Characterization of Patient Shifts from CT Simulation to First Fraction to Improve Tumor Localization

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INTRODUCTION

Radiation simulations are ideally performed such that patients are simulated for planning in identical positions to treatment positions. In some institutions, the CT equipment, such as flat top couchtops, may be retrofitted and introduce inherent position changes between simulation and treatment. Some shifts, such as lateral and longitudinal shifts, may be easily corrected where rotational changes like pitch and yaw may require repositioning. Recognizing these errors can improve positioning at simulation and ultimately improve tumor localization for treatments.

AIM

The purpose of this study was to measure the magnitude and direction of companion animal shifts that were required on the first day of radiation treatment when mis-matched simulation and treatment couches were utilized.

This research highlights potential modifications for consideration in clinics without matched CT simulation and radiotherapy treatment couches. Additionally, treatment sites that may benefit from customized immobilization devices can be identified to further improve reproducibility in target positioning between simulation and treatment.

METHODS

A flat-top PET-CT simulation couch was manually placed on the curved CT couch (**Fig 1A**) prior to each CT simulation at the University of Minnesota Veterinary Medical Center for acquisition of planning CT data. Pets were subsequently treated on a Varian Exact Couch (Varian Medical Systems Inc, Palo Alto, CA) (**Fig 1B**). Cone beam CTs were obtained prior to each treatment and positional shifts approved by a board-certified veterinary radiation oncologist were automatically recorded in MOSAIQ record and verify system (Elekta AB, Stockholm, Sweden). Positional shifts on the first day of treatment were analyzed for selected pets treated with radiation therapy for oral (n=13) and anal/pelvic tumors (n=11) between June 2016-January 2020. Mean shifts on lateral, longitudinal, vertical, and coronal directions were calculated. Unpaired t-tests were used to compare values between tumor sites (oral versus anus/pelvis). Nonparametric one-way ANOVA was used to compare directional shift values between sites with Dunn's post hoc test. Significance was set at a p value < 0.05.

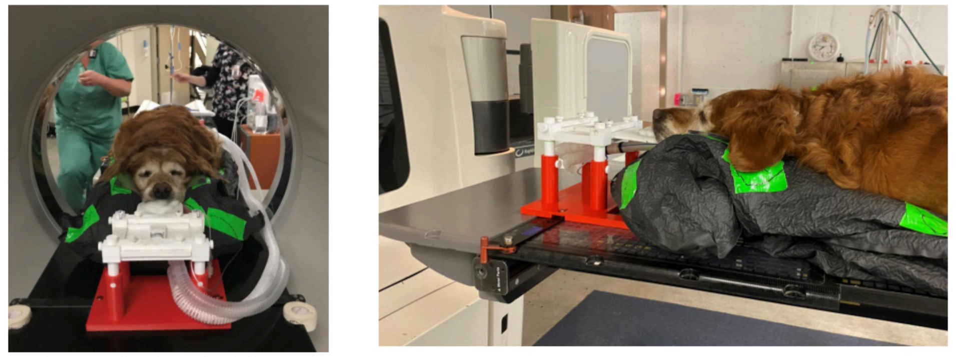

Figure 1: A. (Left): Pet dog positioned for CT simulation using a flat top PET/CT overlay. **B.** (Right); Same pet dog positioned for first day of radiotherapy treatment with the treatment couch.

RESULTS

The majority of clinical patients with oral tumors were comprised of dogs with oral malignant melanoma, while all animals treated with anal/pelvic tumors were dogs with anal sac apocrine gland adenocarcinoma (**Table 1**).

While there was no difference in animal weight (p = 0.42) between treatment sites, dogs treated for anal/pelvic tumors had larger planning target volumes (PTVs) compared to dogs with oral tumors (**Fig 2**).

