Examination of Out-of-Field Dose and Penumbral Width of Flattening Filter Free Beams in Medical Linear Accelerators

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INTRODUCTION

Flattening Filter Free (FFF) beams are a relatively recent innovation in medical linear accelerators offering a slew of potential benefits, including increased dose rate, reduced treatment time, and, perhaps most importantly, reduced scattered radiation. We hypothesize that FFF beams, due to their unique dose distribution, offer superior reduction in dose in the peripheral region of the beam as well as reduced penumbral width compared to flattened beams with similar depth-dose distributions.

MATERIALS AND METHODS

Using TrueBeam Representative Data, beam parameters were compared for the 6 MV FF and 10 MV FFF. These two energies were chosen due to their similar depth-dose distributions. We examined and compared the profiles of these two beams at various depths and field sizes. For penumbral widths, we compared the distance between the locations of 80% and 20% central axis dose. For peripheral dose, we compared the dose relative to central axis at distances of 2, 5, 10, 30, and 50 mm from the field edge (defined to be the location of 50% central axis dose).

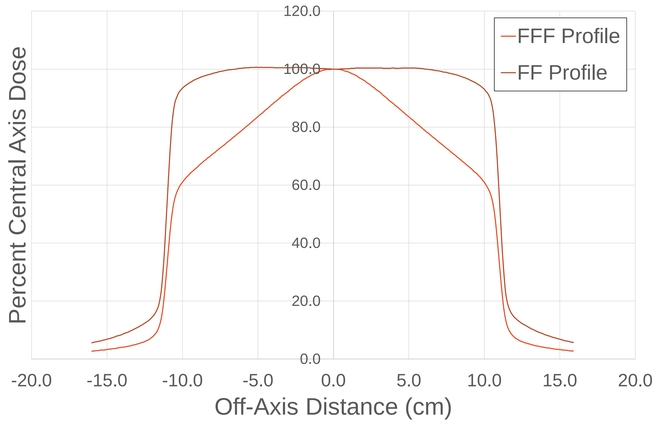

Figure 1: Comparison of raw beam profiles

DATA AND RESULTS

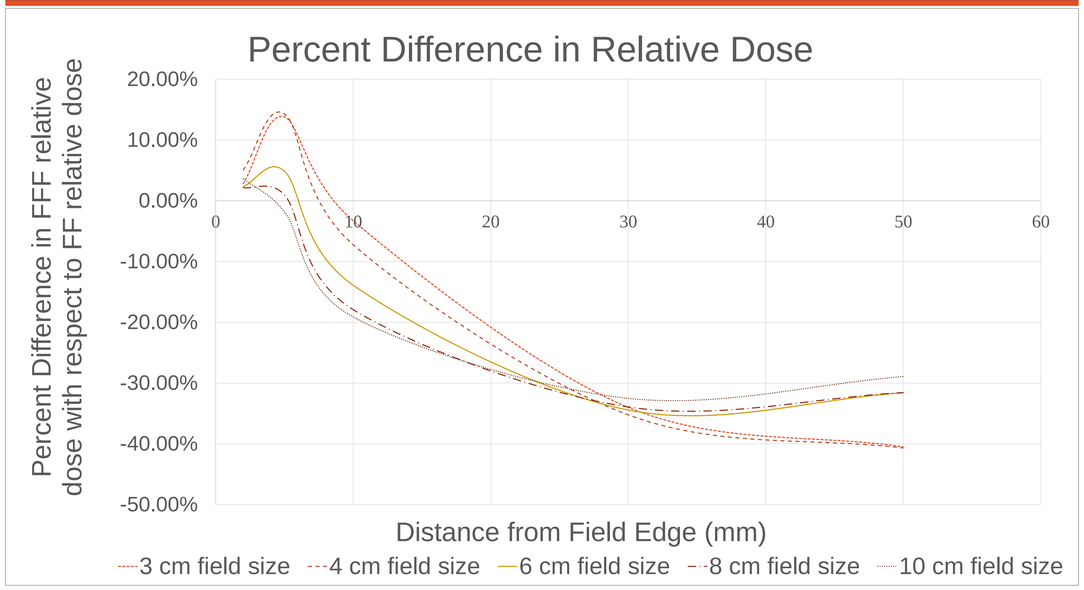

Figure 2: Percent difference in relative dose between FFF beams compared with FF beams at various field sizes and distances from the field edge

