SciMedCentral

Journal of Radiology & Radiation therapy

Research Article

Angled Field-in-Field as a New Advanced Radiotherapy Treatment Planning Form of the Field-in-Field Technique. A Dosimertic and Treatment Planning Study

Sabbah Ibrahiem Hammoury*

Department of Oncology, Alexandria Ayadi Almostakbl Oncology Center, Egypt

***Corresponding author**

Sabbah Ibrahiem Hammoury, Department of Oncology, Alexandria Ayadi Almostakbl Oncology Center- Acacia Street- Alexandria, Egypt, Tel: 002-01000001156; Email: sabbah_ibrahiem@yahoo.com

Submitted: 06 October 2014

Accepted: 02 June 2015

Published: 04 June 2015

ISSN: 2333-7095

Keywords

- Radiotherapy
- Angled Field-in-Field (AFIF)
- Linear accelerator
- Treatment planning system TPS
- IMRT

Abstract

Introduction: Field-In-Field (FIF) is a manually based forward Intensity-Modulated Radiation Therapy (IMRT) plan for which the calculated dose is modified in certain dose distribution areas by creating multiple lower-weighted reduction fields based on the primary field. The most common used form of FIF is the non-angled FIF, but if the inner subfield(s) is/are set at a different gantry angles from the major one, we will get a different design of the FIF technique, which is the angled FIF technique.

Aim: The purpose of this study was to study the Angled Field-In-Field technique - as a new advanced form of FIF technique - and its related isodose lines shapes.

Method: Using TPS and on the 2D-Array, a simple form of Non-Angled FIF (NAFIF) plan consists of 7×7cm^2 field entire another larger 15×15cm^2 field as a main field is designed on TPS. The two fields were set at the zero gantry position. Other FIF plan forms are designed in which the smaller inner field is set to (5°, 10°, 15°, 20° and 25°) gantry angles while the main field is fixed at zero gantry angle. The all FIF plans were verified using the 2-Dimintional Ionization Chamber Array (2D-Array) and its related Verisoft software. The Angled FIF, wedged and open fields were compared for studying their related isodose lines different shapes.

Results: The results showed that the Angled Field-In-Field technique can be used as anew advanced technique for the radiotherapy and it has a new shape of isodose lines which is a stair shape.

Future work: We predict that a Multiple-Angled Field-In-Field technique in which, the inner fields can be set at different angles in the same or reverse direction of the main angled field. This design has unknown isodose shape, but we predict that it can result in a **semi-sloped stair shape,** so it needs more study.

ABBREVIATIONS

FIF: Field-In-Field; IMRT: Intensity-Modulated Radiation Therapy; NAFIF: Non-Angled Field-In-Field; 2D-Array: 2-Dimintional Ionization Chamber Array; CRT: Conformal Radiation Therapy; 3-D CRT: Three-Dimensional Conformal Radiation Therapy; CT: Computed Tomography; RTPS: Radiation; TPS: Treatment Planning Systems; DRRs: Digitally Reconstructed Radiographs; DVHs: Dose Volume Histograms; MLCs: Multi-Leaf Collimators; PTV: Planning Target Volume; AFIF: Angled Field-In-Field technique; Linac: Linear Accelerator; DICOM: Digital Imaging and Communications in Medicine System; SSD: Source to Surface Distance; CMS: Computerized Medical Systems; XiO : Name of Three Dimensions Treatment Planning System; MAFIF: Multiple Angled FIF Technique

INTRODUCTION

Three-Dimensional Conformal Radiation Therapy (3D-CRT)

Three-dimensional (3D) conformal radiation therapy has been demonstrated to improve tumor targeting and to reduce normal tissue volume exposed in several malignancies [1]. The ideas of three-dimensionality, beam shaping, and irradiation of tumours through multiple fields from different beam angles to reduce the dose to normal tissues have always been present in radiotherapy practice. When the appropriate technology to deliver 3-D CRT, such as Computed Tomography (CT) simulators, radiation treatment planning systems (RTPS) capable of performing three dimensional dose calculations, producing digitally reconstructed radiographs (DRRs) and DVHs, and beam shaping devices such as multi-leaf collimators (MLCs) became available, this way of planning and delivering radiotherapy soon gained popularity [2,3].

Field-In-Field technique

Field-in-field planning, another technique used to generate the effect of intensity-modulated fields but based on forward treatment planning (Figure 1). It is used extensively at M. D. Anderson Cancer Center for planning radiation treatments of the breast [4,5].

3D-CRT planning software helps in displaying the 3D dose distribution at different levels in the planned target volume (PTV). Physical or dynamic wedges are commonly applied to obtain homogeneous dose distribution in the PTV. Despite all these planning efforts, there are about 10% increased dose hot spots encountered in final plans. To overcome the effect of formation of hot spots, a manual forward planning method has been used [6,7]. In this method, one or two more beams with multi-leaf collimator (MLC) of different weights are added in addition to the main used beams in the major plan and sometimes; when we use the FIF technique, we can dispense the physical and dynamic wedges.

Non-Angled Field-In-Field technique (NAFIF)

It consists of a main field and a smaller field inside the main one. The smaller field is set at the same gantry angle of the main field. This can give the standard definition of the known and usually used FIF technique.

Angled Field-In-Field technique (AFIF)

It has the same design as the NAFIF technique but the smaller field will be set at a different gantry angle from the main field.

MATERIALS AND METHODS

Phantom setup, CT scanning and preparation within TPS

For the field-related verification process, no special phantom was necessary; the 2-Diminsional Ionization Chamber Array (2D-Array) was impeded between two blocks from solid slab phantom slices. One block of 5cm thickness was put under the 2D-Array for backscattering and the second one of 4.5cm thickness was put above the 2D-Array surface where the chambers of 2D-Array arranged in the device at one plane under the surface by 0.5 cm. Therefore, the depth above the chambers was 5 cm. The 2D-Array device with the blocks was put on the Linac-couch and adjusted where the chamber at the center of the device at isocenter (at 100 cm from the radiation source) [8-10] (see Figure 2). The phantom arrangement was CT scanned then in exactly the same way as it was later used for the verification measurements. To achieve an adequate spatial resolution during the following verification dose calculations, it was essential to scan the phantom with a sufficiently small slice thickness. We have scanned the phantom with a slice thickness of 2 mm. The scanned phantom was imported via a Digital Imaging and Communications in Medicine system (DICOM) to TPS. Directly after import, it was convenient to define a user origin within TPS exactly at the effective measuring point of the central ion chamber of the array.

Treatment Planning Procedures

Open Field procedures (on the TPS):

- The following steps were done respictively;

1) On the 2D-Array phantom, we designed a field with size of 15x15cm^2 at zero gantry and Source to Surface Distance (SSD) =94.8 position as it is shown at the next Figure (3).
2) Dose distribution was calculated by the TPS.
3) The total plan was sent to the VeriSoft to be verified.

Field-In-Field procedures

We can use different arrangements of FIF to deal with the patient treatment planning like; (15,7) field, which means that beam a 15x15 cm^2 square field will be opened as a major one and another smaller (or minor) field will be set inside that the major one. Other different arrangements like: (20,5) , (20,10), ….., (40,20), ….. . In this study we chose the (15,7) as an example of FIF (Figure 4).

Non-Angled Field-In-Field (NAFIF) procedures (on the TPS):

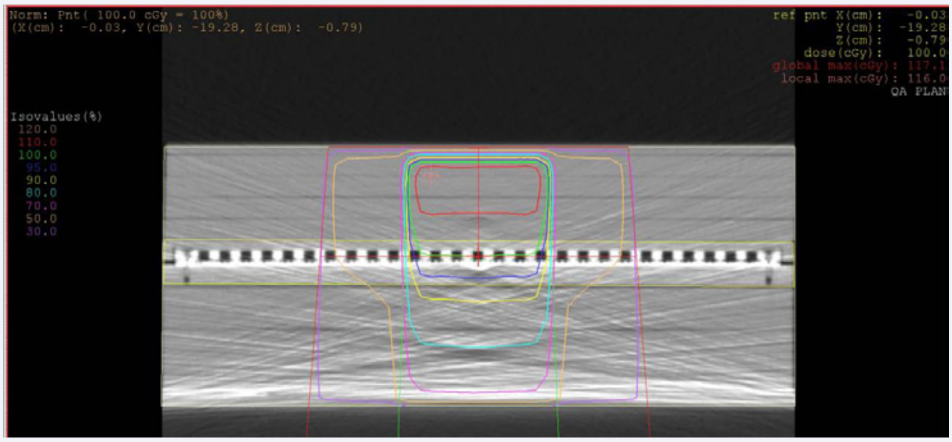


Figure 1 Shows an example of the isodose lines of the FIF technique for a 7x7cm^2 field which is set entire a 15x15cm^2 field at the zero angle position.

Figure 2 For the field-related verification the 2DARRAY was simply located between RW3 plates. 5 cm RW3 material were below and 4.5 cm above the 2D-Array.

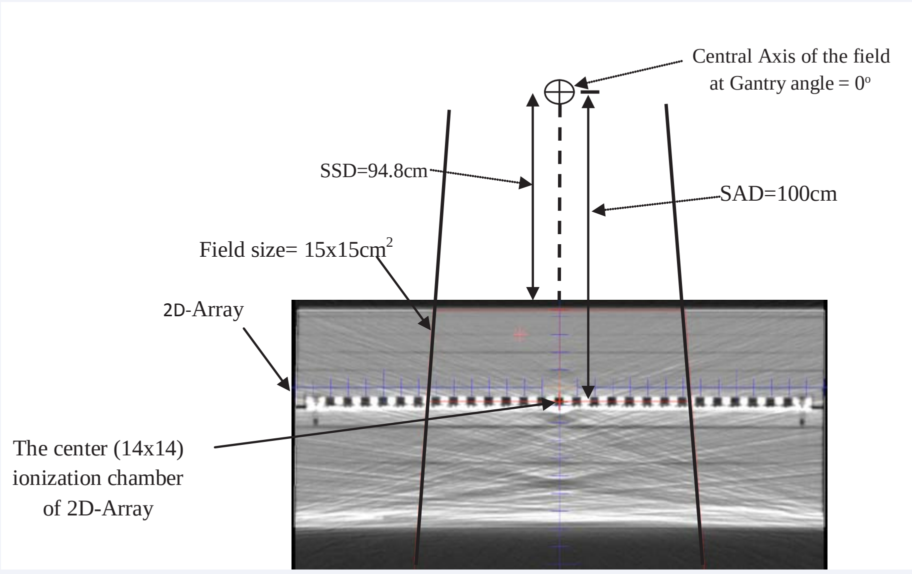


Figure 3 The 2D-Array setup where an open 15x15cm² field was applied at zero gantry position.

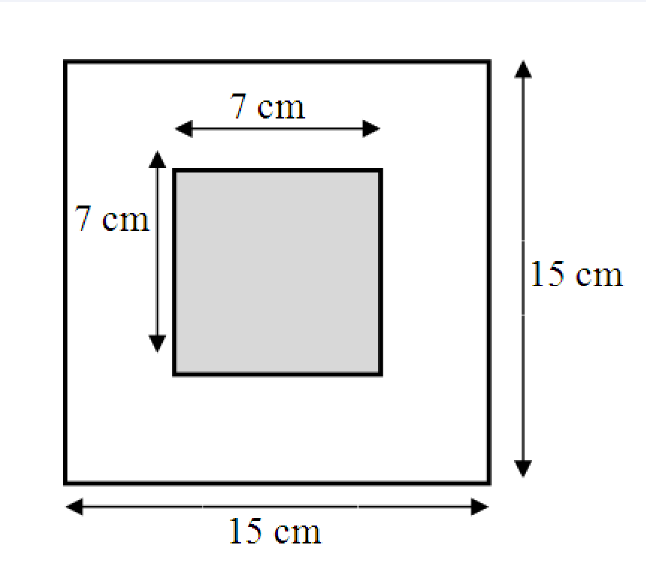


Figure 4 Shows an example of Field-In-Field technique. The darken area is the smaller 7x7cm² beam opened inside the larger 15x15cm² one.

