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RESEARCH ARTICLE

Field Width Comparison of the Photon Beams 6 Mv and 10 Mv Coming Out of the Radiotherapy Linear Accelerator

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ABSTRACT

The current study aims to measure and compare the field width emerging from the radiotherapy linear accelerator in different directions, three dimensions were chosen to measure the field width in an orderly (inline, cross line, diagonal A and B) manner. The 10 Mv and 6 Mv photon beam energies were used, and the Star Track device was adopted to measure the field width in different directions. The radiotherapy linear accelerator at the Baghdad Center for Radiation Therapy and Nuclear Medicine was used every week five weeks. The results recorded that when the energy increased 10 Mv, there was an increase in field width, reaching 10.55/10.45 ± 0.2 cm in the fourth week, while it decreased and became 10.49/10.52 ± 0.2 cm when the energy was 6 Mv. In direction diagonal A and B, the readings were within the limits, as they did not exceed the applicable limits, namely 14.46 ± 0.2 cm for 10 Mv and 14.49 ± 0.2 cm for 6 Mv. All results were within the permissible limits and in force of the global health organizations, where the readings did not exceed 10.52 ± 0.2 cm for 6 Mv, 10.54 ± 0.2 cm for 10 Mv from the tolerance reference.

Keywords: Field width, Quality management, Linear accelerator, Radiation therapy, Star Track

Introduction

Cancer continues to be the leading root of mortality internationally, with nearly 10 million deaths in 2020, or about one in six deaths.[1,2] The most common cancers are breast, lung, colon and rectum, and prostate cancers. The International Agency for Research on Corruption (IARC) recently projected that cancer causes 12.7 million novel cases and 7.6 million deaths annually across the globe. Most of this burden falls on evolving countries, which are said to be responsible for 63% of cancer-related killing.[3–5]

Medical linear accelerators are applied due to the production of high-energy rays that have high penetration depth to tumors and radiation safety to the surrounding health tissues. Technology near accelerator technology is complex and diverse. The target of medical radiotherapy with linear accelerators is to customize a specific amount of radiation within the permissible ranges in the treatment of the cancer group, and in a controlled manner using a beam photon outside a linear accelerator.[6–8] In radiationtherapy, it is necessary that the appropriate dose is delivered to the tumor volume accurately to be

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effective.[9–11] Therefore, the dose given to the patient should be as accurate as possible to the quantity intended.[12–14]

To produce high-power (MV) radiation emissions with well-established therapeutic, practical, and radiation safety benefits, medical linear accelerators are frequently utilized in radiotherapy. These gadgets are sophisticated technologically. Empathetic, the practical operation of these devices and the impact of machine changes on the therapeutic qualities of the generated X-grin beams constitute a significant cut of radio-therapy medical physics training plug-ins. To transfer out routine maintenance and repairs on these devices, most radio-therapy departments use professional service organizations or specific service agreements with the manufacturer.[15–17] In general, more than half of all disease patients utilize radiation therapy, which is indispensable for both curative and palliative care.[18–20]

Radiation-beam of 'field width'

As experimental since the obverse focus of the birthplace, the symmetrical field size is defined by the ICRU as "projection of the distal ending of the machine collimator onto a plane perpendicular to the focal axis of the radiation ray".[21]

The intercept of an isodose is shallow, which is naturally 50%, Although it can also stay in the middle alignment of the radiation beam at a predetermined space from the source, the resolve Dosimetric field size is also identified as the physical field size.[22]

As the field upsurges as an effect of the rise in energy, it leads to an increase in scattering, which calls for constant care in checking the field used in radiotherapy for patients.[11,23,24] The fields used in treatment are many, they may be small or large,[25–27] In the study, a fixed field of 10 cm^2 was used for different energies and different directions to know the extent of staying within the permissible ranges.

Alpha

The alpha particle is the nucleus of the helium atom and consists of two protons and two neutrons. It combines with 2 protons and 2 neutrons, and these four are characterized by the greatest loss of mass when they combine to form the helium nucleus. It has a positive electrical charge of 2 units because it contains 2 protons, and has a weak penetrating power and a weak ability to penetrate due to its weight and low speed. It has a great ability to ionize substances, as the ionization rate in substances that contain alpha particles is directly proportional to the square of the particle's charge.[28–30]

Beta

High velocity electrons start in the nucleus. With a mass of 1/1840 amu and a single unit of negative charge, these "nuclear electrons" are exactly like atomic electrons. An additional kind of β radiation, C. D. Anderson discovered in 1932. Positron radiation is made up of particles with one unit of positive charge that has the same mass as an electron.

