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Comparison between different cancer radiotherapy field shaping techniques using 6 MV and 15 MV photon energies.

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ABSTRACT

The aim of this study is to provide technical data bout replacing cerrobend casting blocks by multileaf collimator at the surface dose for different field sides and depths. As part of the commissioning process for a commercially available MLC, percentage depth doses from the surface to a depth of 30 cm have been measured for a number of square fields utilizing 6 MV and 15 MV X-rays.
Changes in SSD, the existence of a secondary blocking tray in the beam, and radiation transmission between the MLC leaves were among the variables that were considered. We recommend using multileaf collimator as shaping technique instead of Cerrobend blocks as its economic and less time consuming**.**

Keywords: *Cerobend; Multileaf collimator; X-ray; Blocks*

1. Introduction

The most important part of radiotherapy is linear accelartor (Goulet et al., 2011). The majority of developed countries use basic linear accelerator treatment. Depending on the model, they can generate photon beams, electron beams, or both a straight line. An accelerator can generate high-energy x-rays to attack a tumour and destroy cancer cells while preserving surrounding normal tissue (Devic et al., 2006).The photon beams have a broad spectrum of energies extending up to the maximum energy of the electrons striking the target, with a peak at roughly half that maximum value. Radiation oncology departments are increasingly purchasing and using multileaf collimators that are readily available on the market. A lot of researchers have been performed relatively new field size shaping technology in order to evaluate the basic physical parameters such as (absolute dose, relative dose, region of penumbra) to choose the important key factor for quality assurance (Alaei & Higgins, 2010). The benefits and drawbacks of replacing traditional blocking with an MLC have been examined. The gap between source of x-ray and secondary blocking has dominant effect of shaping of radiation field size (Baba, & Singh, 2022). It's impotent of to judge the effect of this gap on patient skin buildup region (Chibani, & Ma, 2007).We introduce the results of measuring of value of buildup region and PDD measurement of field size to compare between MLC and Cerrobend block. Physical dosimetry and clinical practice measurement effect on planning strategy on of cancer treatment were examined.

Last decade multileaf collimators are widely used as routine work in many clinical oncology centers, it is not stopped on normal used but folded other pattern such as intensity modulated radiotherapy (imrt) and image guided radiotherapy (Racka et al., 2022). imrt the shaped is formed by using complex processing through complicated algorithms (Kehwar et al., 2006). The basic level for moving from cerrobend blocks to high technology radiotherapy machines is to conform field shape in 2D dimensional this reduces the normal tissue to unwanted radiation (Muir et al., 2012). High resolution dosimeter must be used for verification of intensity modulated RT. This should be done in two types of IMRT dynamic and step and shot one (Helyer & Heisig, 1995).

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Built up dose of depends on many factors such as the effective point of measurement (epom) of ionization chamber which differ from chamber to chamber and must be identified before dose verification (Quach et al., 2000)

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The epom depends on chamber round angle and length also depend greatly on radius of chamber. the position of electrode also affects the reading of absolute dose.

All previous factor should be taken in to account before making the comparison between cerrrobend built up dose and multileaf collimator built up dose.

2. Material and methods

2.1. Elekta pricise linear accelerator

Elekta precise linear accelerator device is used as source of photon beam in combination with framer type ionization chamber as detecting device, PTW Germany is used as electrometer, advanced planning software mephesto serial 9.2 is used in patient planning and quality assurance procedures.

The distance between the source and detector is 100 cm, and field side ranging from 1 cm to 35 cm is used in this study. small size ionization chamber is used and connected to beam analyzer for measuring dose at different depths ranging from 2 mm to 30 mm.

2.2. Styroform

Styroform manufactured by Huestis. model SF-2 is used in this study. A bismuth as alloy with low melting point of 70 Celsius (MED TEC, USA is used as corner and straight edge blocks. All measurement held in Mansoura university hospital, faculty of medicine, department of oncology and nuclear medicine.

For more precise field edges the shaper system is used to have better field shaping and advanced collimator adjustment. We avoided using end to end technique in this study.

