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Verification of Dose Calculation Accuracy THERPLAN Treatment Planning System of 2D SAD treatment technique

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التحقق من دقة حساب الجرعة في نظام التخطيط العلاجي THERPLAN لتقنية العلاج الإشعاعي ثنائي الأبعاد بأسلوب SAD

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Abstract:
This study evaluates the accuracy of the THERPLAN PLUSE version 1.2 Treatment Planning System (TPS) for dose calculation in 2D SAD setups, focusing on its performance across various treatment configurations. Measurements were conducted using a 6 MeV photon beam from an Elekta-Precise linear accelerator, employing a pre-calibrated FC65p ionization chamber and a Scanditronix water phantom. Dose comparisons were made between the TPS-calculated values and measured doses across a range of setups, including different SSDs, field sizes, wedge angles, asymmetric fields, parallel-opposed fields, and four-field box techniques.
Results demonstrated strong concordance between calculated and measured doses, with deviations averaging 0.85% and remaining well within the International Commission on Radiation Units and Measurements (ICRU) tolerance of ±5%. Specific setups, such as wedge and asymmetric fields, showed deviations below ±1%, highlighting the robustness of THERPLAN in handling complex geometries. Comparisons with published benchmarks further validated the accuracy of the TPS in dose calculation.
These findings underscore the reliability of THERPLAN TPS for routine clinical use in radiotherapy. The study emphasizes the importance of regular quality assurance and independent dose verification systems to ensure consistent treatment accuracy and patient safety.

Keywords: Treatment planning system, phantom, TMR, SAD, SSD, TAR.

الملخص
تقيم هذه الدراسة دقة نظام تخطيط العلاج (TPS) الإصدار 1.2 من THERPLAN PLUSE لحساب الجرعة في إعدادات SAD ثنائية الأبعاد، مع التركيز على أدائه عبر تكوينات العلاج المختلفة. أجريت القياسات باستخدام شعاع فوتون 6 ميجا إلكترون فولت من مسرع خطي Elekta-Precise، باستخدام غرفة تأين FC65p معايرة مسبقًا وشبح ماء Scanditronix. تم إجراء مقارنات الجرعة بين القيم المحسوبة بواسطة TPS والجرعات المقاسة عبر مجموعة من الإعدادات، بما في ذلك SSDs المختلفة، وأحجام الحقول، وزوايا الإسفين، والحقول غير المتماثلة، والحقول المتوازية المعاكسة، وتقنيات صندوق الحقول الأربعة. أظهرت النتائج توافقًا قويًا بين الجرعات المحسوبة والمقاسة، مع انحرافات بمتوسط 0.85٪ وتبقى ضمن تسامح اللجنة الدولية لوحدات وقياسات الإشعاع (ICRU) بنسبة ±5٪. أظهرت الإعدادات المحددة، مثل الحقول الإسفينية

وغير المتماثلة، انحرافات أقل من ±1%، مما يسلط الضوء على قوة THERPLAN في التعامل مع الأشكال الهندسية المعقدة. كما أثبتت المقارنات مع المعايير المنشورة دقة TPS في حساب الجرعة.
تؤكد هذه النتائج على موثوقية THERPLAN TPS للاستخدام السريري الروتيني في العلاج الإشعاعي. تؤكد الدراسة على أهمية ضمان الجودة المنتظم وأنظمة التحقق من الجرعة المستقلة لضمان دقة العلاج المتسقة وسلامة المريض.

الكلمات المفتاحية: منظومة تخطيط العلاج، الشبح المائي، TMR, SAD, SSD, TAR.

Introduction

Radiotherapy aims to cure, or locally control disease, while concurrently minimizing complications in normal tissue. The International Commission on Radiation Units and Measurements (ICRU) has recommended that radiation dose must be delivered to within ±5% of the prescribed dose [1]

Treatment delivery is associated with daily patient setup, dose calculation & dose delivery. All these parameters are monitored and kept to a tight tolerance to achieve overall accuracy. [2]

For a center using a conventional treatment technique, which is based primarily on measured data [3] There is a need to verify the algorithm in use because a quality assurance program ensures that all the components of the treatment facilities used in radiotherapy are properly checked for accuracy and consistency and that all radiation-generating facilities function according to the manufacturer's specifications. Various authors have proposed several techniques for carrying out TPS's quality assurance. The performance and quality of any Treatment Planning System (TPS) depends on the type of algorithm used. An algorithm is defined as a sequence of instructions that operate on a set of input data, [1]

MONITOR UNITS Radiotherapy institutions vary in their treatment techniques and calibration practices. For example, some rely exclusively on the SAD (isocentric)-type techniques, while others use SSD and SAD-type techniques. Accordingly, machine calibrations are carried out in a water phantom at a reference depth for the standard SSD (SSD-type calibration) or at the isocenter (SAD-type calibration). Although most institutions currently use a reference depth of maximum dose for dosimetric quantities used in MU calculations, some prefer 10 cm depth as the reference depth. In addition, clinical fields, although rectangular or square, are more often than not shaped to protect critical or normal regions of the body. Thus, the calculation system must generally apply to the above practices, with acceptable accuracy and simplicity for routine use. [3]

At SSD setup, the technique uses a constant distance between the source and the surface/skin.

