Accurate Applicator Gap Measurements for Intraoperative Radiation Therapy Using LIDAR

D. CRAFT, M. ARMSTRONG, and D. HARRINGTON
Department of Radiation Oncology, Mayo Clinic in Arizona, Phoenix, Arizona

JULY 12–16 2020 VIRTUAL
Improving Health QUALITY, Increasing Global IMPACT
JOINT AAPM | COMP MEETING
EASTERN TIME [GMT-4]

INTRODUCTION

Intraoperative Radiation Therapy (IORT) using a mobile linear accelerator involves placing physical applicators directly onto the desired treatment surface in the patient. Due to patient anatomy and the geometries of physical applicators, it is sometimes impossible to make flush contact between the treatment surface and the applicator. In these cases, a gap correction factor should be used to correctly calculate the monitor units for the treatment. This gap correction factor varies based on gap distance and applicator size and can be as large as a 10% correction. Accurately measuring this gap distance so that the appropriate correction factor is used can be quite challenging in the operative setting, especially for smaller applicator sizes. In this study we have designed and tested a new LIDAR based device that can quickly fit onto any standard applicator and accurately measure the gap distance.

METHODS

We 3D printed a simple mount that can snap onto the end of IORT applicators. An aluminum rod affixes to the interior of the mount, which extends into the applicator. A small LIDAR chip is attached to the end of the rod. We first measured a subset of air gap factors, and then tested the new device with two different experiments.

Gap factor measurements were performed in solid water with gap distances of 0-3 cm. Measurements were made for 4, 7, and 10 cm diameter applicators, and then compared with previously published data.

The first experiment tested the accuracy of LIDAR based gap measurements onto different colors of paper, in both full room lighting and dark conditions. Physical gaps of 0-3 cm were created, and LIDAR measurements were recorded for 3, 4, 7, and 10 cm diameter applicators.

The second experiment (shown in Figure 1) tested the accuracy of gap measurements with a raw steak to better simulate real use conditions in an operating room. For these measurements, the 4, 7, and 10 cm applicators were used, and again, measurements were performed with and without room lighting.

RESULTS

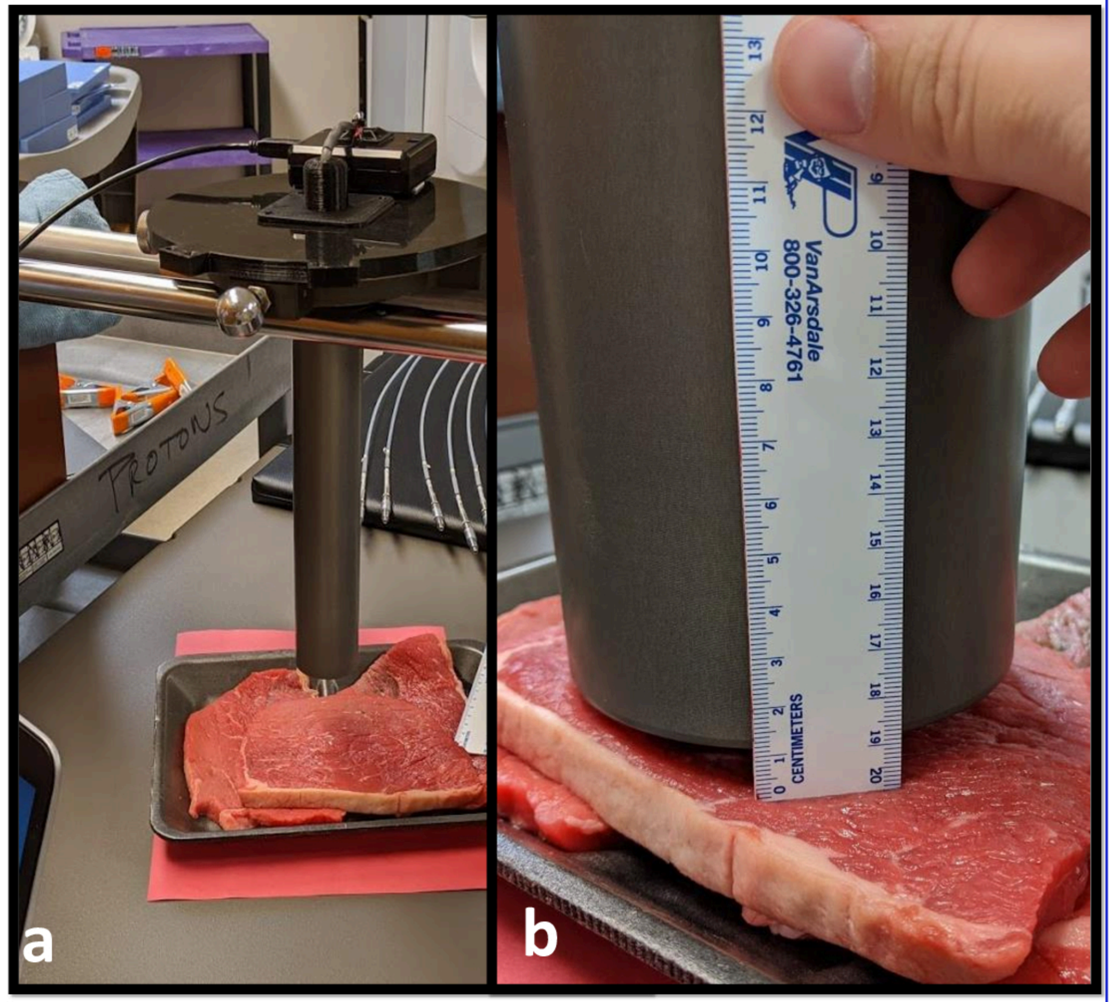

Figure 1: *Experimental setup. Picture a shows a zoomed out view with a 4 cm applicator placed above the steak surface. The table the steak was on was moved up and down a calibrated distance, and gap distances were verified with a ruler. Picture b shows a more zoomed in view of a larger 10 cm applicator closer to the steak surface, and a ruler verifying the correct gap distance has been set before any measurements are taken.*

