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^{169}Yb-based intensity modulated brachytherapy for head & neck cancers

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INTRODUCTION

Intensity modulated brachytherapy (IMBT) is an emerging brachytherapy modality which incorporates a shielded applicator or source to modulate the dose distribution [1]. Static and dynamic approaches have the potential to reduce the dose to organs at risk, provide a method for dose escalation and/or reduce the number of implanted catheters.

We propose to deliver IMBT by incorporating 0.8 mm thick platinum shields with a 180° emission window inside interstitial catheters [2]. The platinum shield can reduce the transmission by ~80%. A prototype shield rotation device (AIM-Brachy) [2] and a custom ^{169}Yb source [3] were designed, built and tested to demonstrate proof of concept. While this delivery system was primarily designed for prostate cancer, there may be advantages for other treatment sites treated with interstitial brachytherapy such as head & neck cancers.

AIM

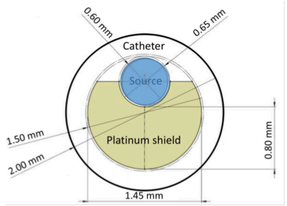
To evaluate the suitability of ^{169}Yb-based dynamic-shield intensity modulated brachytherapy (IMBT) for head & neck cancers with tissue heterogeneities taken into account.

METHOD

- Treatment planning was performed using RapidBrachyMCTPS [4], a Geant4-based Monte Carlo treatment planning system for brachytherapy applications.
- The IMBT plans were generated using fast mixed integer optimization (FMIO) [5] for various head & neck cases: oral tongue, lip, and base of tongue.
- The activated dwell positions were imported from the clinical plan. For each dwell position, 16 dose distributions were generated corresponding to equally spaced shield angles (22.5°).
- Tissue heterogeneities were taken into account by assigning voxel-by-voxel tissue composition (soft tissue, air, or bone) and physical density (HU-to-density curve).
- The dose distribution and dose-volume metrics were compared to conventional ^{192}Ir-based high dose rate brachytherapy (HDR BT) for the planning target volume (PTV) and organs at risk (mandible, parotids, and spinal cord).
- All plans were normalized such that at least 95% of the PTV receives the prescription dose (PD).

RESULTS

- Given equal PTV V_{100} coverage, the mandible D_{1cc} was elevated with ^{169}Yb-based IMBT compared to conventional HDR BT:
  - oral tongue (66.7% PD vs. 36.7% PD),
  - lip (58.7% PD vs. 37.1% PD),
  - base of tongue (120% PD vs. 63.0% PD).
- Conformity index (COIN) improved marginally for the oral tongue and base of tongue cases, and worsened for the lip case.
- Dose reduction to parotids and spinal cord was negligible or not clinically relevant (<2% PD).



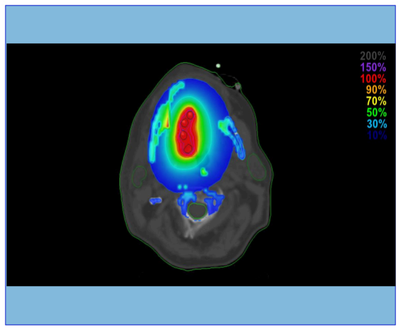


Figure 1: *^{169}Yb-based IMBT dose distribution for oral tongue cancer case.*

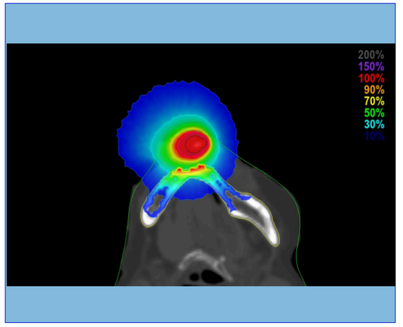


Figure 2: *^{169}Yb-based IMBT dose distribution for lip cancer case.*

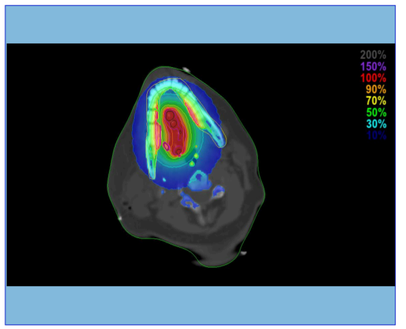


Figure 3: *^{169}Yb-based IMBT dose distribution for base of tongue cancer case.*

CONCLUSIONS

^{169}Yb-based IMBT delivers a higher dose to the mandible that conventional HDR BT. The angular modulation of the dose distribution is not sufficient to overcompensate for the increased absorption of lower-energy photons in dense bony structures.

This study suggests that ^{169}Yb-based IMBT is not an appropriate technique to improve plan quality for head & neck cancers. This work also highlights the need to consider tissue heterogeneities for accurate patient-specific dosimetry with ^{169}Yb brachytherapy sources.

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