EVALUATION OF A DEFORMABLE RE-CONTOURING METHOD FOR ADAPTIVE THERAPY

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Purpose

To evaluate a method for semi-automatic re-contouring on replanning CTs to facilitate clinical workflow in an adaptive radiotherapy treatment strategy.

Methods

Two CTs were acquired for each of 7 head and neck cancer patients. All contours were generated on CMS FocalSim 4.3.3. Contours were manually drawn on the initial planning CT (set A) and replanning CT (B). The deformable adaptive re-contouring method (MIMvista) was used to generate the automatic contours (C) from set A. Set C was then manually modified (D) (Table 1). Consistency between sets was compared using the contour overlap metric, defined as the proportion of the set intersection to the set union of a contour pair (Figure 1).

Table 1
Contour Sets

SET A	Manually drawn on initial CT
SET B	Manually drawn on replanning CT
SET C	Auto Re-contoured on replanning CT
SET D	Modified auto contours on replaning CT

Contour sets generated for this study. Sets B and D were modified, reviewed, and approved by the physician for radiotherapy treatment planning. Set C was automatically generated by the adaptive re-contouring method developed by MIMvista.[1,2]

Table 2
Modification Required

First Set	Second Set	Normal Structure Overlap	Target Overlap
Automatic (C)	Modified (D)	0.736	0.775
Manual (B)	Modified (D)	0.629	0.647
		p=0.005*	p=0.002*

The automatic re-contouring contours were more similar to the modified versions than the modified contours were to the fully manual contours. Thus, the amount of modification which was required to make the automatic re-contouring results "treatment-ready" is less than the amount of typical variability in contours created by the same physician for the same plan.

Figure 1
Contour Overlap

$$\text{Overlap} = \frac{A \cap B}{A \cup B}$$

Where A = Voxels in the first set tested and B = Voxels in the second set tested. Equation for contour overlap metric.

Results

The time to modify automatically generated contours averaged 0.94 hrs (range 0.71 -1.28 hrs) vs 3 - 4.5 hrs for manual re-contouring in our practice.

Automatic and modified contours (C and D) had significantly better overlap than final planning contours (B and D) (0.736 vs 0.629, p=0.005, for normal structures and 0.775 vs 0.647, p=0.0002, for targets), indicating the amount of modification was less than typical variability in planning contours (Table 2). Overlap between the automatic and manual contours (C and B) was not statistically different from the final planning contours (B and D) at p-values of 0.09 for normal structures and 0.16 for targets, indicating that manual modification does not significantly improve consistency (Table 3). For structures with no expected volumetric changes (e.g. brainstem), modified (D) and automatic contours (C) had better volumetric consistency than manual contours (B) with original contours (A) at p=0.03 and 0.004, respectively (Table 4).

Table 3
Consistency Before and After Modification

First Set	Second Set	Normal Structure Overlap	Target Overlap
Manual (B)	Modified (D)	0.629	0.647
Manual (B)	Automatic (C)	0.560	0.604
		p=0.09	p=0.16

Although the modified contours were more similar than the automatic contours to the manual contours, the increased overlap was not statistically significant. The effort taken to modify the contours did not significantly improve contour consistency in final contour sets.

Table 4
Consistency with Original Contours

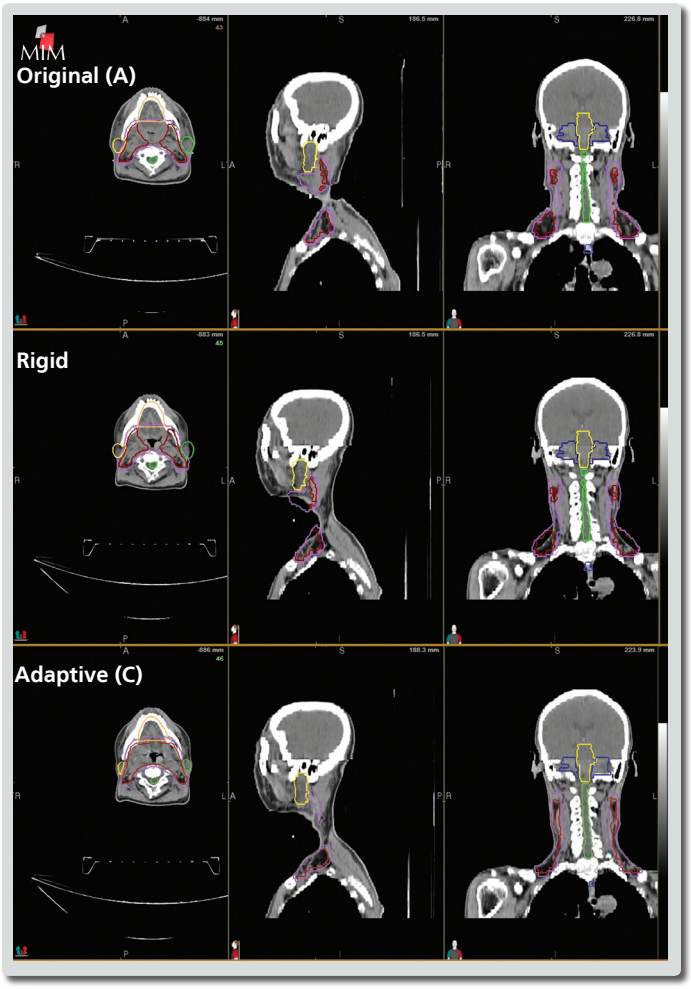
Contour Sets	Average Volume Difference
Automatic (C)	3.94%
Modified (D)	8.27%
Manual (B)	15.40%

Contours with no expected volumetric changes from the initial CT scan to the replanning CT (brain stem, cerebellum, and the spinal cord), showed significantly better volumetric consistency using the automatic and semi-automatic methods than with the manual method. Validating consistency between the replan and the original plan for other contours which would have had volumetric changes is more difficult, but the re-contouring method used here has been validated and shown to capture soft tissue deformations with high accuracy.[1]

Conclusions

Automatic adaptive re-contouring with manual modification resulted in significant time savings, contours more consistent to the originals and errors smaller in magnitude than the variability in acceptable planning contours. It has current clinical benefit and promise for further automation in adaptive radiotherapy.

Figure 2
Automatic Deformable Adaptive Re-contouring



Images showing contours from the initial plan overlayed onto the replanning CT compared with the result of the Automatic Deformable Adaptive Re-Contouring. The deformed contours are more consistent with the anatomy in the replanning CT.

References

1. Piper JW. Evaluation of An Intensity-Based Free-Form Deformable Registration Algorithm. Medical Physics. June 2007;34(6):2353-2354.
2. Choe J, Piper JW, Nelson AS, Nelson AD, Kuc N, Kulasekere R, Greskovich J. Comparison of Contour-to-CT Registration Techniques During Adaptive Re-planning of Radiation Therapy for Patients with Bulky Disease. IJROBP. 2007;69(3 Suppl S):S725.

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