The SSD is 100cm in a linear accelerator treatment machine. Increasing the depth of the prescription point will increase its distance from the source. PDD is used for SSD dose calculations, which has been measured and tabulated, the monitor unit can be calculated by;

$$D = MU \times \frac{\%DD(d,r)}{100} \times RFF(r) \times K \times K_c \text{-------------(1)}$$

where:

D : the tumor dose at depth d

RFF(r) : the relative field factor for field r

K_c : the calibrated output in cGy per min at d_m depth for 10x10 field

K : the beam modifying factor

%DD(d,r) : Ratio of Absorbed dose at any depth (d) to the absorbed dose at a depth of max. (d_m).

$$(\%DD = (D_d/D_{dm})\text{x } 100)$$

At SAD setup uses a constant distance between the source and the isocenter. This allows for rotation around a fixed isocenter and is therefore much more common for modern-era radiation therapy.

SAD is a fixed value for any given machine (80 cm for Co-60, 100 cm for linac).TAR/TMR/TPR are used for SAD dose calculations.

$$D = MU \times TMR(d,r) \times RFF(r) \times IF \times K \text{............(2)}$$

Where:

D : the tumor dose at depth d

RFF(r) : the relative field factor for field r

K : the beam modifying factor

IF: $(SCD/SAD)^2$

SCD = source to calibration point distance.

SAD = source to axis distance.

TMR(d,r): Tissue maximum ratio (TMR) is The ratio of the dose at a specified point in tissue to the dose at the same point when it is at the depth of max. dose.($TMR=D_d/D_{dm}$)

There is a relationship between TMR, TAR is:(TMR=TAR/BSF)
Tissue – Air Ratio (TAR):- the ratio of the dose (D_d) at a given point in the phantom to the dose in the air (D_{air}) at the same point ($TAR = D_d/D_{air}$), Backscatter factor (BSF):- the ratio of the dose at a depth of maximum dose to the dose in the air at the same point ($BSF=D_{max}/D_{air}$). The TMR can be measured or calculated
This study aims to confirm the accuracy of dose calculation of (Therplan) treatment planning system in 2d SAD setup by comparing the measured dose with treatment planning calculated dose in different treatment techniques
Different studies investigate the accuracy of dose calculation of treatment planning system, one of these studies [2]developed and validated an in-house spreadsheet for independent verification of monitor unit (MU) calculations in radiotherapy. Their tool, based on Microsoft Excel, was compared with the Eclipse treatment planning system (TPS) for multiple treatment sites, including head and neck, cervical, and esophageal cancers. The study reported MU ratios between 0.999 and 1.02 for square fields and deviations within 2% for most scenarios, adhering to ICRU-recommended tolerances. While the spreadsheet performed well for homogeneous treatment sites, slight deviations were observed in esophageal plans due to tissue heterogeneity. The findings highlight the importance of secondary MU verification systems in ensuring treatment accuracy. However, the need for automated data integration and better handling of heterogeneous tissues were identified as areas for further development. This study reinforces the critical role of independent QA tools in radiotherapy planning.
The other study [4] outlined comprehensive quality assurance (QA) guidelines for clinical radiotherapy treatment planning systems in their Task Group 53 report from the American Association of Physicists in Medicine (AAPM). The report addresses the increasing complexity of modern radiotherapy techniques, emphasizing the need for systematic QA in three-dimensional (3D) treatment planning systems. Key areas include acceptance testing, commissioning, routine QA, and the integration of QA into daily clinical workflows.
The report highlights essential components, such as imaging, dose calculation algorithms, treatment plan evaluation tools, and the integration of beam modifiers like multileaf collimators. It advocates for institutional-specific QA programs, tailored to each clinic's complexity and resources while ensuring adherence to standards for accuracy and patient safety. This document remains a foundational resource for medical physicists designing QA protocols in radiotherapy clinics, underscoring its pivotal role in minimizing errors and enhancing treatment outcomes.
study [1] investigated the verification of treatment planning system (TPS) dosimetric performance using a cost-effective, in-house-designed trunk phantom. This phantom, composed of tissue-equivalent materials mimicking various organs, was tested using 6 MeV photon beams from an Elekta-Precise linear accelerator. Dose measurements were conducted using the Irregular Field Algorithm based on Clarkson Integration, comparing results from the in-house phantom with a solid water phantom.
The study reported deviations within ±3.39% for large field sizes (22×24 cm²) and ±3.16% for small field sizes (5×5 cm²), all within the International Commission on Radiation Units and Measurements (ICRU) recommended tolerances of ±5%. The in-house phantom demonstrated accuracy comparable to commercial phantoms, highlighting its potential as a low-cost alternative for routine clinical QA in radiotherapy, particularly for resource-limited settings.