Understanding positions is essential to comprehend some radioactive decay pathways, even if they are not as significant from the perspective of radiation shielding as negative b particles. The symbols for beta radiation are β^- (electrons) or β^+ (positrons). The phrase "b radiation" often refers to the negative kind in ordinary speech.[28]

X-ray and γ radiation

X-ray and γ interact with matter via several different processes, the three most significant being pair creation, Compton scattering, and the photoelectric effect All of an X–ray or γ photon's energy is transmitted in the photoelectric effect to an electron in an atom that is expelled from Its parent energetic γ photon may transform into a positron-electron pair in the strong electric field near a charged particle, often a nucleus the two particles that come from this pair formation share the available energy. On the other hand, just a portion of the photon's energy is converted to an atomic electron when Compton Scattering takes place. After that, the dispersed photon continues with less energy.[28,29] Properties of different types of radiation are presented in Table 1.

Table 1. Properties of nuclear radiation.[28]

Radiation	Mass (u)	Charge	Range in air	Range in tissue
α	4	+2	~0.03 m	~0.04 mm
β	1/1840	–1 (positron +1)	~3 m	~5 mm
x and γ radiation	0	0	Very large	Through body
Fast neutron	1	0	Very large	Through body
Thermal neutron	1	0	Very large	~0.15 m

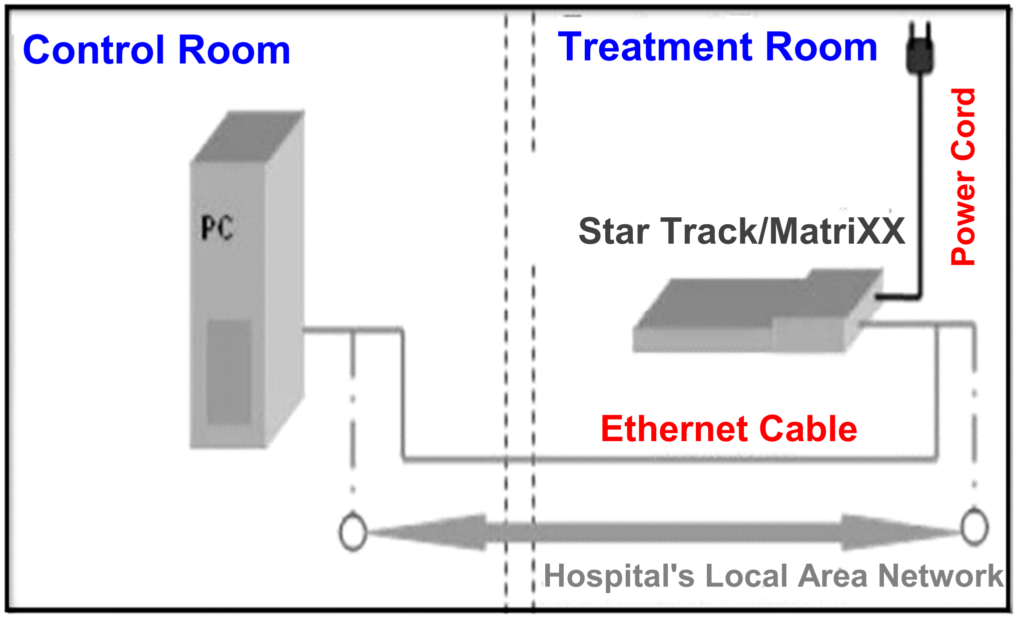

Fig. 1. Work star track system diagram.

