
OPTIMUM FIELD SEPARATION IN ADJACENT FIELDS OF ELECTRON BEAM THERAPY

TUNTIPUMIAMORN L.[1] , M.Sc POLWATSATIEN V.[1] , B.Sc
SUTUD NA AYUTHAYA B.[2] , B.Sc SAINET S.[2] , B.Sc

ABSTRACT

Due to the scattering properties of electrons, the problem of positioning of multiple electron fields is more complicated than in the case of photon beam. In this study we investigated the dose uniformity at the junction region of adjacent electron fields in different field separations for several cone sizes and beam energies with a particular closed-sided applicator by using film dosimetry. Optimum field separation found in this study depends on applicator cone size and beam energy combination.

INTRODUCTION

Treatment with high energy electron beam plays an important role for superficial lesion because of its advantage in sparing normal critical structures. Since there is a limitation in applicator size ,the treatment of extended areas of electron requires the use of two or more adjacent fields. Unlike photon, problem of field positioning in electron cannot be solved by empirical technique or using simple geometric divergence correction because the scattering characteristic of electron results in constriction of the higher value isodoses and bulging out in the lower value isodoses.[1] Therefore, abutting of two electron fields may lead to significant dose inhomogeneities along the junctional region. In this study, we proposed to investigate the dose uniformity in the junction region of electron adjacent fields in different field separations, several applicator sizes and beam energies in the Mitsubishi ML-15 MIII Linear Accelerator to obtain the optimum field separation for being used in our clinical practice.

MATERIAL & METHOD

Film dosimetry was chosen to study the relative dose distribution of electron beam by its advantage in having a high spatial resolution and short measurement time. Type of film using were Kodak ready pack X-Omat TL that the sensitometric curve was already obtained prior to the measurement procedure. Measurement was performed by the film being sandwiched in a polystyrene phantom with the film plane paralleled to the beam central axis. Then the experimental data were taken for various closed-sided electron applicators (10 cm x 10 cm, 10 cm x 18 cm, 14cm x 14 cm, and 18cm x 10 cm) with the 8, 10, 12 and 15 MeV electron in different field separations , 1.0 cm, 0.5 cm, 0.25 cm overlaps and 0.0 cm, 0.25 cm, 0.5 cm gaps. The field separation here was specified to the edge of the light field. After processing, all the films were read by X -Rite 301 Black and White Densitometer having an aperture diameter of 1 mm.

Data was analyzed using parameter "Depth Dose Ratio", DDR, as suggested by

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[1] Division of Radiation Oncology, Department of Radiology, Faculty of Medicine, Siriraj Hospital, Mahidol University, Bangkok-10700, THAILAND

[2] Department of Radiological Technology, Faculty of Medical Technology, Mahidol University, Bangkok-10700, THAILAND

Bagne.[2] The DDR is defined as the ratio of dose at the depth on mid separation axis to the average dose at the same depth on the central axis of both fields. Thus,

$$\mathrm{DDR} = \frac{\text{Percentage Depth Dose at depth d at the mid separation axis}}{\text{Average percentage depth dose at depth d on the central axis of both fields}}$$

Ideally, if the dose in the junction region is uniform, the DDR should equal to 1. In practice,we used a criterion in determining the optimum field separation by examining the DDR value into two regions. First is the depth between 0.5 cm below surface and the depth of dose maximum for shallow lesion, and second the depth between dose of maximum (D_{max}) and the 80th percentile of dose (R_{80}) for deep tumor and required that the DDR be within 0.9 and 1.1

RESULTS

The DDR parameter for electron beam abutted fields at the standard SSD (100 cm) as a function of depth was determined for electron beam energies 8,10,12 and 15 MeV using 10 cm x 10 cm, 10 cm x 18 cm, 14 cm x 14 cm, and 18 cm x 10 cm fields. Results are presented in Figure 2- Figure 5