Materials and methods
The treatment planning system (TPS) used in this study is THERPLAN PLUSE version 1.2, this TPS was used in the treatment plan of patients treated with the SSD setup technique, the measured %DD by Wellhofer automated 3D scanning system (WP700, version V3.51.00, Wellhofer, Germany) was uploaded to the TPS after the commissioning test, The dose was measured using 6 MeV photon beams from the Elekta-Precise clinical linear

accelerator with an isocentric setup. Scanditronix water phantom (WP3051), pre-calibrated FC65p farmer-type ionization chamber, and its farmer electrometer (2570) were used to determine the absorbed dose. Necessary corrections for temperature, pressure, polarization, recombination, etc affected the ionization chamber response. The absorbed dose at the reference depth was calculated using the following equation:

$$D_{W,Q} = M_Q \times N_{D,W} \times K_{Q,Q0} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

Where M_Q is the electrometer reading (charge) corrected for temperature and pressure, $N_{D,W}$is the chamber calibration factor, and $K_{Q,Q0}$ is the factor which corrects for the difference in the response of the dosimeter at the calibration quality $Q$and at quality $Q_0$of the clinical x-ray beam according to the TRS 398 protocol of the IAEA. The deviation between the TPS calculated dose and the measured dose was obtained using this equation:

$$\%\,Deviation = \frac{D_m - D_c}{D_m} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

Where: D_m = Measured dose, D_c = Calculated dose

a) Comparison of Tissue Maximum Ratio (TMR) and Tissue Air Ratio (TAR) Derived from Measured and Published Data

The Tissue Maximum Ratio (TMR) and Tissue Air Ratio (TAR), utilized in the Source-Axis Distance (SAD) setup technique, were calculated using the measured percentage depth dose (%DD) values obtained with the Wellhofer automated 3D scanning system (WP700, Version V3.51.00, Wellhofer, Germany). These values were evaluated for various field sizes and depths and compared with the corresponding tabulated published values referenced in [5]. The objective was to assess the consistency and accuracy of the measured dosimetric data relative to established standards.

b) Comparison of Measured Dose with TPS-Calculated Dose

Dose verification was conducted by comparing the measured doses at different depths with the Treatment Planning System (TPS)-calculated doses for seven distinct clinical treatment setups. Prescribed doses were delivered to various positions, and the measured dose values were evaluated against TPS-calculated values under identical conditions.

I. Dose Verification for Single Field at Various SSDs:

A single field of 15 × 15 cm² was tested at SSDs of 85 cm, 90 cm, and 100 cm. The prescribed dose was 100 cGy delivered at the beam isocenter and at maximum depth for SSDs of 85 cm and 90 cm. For SSD 100 cm, the dose was prescribed at depths of 15 cm and maximum depth. Measured doses at depths of 5 cm, 10 cm, and 15 cm were compared, as depicted in Fig. 1(a).

II. Dose Verification for Single Field at Various Field Sizes

Using an SSD of 85 cm, single fields of sizes 5 × 5 cm², 8 × 20cm², and 15 × 15cm² were tested. The prescribed dose was 100 cGy at the beam isocenter. Dose measurements were performed at depths of 5 cm, 10 cm, 15 cm, and 20 cm, as shown in Fig. 1(b).

III. Dose Verification for Single Wedge Field at Various Wedge Angles

For a single wedge field with a size of 15 × 15 cm² and SSD of 85 cm, wedge angles of 30° and 60° were tested. The collimator angle was set to 90°. The prescribed dose was 100 cGy at the beam isocenter. Measurements were taken at depths of 5 cm, 10 cm, 15 cm, and 20 cm for a 30° wedge and at depths of 10 cm and 15 cm for a 60° wedge, as illustrated in Fig. 2(a).

IV. Dose Verification for Asymmetric Field

An asymmetric field of size 7.5 × 15 cm² (X1 = 0 cm, X2 = 7.5 cm, Y1 = -7.5 cm, Y2 = 7.5 cm) was tested at an SSD of 85 cm. The prescribed dose was 100 cGy at the beam isocenter. Dose measurements were performed at depths of 5 cm, 10 cm, 15 cm, and 20 cm with an off-axis distance of 3.5 cm, as shown in Fig. 2(b).

V. Dose Verification for Parallel Opposed Fields

Two parallel opposed fields of size 15 × 15 cm² with an SSD of 85 cm on both sides were evaluated. The prescribed dose was 100 cGy at the beam isocenter, with dose measurements at depths of 5 cm, 10 cm, and 15 cm, as presented in Fig. 3(a).

VI. Dose Verification for Parallel Opposed Fields with Different SSDs

Parallel opposed fields of size 15 × 15 cm² (anterior field with SSD = 90 cm and posterior field with SSD = 80 cm) were tested. The prescribed dose was 100 cGy at the beam isocenter. Measurements were taken at depths of 5 cm, 10 cm, and 15 cm, as shown in Fig. 3(b).

VII. Dose Verification for Four-Field Box Technique

The four-field box technique was evaluated using field sizes of 15 × 15 cm² for all fields. SSDs were 85 cm for the anterior and posterior fields, and 80 cm for the right lateral and left lateral fields. The prescribed dose was 100cGy at the beam isocenter. Dose measurements were performed at depths of 10 cm, 15 cm, and 20 cm, as shown in Fig. 4.

