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Use of the Rectal Retractor to Reduce the Rectal Dose in High Dose Rate Intracavitary Brachytherapy for a Carcinoma of the Uterine Cervix

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Commercially available rectal retractors can be used in high dose rate intracavitary brachytherapy (HDR ICR) as one of the methods for reducing the rectal dose in radiotherapy for a uterine cervical cancer. However, the extent of the rectal protection achieved using these rectal retractors has not been reported. The aim of the study was to examine the effect of a rectal retractor on reducing the rectal dose in HDR ICR.

Thirty patients were treated with HDR ICR using rectal retractors. Tandem and ovoids were applied in 15 patients and ovoids only were used in the other 15 patients. During the simulation, the rectum was filled with barium, and anteroposterior and lateral radiographs were then taken with and without the rectal retractor. Along the anterior rectal wall outlined, 4 to 8 points (median 6) were chosen to calculate the dose for each patient including the rectal point (RP), which is an author-defined rectal point modified from the definition of the rectal reference point in the ICRU report 38. The length of the measured rectum was 3-7 cm (median 5 cm). The bladder point (BP) dose was measured as recommended by the ICRU. The prescription doses to point A varied from 3.5 to 5 Gy (median 4 Gy). Paired comparisons were made on the individual patients by calculating the normalized mean doses of the RP, the maximal point (MP), and the longitudinal average (LA) with and without the rectal retractor. The doses to the bladder points (BP) were also calculated in parallel to the rectal points.

The anterior rectal walls were displaced posteriorly after inserting the rectal retractor. In the tandem and ovoids group, the number of patients with a reduced dose in the RP, MP and LA were 14 (93.3%), 12 (80.0%) and 13 (86.7%), respectively. In the ovoids only group, the corresponding figures were 14 (93.3%), 14 (93.3%) and 14 (93.3%). In the tandem and ovoids group, the reduced dose in the RP, MP, and LA dose were 0.52 Gy (13.0%), 0.50 Gy (12.5%), and 0.39 Gy (9.8%), respectively ($p<0.05$). In the ovoids only group, the RP, MP, and LA dose were reduced by 0.62 Gy (15.5%), 0.92 Gy (23.0%), and 0.54 Gy(13.5%), respectively ($p<0.05$). There was no significant change in the bladder point doses when the rectal retractor was applied, although the mean BP dose were 0.27 Gy and 0.09 Gy lower for the tandem and ovoids group and for ovoids only group, respectively ($p>0.05$). The mean RP, MP, and LA dose reduction rates of the patient subgroup where the RP dose was < 70% of the prescription dose were compared with the subgroup where the RP dose was > 70%. The effect of the rectal dose reduction was significant only in the subgroup of patients who received > 70% of the prescription dose ($p<0.05$). The use of the rectal retractor was a simple and an effective method for reducing the rectal dose. It was also considered to be a highly reproducible method, which can replace the time-consuming vaginal gauze packing in HDR-ICR.

Key Words: Rectal dose, rectal retractor, high dose rate, intracavitary brachytherapy, carcinoma of the uterine cervix

INTRODUCTION

Radiation therapy is one of the standard treatment modalities for treating a carcinoma of the uterine cervix. Definitive radiation therapy can be applied with good treatment results not only for the early-stage disease but also for the late-stage disease for which curative surgery cannot be performed. The typical technique of radiation therapy is an external beam radiation therapy (EBRT) combined with intracavitary brachyther-

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apy (ICR). The major advantage of ICR is that a high radiation dose can be build-up in the tumor while sparing the adjacent normal tissues, such as the rectum and bladder. Low dose rate (LDR) ICR has been widely used with its proven role in decreasing the local recurrence rate and increasing the survival rate.[1,2] The high dose rate (HDR) ICR was first introduced in the 1960's and the facility has increasingly become available throughout the world with its computer assisted remotely controlled after-loading system. In Korea, HDR ICR is now replacing the long-held position of LDR ICR in radiation therapy for a carcinoma of the uterine cervix.[3,4] The merits of HDR ICR over LDR ICR include the elimination of radiation exposure to the working personnel, the short application time and hence, the better maintenance of the exact applicator geometry, treatment can be performed on the outpatient basis, and patient convenience. Another important advantage in HDR ICR is that the total treatment time can be shortened by the appropriate interdigitation of ICR with an EBRT schedule. However, there have been concerns regarding the possibility of an increased risk of the late complications in HDR ICR because the recovery of radiation damage to the late-responding normal tissue like rectum is much less when the radiation dose per fraction is large or the dose rate is high.[5]