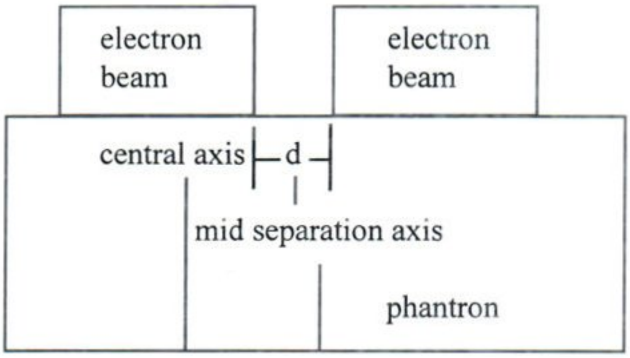
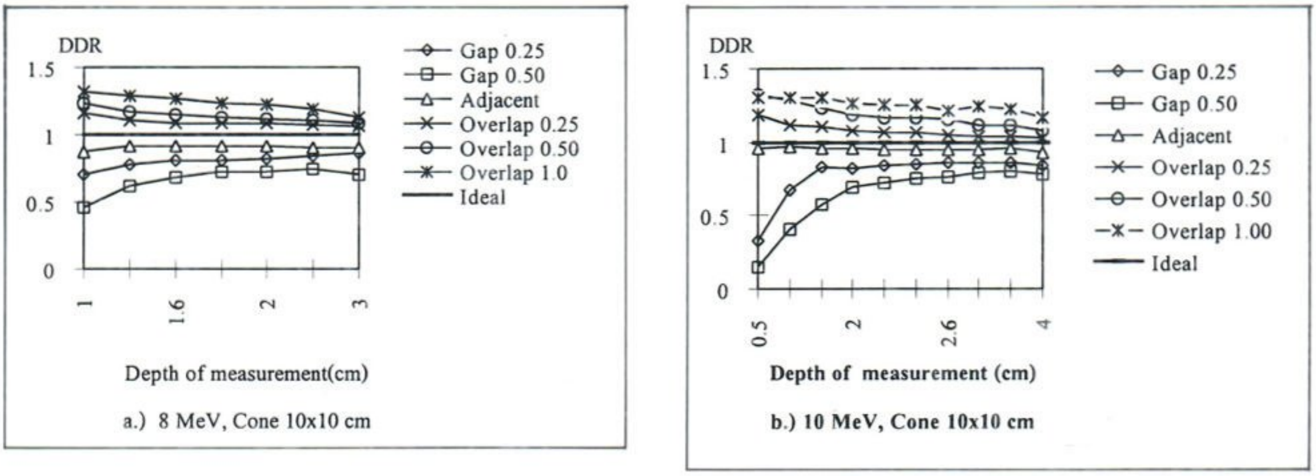
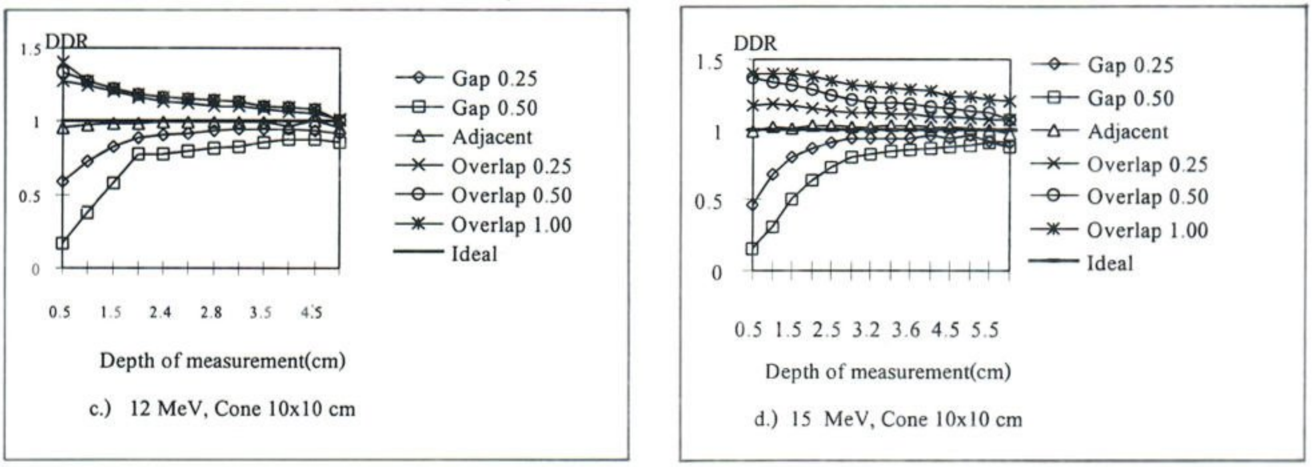