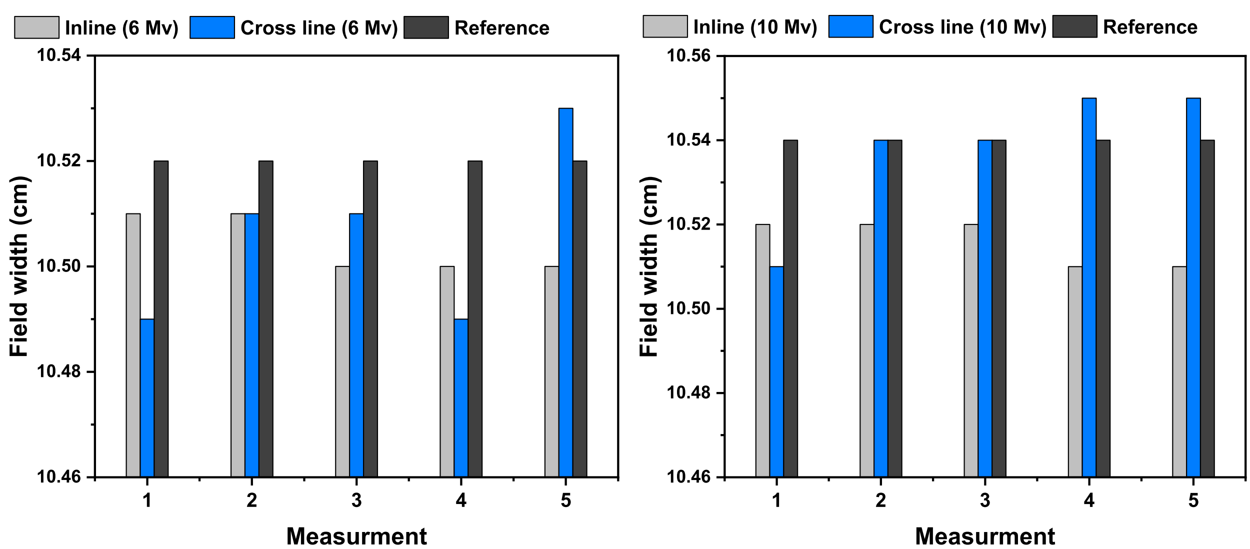

Fig. 2. Field width of energies 6 Mv and 10 Mv in both directions (inline–cross line) with reference.

Radiation interaction with matter

Nuclear radiation is fundamentally different from more widely encountered radiations like heat and light in that they possess enough energy to induce ionization. Ionization can result in molecular changes in water, which is primarily made up of cells. and to the development of chemical species that harm the material of the chromosomes. Damage manifests as modifications to the cell's structure and functionality. These alterations in the human body can show up as clinical symptoms like radiation sickness, cataracts, or, over time, cancer.[28]

The presented work aims to measure and compare the field width emerging from the radiotherapy linear accelerator in different directions. Three dimensions were chosen to measure the field width in an orderly (inline, cross line, diagonal A and B) manner. The 10 Mv and 6 Mv photon beam energies were used, and the Star Track device was adopted to measure the field width in different directions. Radiotherapy linear accelerator at the Baghdad Center for Radiation

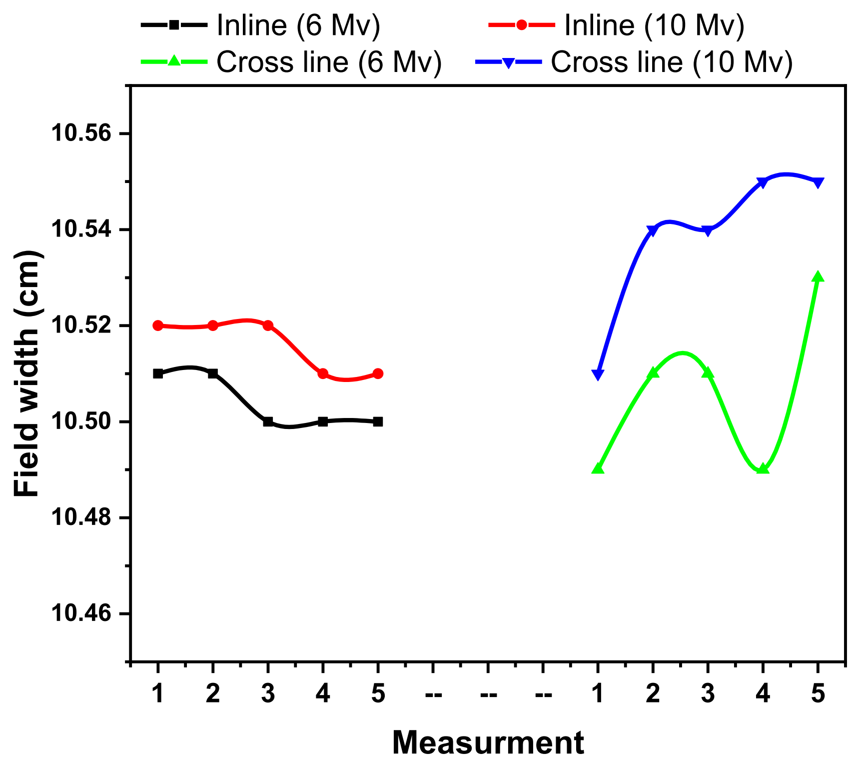

Fig. 3. Field width comparison of energies 6 Mv and 10 Mv in both directions (inline–crossline).