The reported rates of moderate to severe rectal complications in the HDR-ICR range from 5 to 30%.[6-12] The most relevant physical factors implicated in the consequent complications of late-responding normal tissue are the absorbed radiation dose and the volume irradiated. Several reports have shown dose-response relationships for rectal complications.[13-15] Therefore, it is essential to keep the radiation dose to the rectum as low as possible whilst maintaining a sufficient dose to the target volume to increase the therapeutic ratio of the HDR-ICR.

Several conventional methods have been used in an attempt to reduce the rectal dose in ICR. These include the vaginal gauze packing and/or using various kinds of shielded applicators.[16-18] Based on the inverse square law of the radiation absorption dose, a rectal retractor was developed to increase the distance between the radiation sources and the rectum. Commercially available rectal retractors have been introduced and are routinely used in some institutions. However, the amount of radiation to the rectum with the rectal retractor in a clinical setting has not been reported. Therefore, this study examined the role of the rectal retractor in reducing dose by comparing the doses to the rectum with and without the application of the rectal retractor in 30 patients with uterine cervical cancer.

MATERIALS AND METHODS

Thirty patients with carcinoma of the uterine cervix were enrolled in this study to evaluate the radiation dose to the rectum in HDR ICR. Those include 15 patients with an intact uterus treated by the tandem and ovoid pair and another 15 patients who were treated with the ovoid pair for postoperative vaginal vault irradiation. All the patients received external beam radiotherapy (EBRT) with a dose ranging from 36 Gy to 50.4 Gy. HDR ICR was given no later than the 4th to 5th week of EBRT and the treatments were interdigitated with the rest of the EBRT twice a week. The total dose of the ICR was 21 Gy to 30 Gy (median 24 Gy) given in 6 - 8 (median 6) fractions. The dose was prescribed to point A when both the tandem and ovoid pair were applied. In the ovoids only cases, the prescription point was a 5 mm depth from the ovoid surface. All the patients were treated using a HDR Iridium-192 remote after-loading system (micro-Selcetron HDR, ®Nucletron, Veenendaal, the Netherlands).

The rectal retractor was made of acryl and was easily recognizable on conventional radiographs with lead markers along the midline of its body. Two types (small and medium) of rectal retractors were used in this study. They had the same thickness of 5 mm, but different widths, 30 mm (084.421, ®Nucletron) and 40 mm (084.422, ®Nucletron). They can be fixed and immobilized with the ICR applicators by an adjustable fixing mechanism. The applicators used in this study were the Fletcher-Williamson applicator sets (085.230, ®Nucletron) and the standard applicator sets (084.024, ®Nucletron).

At the time of the HDR ICR simulation, the

appropriate applicator for each patient was applied in a routine manner, and then the rectal retractor was introduced underneath the ovoids. The position of the applicator and the rectal retractor was adjusted under fluoroscopy, and they were then securely fixed to the treatment couch by an automatic clamp. The rectum was outlined with barium, and dummy sources were inserted into the applicators. Orthogonal radiographs were taken with and without the rectal retractor for treatment planning and the rectal doses were calculated for each case.