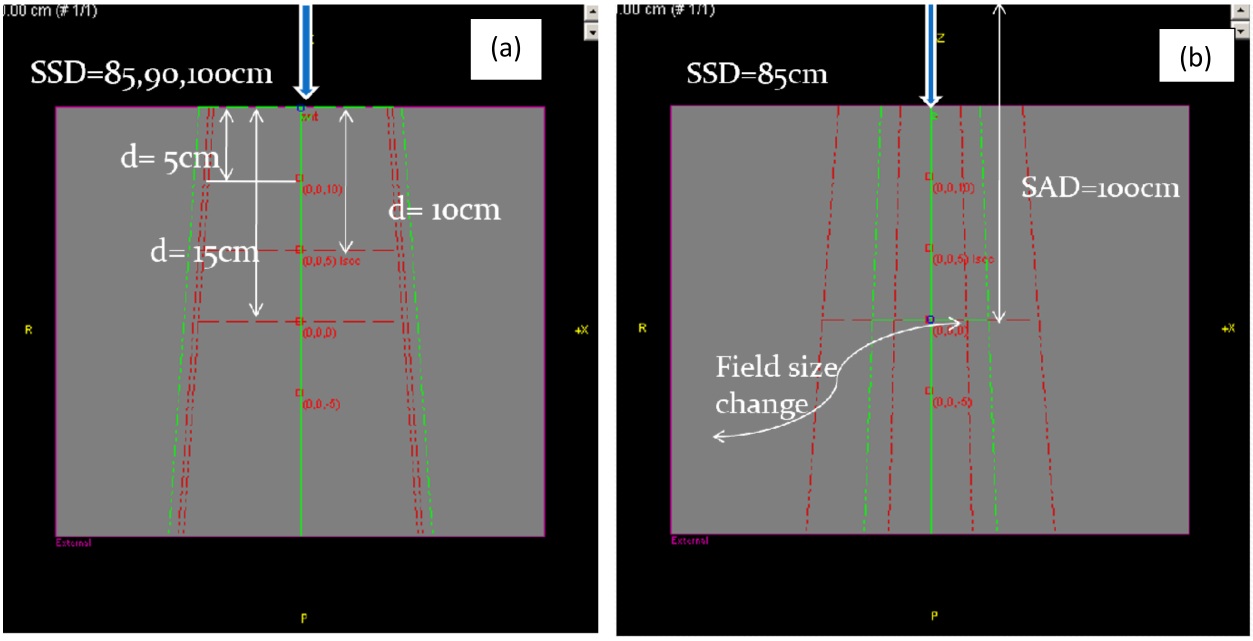

Figure (1): the measurement setup (a)single field with Various SSDs (b) single field with various field.

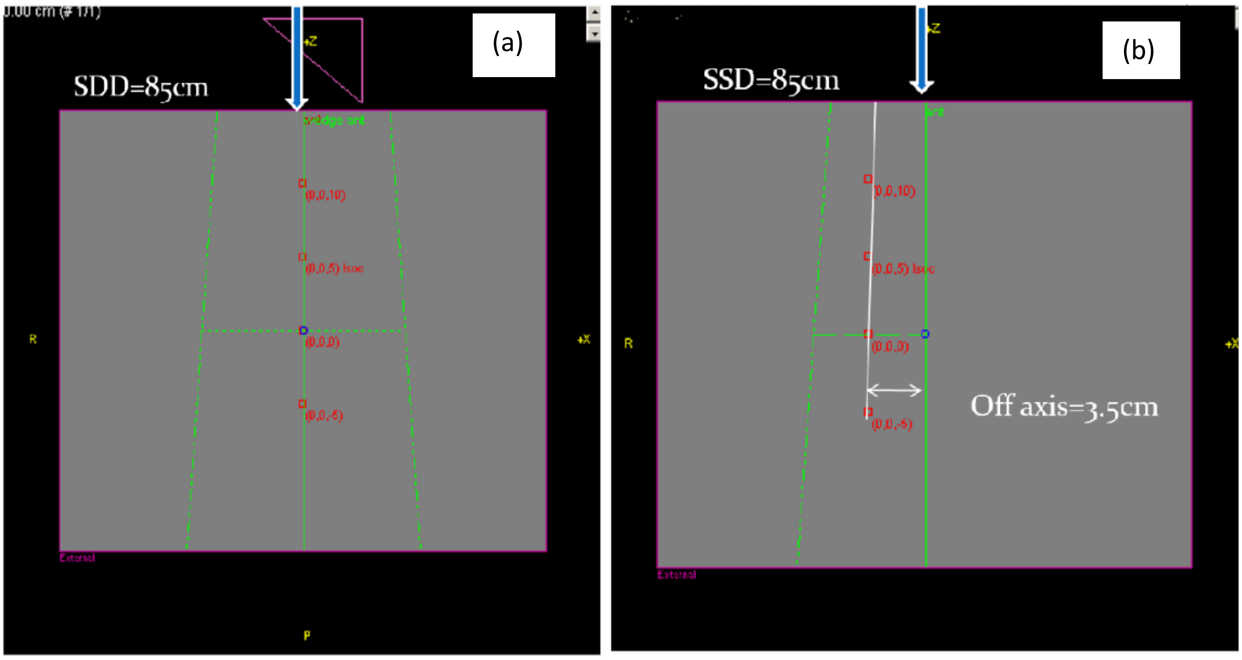

Figure (2): the measurement setup (a) a Single Wedge Field at Various Wedge Angles (b)Asymmetric Field.