- The following steps were done respictively;

1) On 2D-Array phantom, we designed a field of size 15x15cm^2 at zero gantry position, another smaller field of size 7x7cm^2 was designed intire the larger one at the same gantry position as it is shown at the next Figure 5.

2) The dose distribution was calculated by the TPS.

3) The total plan was sent to the VeriSoft to verify the application of this beam on the treatment machine (the Linac).

Angled Field-In-Field (NAFIF) procedures (on the TPS):

- All previous procedures of section 2.2.4 were repeated at (5°, 10°, 15°, 20° and 25°) gantry angles as follows in the next Figures 6-10.

Wedged Field procedures (on the TPS):

- The following steps were done respictively;

1) Using the TPS, a 15x15cm^2 treatment field is designed on the 2D-Array phantom.

2) A wedge of angle 15° is applied to this field as it was shown at the next Figure (11).

3) Then the dose distribution was calculated by the TPS.

4) The total plan was sent to the VeriSoft to be verified.

5) All the previous four steps were repeated but at (30°, 45°, 60°) wedge angles as follows in the next figures 12-14.

Dosimetric Verification of FIF technique using the two-Dimensional Ionization Array (2D-Array) and The Analysis

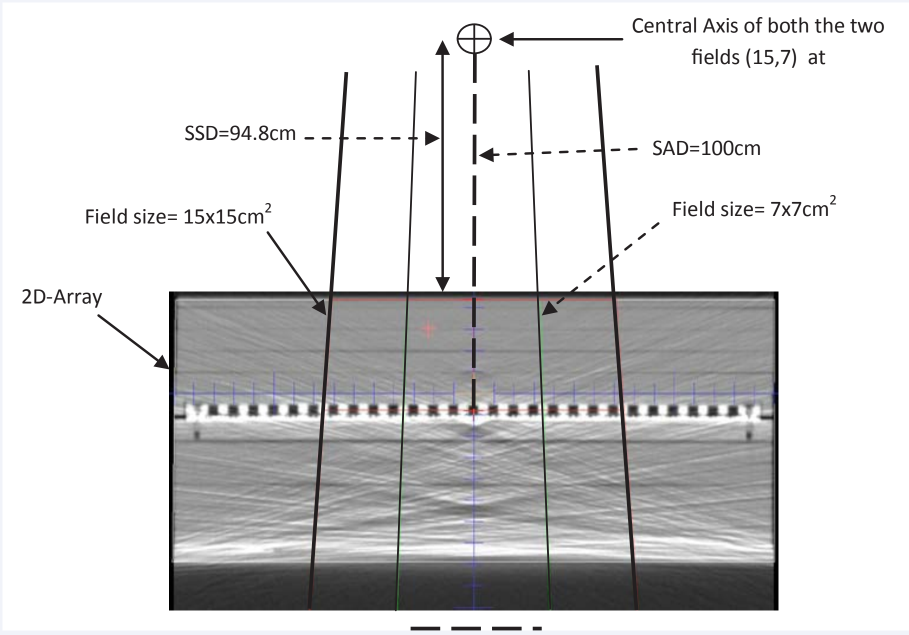


Figure 5 Shows the 2D-Array setup where a 7x7cm^2 field was applied inside a 15x15cm^2 field at the zero gantry position.

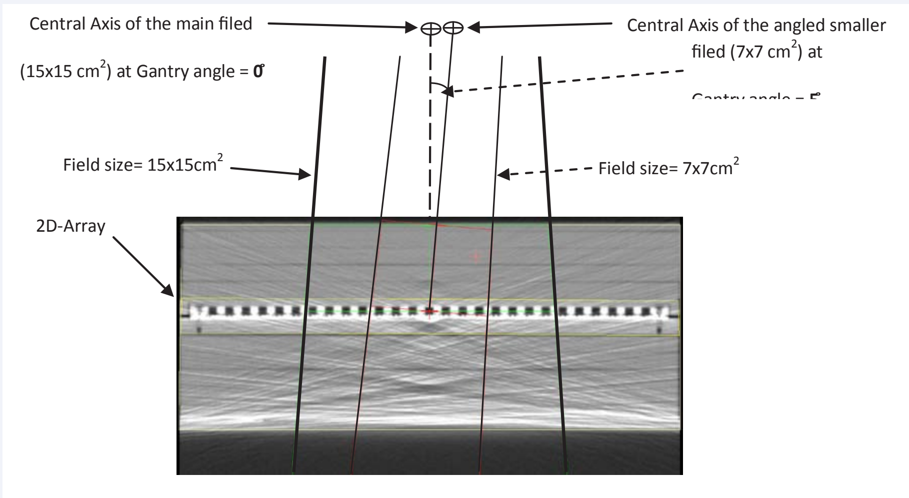


Figure 6 Shows the 2D-Array setup where a 7x7cm^2 field with gantry angle=5° was applied inside a 15x15cm^2 field with gantry angle=0°.

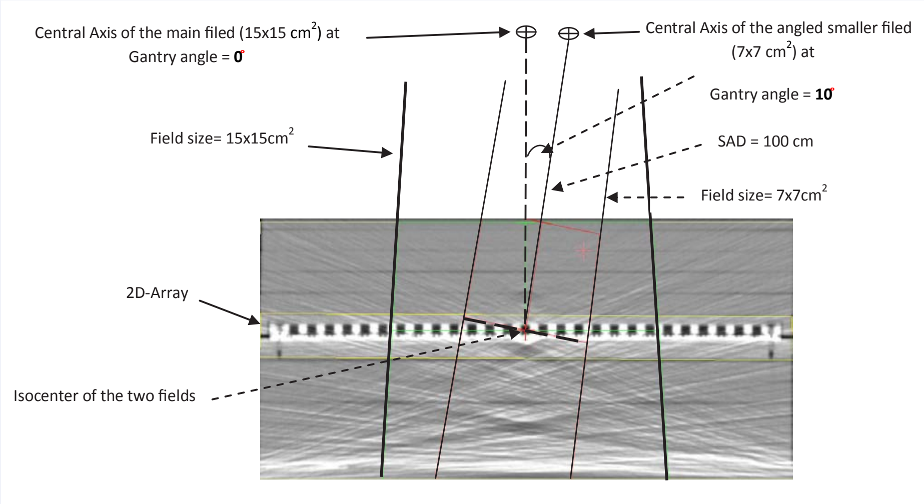


Figure 7 Shows the 2D-Array setup where a 7x7cm² field with gantry angle=10° was applied inside a 15x15cm² field with gantry angle=0°.

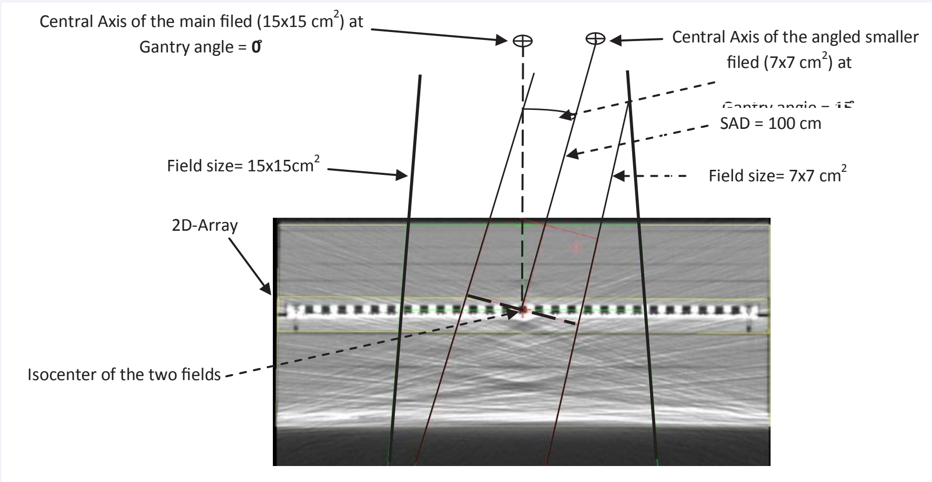


Figure 8 Shows the 2D-Array setup where a 7x7cm² field with gantry angle=15° was applied inside a 15x15cm² field with gantry angle=0°.

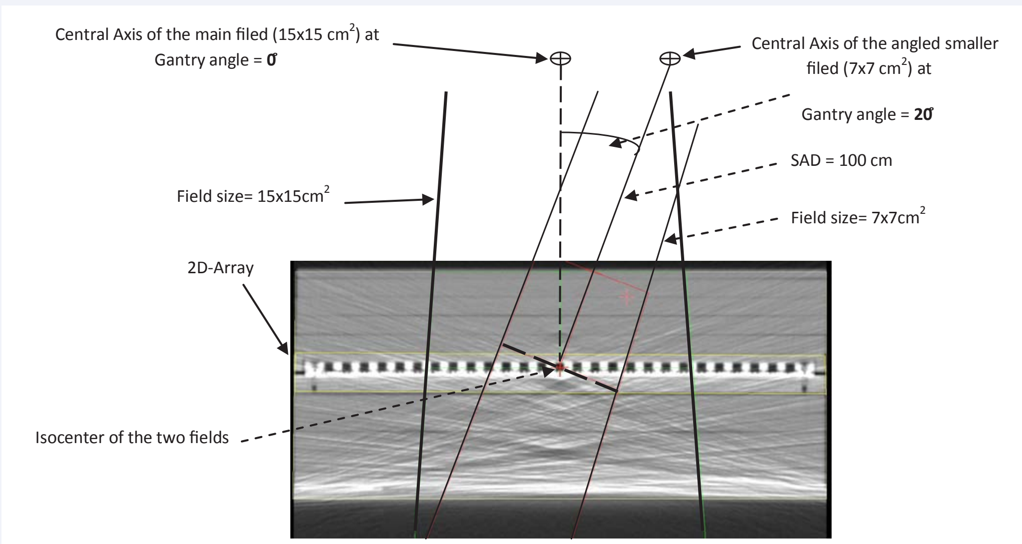


Figure 9 Shows the 2D-Array setup where a 7x7cm² field with gantry angle=20° was applied inside a 15x15cm² field with gantry angle=0°.

Email: sabbah_ibrahiem@yahoo.com

Software "VeriSoft": To be ensured that the FIF fields are valid on the treatment machine during the treatment of the real patient, we made a dosimetric verification of it using the 2D-Array seven29 solid phantom. We performed a treatment planning with FIF for three different cases with three different tumor sites (Breast, Prostate and Brain). The 2D-Array in combination with the VeriSoft analysis software was used as a dosimetric verification tool of clinical FIF fields. For this purpose, the CMS (Xio 4.6.2) was used, which has the ability of performing a FIF plan and SIEMENS ARTISTE Clinac accelerator, which is equipped with dynamic multileaf collimator.

Verification of Angled Field-In-Field planning technique: Using TPS, five angled FIF plans were performed. Each plan contained a large field 15x15cm^2 and a smaller field 7x7cm^2 where the smaller field was inside the larger one and the samller field was set at a different gantry angle for every plan. The five gantry angles used are; (5°, 10°, 15°, 20° and 25°). The dose profiles of plans were sent separately to the VeriSoft to be compared with that measured by the 2D-Array.

