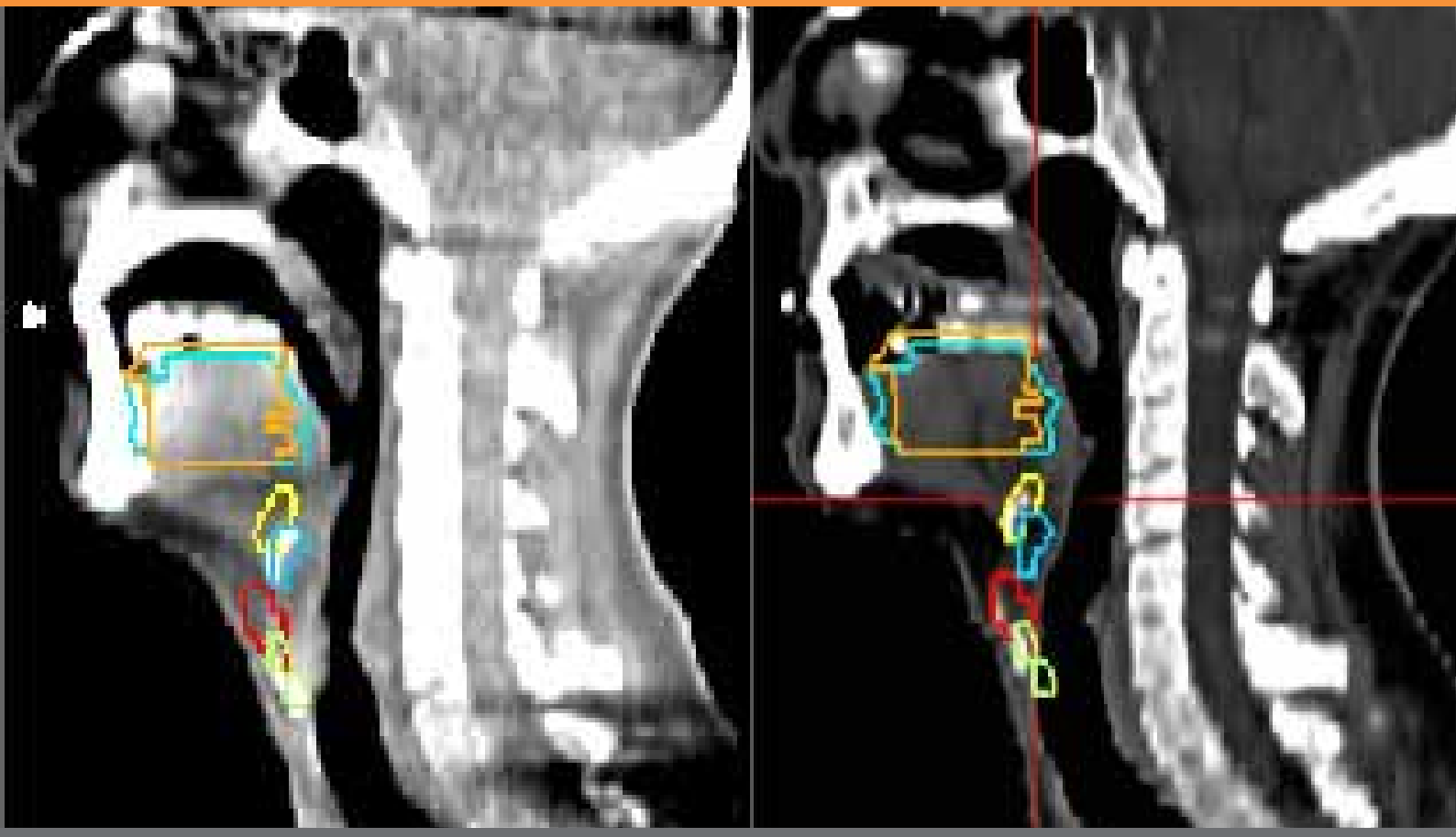
Accuracy study

Quantification of anatomic positional variation and movement over the course of external beam radiation



INSTITUTION: **Departments of Radiation Oncology, Jefferson Medical College, Thomas Jefferson University**

PURPOSE: Intensity modulated radiation therapy (IMRT) in the treatment of head-and-neck cancers has the ability to minimize dose to normal structures. The highly conformal nature of IMRT places an increased importance on knowledge of anatomical displacement over the course of treatment. This is the preliminary analysis of a prospective study analyzing the degree of anatomic displacement during a course of head-and-neck radiotherapy.

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Quantification of anatomic positional variation and movement over the course of external beam radiation

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Methods

This is an Institutional Review Board approved trial in which eligible patients underwent conventional CT-based planning for IMRT or 3D conformal therapy with customized immobilization devices dependent on tumor site. Patients were treated with external beam radiation with cone beam CT that uses an onboard kilovoltage imaging procedure prior to each treatment, fusing the initial planning CT to the CBCT and calculating positional adjustments. VolumeView™ images were fused (using MIMvista® software) to the initial planning CT based on external fiducial markers. Structures (mandible, tongue, hyoid bone and thyroid cartilage) were contoured on both the initial and each CBCT and displacement values were calculated (see figure 1).

