Using EPID in vivo dosimetry to quantify treatment delivery accuracy in canine head and neck tumors

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SPECIFIC AIMS

I. Perform real-time dosimetry using PerFRACTION 3D on the planning CT to assess if 95% dose can be delivered to the planned treatment volume in canine patients with head and neck tumors.

II. Compare the dose delivered to critical organs to those in the treatment plan to determine if dose received is at or below 95% of the planning criteria.

III. Validate the PerFRACTION in air system for quality assurance testing of IMRT.

MATERIALS AND METHODS

Specific Aims 1 and 2

I. Varian Eclipse software was used to create individual radiation treatment plans using patient CTs.

II. Patients were set-up using positioning tools and CBCT image guidance, EPID fluence maps were captured for each fraction.

III. Radiation treatments were delivered by Varian TrueBeam linear accelerator.

IV. Sun Nuclear PerFRACTION software was used to calculate and record radiation dose delivered during each treatment fraction.

V. Radiation dose delivered to PTV and critical organs were compared to the values in the planned treatments.

Specific Aim 3

I. Quality assurance (QA) of the treatment plans was initially performed with MapCHECK with a Solid Water phantom and dose detector prior to implementation of treatment plans.

II. QA with EPID in air was performed for both PTV and critical organ dose delivered.

III. Treatment plans were evaluated for gamma pass rate at 3% 3mm, following clinical protocol, for both MapCHECK and PerFRACTION in air EPID.

BACKGROUND

Why is positioning important in radiation oncology?

Intensity-modulated radiation therapy (IMRT) creates high radiation dose gradients between tumor and normal tissue. Affordable motion and setup changes, positioning precision and accuracy as subtle shifts in the position of target or critical organs can result in inadequate or excessive doses to the tumor or normal tissues. Additionally, radiation treatments are delivered over multiple visits, inviting opportunities for errors in patient positioning setup. This is especially critical for head and neck tumors.

What is EPID?

The Electronic Portal Imaging Device (EPID) measures exit fluence (radiation that passes through the patient body), and with information from the planning the CT and PerFRACTION software, can be used to determine radiation dose delivered to target or normal tissues.

How can EPID benefit radiation treatment?

This study uses EPID to evaluate radiation plan implementation given day-to-day positioning changes. Calculated doses delivered to targets will be compared to planned doses.

Terms

GTV: Gross Tumor Volume, an observable volume
CTV: Clinical Target Volume, GTV + margin for clinical uncertainty
PTV: Planning Target Volume, CTV + margin for uncertainty of setup, patient or organ mobility, and dose delivery

What is QA and why is it performed?

Quality assurance (QA) is performed to verify the machine is capable of delivering the treatment plan. It is traditionally performed by irradiating a phantom with a dose detector.

How can EPID benefit QA?

EPID has increased spatial resolution and can decrease setup time.

CASE HIGHLIGHT

Patient X, a brachycephalic dog, presented to the radiation oncology service for definitive treatment of a nasal carcinoma encompassing the frontal sinus.

Global positioning was confirmed with CBCT prior to each treatment. However, traditional setup checks failed to notice a slight shift made more dramatic by the sharp contour of the face.

PerFRACTION calculated delivered doses to the left ear were consistently higher than planned doses, while PTV doses were consistently lower but within clinical criteria. In this way, PerFRACTION detected a setup error.

RESULTS

A quantification of the effectiveness of EPID dosimetry and software with changes in calculated dose to planned dose and mean dosimeter QA was performed. The tables below display the gamma pass rates at 0.95 and 1.05 for both QA and EPID for PTV and critical organs.

DISCUSSION

Specific aim 1: 95% of fractions delivered met or exceeded 95% dose to planned treatment dose as shown in Table 1. Ideally the PTV delivered dose would be at or greater than the planned dose. Radiation treatments were comparatively successful at meeting this criteria despite the effect of positioning changes.

Specific aim 2: The majority of fractions delivered to critical organs were successful at meeting the criteria of being below 105% of dose to planned treatment dose with the exception of the left inner ear, 61%, and right eye, 81%, as shown in Table 1. Ideally the delivered dose to critical organs would be at or below the planned dose to minimize tissue toxicity.

A systematic correction originating between the algorithm difference between DoseCheck and Eclipse has been applied to fractions 1-19 in Figure 1. Deviations from planned doses for PTV and critical organs are understood to be due to positioning setup changes. This is seen clearly in the minor fluctuations of dose ratios in Figure 1. However, it is not of note the dose delivered to planned for is consistently lower than fraction 0. Positioning changes will contribute to this decrease, however, other causes include radiation dose attenuation due to the couch, mask, pillows or board that is not accounted for in the treatment planning system.

Specific aim 3: T-tests were performed comparing quality assurance pass rates for both PerFRACTION in air EPID and the traditional method MapCHECK at both dose difference 3% and distance 3 mm with a pass tolerance of 95%. This criteria was chosen as it is used clinically to determine if a radiation plan passes QA. P values were significant 4.53-x10^-6 for paired t-tests, indicating that the tests generated significantly different pass rates as shown in Table 3. PerFRACTION appears to be the more specific test, giving a higher failure rate for plans that passed MapCHECK. The difference in failure rate requires further evaluation. It is of note that MapCHECK uses 2d gamma while PerFRACTION uses 3d gamma, which could be contributing to the differences.

CONCLUSIONS

I. PTV: Successfully delivered 95% or greater of planned dose in 85% of fractions.

II. Critical organs: Successfully delivered 105% or less of planned dose to most fractions with the exception of those delivered to the Left Inner Ear and Right Eye.

III. PerFRACTION in air has not been validated as a treatment plan QA method.

REFERENCES