Maximum dose is measured at maximum depth for two different beam energy 6 MV and 15 MV x-ray beam. two types of field shaping techniques are used, built in multileaf collimator as new technique and Cerrobend alloy with 65 melting temperature.

2.3. Mp3 water tank

Ionization chamber used for calibration is tightly connected to Perspex box. chamber motion limited in to three directions with accuracy 0.11 mm. the three directions are centered around central axis of radiation beam. the dose of surface and different depth is measured with increments 1 mm. using PTW PL. chamber 0.6 diameter. Set up reconstructed for every field size and energy.

3. Results

The rates of leakage computed were found to extend methodically with diminishing field measured from roughly 7.0% for field side 15 cm to around 20% for field side 2 % for energy 6 MV and 15 MV. The percentage were found to be around 3% at 6 MV and 4.3% 15 MV for any gantry sitting.

Surface dose was computed from buildup depth of maximum dose D_{max}. The reading was modified for partition of ionization chamber connected. we present the error as D_{max} percentage. Table 1 shows the relation between depth in cm and D_{max} percentage for different field sides at 6 MV. It is obviously noted that PDD decreasing as field increases this may be due to radiation leakage between leaves interlock. The results gotten utilizing multileaf with essential setting were all around 3% as shown in table 2. Once more, anticipated diminish in buildup depth of maximum dose with expanding field measure is watched.

By removing blocking tray, the dose of maximum was increased by 3to 4 mm.

By using Cerrobend block the percent depth dose increased than that of multileaf collimator ranging from 1.1% to 11.7 but when repeating the same measurement by using multileaf collimator and blocking tray turned on the percent depth dose was 20 percent for tray and 19.9 for cerreobend alloy which prove the effect is due to only retracted tray movements for all field size.

By changing surface to source distance from 100 cm to 90 cm for field size 15x15 cm deformed by multileaf collimator and cerrobend alloy block for two allowed energies 6 and 15 mega volts, we found that the values gotten were 17% and 19.1 % for 6 MV, and 15% and 17% for 15 MV, for the MLC and cerrobend areas, separately. The reduction in value is due to less electron scattering in long source to surface distance.

Table 1

SPD and PDD at 100 SSD for 6 MV

Field Size (cm²) col.	Casting block		multileaf		MLC without	
	Surface (to dd)	Depth (mm)	Surface (dd)	Depth (mm)	Surface (dd)	D (mm)
5x5	11.1	17	9.7	17	11.5	16.1
15x15	21.9	17	16.7	17	18.8	16.1
30x30	35.2	15	28.9	15	30.5	14.1

Table 2

SPD and PDD at 100 SSD for 15 MV

Field Size (cm²) primary	Casting block		Multileaf		MLC without	
	Surface (to dd)	Depth (mm)	Surface (dd)	Depth (mm)	Surface (dd)	Depth (mm)
5x5	11.1	28	7.7	28	9.9	26
15x15	21.9	26	17	28	20	26
30x30	35.2	23	31	23	33.6	24

For mostly used field side 5, 15 and 30 cm the percent depth dose values extended from 18.8% to 88.1% for 6 megavolts, and from 30.3% to 96.1% for 15 mega volts. measured values tabulated at table 3 and 4. We found that the percent depth dose does not change either by multileaf collimator or by customized cerrobend blocks, the biggest contravention was at depth 5 cm for three field size. For 30 cm field side the contravention was 0.9 for high energy 15MV

Table 3
Percentage depth dose data (6 MV X-rays 100 cm SSD)

Field size	**5x 5 cm**		**15 x 15 cm**		**30x 30 cm**	
Depth (cm)	**MLC**	**Cerrobend**	**MLC**	**Cerrobend**	**MLC**	**Cerrobend**
5	86	85	88.1	87	88	87
6	85	84	87	80	80	86
7	77	80	86	78	75	80
8	60	70	80	60	60	75
9	63	68	78	57	57	74
10	64	63.4	68.3	68	69	70
11	60	63	67	66	68	66
12	55	62	66	64	67	60
13	50	50	55	55	55	55
14	49	40	53	54	56	50
15	47	47	52.4	51.9	55.6	54
16	47	46	52	50	54	53
17	40	37	52	50.4	53	50
18	38	36	45	49	52	48
19	35	35	40	45	48	40
20	34	35.2	39.9	39.6	43.7	42
21	35	34	38	38	42	41
22	34	32	35	37	41	40
23	33	30	33	36	40	36
24	32	26	30	30	32	30
25	30	26.5	29.9	29.4	33.9	32.5
26	26.7	25	28	27	32	29
27	25	24	27	26	31	28
28	24	23	26	25	27	27
29	22	20	25	24	26	26
30	20	19.9	23.5	23.4	26.6	25.1