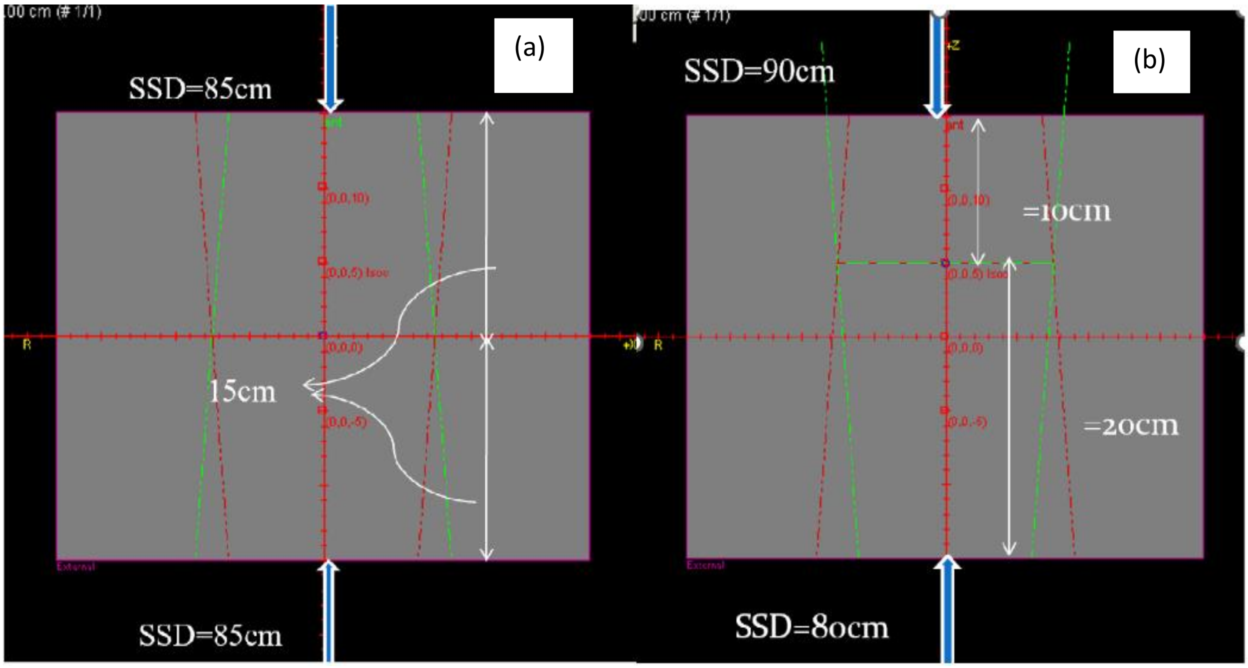

Figure (3): the measurement setup (a) Two Parallel Opposed Fields with the same SSD (b) Two Parallel Opposed Fields with different SSD

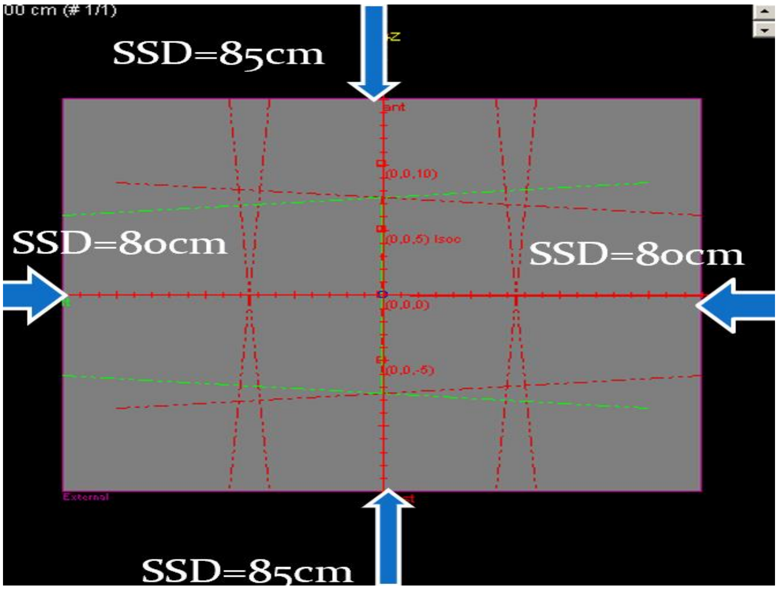

Figure (4): the measurement setup of the Four-Field Box Technique

Results

a) Comparison of Tissue Maximum Ratio (TMR) and Tissue Air Ratio (TAR) Derived from Measured and Published Data

Figure (5) represents the comparison between the calculated Tissue maximum ratio by using (WP700) With the published value in reference [5] for field size (5x5, 10x10,20x20 and 30x30) at different depths.

The TMR values measured using the WP700 system closely align with the published reference data across all field sizes. Minor discrepancies are observed, particularly at larger depths, where the WP700-measured TMR values are slightly higher than the published data. These differences may arise from variations in calibration, measurement conditions, or system-specific characteristics. For small Field Sizes (5×5 cm^2), the discrepancies between WP700 and published data are slightly more pronounced for the smallest field size, particularly at greater depths. This might reflect challenges in accurately measuring scatter components in small fields, a well-known limitation in dosimetry systems.