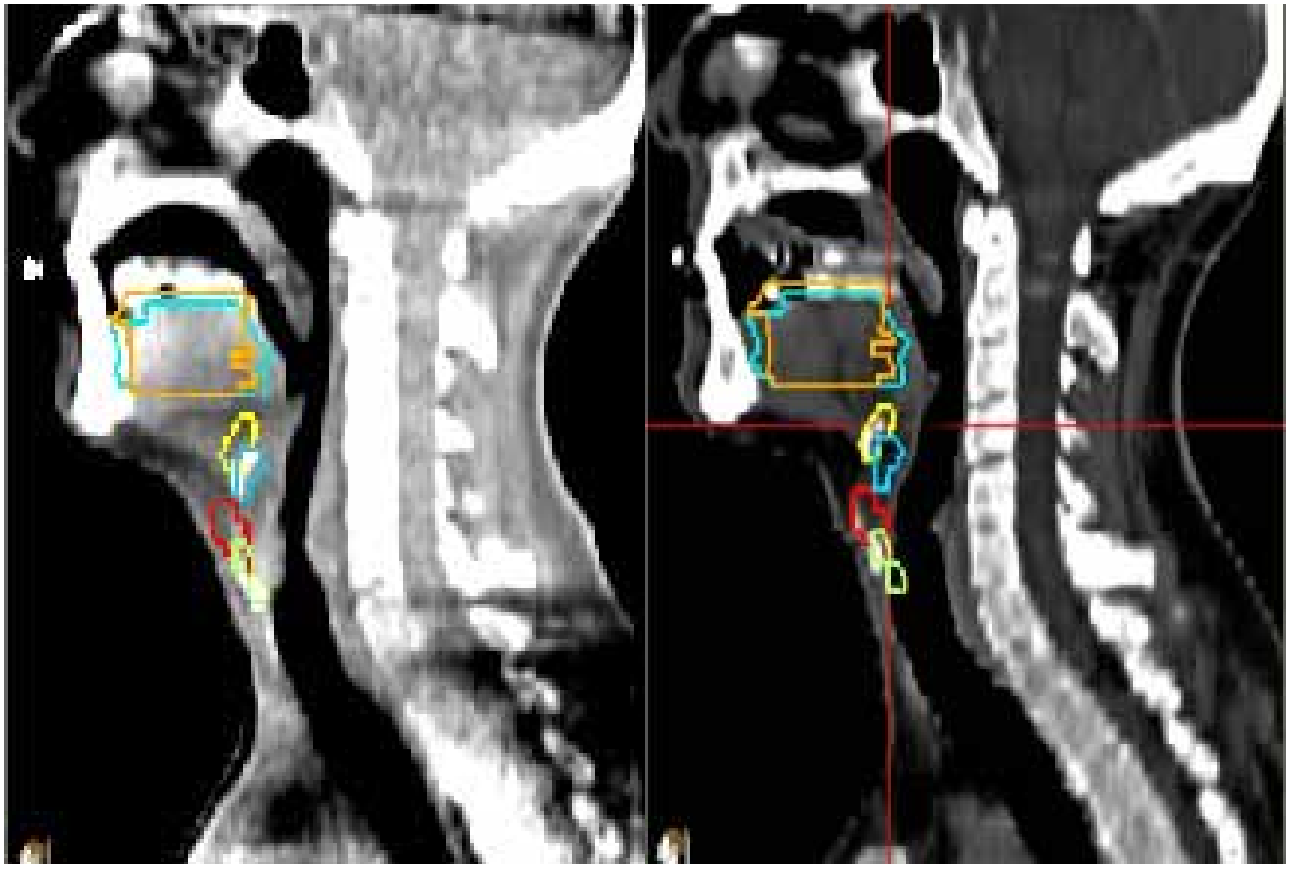

Figure 1: example of planning CT and CBCT with all four anatomical structures independently contoured on each and then fused together.

Results

Fifteen patients and 93 VolumeView™ (one VolumeView per patient per week) images were analyzed. See table 1 for patient characteristics. Structure position as compared to the initial CT scan varied over the course of treatment. Differences in structure centers varied but were typically (98.9% of treatments) less than 1cm compared to the initial CT.

