

Inverse Planning for the MRI - Based Intracavitary High Dose Rate Brachytherapy for Cervical Cancer: A Feasibility Study



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OBJECTIVE

To determine the feasibility of using exclusively MRI to perform dwell position identification, targets and organs at risk delineation, and to apply inverse planning dose optimization to cervical HDR brachytherapy.

MATERIALS AND METHODS

- 15 cervical CA pts. treated with HDR BT at UCSF.
- All patients underwent MRI after placement of tandem and ring applicator containing a gadodiamide-filled dummy marker. This technique allowed accurate definition of the intra-applicator source positions.
- For each patient, we delineated gross target volume, high-risk clinical target volume, and organs at risk, according to GEC-ESTRO guidelines, and performed inverse planning simulated annealing (IPSA).
- We analyzed the DVH with the following endpoints: D100, D90 and V100 for GTV and HR-CTV, D0.1cc, D1cc, D2cc for bladder, rectum and bowel, and dose at point A.

Table 1: Planning Parameters for IPSA

| | Dmin(Gy) | Mmin | Dmax(Gy) | Mmax |
|----------------------|----------|------|----------|------|
| Target - Surface | 7 | 100 | 10.5 | 15 |
| Target - Volume | 7 | 100 | 10.5 | 10 |
| Applicator - Surface | 0 | 0 | 0 | 0 |
| Applicator - Volume | 0 | 0 | 0 | 0 |
| Bladder - Surface | 0 | 0 | 5.25 | 10 |
| Bladder - Volume | 0 | 0 | 5.25 | 10 |
| Rectum - Surface | 0 | 0 | 4.55 | 55 |
| Rectum - Volume | 0 | 0 | 4.55 | 55 |
| Bowel - Surface | 0 | 0 | 5.25 | 50 |
| Bowel - Volume | 0 | 0 | 5.25 | 50 |

Dmin = minimum dose; Dmax = maximum dose

Mmin = slope of penalty fn for violating minimum dose constraint

Mmax = slope of penalty fn for violating maximum dose constraint

RESULTS

Fig. 1: Development of MRI Marker Solution

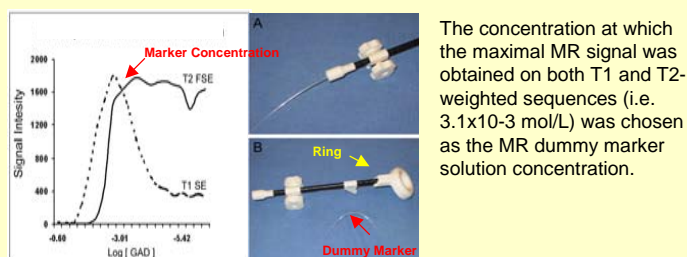
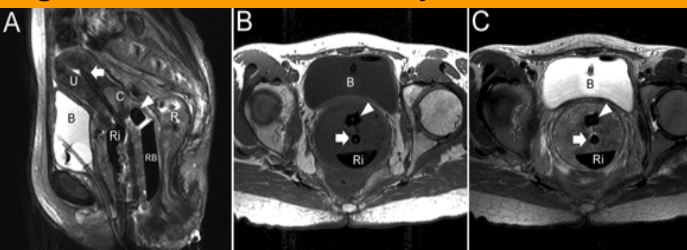


Fig. 2: Visualization of Dummy Marker on MRI



B: Bladder; C: Cervix; R: Rectum; Ri: Ring; RB: Rectal Blade; U: Uterus; White arrows and arrowheads point to dummy marker in tandem and ring, respectively.

Fig. 3: Dose distribution generated by IPSA

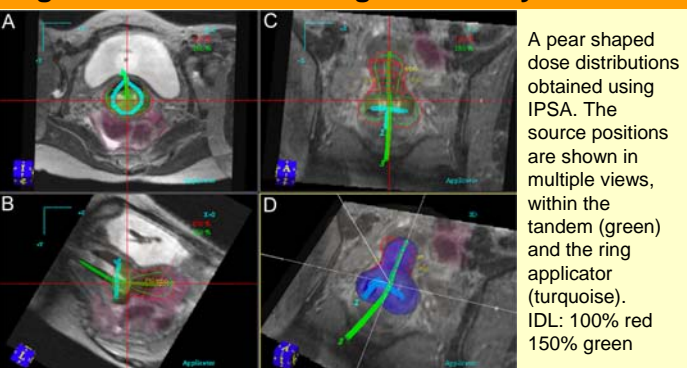


Table 2: Dose and Volume Parameters for Target

| | | Brachytherapy Mean Value + 1 SD % Prescription | Brachytherapy + EBRT Mean Value + 1SD (Gy a/b 10) |
|---------|------|--|---|
| GTV | D100 | 107 ± 17 | 89 ± 10 |
| | D90 | 139 ± 18 | 110 ± 13 |
| | V100 | 100 ± 0.5 | |
| HR-CTV | D100 | 70 ± 10 | 70 ± 5 |
| | D90 | 103 ± 5 | 86 ± 3 |
| | V100 | 92 ± 3 | |
| Point A | Mean | 80 ± 14 | 74 ± 7 |

Table 3: Dose and Volume Parameters for OARs

| | | Brachytherapy Mean Value + 1 SD % Prescription | Brachytherapy + EBRT Mean Value + 1SD (Gy a/b 3) |
|---------|--------|--|--|
| Bladder | D0.1cc | 88 ± 13 | 91 ± 12 |
| | D1cc | 73 ± 10 | 78 ± 8 |
| | D2cc | 67 ± 10 | 74 ± 7 |
| Rectum | D0.1cc | 74 ± 7 | 79 ± 5 |
| | D1cc | 62 ± 6 | 70 ± 4 |
| | D2cc | 57 ± 6 | 67 ± 4 |
| Bowel | D0.1cc | 45 ± 19 | 62 ± 10 |
| | D1cc | 36 ± 14 | 57 ± 7 |
| | D2cc | 32 ± 13 | 55 ± 6 |

D100: min target dose; D90: min dose received by 90% of target vol; V100: target vol receiving 100% of the prescribed dose; D0.1cc, D1cc, D2cc = minimum dose for most irradiated 0.1cm², 1 cm², 2 cm²

CONCLUSIONS

We developed a novel technique that allowed precise determination of dummy source positions on MRI. Using this technique, we successfully performed inverse planning directly from MRI. Furthermore, we developed a class solution of initial parameters that generated plans with excellent target coverage and organ sparing in a fast and consistent manner.

Disclosures: No known conflicts of interest exist in this study.