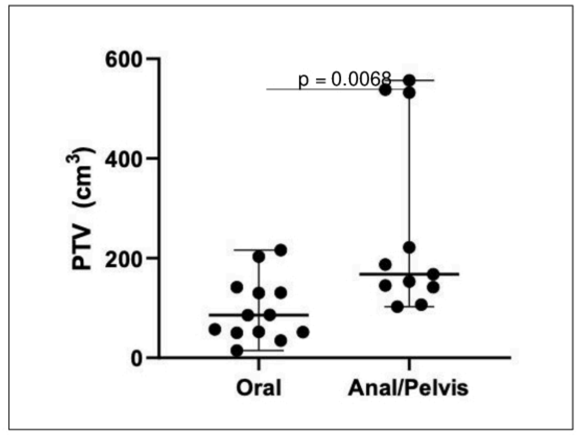

Figure 2: The median PTV volume was significantly different between treatment sites.

Table: 1: Clinical characteristics of pets with spontaneous tumors treated with radiation therapy.

Oral (N = 13)	
Median Weight	17.1 kg
Median PTV	85.7 cm^3
Tumor Type	
Squamous cell carcinoma	3
Malignant melanoma	10
Inclusion of regional lymph nodes in PTV	12
Definitive radiation therapy	12
Conformal	11
IMRT	1
Palliative-intent RT	1
Anal/Pelvis (N = 11)	
Median Weight	26.1 kg
Median PTV (cm^3)	167.6 cm^3
Tumor Type	
Anal sac apocrine gland adenocarcinoma	11
Inclusion of regional lymph nodes in PTV	11
Definitive radiation therapy	
Conformal RT	4
IMRT	4
Palliative-intent RT	3

There was wider variation in positional shifts required for the first radiotherapy fraction for dogs with anal sac tumors compared to dogs with oral tumors, but no significant differences (**Table 2**).

Table 2: Mean shifts ± standard error of the mean shifts required in each direction following cone beam CT for positioning verification in pets with oral tumors or anal/pelvic tumors treated with radiotherapy. P values represent the difference in each positional direction between treatment sites.

Treatment Site	Lateral (mm)	Longitudinal (mm)	Vertical (mm)	Coronal (º)	Magnitude (mm)
Oral (n=13)	2.31 ± 0.57	1.46 ± 0.29	1.00 ± 0.61	1.15 ± 0.33	3.54 ± 0.67
Anal/Pelvic (n=11)	2.18 ± 0.58	2.18 ± 0.80	3.00 ± 0.86	0.93 ± 0.33	5.00 ± 1.05
	p = 0.88	p = 0.38	p = 0.06	p = 0.63	p = 0.23

RESULTS

When direction of shifts was evaluated, only shifts in the vertical direction were significantly different (p = 0.03). Posthoc analysis showed significantly greater shifts in the dorsal (up) direction required for dogs with anal sac tumors compared to oral tumors (**Fig 3**). There were no significant difference in the ventral (down) movement of the couch.

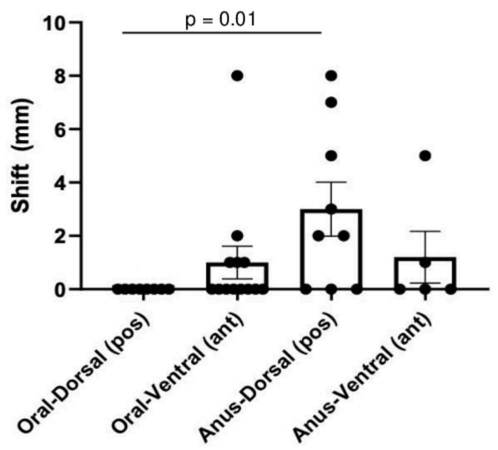

Figure 3: Vertical couch shifts made for pets treated with oral or anus sites. The p value represents a statistical difference between shifts in the upward on posthoc analysis.

CONCLUSIONS

Mis-matched CT simulation overlays and radiotherapy treatment couches can pose clinical challenges unique to the patient and treatment site. In our study, animals with oral tumors were more reliably positioned from CT simulation to first fraction treatment, likely due to a custom immobilization device secured to both flat-top couches (Fig 1). The wider range of shifts observed for anal/pelvic tumors may be due to larger field sizes, as well as lack of secured immobilization devices.

Future work will expand tumor groups in order to identify treatment sites that may benefit from customized immobilization devices, thus improving reproducibility in target positioning between simulation and treatment.

SELECTED REFERENCES

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