Is Every Measurement Necessary? Reducing Commissioning Measurements through Electron Utilization Analysis

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ABSTRACT

Purpose: To quantify the usage of different electron beam treatments and use that data to develop recommendations for maximizing efficiency in electron output factor measurements.

Methods: For a large center with a main campus and 14 satellite facilities, the records of every patient treated with electrons were examined for a one-year period. For each treatment, when possible, the beam energy, applicator size, SSD, and cutout dimensions were recorded. The cutout width (smaller dimension) was rounded down to the next lowest integer value. Cutout widths were analyzed because that is the dimension for which the output factor is most sensitive to a small change. After excluding Total Skin Electron patients and other special procedures, as well as treatments for which there was inadequate data, 351 patient records were examined.

Results: The widths were categorized by beam energy, SSD, and applicator. The vast majority of treatments were made with 6, 9, or 12 MeV beams at 100 or 105 SSD. Only 6 patients (<2%) were treated with 20 MeV, and only 10 (<3%) were treated with the 25cm applicator. Thirty patients (8.5%) were treated at 110 SSD or greater.

Conclusions: Electron cutout factor tables are measured at machine commissioning to reduce the need for patient-specific measurements. This process is made more efficient if the table is limited to only those situations likely to arise in clinical practice. These data suggest not including data for 20 MeV beams or the 25x25 applicator would still cover 95% of clinical cases. Additionally omitting 110 SSD would still cover around 87% of clinical cases. This would require a slight increase in patient-specific QA but provide a large decrease in measurements needed to create the table and therefore reduce commissioning time.

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INTRODUCTION

When commissioning a linear accelerator for electron beam therapy, it is prudent to measure a thorough distribution of output factors (also known as cutout factors), encompassing all prospective energy, applicators, SSDs, and field (cutout) sizes.[1] A sample cutout factor table is given in Fig. 1.

Fig. 1--Ideal Cutout Factor Table (390 data points)

	Cutout Width	6 MeV			9 MeV			12 MeV			16 MeV			20 MeV		
		100 SSD	105 SSD	110 SSD	100 SSD	105 SSD	110 SSD	100 SSD	105 SSD	110 SSD	100 SSD	105 SSD	110 SSD	100 SSD	105 SSD	110 SSD
6 cone	3															
	4															
	5															
10 cone	3															
	4															
	5															
	6															
	8															
15 cone	3															
	4															
	5															
	6															
	8															
	10															
	13															
20 cone	3															
	4															
	5															
	8															
	12															
25 cone	3															
	4															
	5															
	8															
	12															
	20															

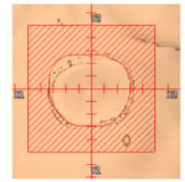
In practice, however, many of these configurations are rarely used clinically, so that it is more work to measure them to generate the table than it would be to do patient-specific measurements when needed. During commissioning, time may be at a premium, so eliminating unneeded measurements is desirable.

This project seeks to determine a set of measurements that reflects actual clinical practice, eliminating configurations that aren't used clinically, and proposing a more efficient commissioning process.

METHODS AND MATERIALS

For a large center with a main campus and 14 satellite facilities, the records of every patient treated with electrons during a one-year period were retrospectively reviewed. Records were eliminated from consideration if they were for a special procedure such as TSET, were for a treatment technique unique to one site, or if there was inadequate data. In total, 349 patient records were examined.

For each patient record, the beam energy, applicator, and SSD were noted. The cutout size was determined either by noting what was recorded in the patient's chart or analyzing the beam's eye view (BEV) from the treatment planning system. All field sizes were set to isocenter. The widths (smaller dimension) of the fields were rounded down to the next lowest integer and were tabulated. Widths were used because cutout factors are relatively unchanging at larger field sizes but decrease considerably at small aperture sizes, so it is the smaller dimension that is controlling.[2] An example is given in Fig. 2.



Length of X 10cm graticule (Meas. w/ruler): 7.3

Length of X aperture (meas. w/ruler): 4.6

Actual X aperture length = 10 * 4.6 / 7.3 = 6.3cm

Fig. 2 – Determination of Aperture Dimensions

RESULTS

The widths were categorized by beam energy, SSD, and applicator. The vast majority of treatments were made with 6, 9, or 12 MeV beams at 100 or 105 SSD. Only 6 patients (<2%) were treated with 20 MeV, and only 10 (<3%) were treated with the 25cm applicator. Thirty patients (8.5%) were treated at 110 SSD or greater.

The dimensions of the cutouts are depicted in Figure 3.

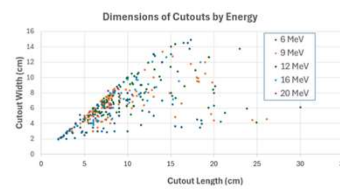
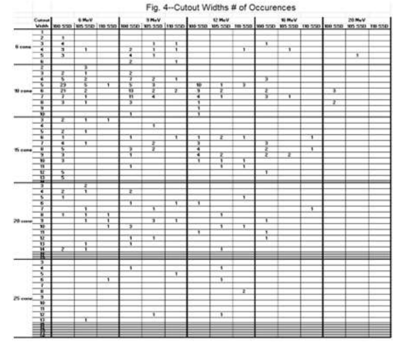


Fig. 3 – Dimensions of Cutouts by Energy

The table of cutout widths is depicted in Figure 4.

Fig. 4--Cutout Widths # of Occurences



DISCUSSION

Only 6 patients (<2%) were treated with 20 MeV. An argument could be made for not doing standard measurements for 20 MeV at all, though this may be a step too far for some. But certainly, extended SSD measurements for 20 MeV (1 patient total) could be eliminated. Similarly, there were 7 patients (~2%) using 16 MeV at extended SSD, so these measurements can also be eliminated.

Only 10 patients (<3%) were treated with the 25cm applicator. Considering the range of field sizes that would be needed to make a robust table, and the amount of blocking material needed to create the standard cutouts, eliminating these measurements is reasonable.

For 6, 9, and 12 MeV there were 27 patients (~8%) treated at 110cm SSD. Eliminating these measurements would substantially reduce commissioning time, although with a larger increase in patient-specific measurements than the other changes.

The new, more efficient cutout factor table is shown in Figure 5. The number of data points to measure is reduced from 390 to 152, a reduction of 61%. This would still cover 88% of the clinical cases. If 20 MeV measurements were eliminated entirely, the number of measurements needed would drop to 133, a reduction of 66%, and still cover 86% of clinical cases.

Fig. 5--Proposed Cutout Factor Table (152 data points)

	Cutout Width	6 MeV		9 MeV		12 MeV		16 MeV	20 MeV
		100 SSD	105 SSD	100 SSD	105 SSD	100 SSD	105 SSD	100 SSD	100 SSD
6 cone	3								
	4								
	5								
10 cone	3								
	4								
	5								
	6								
	8								
15 cone	3								
	4								
	5								
	6								
	8								
	13								
20 cone	3								
	4								
	5								
	8								
	12								

Note: Omitting 20 MeV further reduces the table to 133 data points

CONCLUSIONS

By examining the distribution of actual clinical cases, it is possible to make the commissioning process significantly more efficient. The time savings from doing so more than compensates for the slight increase in patient-specific measurements needed.

REFERENCES

1. **Vossler, M.** "Building An Electron Cutout Factor Table." *Medical Physics* **45**. e251 (2018).
2. **Vossler, M.** and Helmuth, K. "Clinical Implementation of a Sector-Integration Method for Calculating Electron Output Factors." *Medical Physics* **34**. 2425 (2007).