received a mean dose of 8.42 Gy and a median of 10.83 Gy. The mean heart dose for the

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wedges technique was 4.93 Gy, with a median of 2.37 Gy, indicating increased cardiac exposure compared to the Field-in-Field technique. Overall, both mean and median values consistently demonstrated that the Field-in-Field technique delivered lower doses to all evaluated organs at risk compared to the wedges technique.

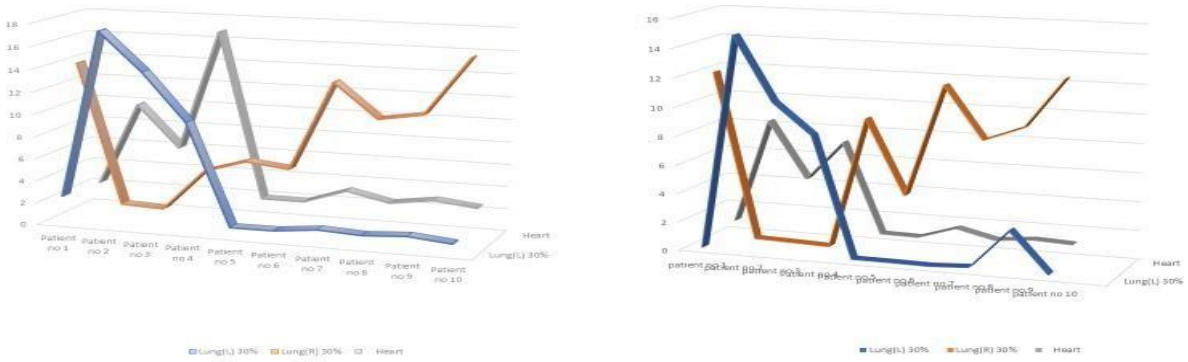


Figure 18 (a) Wedges readings OARs (b) OARs values of field in field

Conclusion

This study presents a dosimetric and clinical comparison of the Field-in-Field (FiF) and tangential wedge techniques for intact breast radiotherapy. The results showed that the FiF technique achieved a more homogeneous dose distribution within the target volume while reducing dose exposure to surrounding normal tissues compared to the wedge technique. Improved sparing of organs at risk, particularly the heart and contralateral breast, was observed with the FiF approach due to reduced dose spread outside the target volume. In contrast, tangential wedge plans exhibited higher dose dispersion and increased exposure to healthy tissues. Overall, the findings indicate that the Field-in-Field technique is an effective and practical treatment approach that provides superior dose homogeneity and better normal tissue protection, making it a favorable option for whole-breast radiotherapy. In the field in field plan as opposed to the tangential wedge plan, the dose distribution inside the target volume was more uniform & the doses for healthy tissue were lower. The absence of the spread-out dosage, which was more pronounced in the wedge plan and resulted in less doses to the contralateral breasts, was another advantage of the FIF plan. In comparison to inverse-planned IMRT utilizing five or nine fields, field in field resulted in a lower mean heart & contralateral breast dose with similar HI of the whole-breast PTV.

FIF is a very effective plan for treatment for tumor as compare to the wedges.

hotspot of treatment plan and OARs. Noted the heart dose lungs dose and bilateral breast and reduce the chance of effected dose.

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