Treatment planning and dose calculation for the HDR ICR was performed using a Plato Brachytherapy Planning System version 13.5 (®Nucletron, Netherlands). In order to calculate the radiation dose to the rectum, 4 to 8 points (median 6) including the rectal point (RP) were marked with a 1 cm step along the anterior rectal wall (Fig. 1). The length of the measured rectum ranged from 4 to 7 cm (median 5 cm). The authors defined the RP with some modification of the rectal reference point recommended by the International Commission on Radiation Units and Measurements (ICRU) Report 38.[19] Briefly, the RP was defined as the point in the middle of the two radiation sources for each ovoid on the anteroposterior radiograph (Fig. 1A). On the lateral film, the RP was defined as a point where the line drawn from the RP on the AP radiograph meets the visible anterior rectal contour with barium (Fig. 1B). In the ICRU recommendation, the rectal reference point was defined as being 5 mm behind the visible posterior vaginal wall. Instead, the distances of the anterior rectal wall and the center point of the applicators was measured to calculate the rectal dose and was defined as rectal point (RP). The maximal point (MP) was defined as the point where the calculated dose was highest among the selected points.

The distances from the center of the applicators to the checked points along the anterior rectal wall were measured with and without the rectal retractor, and the amount of the posterior displacement with the rectal retractor was measured on the lateral radiograph for each patient.

The amount of the rectal dose in terms of the RP and MP was calculated, as illustrated in Fig. 3. Since the RP or MP is a single point and do not represent the whole area of concern, the average dose of all the marked points along the chosen length of the anterior rectal wall was called longitudinal average dose (LA), which was used as an additional parameter. The doses thus obtained with and without the rectal retractor were compared for all three parameters described by a paired t-test.[20] SAS® software Version 8.01 was used for all the statistical analyses. All doses to each point were normalized to the median dose of 4 Gy to the different prescribed doses could be compared.

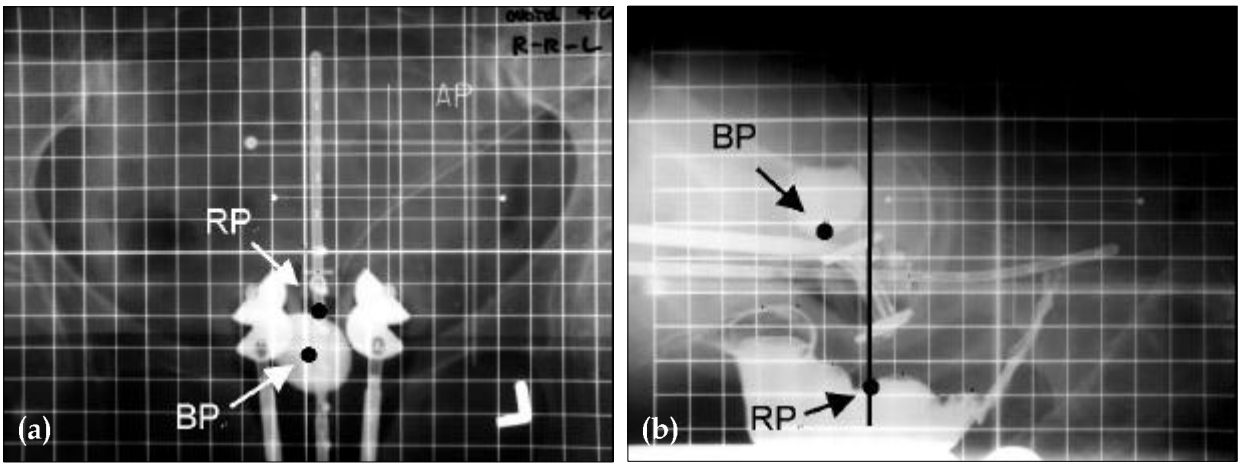

Fig. 1. Orthogonal radiographs for the dose calculation: (a) A-P view, (b) Lateral view.

