# Investigating the impact of using TCP and NTCP objectives in treatment plan optimization of head & neck cancers

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## Purpose/Objective

To investigate treatment plan quality of head and neck cancers via tumor control and normal tissue complication probability (TCP and NTCP) objectives in the plan optimization process.

## Materials/Methods

Four patients with oropharyngeal squamous cell carcinoma were used to create two sets of simultaneous integrated boost (SIB) treatment plans. One plan used conventional physical objectives for target coverage and OAR sparing while the second plan used TCP and NTCP biological objectives. The Poisson TCP model was used for the targets and the relative seriality NTCP model for the OARs. The models' parameters that were used were taken from the literature or derived from own clinical data. TCP/NTCP values and doses of the respective plans were compared between each other and against the clinical goals.

| Structure | $D_{50}$ (Gy) | γ | *s* | *α/β* | Endpoint |
|---|---|---|---|---|---|
| PTV-HR | 47.0 | 4.0 | — | 10.0 | Control |
| PTV-SR | 40.0 | 4.0 | — | 10.0 | Control |
| Spinal cord | 57.0 | 6.7 | 1.00 | 3.0 | Cervical myelopathy |
| Cochlea | 46.5 | 1.1 | 0.0001 | 3.0 | Tinnitus |
| Parotid gland | 25.8 | 0.58 | 0.1 | 3.0 | Xerostomia |
| SMG gland | 46.4 | 0.45 | 0.0001 | 3.0 | Xerostomia |
| Pharyngeal constrictor | 65.4 | 3.14 | 0.0001 | 3.0 | Dysphagia |
| Brainstem | 65.1 | 2.4 | 1.00 | 3.0 | Necrosis infarction |
| Brain | 60.0 | 2.6 | 0.64 | 3.0 | Necrosis infarction |
| Larynx | 78.8 | 4.8 | 0.66 | 3.0 | Cartilage necrosis |
| Esophagus | 61.5 | 1.4 | 0.1 | 3.0 | Clinical stricture |
| Oral cavity | 70.0 | 3.0 | 0.50 | 3.0 | Mucositis |

Table1. Summary of the TCP/NTCP model parameter values for the different targets/OARs.

## Conclusions

Radiobiological optimized planning can produce nearly clinically acceptable plans but lack the mechanism to push all OAR doses as low as can be achieved.

## Results

- All high risk and standard risk PTV's prescription doses satisfied $D_{95\%}$ coverage constraint
- Calculated TCP values were >98% for all PTVs, in both sets of plans.
- Average $CI_{60Gy}$ & $CI_{54Gy}$: 0.9 & 0.9 for physical and radiobiological optimized plans.
- Physical optimized plans achieved significantly lower clinical goal values for brainstem, cord, left cochlea, and larynx
- All other organs at risk (OARs) the differences between the physical and radiobiological plans were within 3 Gy.

| PTV Dosimetric Data | | |
|---|---|---|
| Plan Type | Physical | Radiobiological |
| Coverage | ≥ 95% | ≥ 95% |
| TCP | ≥ 98% | ≥ 98% |
| CI [average] | 0.9 | 0.9 |

Table 2. PTV dosimetric data for all PTVs for both physical and radiobiological optimized plans.