Fig 1. Geometry of experimental setting-up, d= field separation



a.) 8 MeV, Cone 10x10 cm

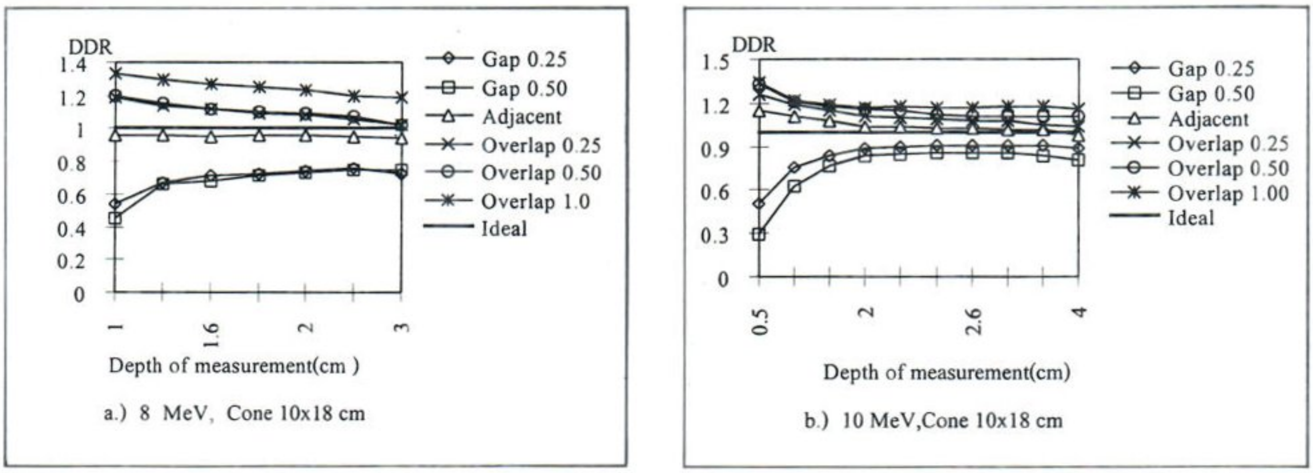
b.) 10 MeV, Cone 10x10 cm



c.) 12 MeV, Cone 10x10 cm

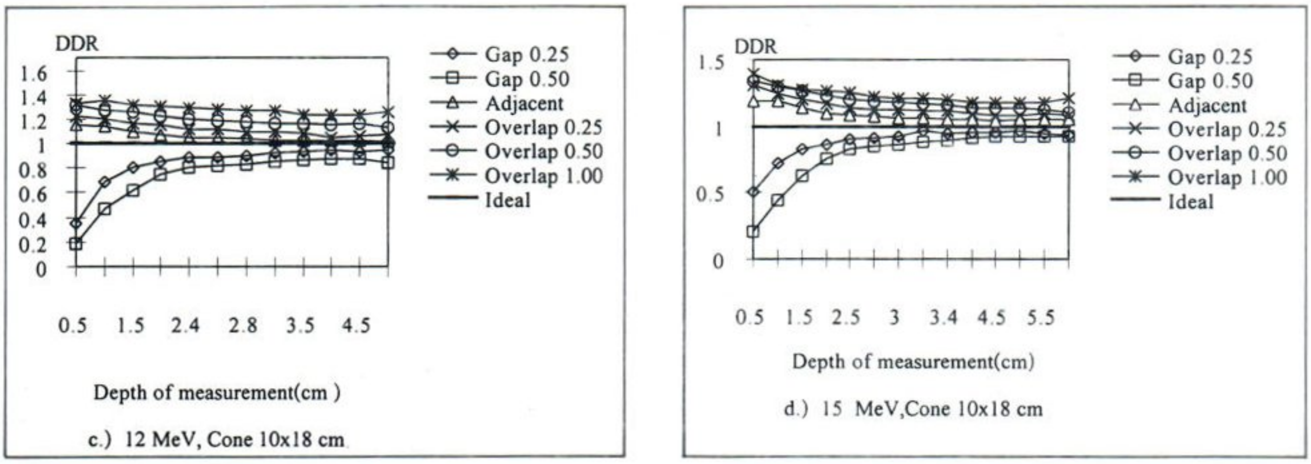
d.) 15 MeV, Cone 10x10 cm

Fig. 2 Depth dose ratio (DDR) as a function of depth for 10cmx10cm applicator, 100 cm SSD, with a 1.0 cm , 0.5 cm, 0.25 cm overlaps and 0.0 cm,0.25 cm,0.5 cm gaps