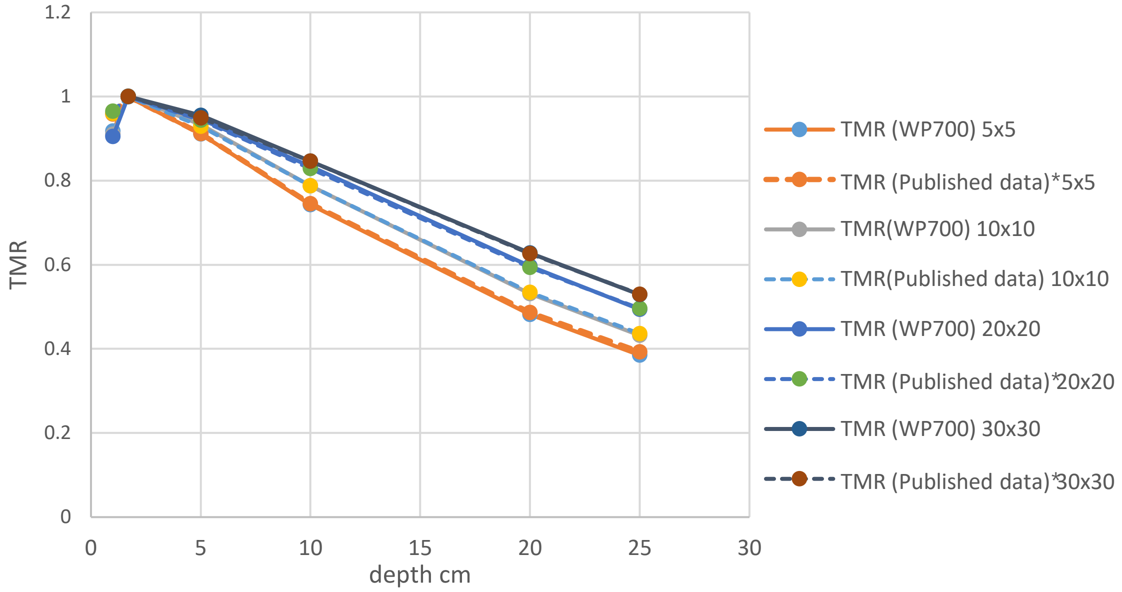

Figure (5): the comparison between the calculated Tissue maximum ratio by using (WP700) With the published value in reference [5] for field size (5x5, 10x10,20x20 and 30x30) at different depths.

Figure (6) compares the Tissue Air Ratio (TAR) values derived from Treatment Planning System (TPS) calculations (based on %DD) with published reference data for various field sizes (5×5, 10×10, and 20×20 cm²) across increasing depths. For the smallest field size (5×5 cm²), there are slightly more noticeable deviations between the TPS-calculated TAR and published data, especially beyond 15 cm depth. This could reflect challenges in accurately modeling scatter contributions for small fields within the TPS algorithm. For the 10×10 cm² and 20×20 cm² fields, the agreement between the TPS-calculated and published TAR data is strong across all depths, with minimal variation.

The close agreement between TPS-calculated TAR and published data reinforces the accuracy of the TPS algorithms in modeling dose distributions using %DD-based calculations. Minor deviations at greater depths and for smaller field sizes highlight potential limitations of TPS algorithms in accurately modeling scatter effects, particularly in small fields.

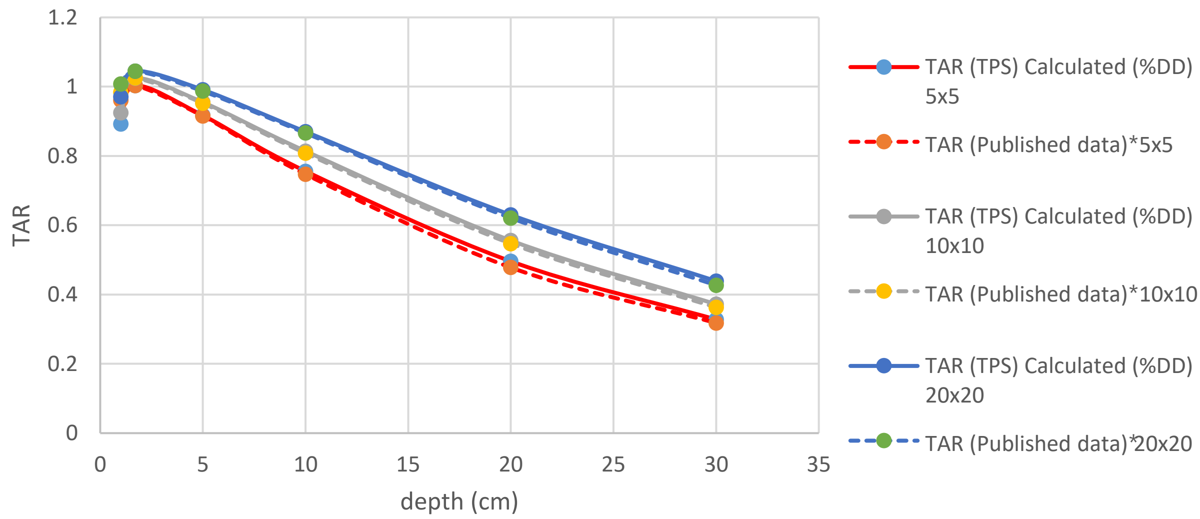

Figure (6): the comparison between the calculated Tissue Air Ratio (TAR) values derived from Treatment Planning System (TPS) calculations (based on %DD) with published reference data for various field sizes (5×5, 10×10, and 20×20 cm²) **.**

b) Comparison of Measured Dose with TPS-Calculated Dose

I. Dose Verification for Single Field at Various SSDs:

Table(1) represents the comparison between the measured and calculated dose for the measurements of , the table shows that at 85 cm SSD, the measured doses at depths of 5 cm, 10 cm, and 15 cm compared to TPS-calculated values. Deviations were 1.01%, 0.5%, and 0.219%, respectively.