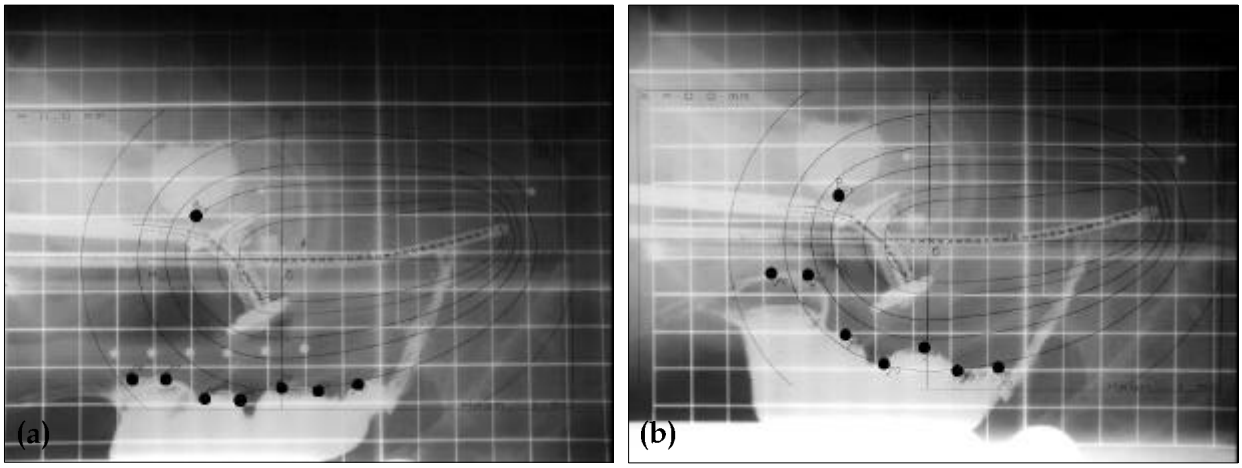

Fig. 2. An example of the posteriorly displaced rectum: (a) without rectal retractor, (b) with rectal retractor.