RESULTS AND DISCUSSION

Results

Field-in-field is a new technique enables us to generate the same or better effect of intensity-modulated fields. Additionally,

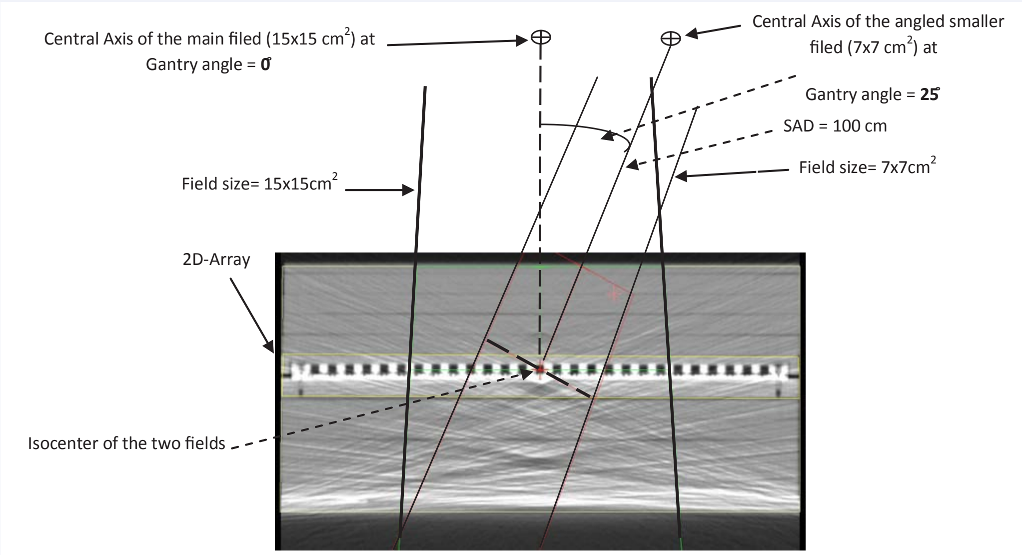


Figure 10 Shows the 2D-Array setup where a 7x7cm^2 field with gantry angle=25° was applied inside a 15x15cm^2 field with gantry angle=0° .

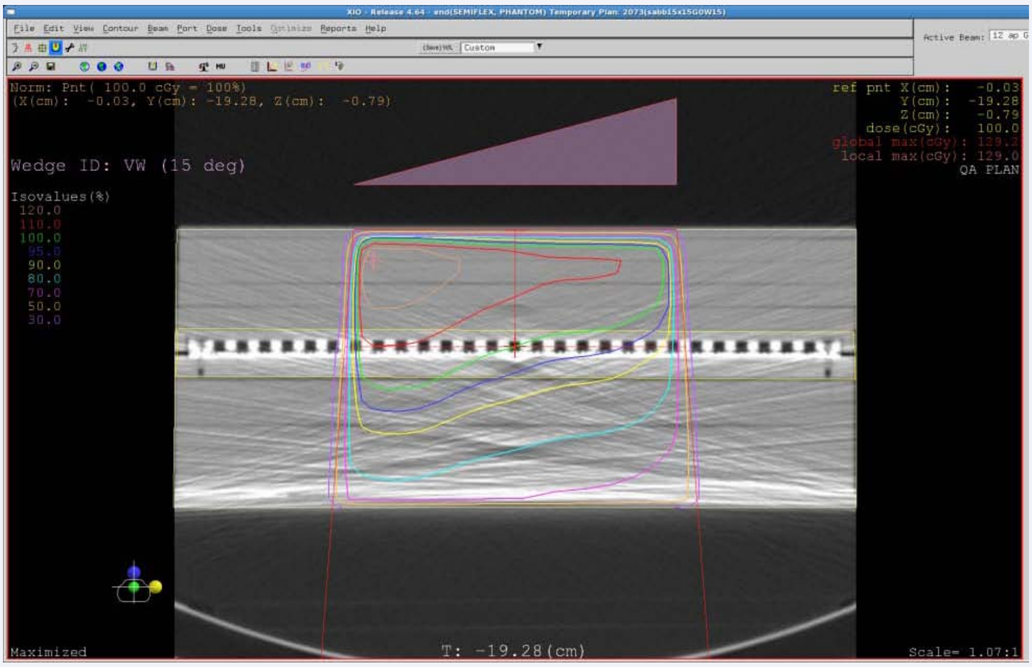


Figure 11 Shows the 2D-Array setup where a 15x15cm^2 field with a wedge angle = 15° and gantry angle=0° was applied.

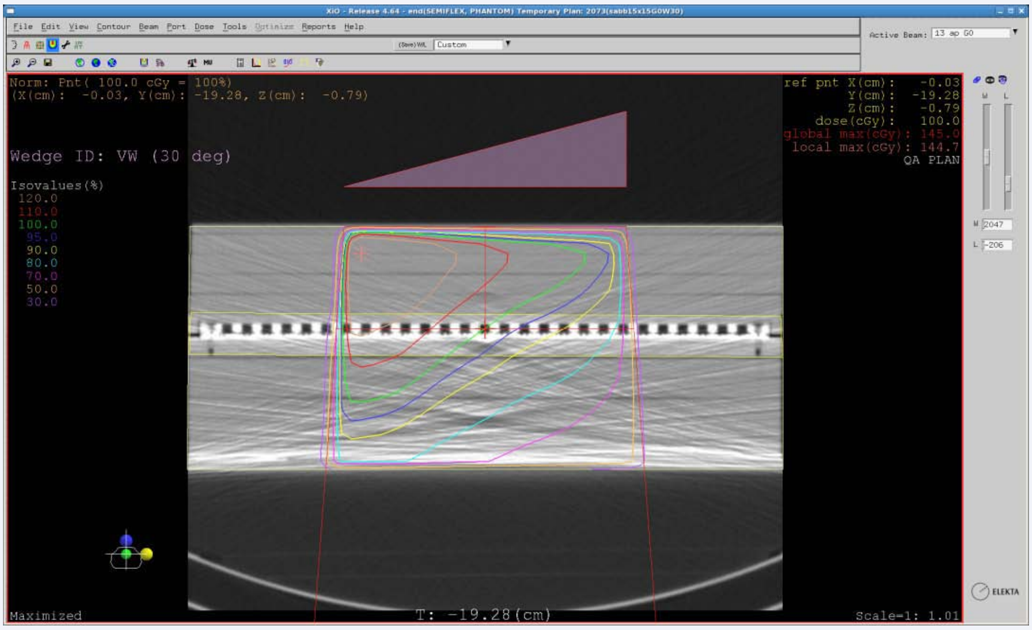


Figure 12 Shows the 2D-Array setup where a 15x15cm² field with a wedge angle = 30° and gantry angle=0° was applied.

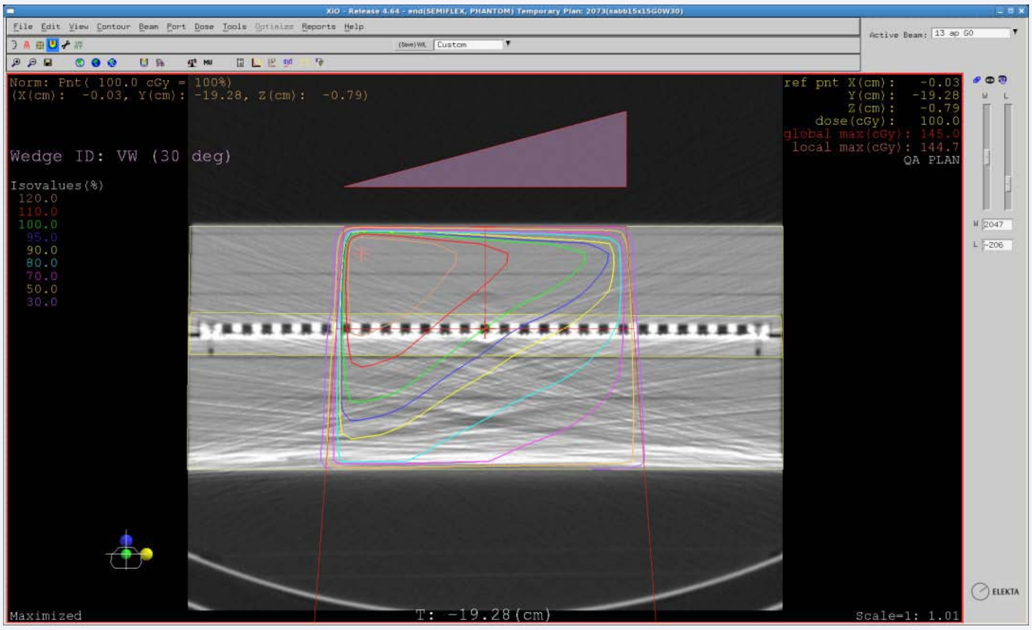


Figure 13 Shows the 2D-Array setup where a 15x15cm² field with a wedge angle = 45° and gantry angle=0° was applied.

FIF is carrying on forward treatment planning.

Verification of Field-In-Field planning technique: The next Figure 15 showed the matching percentage between the plan received from TPS and that measured by 2D-Array. The result was 100% (excellent) matching, where the total dose point were 729, the evaluated dose points were 371, the passed points were 371 and the failed points were 0 points. Although of being the result of matching was 100% but we noticed some semi yellow colored regions within the gamma distribution (in the right lower window of Figure 15) which means that there were some failed points which couldn't be counted in the matching percentage. This was because of being the used gamma index criteria was; 3 mm Distance-To-Agreement, 3% Dose Difference with reference to maximum dose of measured data set and suppress doses below 5% of maximum dose of measured data set (see Figure 16). This criteria was the standard one according to the VeriSoft system guide but if we used a different criteria, the matching percentage might be changed.

Figure 15: Shows a print screen of the VeriSoft software that shows a comparison result between the (15,7) FIF plan (at gantry angle=0°) received from the TPS and the measured one by the 2D-Array.

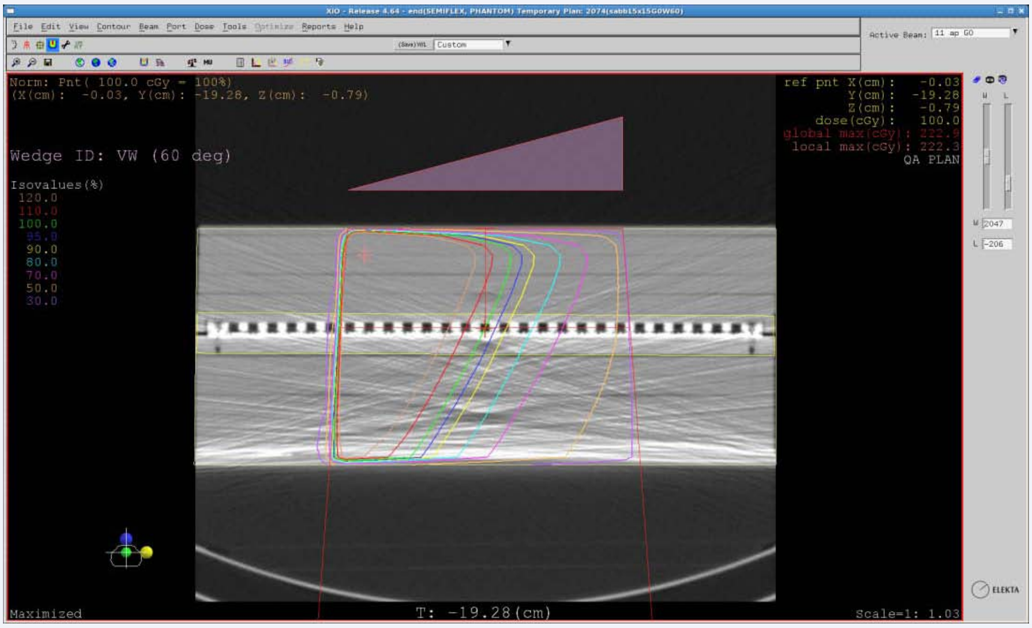


Figure 14 Shows the 2D-Array setup where a 15x15cm² field with a wedge angle = 60° and gantry angle=0° was applied.