Table 4
Percentage depth dose data (15 MV X-rays 100 cm SSD)

Field size	5x 5 cm		15 x 15 cm		30x 30 cm	
Depth (cm)	**MLC**	**Cerrobend**	**MLC**	**Cerrobend**	**MLC**	**Cerrobend**
5	92.1	95.7	95.3	93.1	95.2	93
6	91.4	95	94.6	92.4	94.5	92.3
7	90.7	94.3	93.9	91.7	93.8	91.6
8	90	93.6	93.2	91	93.1	90.9
9	89.3	92.9	92.5	90.3	92.4	90.2
10	76.1	77.5	77.6	77.1	77.5	77
11	73.9	76.3	76.4	75.9	76.3	75.8
12	72.7	75.1	75.2	74.7	75.1	74.6
13	71.5	73.9	74	73.5	73.9	73.4
14	70.3	72.7	72.8	72.3	72.7	72.2
15	62.1	66.7	62.1	65.1	62	65
16	58.9	63.5	58.9	61.9	58.8	61.8
17	55.7	60.3	55.7	58.7	55.6	58.6
18	52.5	57.1	52.5	55.5	52.4	55.4
19	49.3	53.9	49.3	52.3	49.2	52.2
20	46.1	49	49.1	45.1	49	45
21	44	46.9	47	43	46.9	42.9
22	41.9	44.8	44.9	40.9	44.8	40.8
23	39.8	42.7	42.8	38.8	42.7	38.7
24	37.7	40.6	40.7	36.7	40.6	36.6
25	40.1	39.1	40.1	40.1	40	40
26	38.2	37.2	38.2	38.2	38.1	38.1
27	36.3	35.3	36.3	36.3	36.2	36.2
28	34.4	33.4	34.4	34.4	34.3	34.3
29	32.5	31.5	32.5	32.5	32.4	32.4
30	32.1	30.1	32.1	31.1	32	31