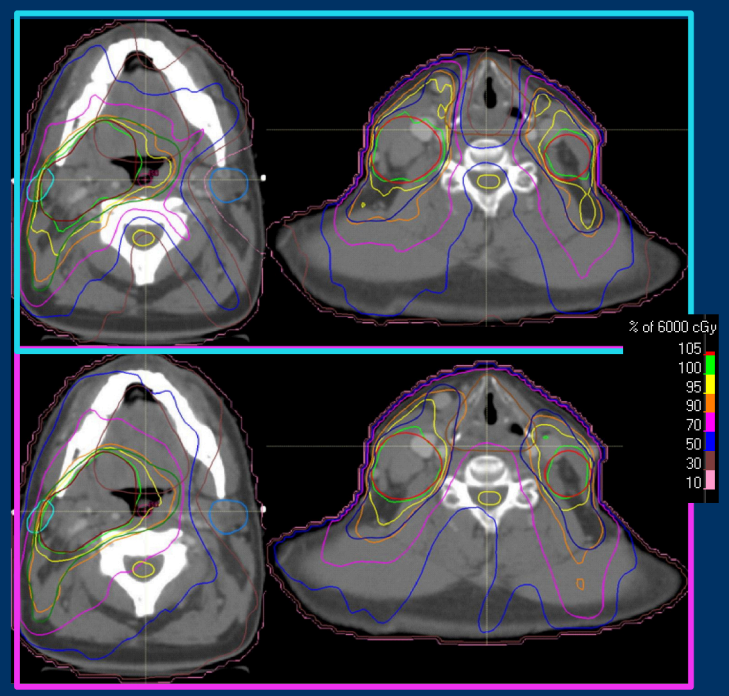


Fig. 1: Isodose line distributions of the physical (upper) and radiobiologically (lower) optimized plans for the same patient.

| OARs | Clinical goals | Dosimetric Data | | |
|---|---|---|---|---|
| | | Physical Average Dose | Radiobiological Average Dose | Physical - RadBio Difference (Gy) |
| Brain | NTCP ≤ 10% | 0.0 | 0.0 | 0.0 |
| Brain | D0.1cc < 60Gy | 48.8 | 50.1 | -1.3 |
| Brainstem | NTCP ≤ 10% | 0.0 | 0.0 | 0.0 |
| Brainstem | D0.1cc < 54Gy | 28.2 | 44.6 | **-16.3** |
| Left Parotid | NTCP ≤ 10% | 28.3 | 27.3 | 1.0 |
| Left Parotid | V30Gy ≤ 50% | 22.7 | 21.9 | 0.7 |
| Left Parotid | Dmean ≤ 26Gy | 17.9 | 19.2 | -1.3 |
| Right Parotid | NTCP ≤ 10% | 47.8 | 44.5 | 3.3 |
| Right Parotid | V30Gy ≤ 50% | 41.4 | 38.6 | 2.7 |
| Right Parotid | Dmean ≤ 26Gy | 27.7 | 26.7 | 1.0 |
| Left Submandibular | NTCP ≤ 10% | 38.8 | 39.0 | -0.3 |
| Left Submandibular | Dmean ≤ 35Gy | 39.1 | 39.4 | -0.3 |
| Right Submandibular | NTCP ≤ 10% | 55.8 | 54.8 | 1.0 |
| Right Submandibular | Dmean ≤ 35Gy | 53.3 | 52.7 | 0.5 |
| Constrictors | NTCP ≤ 10% | 7.3 | 10.0 | -2.8 |
| Constrictors | Dmean ≤ 50Gy | 56.4 | 57.4 | -1.0 |
| Left Cochlea | NTCP ≤ 10% | 0.0 | 0.0 | 0.0 |
| Left Cochlea | Dmean ≤ 45Gy | 8.9 | 16.6 | **-7.8** |
| Right Cochlea | NTCP ≤ 10% | 0.0 | 0.0 | 0.0 |
| Right Cochlea | Dmean ≤ 45Gy | 14.2 | 17.4 | -3.2 |
| Cord | NTCP ≤ 10% | 0.0 | 0.0 | 0.0 |
| Cord | D0.1cc < 50Gy | 27.0 | 45.7 | **-18.7** |
| Esophagus | NTCP ≤ 10% | 0.5 | 0.5 | 0.0 |
| Esophagus | V65Gy ≤ 33% | 0.0 | 0.0 | 0.0 |
| Esophagus | V55Gy ≤ 67% | 0.0 | 0.2 | -0.1 |
| Larynx | NTCP ≤ 10% | 0.0 | 0.0 | 0.0 |
| Larynx | V60Gy ≤ 24% | 2.0 | 2.3 | -0.3 |
| Larynx | Dmean ≤ 41Gy | 24.8 | 45.9 | **-21.2** |
| Oral Cavity | NTCP ≤ 10% | 1.0 | 1.5 | -0.5 |
| Oral Cavity | Dmean ≤ 39Gy | 39.9 | 47.1 | **-7.3** |

Table 3. Average OAR dosimetric data and difference between plans for N = 4 patients. Color indicates which plan showed superior sparing.

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