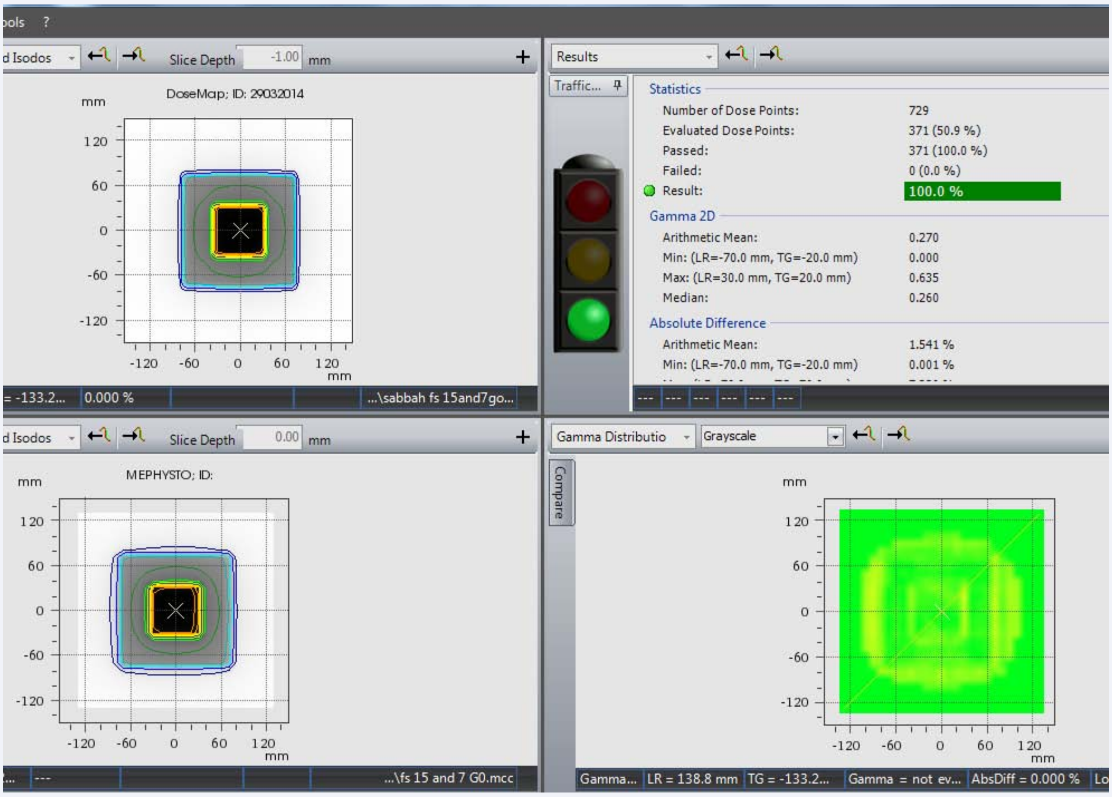


Figure 15 Shows a print screen of the VeriSoft software that shows a comparison result between the (15,7) FIF plan (at gantry angle=0°) received from the TPS and the measured one by the 2D-Array.

Verification of Angled Field-In-Field planning technique: When we compared every angled treatment planning technique received from the TPS with that measured by the 2D-Array at the same plan gantry angles, we got the next results as it is shown in Figures 17-26.

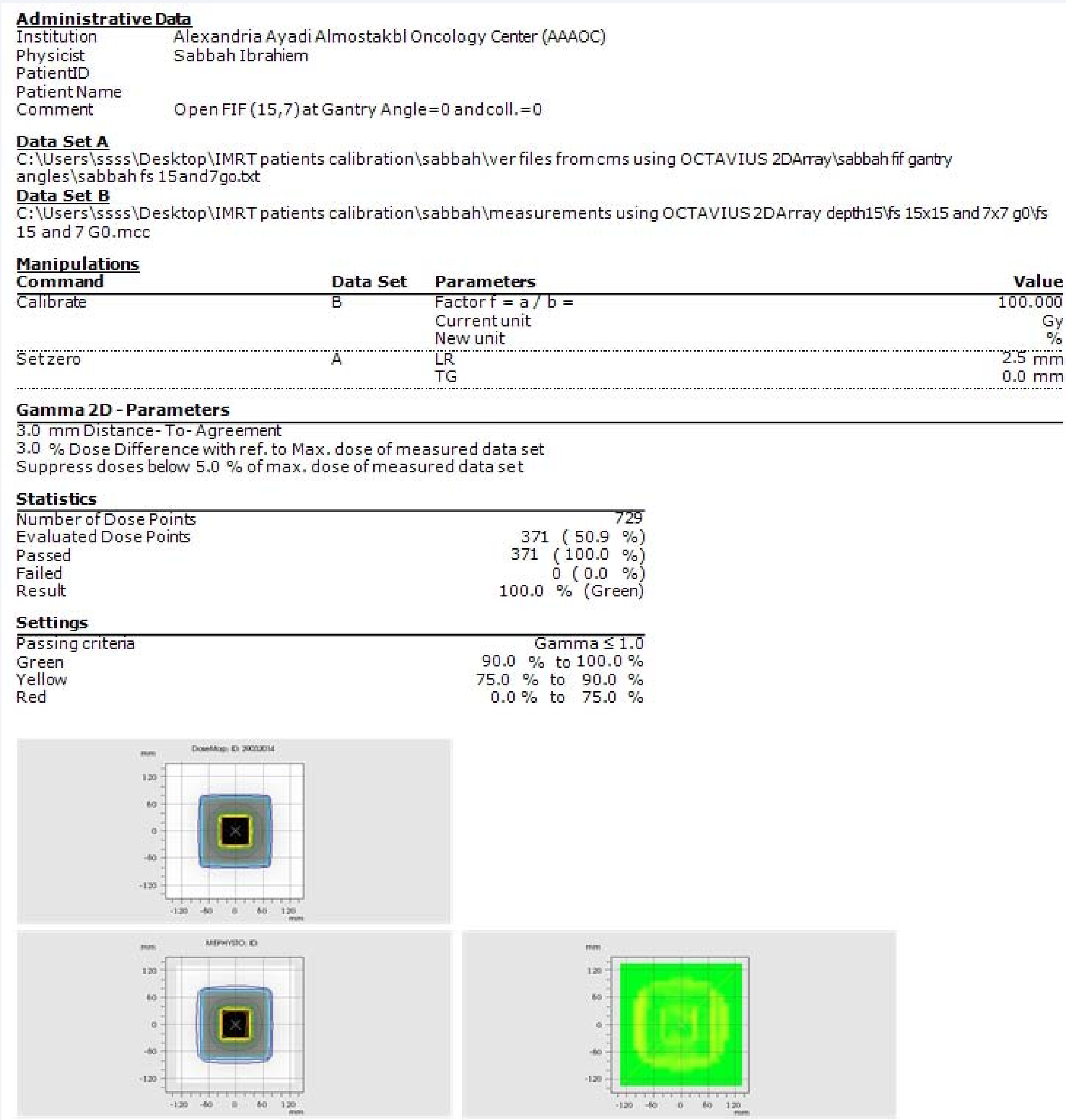
As we noticed from the last ten figures, all the five angled Field-In-Field plans were verified and the all comparison results were excellent. This led us to a major result, is that also the angled Field-In-Filed radiotherapy planning technique is already accurately applicable on the linear accelerator.

Comparison between Angled Field-In-Field and Wedged Field planning techniques: We used the (15,7) FIF plan (where the 7x7cm^2 field was at gantry angle=25° and the larger filed 15x15cm^2 was at gantry angle=0°) versus a wedged plan of a single 15x15cm^2 field with a 60° virtual wedge. The angled (15,7) FIF plan at Figure 27a already had the same effect of the wedged field regarding to the dose distribution, where it decreased the dose weight to the volume against the gantry angle which achieved the same effect of the thick side of the wedge and increased the dose weight to the volume toward the gantry angle which achieved the same effect of the thin side of the wedge. Also we noticed that the isodose lines of the AFIF plan had a shape differs from the shape of the wedged filed plan isodose lines, where in FIF plan, the decreased dose weight at the volume against gantry angle made the isodose lines also decreased toward the phantom surface at the same volume but the increased dose weight at the volume toward gantry angle made the isodose lines increased far from the phantom surface at the same volume. The resulted shape of Angled FIF isodose lines was like stairs shape. So we called that shape of the AFIF isodose lines **(the Stair Shape) (new addition)**. And the wedged and open fields gave a slope and straight shapes respectively (see Figure 27 and 28).

The next table 1, showed a comparison between the local doses received by the 2D-Array 15 ionization chambers marked in figure 24c for angled field-in-field, wedged and open fields.

Figure 28: showed a line chart for the local doses shows in table 1. For the open field the line chart nearly took a straight shape, but for the wedged field seemed as a sloped shape and for the angled field-in-field nearly took a stair shape. The **stair isodose** is a completely new shape of isodose lines which did not be mentioned before so it is a **new addition**.

Radiation Therapy Planning: As we mentioned in the



Administrative Data

Institution	Alexandria Ayadi Almostakbl Oncology Center (AAAOC)
Physicist	Sabbah Ibrahiem
PatientID	
Patient Name	
Comment	Open FIF (15,7) at Gantry Angle=0 and coll.=0

Data Set A
C:\Users\ssss\Desktop\IMRT patients calibration\sabbah\ver files from cms using OCTAVIUS 2DArray\sabbah fif gantry angles\sabbah fs 15and7go.txt
Data Set B
C:\Users\ssss\Desktop\IMRT patients calibration\sabbah\measurements using OCTAVIUS 2DArray depth15\fs 15x15 and 7x7 g0\fs 15 and 7 G0.mcc

Manipulations

Command	Data Set	Parameters	Value
Calibrate	B	Factor f = a / b =	100.000
		Current unit	Gy
		New unit	%
Set zero	A	LR	2.5 mm
		TG	0.0 mm

Gamma 2D - Parameters
3.0 mm Distance- To- Agreement
3.0 % Dose Difference with ref. to Max. dose of measured data set
Suppress doses below 5.0 % of max. dose of measured data set

Statistics

Number of Dose Points	729
Evaluated Dose Points	371 (50.9 %)
Passed	371 (100.0 %)
Failed	0 (0.0 %)
Result	100.0 % (Green)

Settings

Passing criteria	Gamma ≤ 1.0
Green	90.0 % to 100.0 %
Yellow	75.0 % to 90.0 %
Red	0.0 % to 75.0 %

Figure 16 A print screen of the VeriSoft software verification result print review that shows a comparison result between the (15,7) FIF plan (at gantry angle=0°) received from the TPS and the measured one by the 2D-Array.