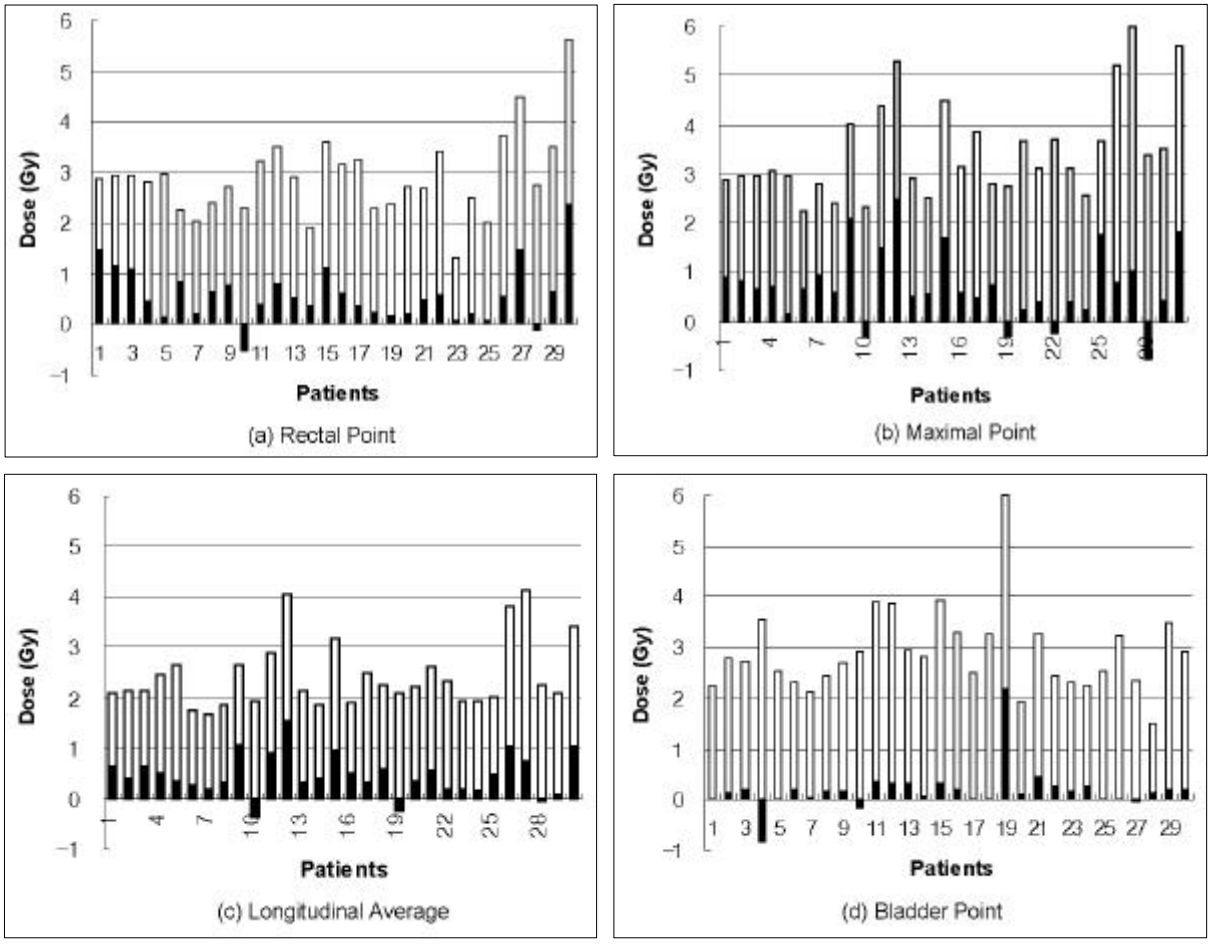

Fig. 3. Mean dose reduction for the rectal point, the maximal point, the longitudinal average in rectal point and the bladder point in each patient after application of the rectal retractor. The whole rectangles, excluding the dark rectangle below zero, represent the absorbed dose without the rectal retractor. The heights of the open rectangles are the doses with a rectal retractor, and those of the dark rectangles are the differences with the rectal retractors. The dark rectangles below zero denote the increase in the absorption dose with the rectal retractor: (a) the rectal point, (b) the maximal point, (c) the

RESULTS

An example of the posteriorly displaced rectum is demonstrated in Fig. 2 with superimposed isodose lines over the simulation radiographs. The doses calculated for the RP, MP, LA, and BP of all patients are shown in Fig. 3 with a normalized dose of 4 Gy for comparison. In the tandem and ovoids group, the number of patients with a reduced dose in the RP, MP, and LA were 14 (93.3%), 12 (80.0%) and 13 (86.7%), respectively. In the ovoids only group, the corresponding figures were 14 (93.3%), 14 (93.3%) and 14 (93.3%) (Fig. 3).

In the tandem and ovoids group, the mean RP doses with and without the rectal retractor were 2.52 Gy (63.0% of the prescription dose) and 3.04 Gy (76.0% of the prescription dose), respectively. Therefore, the reduced dose in the RP points was 0.52 Gy, and the dose reduction rate was 13.0%, which was statistically significant (p=0.007, Table 1). In the ovoids only group, the mean RP doses with and without the rectal retractor were 2.10 Gy (52.5% of the prescription dose) and 2.73 Gy (68.3% of the prescription dose), respectively. The mean dose reduction was 0.62 Gy, which translates to a dose reduction rate of 15.5% (p=<0.001, Table 2). In the tandem and ovoids group, the mean MP dose was decreased from 3.65 Gy to 3.15 Gy (from 91.3% to 78.8% of the prescription dose) when the rectal retractor was applied. The mean MP dose was reduced by 0.50 Gy and the dose reduction rate was 12.5% (p=0.013, Table 1). In the ovoids only group, the mean MP dose had decreased from 3.19 Gy to 2.27 Gy (from 79.8% to 56.8% of the prescription dose) when the rectal retractor was applied. The mean MP dose reduction was 0.92 Gy and the dose reduction rate was 23.0% (p=<0.001, Table 2). When all the points along the anterior rectal wall were aver-

Table 1. Mean Dose, Dose Range, and Reduced Dose with a Rectal Retractor (RR) for the Rectal Point (RP), the Maximal Point (MP), the Longitudinal Average (LA) in the Rectal Points, and the Bladder Point (BP) in the Tandem and Ovoids Group