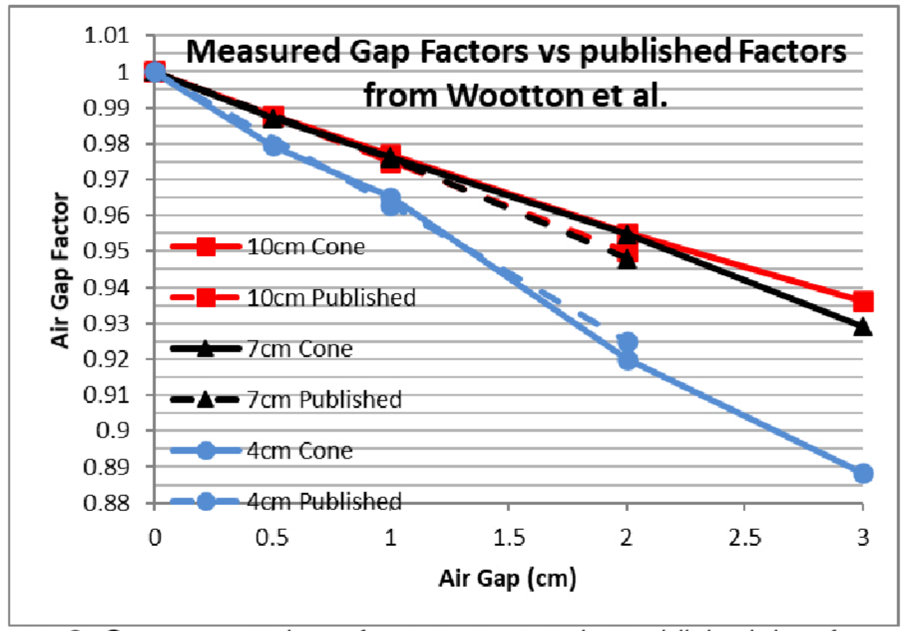

Figure 2: *Our measured gap factors compared to published data for an equivalent machine from Wootton et al. (2017). Our data matched well with previously published results. These results confirm the importance of using the correct gap factor, as an error in air gap of 1 cm could result in an error in the MU calculation as large as 5%.*

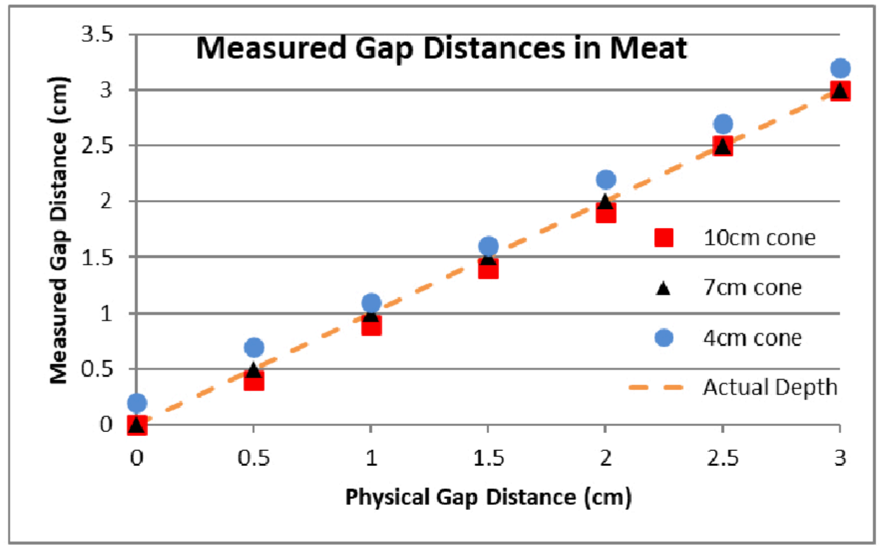

Figure 3: *Physical vs measured gap values for different applicator sizes. The measurements were accurate everywhere within 2 mm, but were consistently overestimated by approximately 1 mm for the smallest (4 cm) applicator size.*

RESULTS

As seen in Figure 2, our gap factor measurements agreed with previously published data within 1% and confirmed that accurate our gap measurements are important. Measured gap distances onto all colored papers agreed with physical distances within 1 mm for all applicators. Measured gap distances onto the steak surface (shown in Figure 3) agreed with physical distances within 2 mm for all applicators, with an average absolute error for all positions of 0.86 mm. Room lighting had no effect on LIDAR measurements.

CONCLUSIONS

Our LIDAR device is capable of being placed on an IORT applicator, taking a gap distance measurement, and being removed in less than 5 minutes. It is accurate under all experimental conditions within 2 mm and doesn't disturb the treatment set up. Additionally, the device was inexpensive to fabricate (<$100) and doesn't physically touch the patient, which simplifies sterilization requirements. In conclusion, our LIDAR device is a simple, accurate, and rapid way to improve applicator gap measurements for IORT.

REFERENCES

L. Wootton et al. "Commissioning, clinical implementation, and performance of the Mobetron 2000 for intraoperative radiation therapy." J Appl Clin Med Phys. vol. 18,1 (2017): 230-242.

CONTACT INFORMATION

Daniel Craft: DanielFCraft@gmail.com