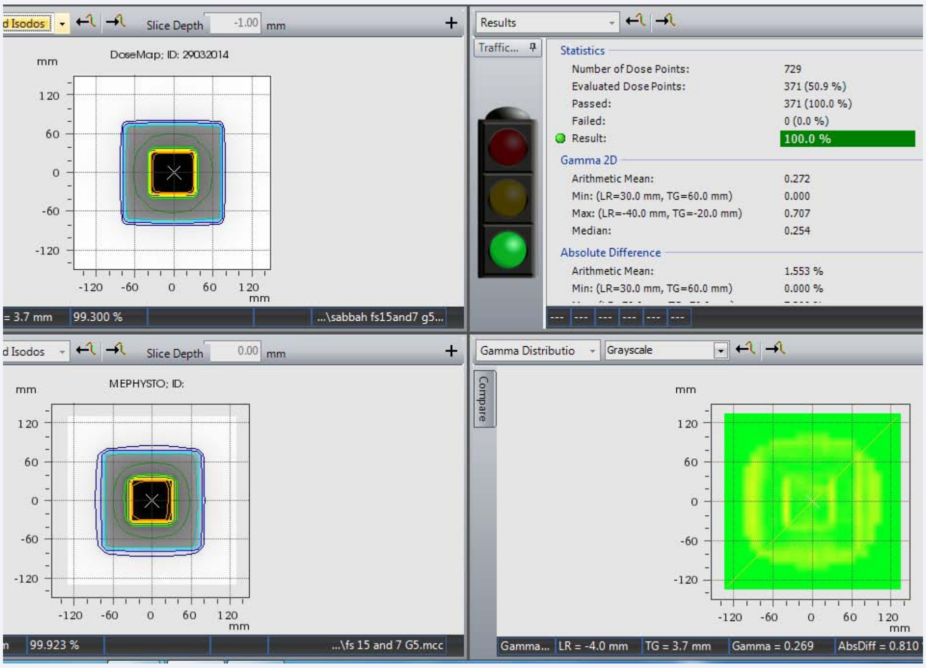
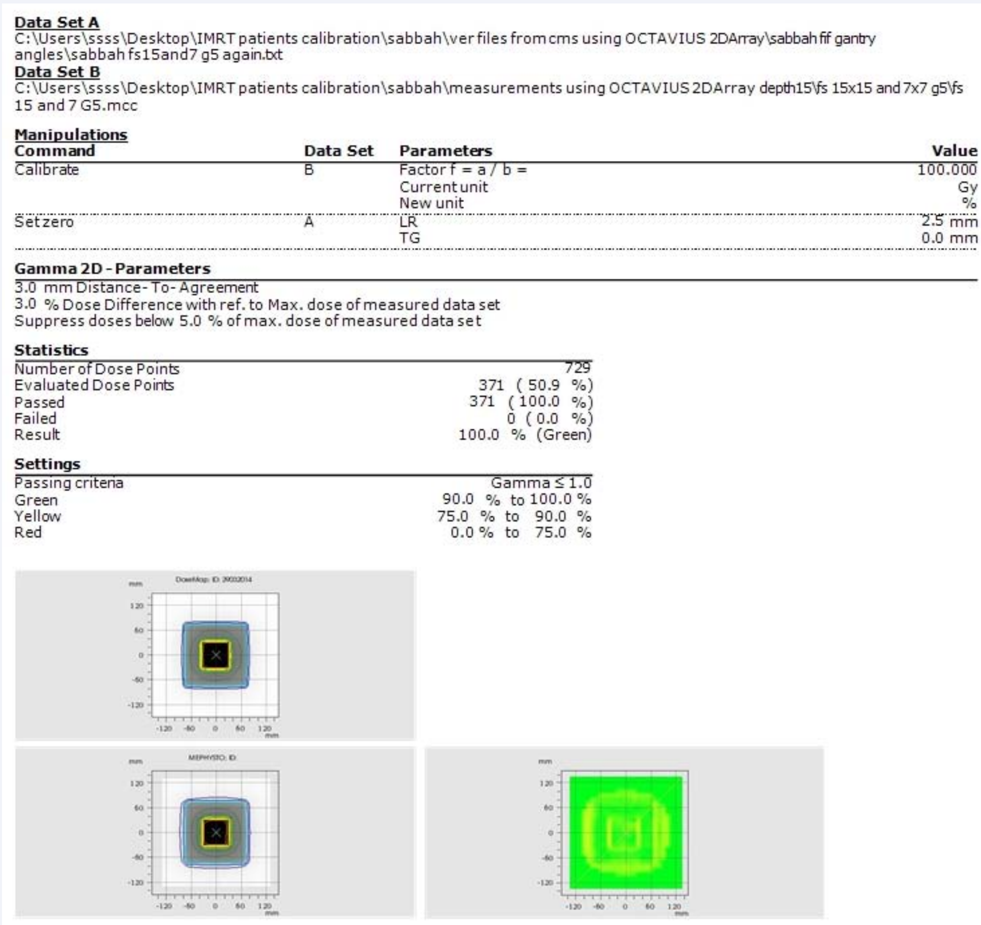


Figure 17 Shows a print screen of the VeriSoft software that shows a comparison result between the (15,7) FIF plan at gantry angle=5° received from the TPS and the measured one by the 2D-Array.



Data Set A
C:\Users\ssss\Desktop\IMRT patients calibration\sabbah\ver files from cms using OCTAVIUS 2DArray\sabbah fif gantry angles\sabbah fs15and7 g5 again.txt
Data Set B
C:\Users\ssss\Desktop\IMRT patients calibration\sabbah\measurements using OCTAVIUS 2DArray depth15\fs 15x15 and 7x7 g5\fs 15 and 7 G5.mcc

Manipulations

Command	Data Set	Parameters	Value
Calibrate	B	Factor f = a / b =	100.000
		Current unit	Gy
		New unit	%
Set zero	A	LR	2.5 mm
		TG	0.0 mm

Gamma 2D - Parameters
3.0 mm Distance-To-Agreement
3.0 % Dose Difference with ref. to Max. dose of measured data set
Suppress doses below 5.0 % of max. dose of measured data set

Statistics

Number of Dose Points	729
Evaluated Dose Points	371 (50.9 %)
Passed	371 (100.0 %)
Failed	0 (0.0 %)
Result	100.0 % (Green)

Settings

Passing criteria	Gamma ≤ 1.0
Green	90.0 % to 100.0 %
Yellow	75.0 % to 90.0 %
Red	0.0 % to 75.0 %

Figure 18 A print screen of the VeriSoft software verification result print review that shows a comparison result between the (15,7) FIF plan (at gantry angle=5°) received from the TPS and the measured one by the 2D-Array.

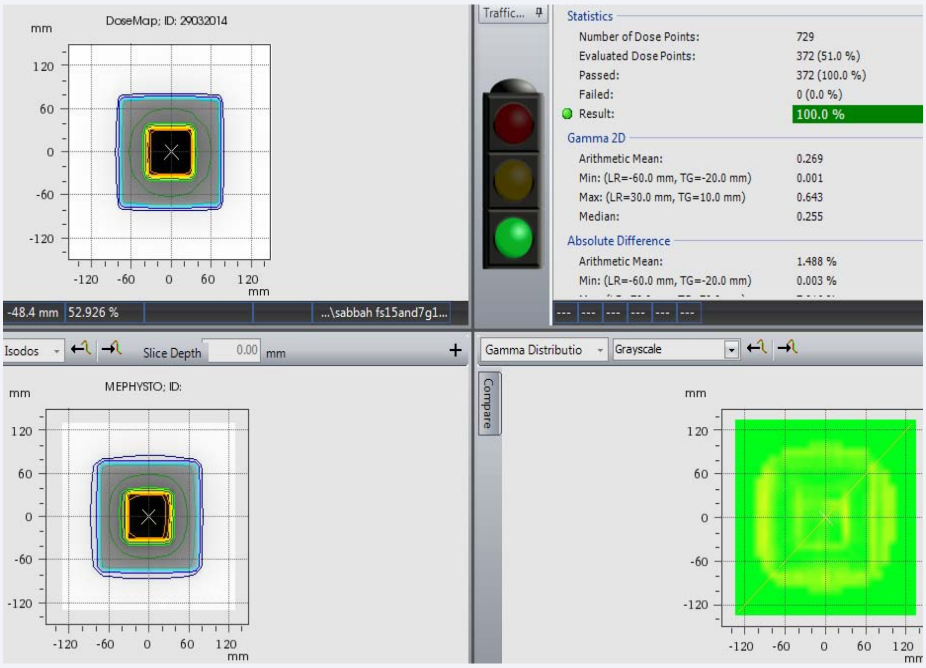
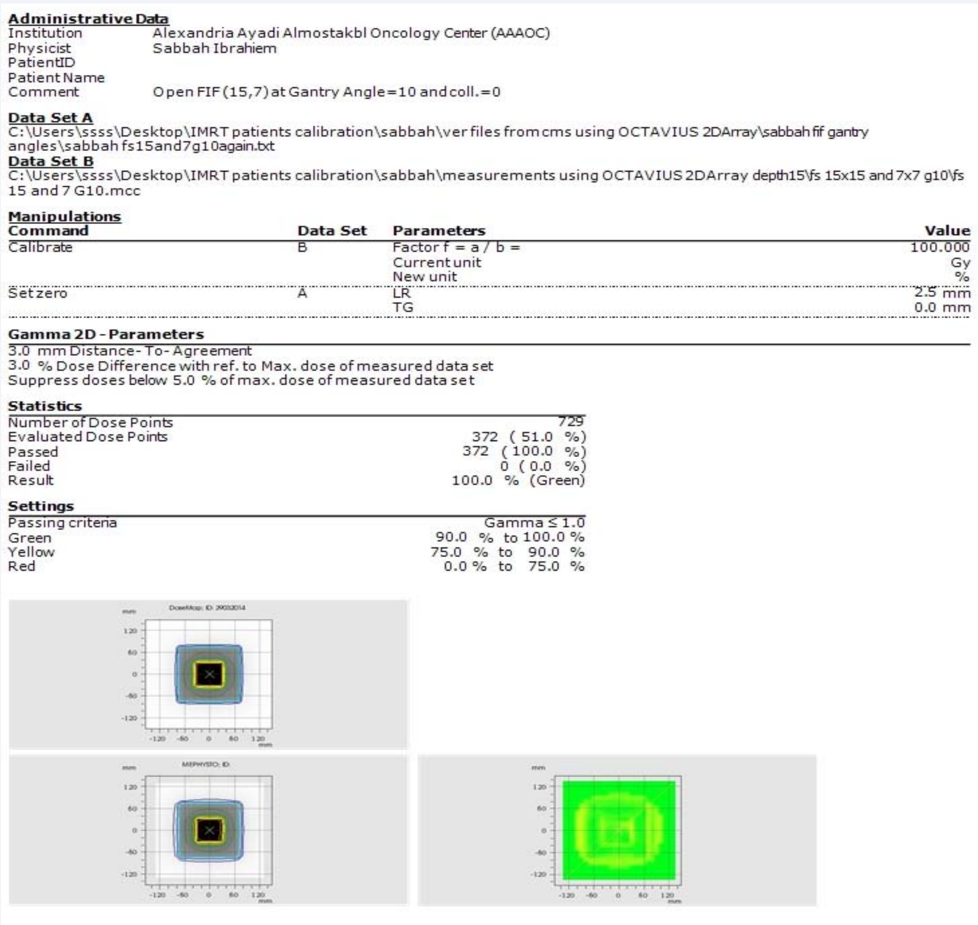


Figure 19 A print screen of the VeriSoft software that shows a comparison result between the (15,7) FIF plan (at gantry angle=10°) received from the TPS and the measured one by the 2D-Array.



Administrative Data

Institution Alexandria Ayadi Almostakbl Oncology Center (AAAOC)
Physicist Sabbah Ibrahiem
PatientID
Patient Name
Comment Open FIF (15,7) at Gantry Angle=10 and coll.=0

Data Set A
C:\Users\ssss\Desktop\IMRT patients calibration\sabbah\ver files from cms using OCTAVIUS 2DArray\sabbah fif gantry angles\sabbah fs15and7g10again.txt

Data Set B
C:\Users\ssss\Desktop\IMRT patients calibration\sabbah\measurements using OCTAVIUS 2DArray depth15\fs 15x15 and 7x7 g10\fs 15 and 7 G10.mcc

Manipulations

Command	Data Set	Parameters	Value
Calibrate	B	Factor f = a / b =	100.000
		Current unit	Gy
		New unit	%
Set zero	A	LR	2.5 mm
		TG	0.0 mm

Gamma 2D - Parameters
3.0 mm Distance- To- Agreement
3.0 % Dose Difference with ref. to Max. dose of measured data set
Suppress doses below 5.0 % of max. dose of measured data set

Statistics

Number of Dose Points	729
Evaluated Dose Points	372 (51.0 %)
Passed	372 (100.0 %)
Failed	0 (0.0 %)
Result	100.0 % (Green)

Settings

Passing criteria	Gamma ≤ 1.0
Green	90.0 % to 100.0 %
Yellow	75.0 % to 90.0 %
Red	0.0 % to 75.0 %

Figure 20 Shows a print screen of the VeriSoft software verification result print review that shows a comparison result between the (15,7) FIF plan (at gantry angle=10°) received from the TPS and the measured one by the 2D-Array.