	Use of RR	Mean dose, Gy (%)*	Dose range, Gy (%)*	Reduced dose, Gy (%)*	p-value†
RP	No	3.04 (76.0)	1.31 - 5.62 (32.8 - 140.5)	0.52 (13.0)	0.007
	Yes	2.52 (63.0)	1.24 - 3.24 (31.0 - 81.0)		
MP	No	3.65 (91.3)	2.49 - 5.62 (62.3 - 140.5)	0.50 (12.5)	0.013
	Yes	3.15 (78.8)	1.92 - 4.97 (48.0 - 124.3)		
LA	No	2.47 (61.8)	1.83 - 4.11 (45.8 - 102.8)	0.39 (9.8)	0.001
	Yes	2.08 (52.0)	1.38 - 3.35 (34.5 - 83.8)		
BP	No	2.87 (71.8)	1.49 - 3.4 (37.3 - 87.3)	0.27 (6.8)	0.074
	Yes	2.60 (65.0)	1.35 - 3.81 (33.8 - 95.3)		

*Percentages of prescription dose.
†Paired t-test.

Table 2. Mean Dose, Dose Range, and Reduced Dose with Rectal Retractor (RR) for the Rectal Point (RP), the Maximal Point (MP), the Longitudinal Average (LA) in the Rectal Points, and the Bladder Point (BP) in the Ovoids Only Group

	Use of RR	Mean dose, Gy (%)*	Dose range, Gy (%)*	Reduced dose, Gy (%)*	p-value†
RP	No	2.73 (68.3)	1.79 - 3.61 (44.8 - 90.3)	0.62 (15.5)	<0.001
	Yes	2.10 (52.5)	1.41 - 2.86 (35.3 - 71.5)		
MP	No	3.19 (79.8)	2.00 - 5.29 (50.0 - 132.3)	0.92 (23.0)	<0.001
	Yes	2.27 (56.8)	1.60 - 2.86 (40.0 - 71.5)		
LA	No	2.34 (58.5)	1.58 - 4.04 (39.5 - 101.0)	0.54 (13.5)	<0.001
	Yes	1.80 (45.0)	1.46 - 2.50 (36.5 - 62.5)		
BP	No	2.85 (71.3)	2.13 - 3.93 (53.3 - 98.3)	0.09 (2.3)	0.247
	Yes	2.76 (69.0)	2.08 - 3.59 (52.0 - 89.8)		

*Percentages of prescription dose.
†Paired t-test.

aged (LA), the magnitude of the reduction was lower but the resulting rectal doses were still significantly affected by the use of the rectal retractor. In the tandem and ovoids group, the mean reduction dose was 0.39 Gy (p=0.001, Table 1) and the dose reduction rate for the LA was 9.8%. In the ovoids only group, the dose was reduced in the LA was 0.54 Gy, from 2.34 Gy to 1.80 Gy (p=< 0.001, Table 2), which was equivalent to a 13.5% dose reduction effect. However, for the bladder point, there was no significant change, even though mean reduction dose in the BP dose was 0.27 Gy in the tandem and ovoids group (p=0.074, Table 1). The change in the BP dose for ovoids only group was negligible (0.09 Gy decrease, p=0.247, Table 2).

In the tandem and ovoids group, the mean dose reduction rates of the two subgroups were compared: the patient group where the rectal dose was < 70% of prescription dose and the group with a rectal dose < 70% (Table 3). Nine patients received a rectal dose > 70% of the prescribed tumor dose and a reduction of 0.78 Gy on average was obtained using the rectal retractor (p=0.004). The patient group who received a RP dose < 70% of the prescription dose received 0.38 Gy less on average when the rectal retractor was used (p= 0.156). Ten patients received > 70% of MP rectal dose and the mean dose reduction was 1.15 Gy (p=0.002). In the group of patients < 70% of prescription dose, the mean MP dose reduction was 0.48 Gy (p=0.125). The comparative figures in terms of the LA rectal dose, the dose reduction was 0.39 Gy for the 12 patients in the < 70% group (p=0.007) and the other group showed a 1.12 Gy dose reduction (p=0.250). For the bladder point, insignificant mean dose changes were noticed in both subgroups (0.04 Gy increase and 0.28 Gy decrease, respectively, p > 0.05).