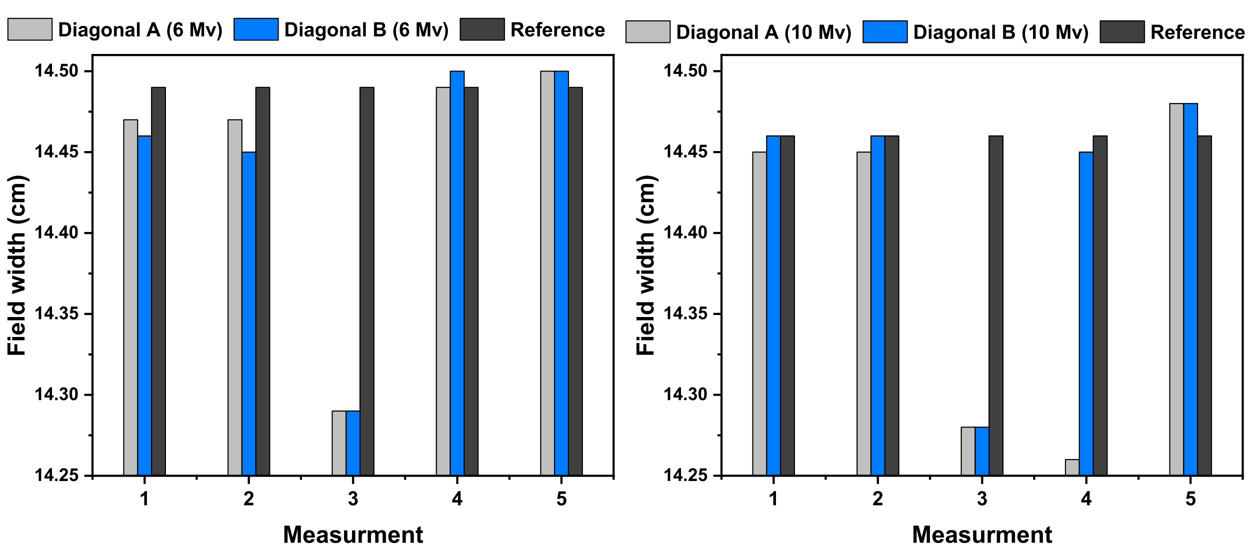

Fig. 4. Field width of energies 6 Mv and 10 Mv in two diagonals (A, B).

Therapy and Nuclear Medicine was used every week for five weeks. Compared to traditional methods, it will be more precise and accurate testing for linear accelerator quality management.

Materials and methods

The field width measurement was performed for photon beams (6 MV, 10 MV). All measurements were taken using the Star track and linear accelerator device at the Baghdad Center for Irradiation and Nuclear Medicine at Baghdad Teaching Hospital.

Measurement of field width by the Star Track method

All field width measurements were performed at 100 cm from source to surface and depth of D_{max} (Dose depth).