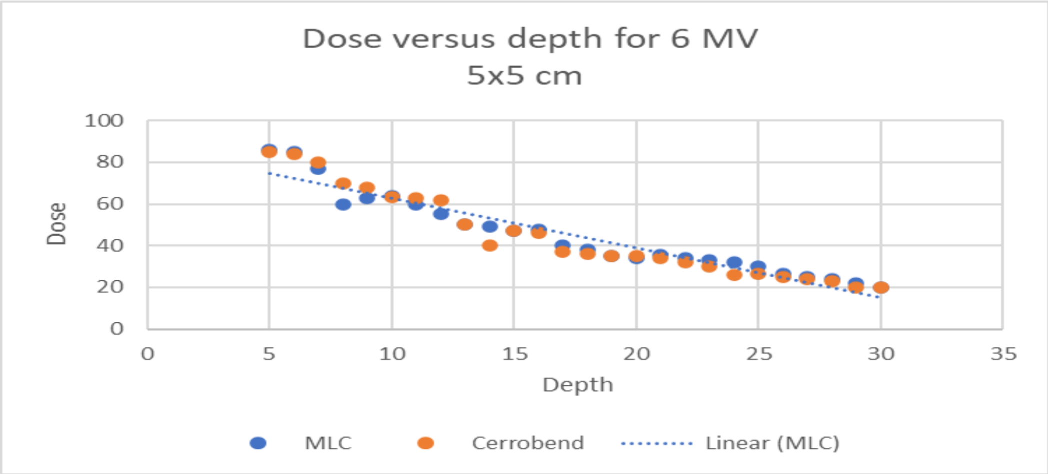

Figure 1 Relation between dose and depth for field size 5 x5 for MLC and cast

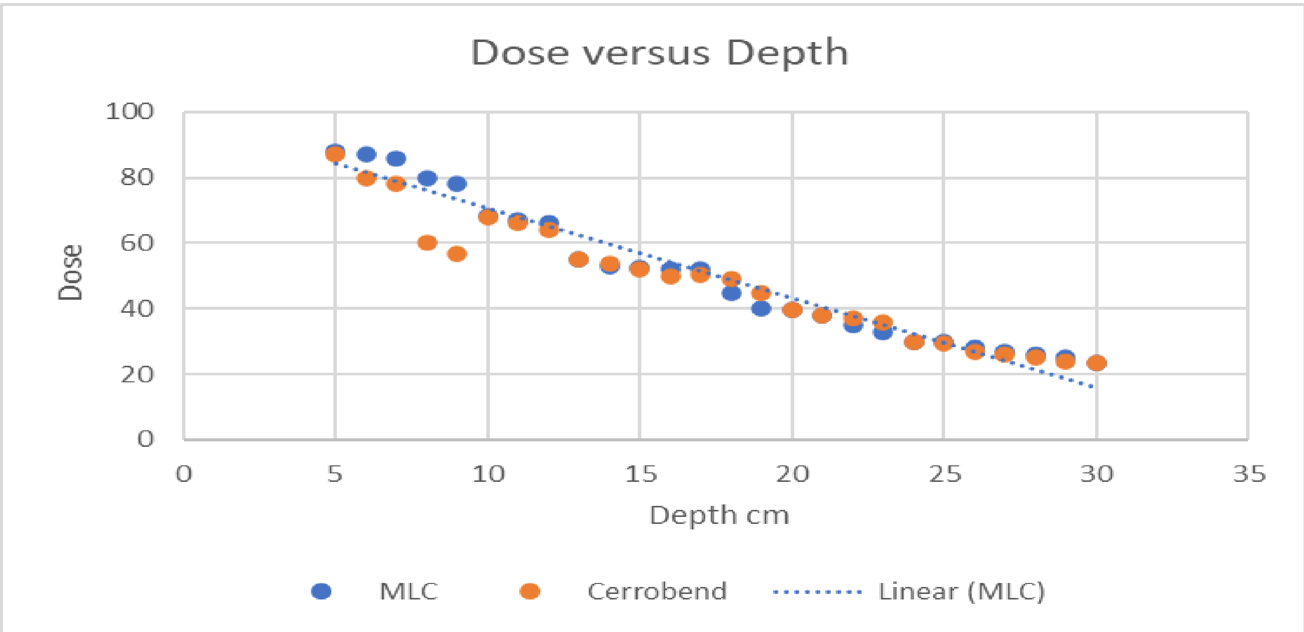

Figure 2 Relation between dose and depth for field size15 x15 for MLC and cast

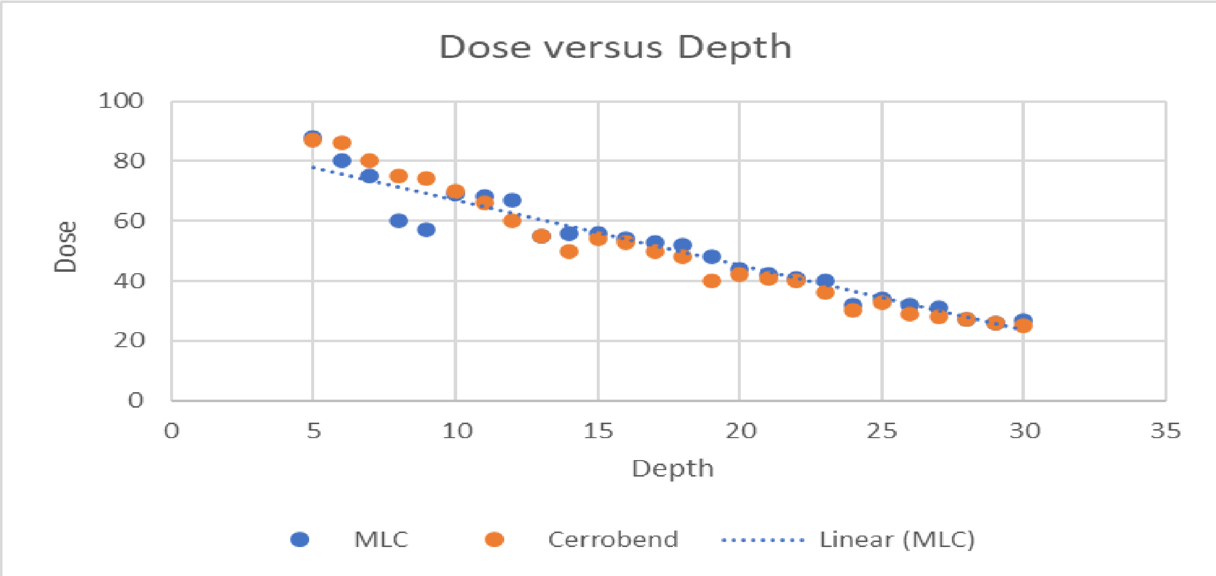

Figure 3 Relation between dose and depth for field size 30x30 for MLC and cast

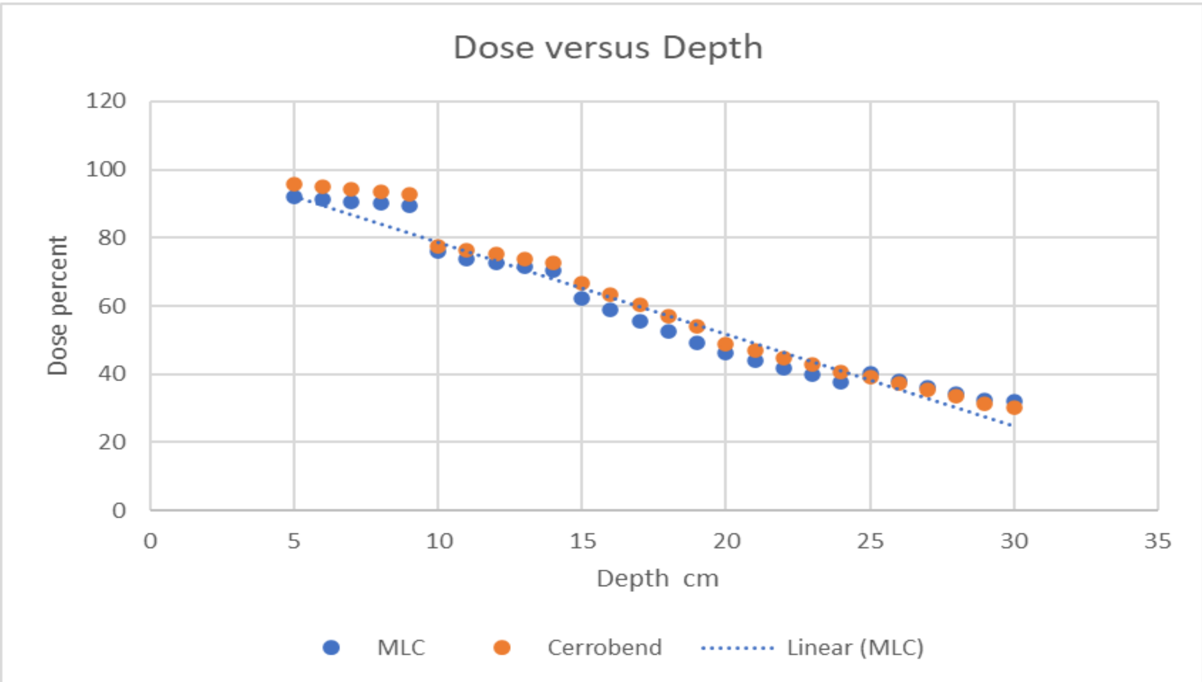

Figure 4 Relation between dose and depth for field size 5 x5 for MLC and cast

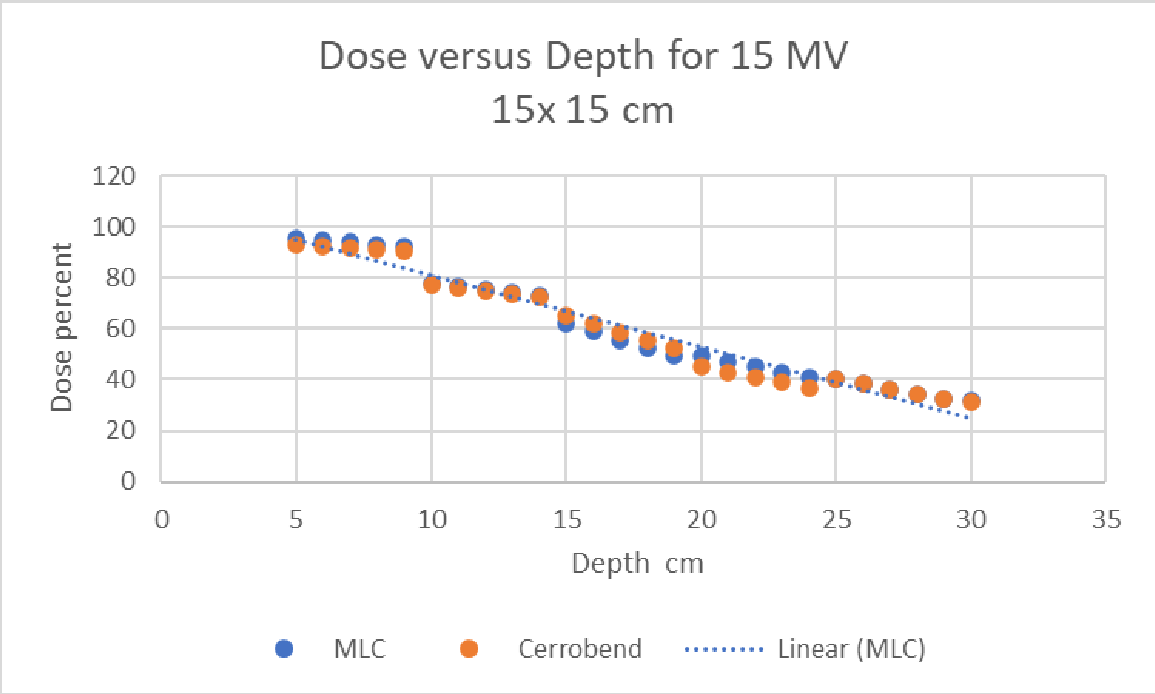

Figure 5 Relation between dose and depth for field size 15 x15 for MLC and cast

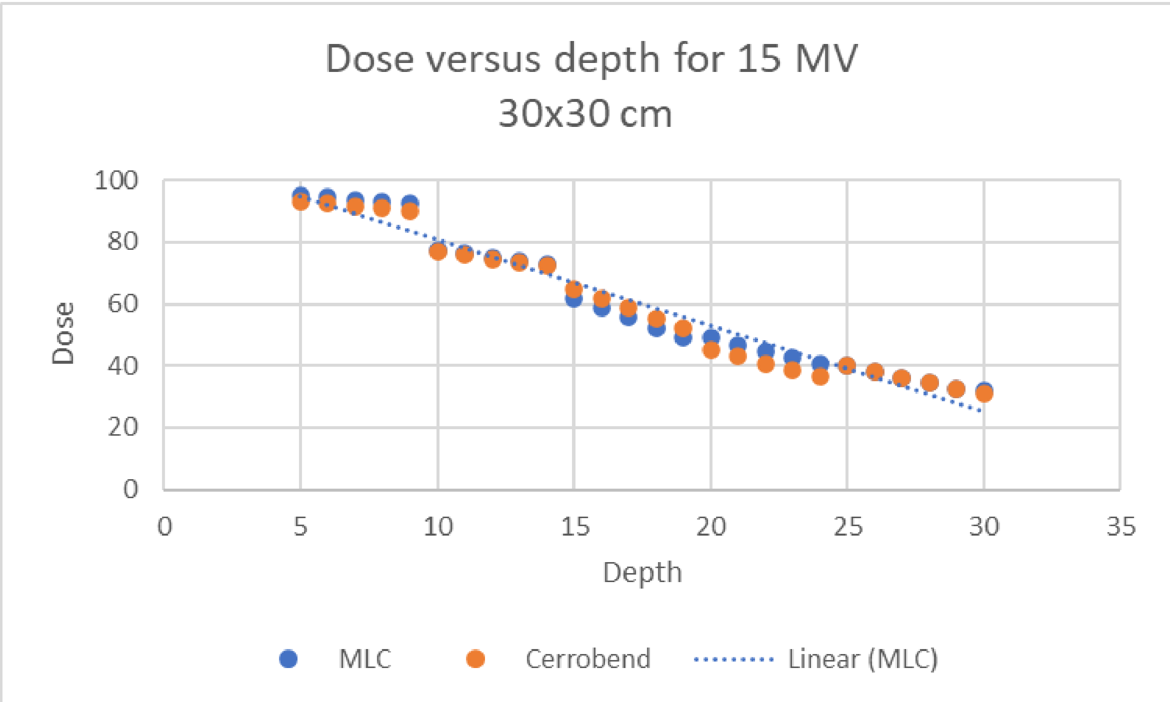

Figure 6 Relation between dose and depth for field size 30x30 for MLC and cast

This study compares the percent depth dose of cerrobend blocks against data obtained by multileaf collimator in water phantom irradiated by phantom beam of 6 MV and 15 MV energy. this study is unique in comparing blocks and MLC in full depths with increment of 1 cm which makes it superior to other articles mentioned.