In the ovoids only group, a similar mean dose reduction in the two subgroups to that obtained in the tandem and ovoids group was found (Table

4). For the RP dose, 7 patients and 8 patients who received greater than and less than 70% of the prescription dose, showed a 0.94 Gy and 0.16 Gy dose reduction, respectively (p=0.016 and 0.039, respectively). For the MP rectal dose, 12 patients who received >70% of the prescription dose showed a 0.7 Gy dose reduction (p=0.002). Although 3 patients who received < 70% of the prescription dose showed a 0.27 Gy dose increase (p>0.05). The comparative figures in terms of the LA rectal dose was a 0.25 Gy reduction for 12 patients who received < 70% of the rectal dose (p=0.009) and a 0.94 Gy dose reduction (p=0.250) for the other group. There was no statistically significant change in the doses for the bladder points.

DISCUSSION

Traditionally, intra-vaginal gauze packing has been widely used not only to give geometrical stability, but also to reduce the rectal dose in ICR for uterine cervix cancer. Kapp et al. reported that the dose to the anterior rectal wall was reduced by 12% with the application of a vaginal packing.[21] However, this technique takes considerable time

Table 3. Mean Dose Reduction with the Rectal Retractor (RR) between the Subgroups - Rectal Dose Received <70% vs. ≥ 70% of Prescription Dose in Tandem and Ovoids Group

	% of prescription dose	No. of patients	Mean dose reduction (No RR - with RR)	p-value*
RP	< 70	6	0.38	0.156
	> 70	9	0.78	0.004
MP	< 70	5	0.48	0.125
	> 70	10	1.15	0.002
LA	< 70	12	0.39	0.007
	> 70	3	1.12	0.25
BP	< 70	10	-0.04	0.322
	> 70	5	0.28	0.063

*Paired t-test.

Table 4. Mean Dose Reduction with the Rectal Retractor (RR) Between the Subgroups - Rectal Dose Received <70%, and ≥ 70% of Prescription Dose in Ovoids Only Group

	% of prescription dose	No. of patients	Mean Dose Reduction (No RR - with RR)	p-value*
RP	< 70	8	0.16	0.039
	> 70	7	0.94	0.016
MP	< 70	3	-0.27	0.5
	> 70	12	0.7	0.002
LA	< 70	12	0.25	0.009
	> 70	3	0.94	0.25
BP	< 70	8	0.11	0.078
	> 70	7	0.46	0.063

*Paired t-test.

for each session and the reproducibility is not as good as it should be because the amount and position of the gauze packed beneath the ovoids can change each time. It is often encountered that a gradual narrowing of the upper vagina caused either by the fibrotic changes after tumor shrinkage or by an inflammatory reaction hampers the consistent amount of packing under the applicators. According to our experience, the application of the rectal retractor is a relatively easy and effective way of reducing the rectal dose with good patient compliance. The reproducibility is excellent with an adjustable fixing mechanism, which holds the applicators and the rectal retractor together.

There have been many studies on the methods for measuring and reporting the rectal doses in ICR of the uterine cervix cancer. The measurement methods include point dose calculations, volumetric dose calculations and *in vivo* measurements using thermoluminescent dosimeters or diodes.[22-26] Among those, point dose calculations are the most popularly used method for defining the rectal reference point according to the ICRU report 38 criteria and the barium contrast criteria[12,18,27,28] because of its convenience and practicality. Several authors reported a correlation of the specific point dose with the clinical complications using the definition of the ICRU Report 386,9. Clark, et al. reported a significant correlation between the ICRU rectal point dose and the incidence of late rectal complications, and concluded that the dose to the ICRU rectal reference point can be used as a good indicator for predicting the late rectal complications in HDR ICR.[6] Stryker et al. reported a good correlation between the rectal dose and the rectal complications using the contrast material in the rectum and calculating the doses from the orthogonal radiographs.[29] In the current study, the authors defined the RP by combining the concept of the ICRU report 38 and the contrast method. The dose comparison at the MP was also performed because the RP alone may not represent the highest dose region of the rectum. The MP was not the same as the RP in 10 patients, although it was located within ± 1 cm of the RP in the longitudinal direction on the lateral radiographs. The position of the MP was altered in 11 patients after the rectal retractor was applied, because the change in the contour of the anterior rectal wall was caused by the use of the rectal retractor. Although the MP was the point where the maximum dose was given, the variability of the rectal anatomy found in association with the insertion of the rectal retractor in this study made the point not as reliable as a fixed anatomic location such as the RP. The increased MP dose in the 3 patients after applying the rectal retractor in this study appears to reflect this unreliability of the MP as a standard point for communication. In the tandem and ovoids group, both the RP and MP doses were significantly reduced by 0.52 Gy and 0.50 Gy using the rectal retractor, respectively ($p < 0.05$, Table 1). In the ovoids group, those were 0.62 Gy and 0.92 Gy, respectively ($p < 0.05$, Table 2). In addition, the MP and RP doses were reduced more significantly in the patient subgroup whose rectal dose was > 70% of the prescription dose compared to those who received < 70% of the prescription dose (Table 3, Table 4).