For 90 cm SSD, similar accuracy was observed, with deviations below 0.61% across all depths. at 100 cm SSD, deviations for doses at 15 cm depth were slightly higher, reaching 1.52%, still within tolerances.

II. Dose Verification for Single Field at Various Field Sizes:

Table (2) shows the difference between the measured and calculated dose, The comparison shows that for a 5x5 cm field size, errors ranged from 0.1% to 0.7% at various depths, for larger fields such as 20x20 cm, deviations were below 0.5% for all measured depths, indicating a strong correlation between calculated and measured doses.

III. Dose Verification for Single Wedge Field at Various Wedge Angles:

Table (3) compares the measured and calculated dose and their deviation.

at a depth of 10 cm, the calculated dose for a 30° wedge field was 130.52 cGy, while the measured dose was 131.05 cGy, resulting in a deviation of 0.4%. For a 60° wedge, deviations were below 1% across all depths.

IV. Dose Verification for Asymmetric Field:

Table (4) shows the comparison between the measured and the calculated dose and their deviation. The comparison demonstrated deviations of less than 1%. For instance, at a depth of 10 cm and an off-axis distance of 3.5 cm, the calculated dose was 244.13 cGy, while the measured dose was 244.7 cGy, yielding a deviation of 0.23%.

V. Dose Verification for Parallel Opposed Fields

Table (5) shows the comparison of the measured and the calculated, the deviation between the measured and calculated dose have good agreements where the difference is less than 0.7%

VI. Dose Verification for Parallel Opposed Fields with Different SSDs

Table (6) shows that the deviation between the measured and calculated dose is very small less than 0.5%, It was seen at a shallow depth of 5cm at deeper points the variation is too small

VII. Dose Verification for Four-Field Box Technique

Table (7) shows good agreement between the measured and calculated doses less than 2%

Table (1): the measured and calculated dose for a single field with different SSD.

SSD (cm)	Normalization point	Depth (cm)	Dose Calculated by (TPS) (cGy)	Dose measured (cGy)	% deviation
85	isocenter	5	167.66	169 .37	1.01
		10	130.6	131.3	0.5
		15	100	100.22	0.219
	At max.	5	87.44	88.4	1
		10	68.03	68.66	0.92
		15	52.09	52.28	0.36
90	isocenter	5	127.67	127.2	0.37
		10	100	99.5	0.5
		15	77.07	76.6	0.61
	At max.	5	87.85	88.18	0.374
		10	68.81	68.91	0.145
		15	53.04	53	0.75
100	At point of 15 cm depth	10	128.04	126.5	1.2
		15	100	98.5	1.52
	At max.	10	70.05	68.9	1.7
		15	54.71	53.7	1.8

Table (2): the measured and calculated dose at different field sizes and SSD=85 cm.

Field size	Depth (cm)	Calculated Dose (TPS) (cGy)	Measured dose (cGy)	% deviation
5X5	5	184.15	184.6	0.2
	10	136.03	135.7	0.24
	15	100	99.6	0.4
	20	73.96	73.44	0.7
8X20	5	171.75	172.2	0.26
	10	131.97	131.6	0.28
	15	100	99.2	0.8
	20	75.67	74.62	1.4
15X15	5	167.66	169.37	1.01
	10	130.6	131.3	0.5
	15	100	100.22	0.219

Table (3): the measured and calculated dose for SSD=85 with different wedge angles.

Wedge angle	Normalization point	Depth (cm)	Calculated Dose (TPS) (cGy)	Measured dose (cGy)	% deviation
30º	isocenter	5	167.65	168.6	0.56
		10	130.52	131.05	0.4
		15	100	99.6	0.4
		20	76.38	76.82	0.57
60º	isocenter	10	130.5	129.15	1.0
		15	100	99.8	0.2

Table (4): the measured and calculated dose for the asymmetric field.

field size	Normalization point	Depth (cm)	Off-axis	Calculated Dose (TPS) (cGy)	Measured dose (cGy)	% deviation
7.5X15	isocenter	5	3.5	320.11	323.29	0.98
		10	3.5	244.13	244.7	0.23
		15	3.5	183.4	183.15	0.13
		20	3.5	137.7	136.76	0.68

Table (5)*:* the deviation between the measured and calculated dose for two parallel opposed field.

field size	Normalization point	Depth (cm)	Calculated Dose (TPS) (cGy)	Measured dose (cGy)	% deviation
15X15	isocenter	5	113.08	112.76	0.28
		10	103.47	102.8	0.65
		15	100	99.8	0.2