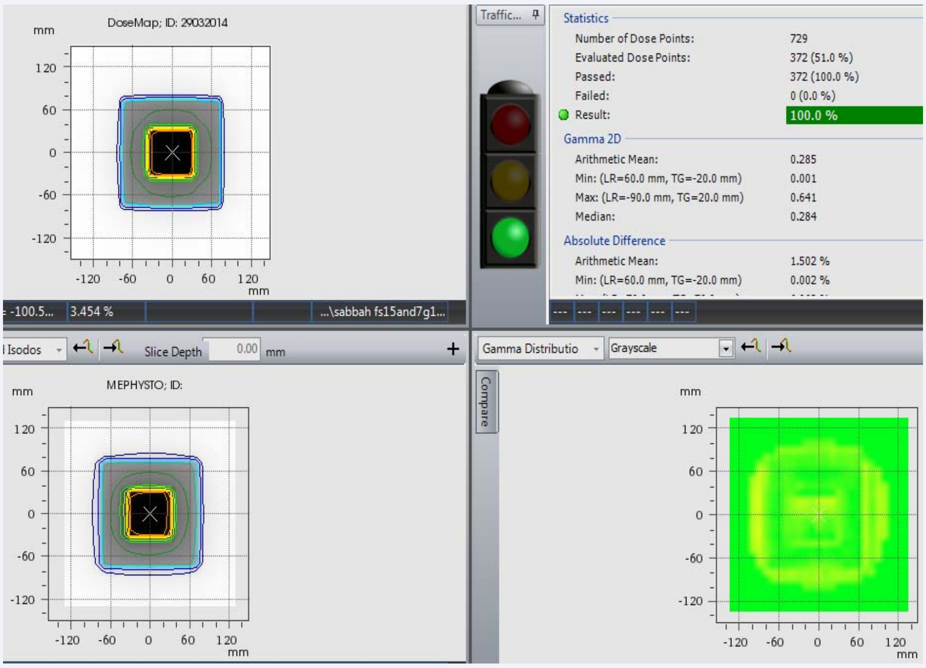
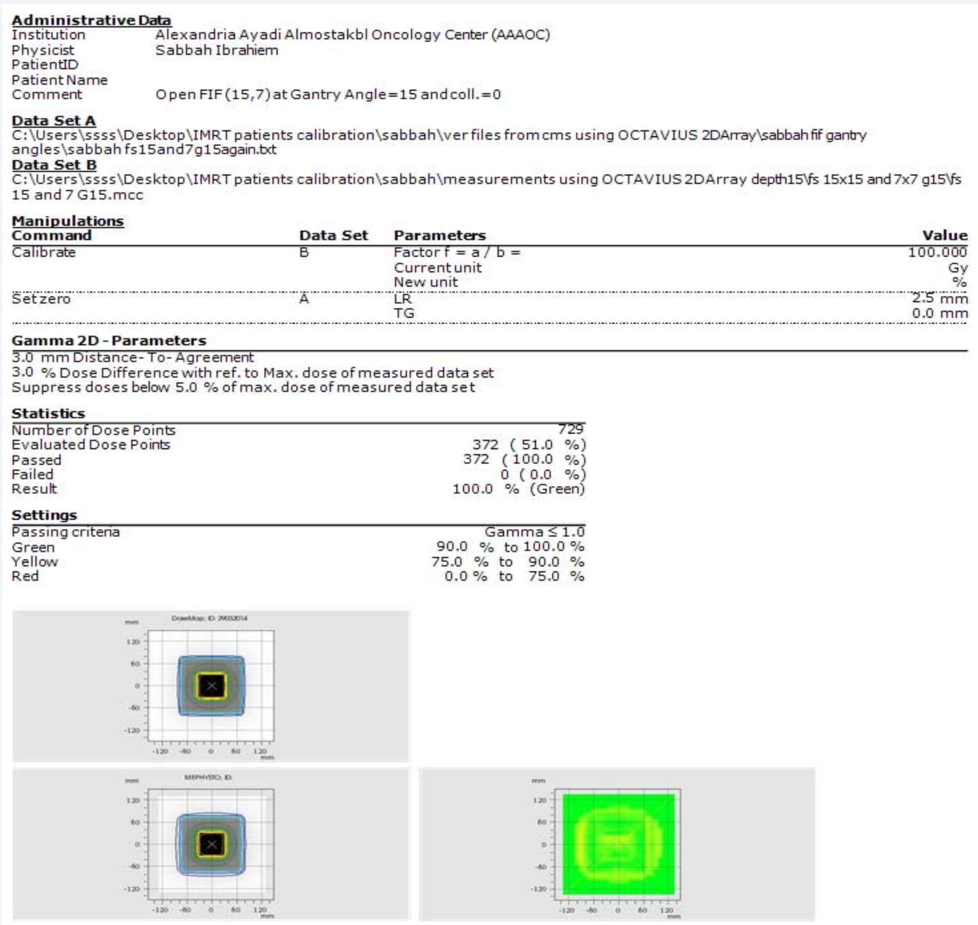


Figure 21 Shows a print screen of the VeriSoft software that shows a comparison result between the (15,7) FIF plan (at gantry angle=15°) received from the TPS and the measured one by the 2D-Array.



Administrative Data

Institution	Alexandria Ayadi Almostakbl Oncology Center (AAAOC)
Physicist	Sabbah Ibrahiem
PatientID	
Patient Name	
Comment	Open FIF (15,7) at Gantry Angle=15 and coll.=0

Data Set A
C:\Users\ssss\Desktop\IMRT patients calibration\sabbah\ver files from cms using OCTAVIUS 2DArray\sabbah fif gantry angles\sabbah fs15and7g15again.txt

Data Set B
C:\Users\ssss\Desktop\IMRT patients calibration\sabbah\measurements using OCTAVIUS 2DArray depth15\fs 15x15 and 7x7 g15\fs 15 and 7 G15.mcc

Manipulations

Command	Data Set	Parameters	Value
Calibrate	B	Factor f = a / b =	100.000
		Current unit	Gy
		New unit	%
Set zero	A	LR	2.5 mm
		TG	0.0 mm

Gamma 2D - Parameters
3.0 mm Distance-To-Agreement
3.0 % Dose Difference with ref. to Max. dose of measured data set
Suppress doses below 5.0 % of max. dose of measured data set

Statistics

Number of Dose Points	729
Evaluated Dose Points	372 (51.0 %)
Passed	372 (100.0 %)
Failed	0 (0.0 %)
Result	100.0 % (Green)

Settings

Passing criteria	Gamma ≤ 1.0
Green	90.0 % to 100.0 %
Yellow	75.0 % to 90.0 %
Red	0.0 % to 75.0 %

Figure 22 Shows a print screen of the VeriSoft software verification result print review that shows a comparison result between the (15,7) FIF plan (at gantry angle=15°) received from the TPS and the measured one by the 2D-Array.

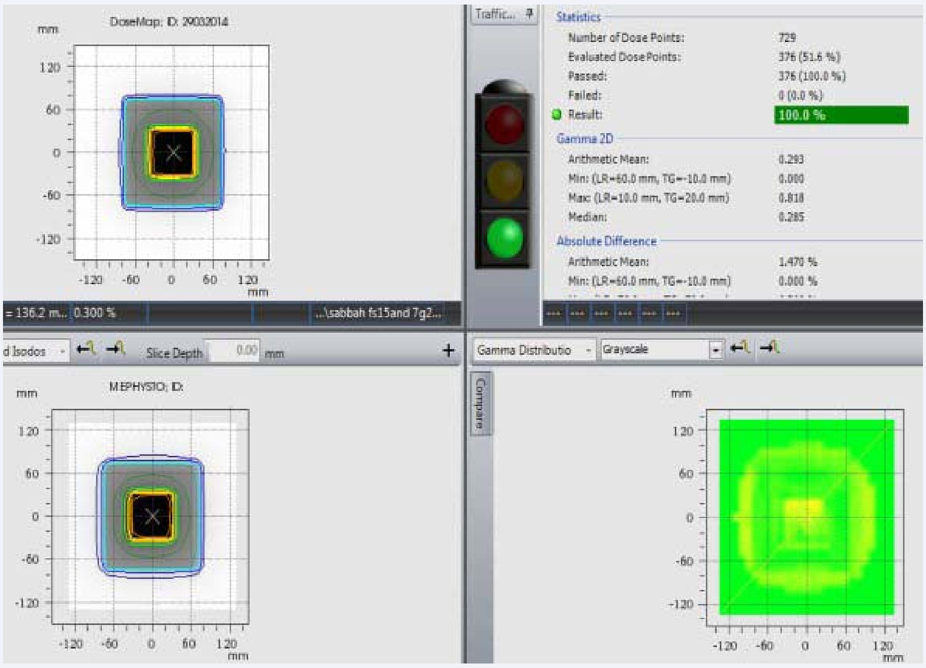
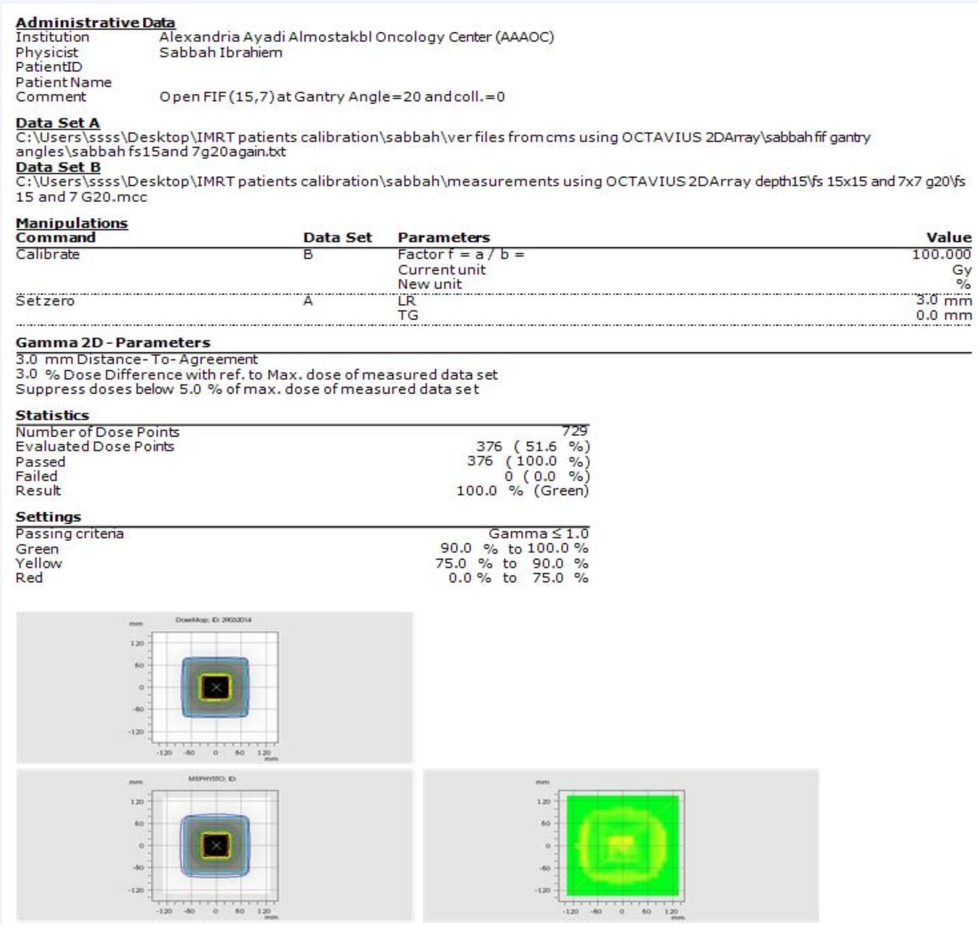


Figure 23 Shows a print screen of the VeriSoft software that shows a comparison result between the (15,7) FIF plan (at gantry angle=20°) received from the TPS and the measured one by the 2D-Array.