a.) 8 MeV, Cone 10x18 cm

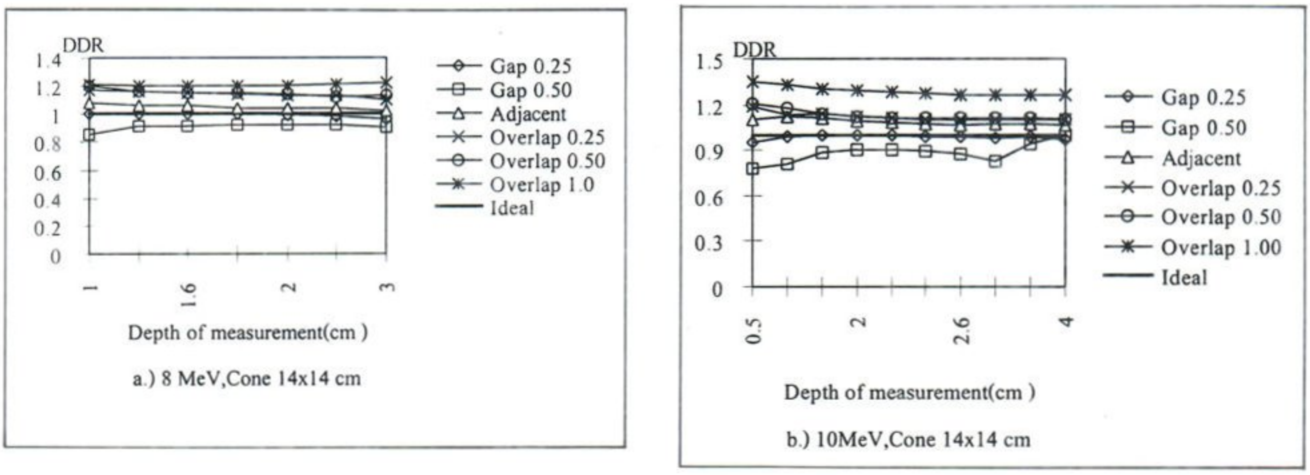
b.) 10 MeV,Cone 10x18 cm



c.) 12 MeV, Cone 10x18 cm

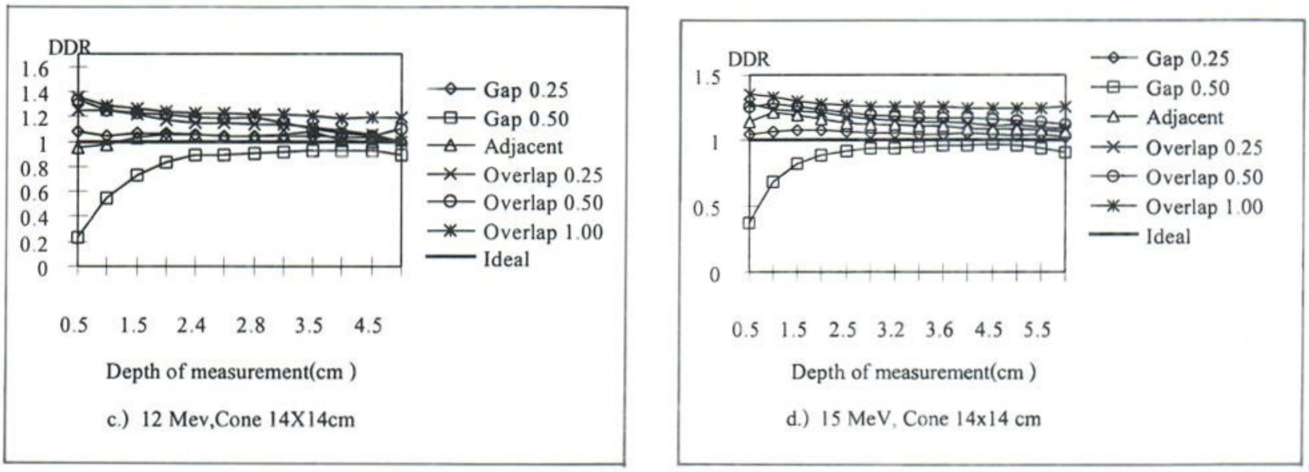
d.) 15 MeV,Cone 10x18 cm

Fig. 3 Depth dose ratio (DDR) as a function of depth for 10 cm x 18 cm applicator, 100 cm SSD, with a 1.0 cm, 0.5 cm, 0.25 cm overlaps and 0.0 cm, 0.25 cm, 0.5 cm gaps