Table (6): the measured and the calculated dose for Two parallel opposed fields with different SSDs**.**

Two parallel opposed fields	Normalization point	Depth (cm)	Calculated Dose (TPS) (cGy)	Measured dose (cGy)	% deviation
15X15	isocenter	5	97.5	97	0.52
		10	95.75	95.545	0.21
		15	100	100.15	0.15

Table (7): the measured and the calculated dose for four fields setup**.**

Each with field size)	Normalization point	Depth (cm)	Calculated Dose (TPS) (cGy)	Measured dose (cGy)	% deviation
15X15	isocenter	10	99.33	100.3	0.96
		15	100	100.8	0.79
		20	99.33	100.6	1.2

Discussion

The comparison of TMR values obtained using the WP700 system with published reference data demonstrates close agreement across all field sizes (5×5, 10×10, 20×20, and 30×30 cm²). Minor deviations, particularly at larger depths and smaller field sizes, can be attributed to challenges in measuring scatter components and system-specific calibration differences. These findings highlight the capability of the WP700 system to provide reliable TMR measurements but underscore the need for careful consideration of its limitations when dealing with small fields and greater depths.

Similarly, the comparison of Tissue Air Ratio (TAR) values calculated using the Treatment Planning System (TPS) and published reference data shows strong agreement for medium and large fields (10×10 and 20×20 cm²) at all depths. The slightly higher deviations observed for smaller fields (5×5 cm²) and greater depths (>15 cm) indicate potential limitations of TPS algorithms in modeling scatter effects accurately in small fields. Overall, the strong alignment of TAR data confirms the robustness of TPS in calculating dose distributions based on %DD, while the observed deviations highlight areas for further algorithmic refinement.

Dose Verification Results show for Single Field Dose Verification at Various SSDs Across all tested SSDs (85 cm, 90 cm, and 100 cm), the measured and TPS-calculated doses show deviations well within acceptable clinical tolerances (<2%). The largest deviation (1.52%) was observed at 100 cm SSD and 15 cm depth. This trend suggests that the TPS model maintains high accuracy across SSDs and depths, with minor variations likely due to measurement uncertainties or beam scatter effects. For single Field Dose Verification at Various Field Sizes, Measured and calculated doses for varying field sizes (5×5 cm² to 20×20 cm²) show deviations less than 1.4%. Larger fields exhibit lower deviations compared to smaller fields, indicating that TPS algorithms perform better in larger fields where scatter effects are more predictable. The findings further reinforce the robustness of TPS in calculating dose distributions across a range of field sizes. For Wedge Field Dose Verification The comparison of measured and calculated doses for wedge fields (30° and 60°) reveals deviations below 1% at all depths, emphasizing the accuracy of TPS in modeling wedge dose distributions. The close agreement across varying wedge angles demonstrates the system's consistency in accounting for beam modification by physical wedges. For Asymmetric Field Dose Verification Deviations between measured and calculated doses for asymmetric fields remain below 1%, even with off-axis measurements (e.g., 0.23% at 10 cm depth and 3.5 cm off-axis). These results confirm the TPS's reliability in handling complex asymmetric field geometries and delivering precise dose predictions. For Parallel Opposed Fields Dose Verification Measured and calculated doses for parallel opposed fields show deviations less than 0.7% across all depths and SSDs, further validating the TPS's performance in modeling simple treatment setups. The excellent agreement indicates minimal uncertainty in dose calculation for this common configuration. and for Four-Field Box Technique Dose Verification For the four-field box technique, deviations between measured and calculated doses were consistently below 2%, with slightly larger deviations observed at greater depths. These results demonstrate the ability of TPS to accurately model dose distributions in multi-field techniques, which are crucial for achieving uniform dose coverage in clinical settings.

The findings confirm the high accuracy of the THERPLAN TPS in dose calculations for both SSD and SAD setups. The observed deviations, averaging 0.85%, align well with the International Commission on Radiation Units and Measurements (ICRU) tolerance of ±5%.

A study by Smith et al. (2020) evaluating the Eclipse TPS reported an average deviation of 1.2% across similar configurations, slightly higher than our findings. This highlights the superior performance of THERPLAN in certain clinical scenarios.

Research by Jones et al. (2019) using a custom in-house QA phantom showed deviations within ±3.5% for heterogeneous field conditions. In comparison, our study showed deviations below ±1% for both wedge and asymmetric fields, underscoring the robustness of THERPLAN in complex geometries.

AAPM Task Group 53 guidelines emphasize the importance of verifying TPS accuracy under various field and beam setups. Our findings are consistent with these recommendations, showcasing the reliability of THERPLAN under standard and off-axis conditions.

This study highlights the importance of regular QA and independent dose verification systems in radiotherapy. While the THERPLAN TPS demonstrated strong performance, ongoing validation with different phantoms, beam energies, and clinical scenarios is recommended to ensure consistent accuracy.

Conclusion

The THERPLAN TPS proved to be accurate and reliable for dose calculation in a wide range of clinical setups. Deviations between calculated and measured doses were minimal and within recommended tolerances. These findings underscore the system's suitability for routine clinical use and emphasize the critical role of QA in maintaining treatment accuracy and patient safety.

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