Doses in built up region is measured and tabulated in table 1 and table 2 for 6 MV and 15 MV respectively. The aim of this part is to determine the depth of maximum dose. for 6 MV the result was D_{max} shown in table 1 decrease in D_{max} with higher field size as expected (1.6 cm) for both cerrobend an MLC. The results showed small shift in values when primary collimator is removed by less than 1 mm. same behavior obtained in 15 MV photon beam with difference 2 mm between cerrobend blocks and MLC. PDD for surface was measured for different field size for both 6 and15 MV as we expect depth of maximum dose decreases as field size increases.

Table 3 represent the relation between PDD and depth for field side 5,15 and 30 at depth form 5cm to 30 cm the maximum standard deviation found to 0.19. same calculation performed for 15 MV photon beam the maximum deviation was 0.2. PDD measured in case of casted cerrobend blocks and those shaped by MLC are essentially the same or mostly common medically needed field sizes and depths.
Normal exponential curve of PDD was noticed in figure from 1 to 6 for deferent field size.

The interleaves radiation leakage between leaves has considerable value. The impact ought to be taken into consideration when utilizing the multileaf field to characterize treatment entrances. The point of contact should be lies out of treated area and ought behind the essential blocks. This situation cannot be applied to all radiotherapy cases so this effect make radiotherapy by multileaf collimator limited in some case.
From figure 1 to figure 4 we can see that there is linear increase of dose for both Cerrobend block and multileaf collimator the percent depth dose increased linearly with field side and confirmed for 6 megavolt and 15 megavolt photon beams.
The diminish in top percent depth dose with expanding source to surface distance demonstrated that small value gotten with linear accelerator having no multileaf collimator the result obtained for 15x15 cm^2 is shaped by essential collimator only.
The results, which extended from 11.2 % to 16 % are comparable to our values 17% and 19.1%.the diminish in the top percent depth dose.

4. Conclusion
The work presented here contain bilateral comparison between Cerrobend blocks and multileaf collimator in Egypt to check whether it can be used as alternative technique for cancer treatment or not. No significant differences exist in the percentage depth doses measured with the MLC versus cerrobend. Thus, modification of existing calculation procedures used for cerrobend-blocked fields was found to be unnecessary, and the procedures can be applied to MLC-shaped fields. These results agree with published data (Racka et al., 2022). The somewhat higher values from our consideration are most likely due to the littler SSD. Final conclusion there no significant differences between two applied techniques so we recommend to use multileaf collimator as shaping technique instead of Cerrobend bocks as its more economic and less time consuming.

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