a.) 8 MeV,Cone 14x14 cm

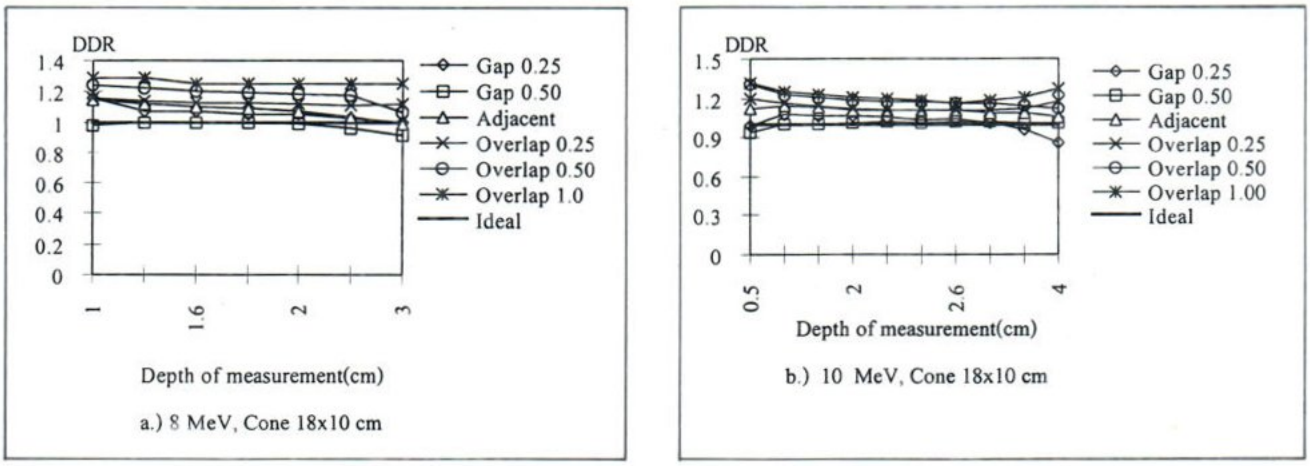
b.) 10MeV,Cone 14x14 cm



c.) 12 Mev,Cone 14X14cm

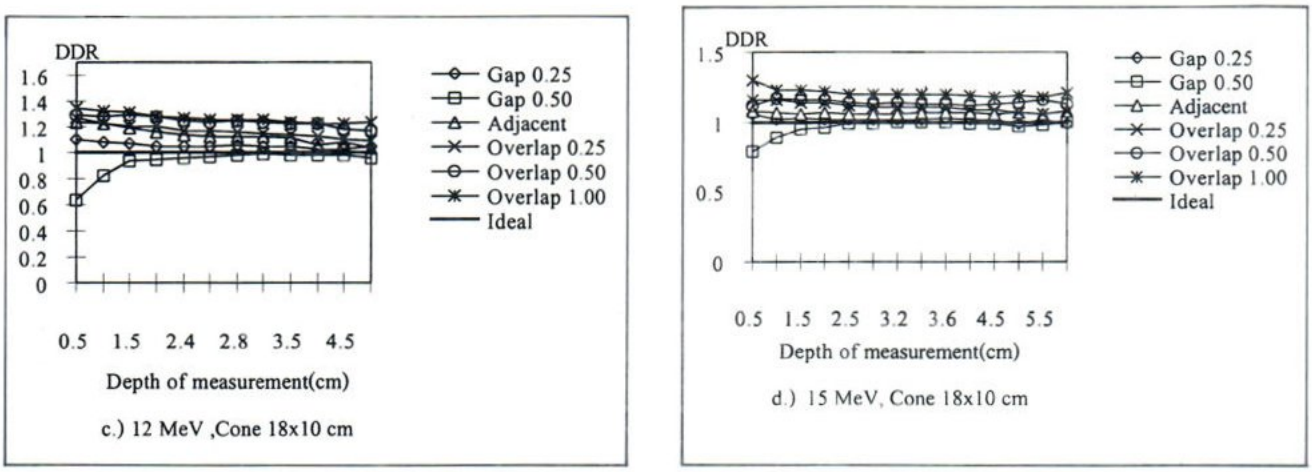
d.) 15 MeV, Cone 14x14 cm

Fig. 4 Depth dose ratio (DDR) as a function of depth for 14 cm x 14 cm applicator, 100 cm SSD, with a 1.0 cm, 0.5 cm, 0.25 cm overlaps and 0.0 cm, 0.25 cm, 0.5 cm gaps



a.) 8 MeV, Cone 18x10 cm

b.) 10 MeV, Cone 18x10 cm



c.) 12 MeV ,Cone 18x10 cm

d.) 15 MeV, Cone 18x10 cm

Fig. 5 Depth dose ratio (DDR) as a function of depth for 18 cm x 10 cm applicator, 100 cm SSD, with a 1.0 cm , 0.5 cm, 0.25 cm overlaps and 0.0 cm, 0.25 cm, 0.5 cm gaps

From the above data, surface field separations that provided DDR value of 0.9 to 1.1 in the region between depth of dose maximum (D_{max}) and the depth of 80th percentile of dose (R_{80}) for the four energies and field sizes are shown in Table 1.