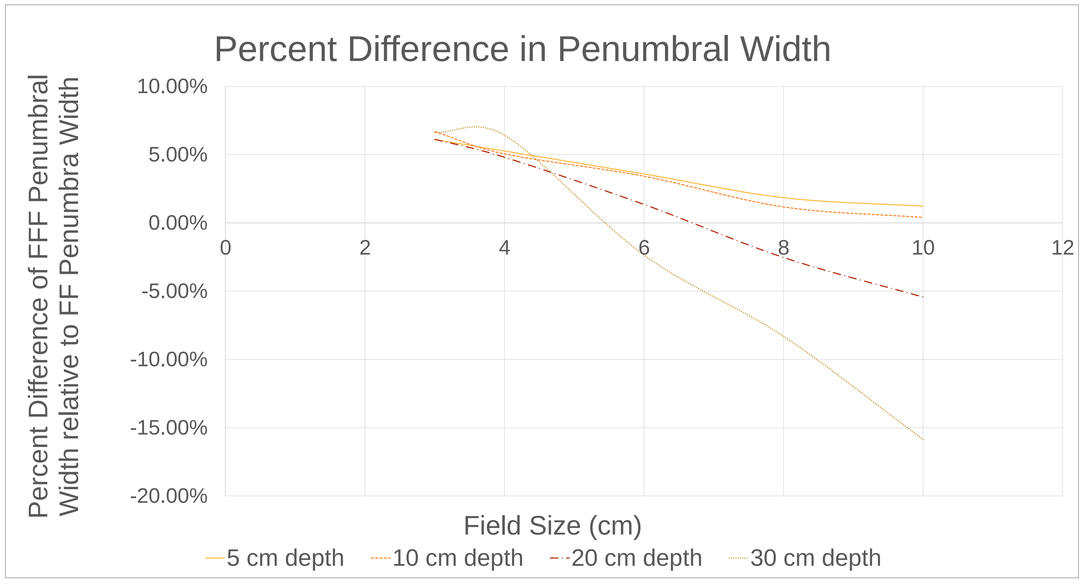

Figure 3: Percent difference in penumbral width of FFF beams relative to FF beams at various field sizes and depths

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NORMALIZATION

Due to the unique shapes of the FFF profiles, normalization had to be done in such a way as to make a fair comparison of the penumbra. To do this, we first normalized the FF beams such that central axis dose was 105% of prescribed dose; the location of 100% prescribed dose for the FF beam was then located; the dose from the FFF beam at this location was then used to normalize the FFF profile. This allowed us to control for varying profile shapes while keeping dose distribution within the treatment field within clinically acceptable limits.

DISCUSSION

The FFF beams showed a favorable reduction in relative dose at distances greater than about 1 cm from the field edge for all field sizes (Fig.2).The reduction in relative dose increased with increasing distance from the field edge. There was no apparent improvement or reduction in relative dose due to depth.

The penumbral width of the FFF beam relative to that of the FF beam was seen to decrease with increasing field size (Fig. 3); additionally, the rate of reduction in penumbral width was seen to increase with increasing field sizes. Penumbra were observed to be larger for the FFF beam for most depths and field sizes; however, this could be due to the limited spatial resolution of the ion chambers used to obtain these measurements.

CONCLUSIONS

The results of this study suggest that FFF beams may reduce dose in regions beyond 1 cm from the field edge, indicating that there may be clinically relevant reduction of dose to normal tissues and organs for FFF beams compared to FF beams with similar depth-dose distributions.