Administrative Data

Institution	Alexandria Ayadi Almostakbl Oncology Center (AAAOC)
Physicist	Sabbah Ibrahiem
PatientID	
Patient Name	
Comment	Open FIF (15,7) at Gantry Angle=20 and coll.=0

Data Set A
C:\Users\ssss\Desktop\IMRT patients calibration\sabbah\ver files from cms using OCTAVIUS 2DArray\sabbah fif gantry angles\sabbah fs15and 7g20again.txt

Data Set B
C:\Users\ssss\Desktop\IMRT patients calibration\sabbah\measurements using OCTAVIUS 2DArray depth15\fs 15x15 and 7x7 g20\fs 15 and 7 G20.mcc

Manipulations

Command	Data Set	Parameters	Value
Calibrate	B	Factor f = a / b =	100.000
		Current unit	Gy
		New unit	%
Set zero	A	LR	3.0 mm
		TG	0.0 mm

Gamma 2D - Parameters
3.0 mm Distance-To-Agreement
3.0 % Dose Difference with ref. to Max. dose of measured data set
Suppress doses below 5.0 % of max. dose of measured data set

Statistics

Number of Dose Points	729
Evaluated Dose Points	376 (51.6 %)
Passed	376 (100.0 %)
Failed	0 (0.0 %)
Result	100.0 % (Green)

Settings

Passing criteria	Gamma ≤ 1.0
Green	90.0 % to 100.0 %
Yellow	75.0 % to 90.0 %
Red	0.0 % to 75.0 %

Figure 24 Shows a print screen of the VeriSoft software verification result print review that shows a comparison result between the (15,7) FIF plan (at gantry angle=20°) received from the TPS and the measured one by the 2D-Array.

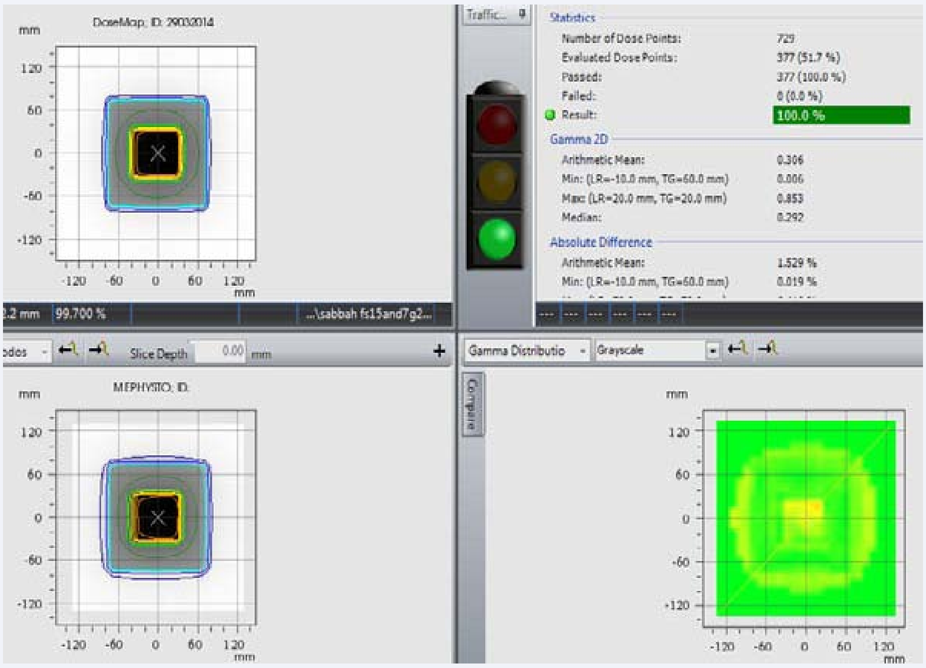
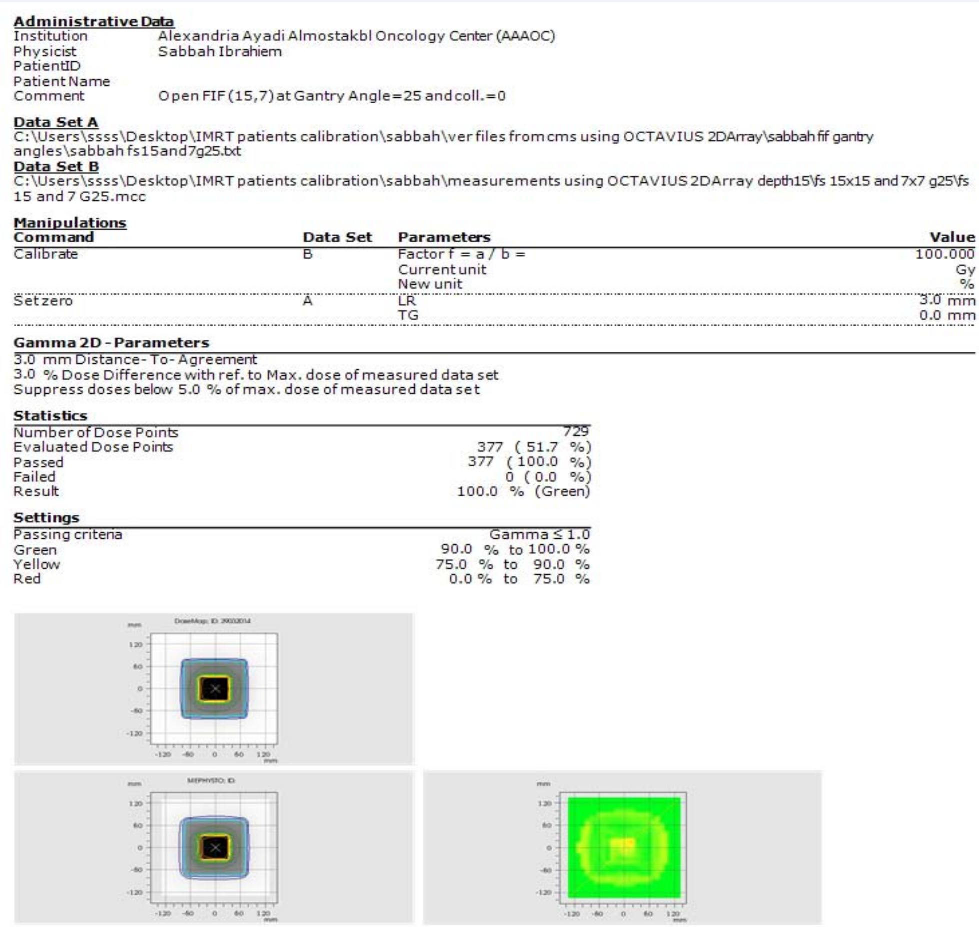


Figure 25 Shows a print screen of the VeriSoft software that shows a comparison result between the (15,7) FIF plan (at gantry angle=25°) received from the TPS and the measured one by the 2D-Array.



Administrative Data

Institution	Alexandria Ayadi Almostakbl Oncology Center (AAAOC)
Physicist	Sabbah Ibrahiem
PatientID	
Patient Name	
Comment	Open FIF (15,7) at Gantry Angle=25 and coll.=0

Data Set A
C:\Users\ssss\Desktop\IMRT patients calibration\sabbah\ver files from cms using OCTAVIUS 2DArray\sabbah fif gantry angles\sabbah fs15and7g25.txt
Data Set B
C:\Users\ssss\Desktop\IMRT patients calibration\sabbah\measurements using OCTAVIUS 2DArray depth15\fs 15x15 and 7x7 g25\fs 15 and 7 G25.mcc

Manipulations

Command	Data Set	Parameters	Value
Calibrate	B	Factor f = a / b =	100.000
		Current unit	Gy
		New unit	%
Set zero	A	LR	3.0 mm
		TG	0.0 mm

Gamma 2D - Parameters
3.0 mm Distance- To- Agreement
3.0 % Dose Difference with ref. to Max. dose of measured data set
Suppress doses below 5.0 % of max. dose of measured data set

Statistics

Number of Dose Points	729
Evaluated Dose Points	377 (51.7 %)
Passed	377 (100.0 %)
Failed	0 (0.0 %)
Result	100.0 % (Green)

Settings

Passing criteria	Gamma ≤ 1.0
Green	90.0 % to 100.0 %
Yellow	75.0 % to 90.0 %
Red	0.0 % to 75.0 %

Figure 26 Shows a print screen of the VeriSoft software verification result print review that shows a comparison result between the (15,7) FIF plan (at gantry angle=25°) received from the TPS and the measured one by the 2D-Array.

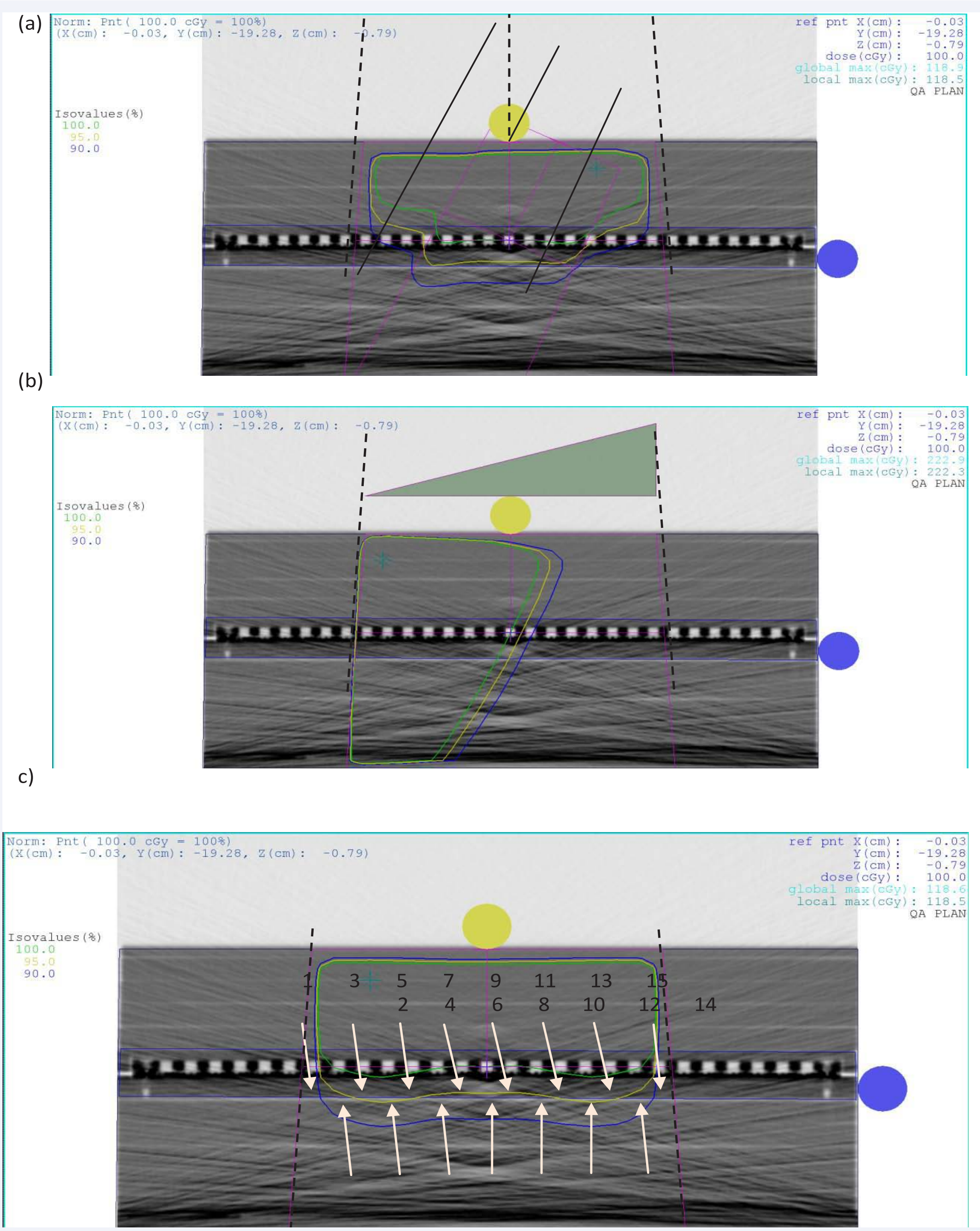


Figure 27 (a): Shows a print screen of an angled (15,7) Field-In-Field isodose lines, (b): Shows Wedged (15x15 cm²) field isodose lines and (c): Shows a (15x15 cm²) open field isodose lines.

previous chapter, we used three types of cancer tumors, Breast, Brain and Prostate tumors. We used two radiotherapy planning techniques, Field-In-Filed (FIF) and Intensity Modulated Radiation Therapy (IMRT) techniques for each tumor type.