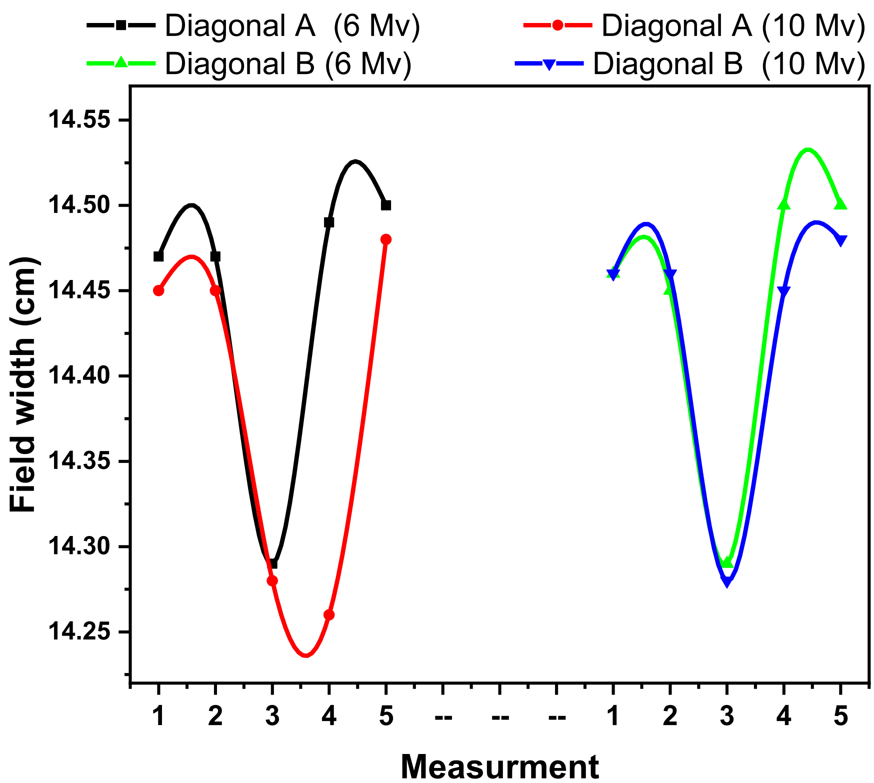

Fig. 5. Difference between widths of the field for energies 6 Mv and 10 MV in two diagonals (A, B).

Star Track was positioned on the medical couch directly underneath the linear accelerator for these measurements; (inline, crossline, and diagonal A, B axes) to serve as the foundation for determining the measuring radiation field's size. The work star track system diagram is shown in Fig. 1.

Then, open a system-specific window by selecting the symbol designated for setup, looking at the right mark on the two measurement alternatives, and returning to the previous menu.

In the work room, both the instrument and the linear accelerator must be calibrated within the fixed measurements, which are energy 6 Mv and 10 Mv for the photon beam, the field is 10 cm^2, and beam depth is at D_{max}.[31]

Results and discussion

In the present work, four case measurements are considered (inline, crossline, and diagonal A, B axes) to serve as the foundation for determining the measuring radiation field's size. In each case five measurements (in five weeks) were achieved, and results were obtained.

Tables 2 and 3 present the field width applying energies 6 Mv and 10 Mv. In each table, the reference tolerance values are listed to compare the obtained

Table 2. Measurement of the field width for 6 Mv photon beam (inline and crossline).

Field width (cm) inline	Field width (cm) Crossline	Reference/tolerance	status
10.51	10.49	10.52/ ± 0.2 cm	Passed
10.51	10.51	10.52/ ± 0.2 cm	Passed
10.50	10.51	10.52/ ± 0.2 cm	Passed
10.50	10.49	10.52/ ± 0.2 cm	Passed
10.50	10.53	10.52/ ± 0.2 cm	Passed

Table 3. Measurement of the field width for 10 Mv photon beam (inline and Crosse line).

Field width (cm) inline	Field width (cm) Crossline	Reference/tolerance	status
10.52	10.51	10.54/ ± 0.2 cm	Passed
10.52	10.54	10.54/ ± 0.2 cm	Passed
10.52	10.54	10.54/ ± 0.2 cm	Passed
10.51	10.55	10.54/ ± 0.2 cm	Passed
10.51	10.55	10.54/ ± 0.2 cm	Passed

results. A more detailed explanation for these results is shown in Fig. 2, the field width of energies 6 Mv and 10 Mv in both directions (inline–cross line) with reference are presented. From tables and Fig. 2, the effect of energy is clear in the case of cross line more than in the inline case. In the two cases, results of field width are within reference ± tolerance values. In Figs. 1 and 2, the results are close to the

Table 4. Measurement of the field width for 10 Mv photon beam (diagonal A and B).

Field width (cm) diagonal A	field width (cm) diagonal B	Reference/tolerance	status
14.45	14.46	14.46 ± 0.2 cm	Passed
14.45	14.46	14.46 ± 0.2 cm	Passed
14.28	14.28	14.46 ± 0.2 cm	Passed
14.26	14.45	14.46 ± 0.2 cm	Passed
14.48	14.48	14.46 ± 0.2 cm	Passed

Table 5. Measurement of the field width for 6 Mv photon beam (diagonal A and B).

Field width (cm) diagonal A	field width (cm) diagonal B	Reference/tolerance	status
14.47	14.46	14.49 ± 0.2 cm	Passed
14.47	**14.45**	**14.49 ± 0.2 cm**	**Passed**
14.29	14.29	14.49 ± 0.2 cm	Passed
14.49	**14.50**	**14.49 ± 0.2 cm**	**Passed**
14.50	14.50	14.49 ± 0.2 cm	Passed

reference values, with a slight difference permitted and declared by the device manufacturer.[15] Fig. 3 shows a field width comparison of energies 6 Mv and 10 Mv in both directions (inline–cross line). The more harmonic trend is observed in the case of inline than crossline case due to the field size effects. Also, the effect of energy is clear as the energy increases from 6 Mv to 10 Mv the field size increases.

