The effect of shoulder variation on IMRT and SmartArc for head and neck cancer

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Introduction
Patient positioning and immobilization is essential in radiation therapy, particularly with IMRT and VMAT which include sharp dose gradients to spare tissues surrounding the target. Although extensive effort is spent in positioning and immobilization the patient, this is almost exclusively limited to accurate isocenter setup; the position of the body away from isocenter is often ignored. Nevertheless, such distant body positions may also have an impact on the delivered dose distribution. For head and neck radiotherapy, or other treatments involving the low neck, the position of the shoulders may be of particular concern. Their position is generally not considered when setting up the patient each day. However, without any displacement of isocenter, the shoulders can still be in a position different from the one in the treatment plan.

Methods – con’t
Three Baseline head and neck IMRT and SmartArc plans were generated in Pinnacle 3 (Phillips, Fitchburg, WI) based on simulation CTs. The CT datasets (external contour and bony structures) were then modified to represent shifts of the shoulder (relative to isocenter) between 3 mm and 15 mm in the SI, AP, and LR directions (Figure 1). The initial plans were recalculated on the image sets with shifted shoulders. The dose changes to CTVs and critical structures were evaluated, and a set of daily shoulder shifts (Figure 2) were applied to the treatment plans to find the clinical effect of the shoulder variability.

Results
• Superior shifts resulted in the greatest loss of CTV volume coverage in lower neck targets. Large superior shifts resulted in loss of coverage by the 95% isodose line (Figure 4).
• Inferior shifts did not result in an increase in target coverage, but did show increased brachial plexus dose by 2 Gy (Table 2).
• Posterior shifts caused a loss of lower neck target coverage for IMRT plans but not VMAT.
• Large, anterior shifts did not cause an equal increase in coverage, however, they also caused an increase in brachial plexus dose by 1 Gy (Table 2).
• When the set of observed shifts were applied to the treatment plans, the worst dose loss observed to 99% of a lower neck CTV was ~1 Gy.
• For the same set of shifts, the worst dose increase to 0.1 cc of the brachial plexus was 72 cGy.

Discussion
It is important to note that the coverage loss from superior and posterior shifts was not compensated for by an equivalent increase in coverage from inferior or anterior shifts. That is, the effect of the shift does not average out over treatment (Figure 5). The position of the shoulder each day has an impact on coverage. Table 3 shows the frequency of shoulder shifts required to cause important dose losses to low neck targets.

Conclusions
Large, superior shifts can lead to underdosing of lower neck targets if they occur frequently. Because up to 1 Gy can be lost from shoulder variation over the course of treatment, it may be necessary to include shoulder position in daily set up procedures for head and neck patients with lower neck targets. The losses demonstrated in this study may be particularly important for hypofractionated or single fraction treatments, therefore the position of the shoulder is of particular concern in these instances.

The 72 cGy increase in dose to 0.1 cc of the brachial plexus is not likely to cause harm because the max dose to the brachial plexus is not always in the same location within the structure, depending on shoulder position. The daily increase in brachial plexus dose was a few cGy, therefore the dose escalation required to receive a TDS/5 dose of over 60 Gy (3) on a single day was not observed.

References