Dose Variation of HR-CTV and Applicator shift in Image-Guided Brachytherapy for cervical cancer

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INTRODUCTION

- 3D-IGBT(Image-Guided Brachytherapy) allows to determine the dose according to the size / shape of each patient's tumor while minimizing the dose to the OAR. On the other hand, 3D treatment planning requires more time in comparison with 2D treatment planning, resulting in intra-fractional dose variations may occur in target and OAR[1,2].
- At JASTRO 2019*, we reported that intra-fractional dose variation of HR-CTV(High-Risk Clinical Target Volume). Significant intra-fractional dose variation was observed for all dose evaluation indices (D90, D98, D100). Average dose variations of -12.4% for D100, -9.40% for D98 and -5.20% for D90 were observed for 53 fractions of 22 patients. *Japanese Society for Radiation Oncology, 2019 11/22
- The intra-fractional dose variations for HR CTV include contouring error, inter-observer reconstruction uncertainties and applicator shift during irradiation[3] There are few references investigating the correlation between applicator shift during irradiation and HR-CTV dose evaluation index

AIM

To evaluate applicator shift during irradiation and analyze correlation with dose evaluation index of HR-CTV during High-dose-rate CT-guided brachytherapy for cervical cancer

MATERIALS AND METHODS

- Patient information is presented in Table 1: 52 fractions of 21 patients were analyzed.
- For all cases, planning CT images were obtained after applicator insertion(tandem and ovoid applicator: metallic), and an original CT was imaged, and treatment planning was performed using this CT image for planning (Original Plan). In addition, CT images (After CT) were taken immediately after irradiation to confirm the position of the applicator (Fig1) All CT images were taken in the same room as the treatment room and the applicator was fixed using a fixing device.
- Two CT images(Original CT and After CT) were matched by pelvic structures using MIM Maestsro, and transferred to ECLIPSE TPS(Fig2). In both images, we defined the tandem by the tip and the base as the marker point (Fig3)
- The position of the marker point is represented in the coordinate space, and the coordinates of the marker point on the "Original CT" are set as the origin
- The distance from the origin to the marker point on the "After CT" was calculated and regarded as the applicator shift, for both the tip and base of the tandem separately
  - ➢Absolute shift
  - ➢Relative shift
- We evaluated applicator shift, including X, Y and Z
  X: anterior-posterior direction , Y: left-right direction, Z: cranio-caudal direction (Regarding relative shift, ■ as positive direction)
- Applicator shift vs D100, D98, D90 of HR-CTV
  - ➢Pearson's correlation coefficient
  - ➢Spearman's rank correlation coefficient **D100, D98, D90 (the doses received by 100%, 98%, and 90% of the volume

Statistical significance was accepted with a *p* value <0.05.

	Patients (n = 21)
Age	
Median, y	71
Range	37-88
FIGO stage	
IB	4
IIB	4
IIIB	10
IVA	1
IVB	2

Table1. Patients and tumor characteristics

Fig1.Flow of brachytherapy

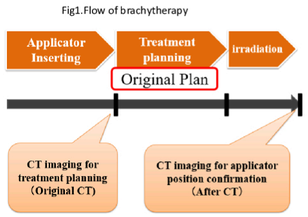

Fig2 . Fusion using MIM Maestro

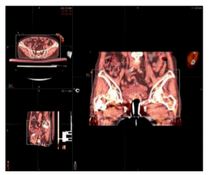

Fig3 . Tandem and ovoid

RESULTS

Absolute shift

	X mm			Y mm			Z mm		
	Average	SD	Range	Average	SD	Range	Average	SD	Range
Tip (n=52)	1.7	1.7	0 to 7.8	1.5	1.4	0 to 6.5	1.9	1.8	0 to 10.0
Base (n=52)	1.2	1.0	0 to 4.3	0.9	1.0	0 to 4.1	1.4	1.8	0 to 10.0

Relative shift

	X (to posterior) mm			Y(to left) mm			Z (to head) mm		
	Average	SD	Range	Average	SD	Range	Average	SD	Range
Tip (n=52)	0.4	2.4	-7.2 to 7.8	-0.3	2.1	-6.5 to 4.3	-0.9	2.5	-6.0 to 10.0
Base (n=52)	0.3	1.5	-4.3 to 3.8	0.1	1.4	-4.1 to 4.0	-0.7	2.2	-6.0 to 10.0

Correlation between Relative shift and dose variations of HR-CTV

Base	HR-CTV					
	D90		D98		D100	
	Correlation coefficient	p value	Correlation coefficient	p value	Correlation coefficient	p value
X shift	0.0041	0.846	0.1310	0.3547	0.0452	0.7502
Y shift	-0.1007	0.4775	-0.0073	0.9589	-0.0164	0.9080
Z shift	0.0430	0.7620	0.0493	0.7284	-0.0142	0.9206

Tip	HR-CTV					
	D90		D98		D100	
	Correlation coefficient	p value	Correlation coefficient	p value	Correlation coefficient	p value
X shift	0.0276	0.9772	0.2978	0.0320*	0.2904	0.0368*
Y shift	-0.2059	0.1431	-0.1958	0.1641	-0.2033	0.1483
Z shift	0.1964	0.1630	0.1403	0.3213	0.0327	0.8178

*p value < 0.05

DISCUSSION

- As with the previous study[4,5], this study showed that on average the shift of both tip and base of the tandem is in the posterior and caudal directions. It is considered that the applicator hardly shifted in the left-right direction due to the anatomical variations of the normal organs[4]. It's necessary to investigate the movement of normal organs during irradiation in detail.
- This study found that applicator shift had little effect on target dose. There is little correlation between D90 of HR-CTV and the applicator shift during irradiation . There was no correlation between D90 and cranio-caudal applicator shift [5,6]
- Weak correlation was observed between D98, D100 and the relative shift of tip .D100, D98 are the minimum dose to the tumor and are likely to be susceptible to small applicator shift during irradiation[7]
- The limitation in this study is the thickness of the CT slice. Due to the thickness of the slice was 2 mm, it was impossible to detect shifts of less than 2 mm in the direction of the cranio-caudal direction.

CONCLUSIONS

- There was little correlation between applicator shift during irradiation and intra-fractional dose variations of HR-CTV
- Dose uncertainties before and after treatment seems to be mainly due to contouring errors

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