Tables 4 and 5 with Fig. 4 show the field width applying energy 6 Mv and 10 Mv in two direction diagonals (A and B). Although results vary due to collimator tip dispersion and a rise in energy, the values were stable and fluctuated around the reference value.[15]

Fig. 5 explains the difference between the field widths of energies 6 Mv and 10 MV in two diagonals (A, B). Unlike the cases of inline and crossline cases, the effect of energy is not clear in the case of diagonals (A and B). In Fig. 5, there is a convergence in values, and this confirms the accuracy of the readings with a small difference within the permissible limit. There is an increase in field due to an increase in energy.

Conclusion

The search goal is specific to accelerator devices and results identical to the results assigned to them can be obtained and follow the recommendations for measuring x-rays. Verifying the use of radiation in the treatment of tumors is an important basis for the success of the treatment steps. Therefore, the accuracy of the readings and their non-deviation from the internationally established limits confirmed the effectiveness and readiness of the device for treatment. In the presented work, four case measurements were considered (inline, crossline, and diagonal A, B axes) to serve as the foundation for determining the measuring radiation field size by applying two energies 6 Mv and 10 Mv. In each case five measurements were achieved, and results were obtained. The effect of energy is clearer in the case of a cross line than in the inline case for the two energies 6 Mv and 10 Mv. Although results vary due to collimator tip dispersion and a rise in energy results of field width are within reference ± tolerance values. Unlike the cases of inline and crossline cases, the effect of energy is not clear in the case of diagonals (A and B). The results confirmed that it was consistent with the recommendations for measuring dosage, it confirmed the accuracy of the device in measuring. Therefore, I recommend using the device to verify the quality of linear accelerators.

Authors' declaration

- Conflicts of Interest: None.
- We hereby confirm that all the Figures and Tables in the manuscript are ours. Furthermore, any Figures and images, that are not ours, have been included with the necessary permission for republication, which is attached to the manuscript.
- No animal studies are present in the manuscript.
- No human studies are present in the manuscript.
- Ethical Clearance: The project was approved by the local ethical committee at Minia University, El-Minia, Egypt.

Authors' contribution statement

B.S.L, B.K.R. and M.M. designed the study. B.S.L, B.K.R. and I.J.H performed the experiments. H.K. and M.M. performed analyzing data. H.K, B.S.L and M.M. making figure presentation, B.K.R, H.K. and M.M. wrote the original draft paper with input from all authors. all authors read, revise and accept the final version.

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مقارنة عرض المجال لحزم الفوتون 6 ميجا فولت و10 ميجا فولت الخارجة من المسرع الخطي للعلاج الإشعاعي

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[4]قسم الفيزياء، كلية العلوم، جامعة المنيا، 61519، المنيا، مصر.

الخلاصة

تهدف الدراسة الحالية إلى قياس ومقارنة عرض المجال الخارج من المسرع الخطي للعلاج الإشعاعي في اتجاهات مختلفة، وقد تم اختيار ثلاثة أبعاد لقياس عرض المجال بطريقة منظمة (مضمنة، خط متقاطع، قطري A وB). تم استخدام طاقات شعاع الفوتون Mv10 و Mv6، وتم اعتماد جهاز Star Track لقياس عرض المجال في اتجاهات مختلفة. تم استخدام المعجل الخطي للعلاج الإشعاعي في مركز بغداد للعلاج الإشعاعي والطب النووي بشكل أسبوعي لمدة خمسة أسابيع. سجلت النتائج أنه عند زيادة الطاقة 10 ميجا فولت حدث زيادة في عرض المجال حيث وصل إلى 10.45/10.55 ± 0.2 سم في الأسبوع الرابع بينما يتناقص ويصبح 10.49 /10.52 ± 0.2 سم عندما تكون الطاقة 6 ميجا فولت. في الاتجاه القطري A وB، كانت القراءات ضمن الحدود، حيث أنها لم تتجاوز الحدود المطبقة، وهي 14.46± 0.2 سم لـ 10 ميجا فولت و14.49 ± 0.2 سم لـ 6 ميجا فولت. جميع النتائج كانت ضمن الحدود المسموح بها والمعمول بها من قبل منظمات الصحة العالمية، حيث لم تتجاوز القراءات 10.52 ± 0.2 سم لـ 6 ميجا فولت، 10.54 ± 0.2 سم لـ 10 ميجا فولت من مرجع التسامح.

الكلمات المفتاحية: عرض المجال، إدارة الجودة ،معجل خطي، علاج إشعاعي، المسار نجمة.