Table. 1 Optimum separation for abutted electron fields at standard SSD 100 cm for the depth between D_{max} - R_{80}

Energy	Field Size (cm)			
(MeV)	10X10	10X18	14X14	18X10
8	0.0 cm gap 0.25 cm overlap	0.0 cm gap 0.25 cm overlap	0.0,0.25,0.5 cm gap	0.0,0.25,0.5 cm gap
10	0.0 cm gap 0.25 cm overlap	0.0,0.25 cm gap 0.25 cm overlap	0.0,0.25,0.5 cm gap	0.0,0.25,0.5 cm gap
12	0.0,0.25 cm gap 0.25 cm overlap	0.0,0.25 cm gap 0.25 cm overlap	0.0,0.25,0.5 cm gap	0.0,0.25,0.5 cm gap
15	0.0,0.25 cm gap 0.25 cm overlap	0.0,0.25 cm gap 0.25 cm overlap	0.0,0.25,0.5 cm gap	0.0,0.25,0.5 cm gap

In some clinical situations if the shallow tissues are at risk, these data may not be clinically acceptable. Therefore, optimum separation of abutted electron fields in shallow depth region (depth 0.5 cm below surface to D_{max}) are also presented in Table. 2

Table. 2 Optimum separation for abutted electron field in depth between 0.5 cm-D_{max}

Energy	Field Size (cm)			
(MeV)	10x10	10x18	14x14	18x10
8	*	0.0 cm gap	0.25 cm gap	0.5 cm gap
10	0.0 cm gap	*	0.25 cm gap	0.5 cm gap
12	0.0 cm gap	*	0.25 cm gap	0.25 cm gap
15	0.0 cm gap	*	0.25 cm gap	0.25 cm gap

- * = No gap gave DDR between 0.9 and 1.1 throughout the region from depth 0.5 cm below surface to depth of dose maximum

DISCUSSION AND CONCLUSION

Several techniques have been proposed for matching electron adjacent fields in order to obtain an acceptable dose distribution in the junction region.3-7 Among them, the simplest technique is to optimize the skin gap between the two electron beam edges. The dose uniformity along the junction region produced by gapping and overlapping of electron fields can be simply evaluated using the parameter DDR. One shortcoming of the DDR is that it provided only the doses along the junction region that perpendicular to the phantom surface ,but not the specification of the volume of the high or low dose region caused by the abutments. However, because of its simplicity make it the most suitable technique in obtaining the data.

It clearly showed from the study that the surface field separation strongly influenced on the dose uniformity in the junction region of all energies studied and could be seen more prominently in the region of shallow depth and small applicator size Overlapping electron fields by only 0.25 cm produced hot spots of 110-130% of the dose at the field center while 0.25 cm gapping caused underdose region (30-94%). Deviation from the optimum value may result in the serious high and low dose areas in the junction region.

In contrast , the dose uniformity in depth between D_{max} to R_{80} was not affected by the field separation as strongly as the region of shallow depth was. Optimum separations found in this depth of treatment ,in large applicator size of all energies, could be either 0.0 cm, 0.25 cm or 0.5 cm gaps. While in smaller field width (10x10 cm, 10x18 cm) at each energy , optimum separations were 0.0 cm, 0.25cm gaps and 0.25 cm overlap. Except only the 8 MeV electron in small field that gapping 0.25 cm could produce low dose region. Choosing which optimum separation being used in clinical practice should be based on an emphasis of reducing any setting-up error.

As the results presented, it could be pointed out that the optimum separation in electron adjacent fields could not be calculated from the basic knowledge of beam divergence as in the case of photon. And with the fact that, the beam characteristics of the electron strongly depend on how the field is flattened and the collimator system used, therefore no single standard field separation could be used universally. Optimum field separations found in this study depend on field width, beam energy and depth of treatment.

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