Discussion

This study was designed to study the Angled Field-In-Field as a new advanced radiotherapy treatment planning form of the Field-In-Field technique.

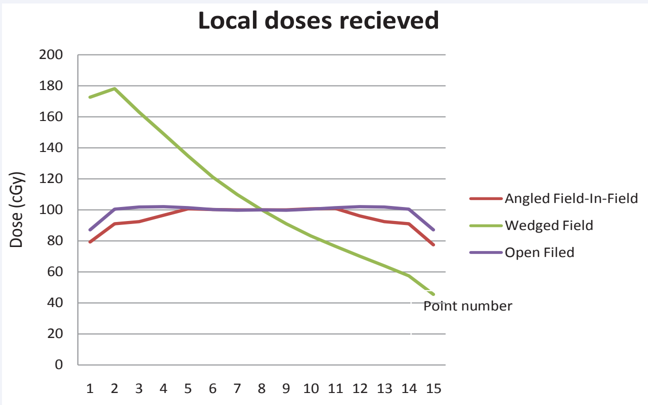


Figure 28 Local doses received by the 15 ionization chambers included in the field 15x15 cm^2 for angled field-in-field, wedged and open fields.

Table 1: The local doses received by the 15 ionization chambers included in the field 15x15 cm^2 for angled field-in-field, wedged and open fields.

Points	Angled Field-In-Field	Wedged Field	Open Filed
1	79.3	172.6	87.1
2	91	178.2	100.5
3	92.3	163	101.8
4	96.5	148.9	102.1
5	100.5	134.6	101.3
6	100.1	121.1	100.3
7	99.9	109.8	99.9
8	100	100	100
9	100	90.9	99.9
10	100.5	83.1	100.4
11	100.8	76.4	101.3
12	95.9	70.1	102.1
13	92.3	63.7	101.8
14	90.9	57.3	100.5
15	77.5	45.4	87.1

Nearly, all the previous publications that used the FIF technique, used it in its simple design, which is the Non-Angled FIF [3,11-14]. For example but not limited to; [15], quantified the cold spots under geometrical uncertainties in field-in-field techniques for whole breast radiotherapy, and [16], evaluated a simplified "field-in-field" technique (SFF) that was implemented in their department of Radiation Oncology for breast treatment. In both the two examples, FIF was used in the NAFIF form. But when we used it in the AFIF form, we got the result of being it can be used as an alternative plan of the wedged plan and also we got a new isodose lines shape (the Stair shape).

FUTURE WORK

1- Prediction of **Advanced** Field-In-Field **(FIF) forms**: We predict two types of AFIF that may be applied separately or mixed. They are:

- **Multiple non-angled FIF technique:** It can be consisted of a main field and multiple smaller fields inside the main one. All fields are at the same gantry angle of the main field. Each one of the smaller fields will have a portion of the main field's dose weight aiming to achieve a good dose distribution, a good avoidance to the organs at risk, and reduction of both the hot and/or the cold areas within the treatment field. In the next Figure 29, we used, for example, a main field of 20x20 cm^2 size and multiple three smaller fields of sizes 15x15 cm^2, 10x10 cm^2 and 5x5 cm^2 and they are arranged from outside to inside respectively where the filed 15x15 cm^2 will be inside the 20x20 cm^2 field, the field 10x10 cm^2 will be inside the 15x15 cm^2 field and so on. There will be a very important note because it can be used as a 3D compensator rather than the resulted stair isodose shape.

- **Multiple angled FIF technique (MAFIF):** It has the same design as the multiple non-angled FIF technique but all/some of the smaller fields will be at a different gantry angle from the main field. As it is shown in the next Figure 30, we designed an example of the multiple angled FIF technique which consists of a main 20x20 cm^2 field, and three smaller 15x15 cm^2, 10x10 cm^2 and 5x5 cm^2 fields. The smaller three fields are arranged from outside to inside respectively. Each one of these three fields will be given a dose weight from the main weight. The isodose lines will take the **semi-sloped stair shape** as it is shown in the figure 18.

- The inner fields can be set in different angles in the same or reverse direction of the main angled field. This design has unknown isodose shape, so it needs more study.

REFERENCES

1. Ahmad N, Attia G, El-Ghoneimy E, Radwan A, El-Badawy S. Conventional (2D) Versus Conformal (3D) Techniques in Radiotherapy for Malignant Pediatric Tumors: Dosimetric Perspectives. J Egypt Natl Canc Inst. 2009; 21: 309-314.

2. International Atomic Energy Agency (IAEA)-TECDOC Publication. Transition from 2-D Radiotherapy to 3-D Conformal and Intensity Modulated Radiotherapy. IAEA-TECDOC-1588. 2008; 1-8.

3. Baycan D, Karacetin D, Balkanay AY, Barut Y. Field-in-field IMRT

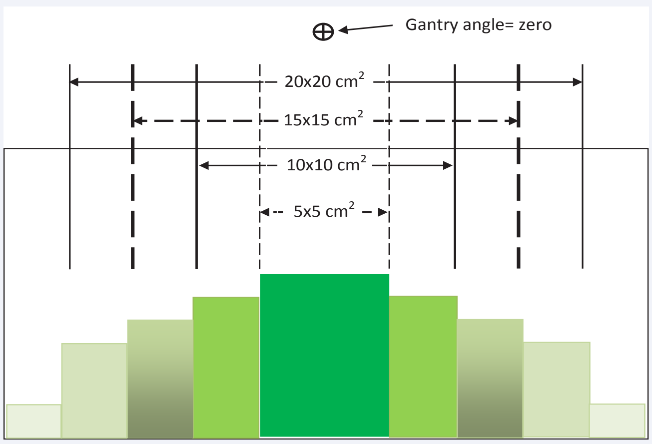


Figure 29 A schematic designed example of multiple non-angled FIF technique and its expected isodoses.

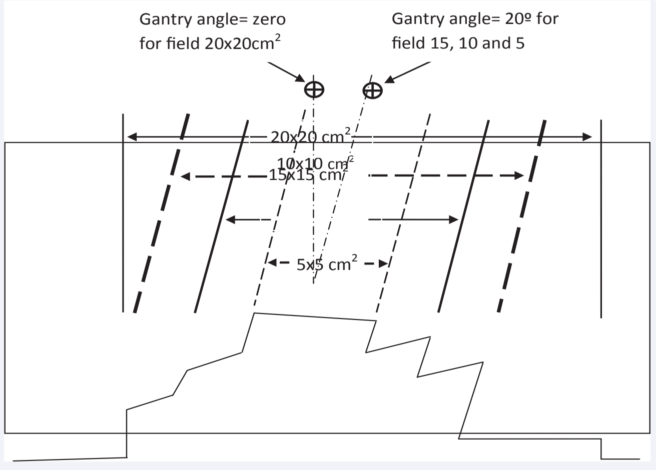


Figure 30 A schematic manual designed example of multiple angled FIF technique and its expected isodose shape.

versus 3D-CRT of the breast. Cardiac vessels, ipsilateral lung, and contralateral breast absorbed doses in patients with left-sided lumpectomy: a dosimetric comparison. Jpn J Radiol. 2012; 30: 819-823.

4. Cox JD, Ang KK. Radiation Oncology: Rationale, Technique, Results. Ninth edition. Part 1, chapter 2. 2002.

5. Prabhakar R, Haresh KP, Kumar M, Sharma DN, Julka PK, Rath GK. Field-in-field technique for upper abdominal malignancies in clinical radiotherapy. J Cancer Res Ther. 2009; 5: 20-23.

6. Murthy KK, Sivakumar SS, Davis CA, Ravichandran R, El Ghamrawy K. Optimization of dose distribution with multi-leaf collimator using field-in-field technique for parallel opposing tangential beams of breast cancers. J Med Phys. 2008; 33: 60-63.

7. Ercan T, Iğdem S, Alço G, Zengin F, Atilla S, Dinçer M, et al. Dosimetric comparison of field in field intensity-modulated radiotherapy technique with conformal radiotherapy techniques in breast cancer. Jpn J Radiol. 2010; 28: 283-289.

8. Spezi E, Angelini AL, Romani F, Ferri A. Characterization of a 2D ion chamber array for the verification of radiotherapy treatments. Phys Med Biol. 2005; 50: 3361-3373.

9. González-Castaño D, Pena J, Sánchez-Doblado F, Hartmann GH, Gómez F, Leal A. The change of response of ionization chambers in the penumbra and transmission regions: impact for IMRT verification. Med Biol Eng Comput. 2008; 46: 373-380.

10. Kumar A, Mukherjee G, Yadav G, Pandey V, Bhattacharya K. Optimized point dose measurement: An effective tool for QA in intensity-modulated radiotherapy. J Med Phys. 2007; 32: 156-160.

11. Jin GH, Chen LX, Deng XW, Liu XW, Huang Y, Huang XB. A comparative dosimetric study for treating left-sided breast cancer for small breast size using five different radiotherapy techniques: conventional tangential field, filed-in-filed, tangential-IMRT, multi-beam IMRT and VMAT. Radiat Oncol. 2013.

12. Yavas G, Yavas C, Acar H, Buyukyoruk A, Cobanoglu G, Kerimoglu OS, et al. Dosimetric comparison of 3-dimensional conformal and field-in-field radiotherapy techniques for the adjuvant treatment of early stage endometrial cancer. Phys Med. 2013; 29: 577-582.

13. Yang DS, Lee JA, Yoon WS, Chung SY, Lee S, Kim CY, et al. Whole breast irradiation for small-sized breasts after conserving surgery: is the field-in-field technique optimal? Breast Cancer. 2014; 21: 162-169.

14. Pili G, Grimaldi L, Fidanza C, Florio ET, Petruzzelli MF, D'Errico MP, et al. Geometric and dosimetric approach to determine probability of late cardiac mortality in left tangential breast irradiation: comparison between wedged beams and field-in-field technique. Int J Radiat Oncol Biol Phys. 2011; 81: 894-900.

15. Fournier-Bidoz N, Kirova YM, Campana F, Dendale R, Fourquet A. Simplified field-in-field technique for a large-scale implementation in breast radiation treatment. Med Dosim. 2012; 37: 131-137.

16. Nakamura N, Hatanaka S, Shikama N, Akahane K, Sekiguchi K. Quantification of cold spots caused by geometrical uncertainty in field-in-field techniques for whole breast radiotherapy. Jpn J Clin Oncol. 2011; 41: 1127-1131.

Cite this article

Hammoury SI (2015) Angled Field-in-Field as a New Advanced Radiotherapy Treatment Planning Form of the Field-in-Field Technique. A Dosimertic and Treatment Planning Study. J Radiol Radiat Ther 3(1): 1055.