Table 1: patient characteristics

Patient no.	Age	Sex	Disease site	Stage	Trach	Bite block
01	5	M	Larynx	T4N1	Yes	No
02	45	F	Larynx	T3N0	Yes	No
03	53	F	Esophageal with cervical mets	T3N1	No	No
04	45	M	Soft palate	T3N0	No	Yes
05	44	M	Tonsil	T2N0	No	No
06	78	M	Oral cavity	T4N1	Yes	No
07	33	M	Oral cavity	T3N2	No	Yes
08	60	M	Larynx	T3N2	Yes	No
09	60	M	Tonsil	T3N2	No	No
10	57	M	Base of tongue	T2N2	No	No
11	55	F	Larynx	T2N0	No	No
12	68	F	Oral tongue	T2N0	No	Yes
13	75	M	Larynx	T2N0	No	No
14	60	M	Larynx	T1N0	No	No
15	43	M	Larynx	Recurrent	Yes	No

The median variance and standard deviation was 3.7 ± 1.4, 4.9 ± 3.9, 5.0 ± 1.5, and 5.5 ± 1.9 mm for the mandible, tongue, hyoid and thyroid respectively (figure 2). Overall, variance of structures on the VolumeView image was statistically significantly different from the initial planning CT and the displacement of the 4 structures were significantly different from each other. No significant difference was seen in position for each structure as a function of time during treatment (4.6mm variance in week 1 compared to 4.7mm in the final week). However, when patients were stratified into those with above and below median variance in week 1, the difference in variance in subsequent weeks was significantly different (figure 3). This graph represents the average anatomical variation of the hyoid bone over time by two groups. Group 1 (blue) is patients who had a below average displacement of the hyoid bone in week 1, while group 2 (pink) had an above average displacement of the hyoid bone in week 1.

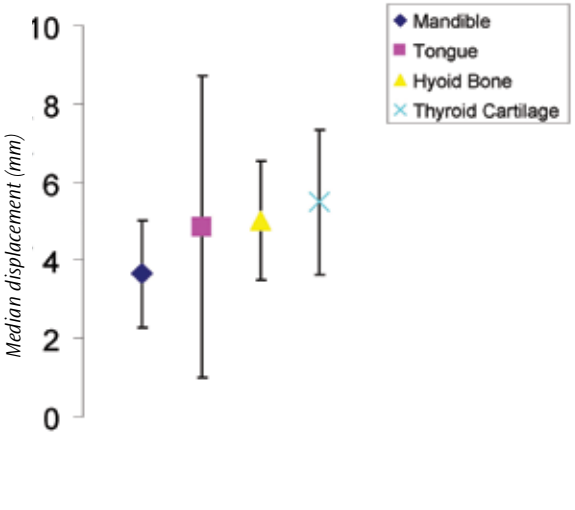

Figure 2: median displacement with standard deviation

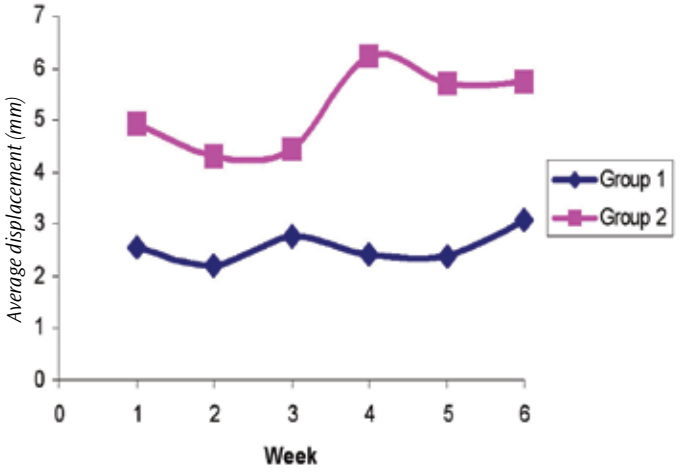

Figure 3: average anatomical variation of hyoid bone.

(continued overleaf)

Discussion

We have shown that patient set-up and treatment margins may need to be adjusted depending on the treatment site. Since the hyoid bone, thyroid cartilage and tongue have a greater than median displacement, greater margins for these structures may be indicated. Another clinically relevant result of this study is the amount of radiation delivered to normal structures secondary to anatomic structure displacement. If the patients were set up and treated using fiducial markers without any other means of correction (such as VolumeView™ imaging) the hyoid bone (and thus larynx and constrictor muscles) would get a variable dose of radiation.

An important question with any new technology is which patients will benefit from its use. Our data has shown that patients with greater displacement in the first week will tend to continue to have greater degrees of displacement over the remainder of therapy. Thus, if a VolumeView image or similar study was used on every patient in the first week of treatment, patients could be selected (based on these initial displacement findings) regarding which patients should continue to receive VolumeView imaging over the remainder of treatments.

Conclusion

Anatomical positional variation for several structures in the head-and-neck have displacement independent of one another, especially in the inferior-superior dimension. This displacement can cause alteration of dose to normal structures. Daily verification (such as VolumeView imaging) can be used to reduce positional variation and more reliable dose to normal structures and may be most useful for patients with significant displacement during the first week, as these patients appear to be more prone to subsequent displacements.

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