Van Lancker, et al.[18] reported that neither a single reference point nor combinations of them were good predictors of late complications. They reported that the volume calculation was highly reliable in predicting the late complications. Several authors introduced the concept of a dose volume histogram (DVH) using the CT image data.[30,31] However, it is impractical to obtain CT images to calculate the dose to the rectum for every patient. In this study, as a clinically relevant and easy to use method, the authors calculated the longitudinal average dose of the anterior rectal wall, which encompasses the highest dose regions, to compare the rectal doses with and without a rectal retractor. In the tandem and ovoids group, there was significant dose reduction of 0.39 Gy and the dose reduction rate was 9.8% (p=0.001, Table 1). In ovoids group, there was a significant dose reduction of 0.54 Gy and the dose reduction rate was 13.5% (p=< 0.001, Table 2). Although the longitudinal average dose may not represent the volume of the rectum receiving the significant dose, this study found it to be an easy and reliable method for estimating the effect of the rectal retractor.

Various kinds of shielded applicators were developed to reduce the bladder and rectal com-

plications.[16-18] The rectal retractor can be used concomitantly with shielded applicators, and the rectal dose can be more reduced even further. It was reported that the bladder and rectum receive a 10 - 20% lower dose when shielded applicators were used.[32,33] However, the actual dose to the rectum with the shielded applicator cannot be readily noted because most brachytherapy planning systems do not take this shielding effect into consideration when calculating the rectal doses. Cho, et al. reported the shielding effect of the Fletcher-Williams applicator sets (FWAS), the same shielded applicators used in this study, using the same brachytherapy planning system.[34] The ovoids of the FWAS have a 2.0 mm thick shielding material of Densimet, a tungsten alloy. They reported that the maximum shielding effects to the rectum and bladder of FWAS were 26.0% and 23.0%, respectively. The shielding effect to the rectum is believed to range from 11.0% to 26.0% as the distance from the source varies from 20 to 60 mm. Based on these figures, the rectal dose is expected to be reduced by 27 - 44% when the rectal retractor is combined with these shielded applicators because a further 16 - 18% dose reduction might be achieved using the rectal retractor.

It was suggested that the dose to the late-responding tissue should be kept < 80% of the tumor dose when HDR ICR is fractionated by 4 to 6.[35] With the rectal retractor, the rectal doses in HDR ICR for uterine cervix cancer were significantly reduced particularly for the group of patients whose rectal dose is > 70% of the point A dose (Table 3 and Table 4). The application of the rectal retractor in HDR ICR is a convenient and effective method for reducing the radiation dose to the rectum. In this study, a comparison of the calculated rectal doses to the clinical outcome could not be made because all patients recruited were treated with the rectal retractors anyway. By using the rectal retractors, the rectal dose could be well below the ICRU-recommend 80% of the prescribed dose in 70% (21/30) to 96.7%(29/30) of the patients. This matches with the clinical observation where rectal complications of any grade did not occur in this group of patients who were followed up for 4 years. A further study should be aimed at comparing the late rectal complication rates of patients treated with rectal retractors to that of the historical control group when a sufficient number of patients are enrolled in the rectal retractor group. From our experience, the routine use of a rectal retractor is recommended in the HDR-ICR treatment of the patients with a uterine cervical carcinoma. There were some limitations of the rectal retractor in a reducing rectal dose. First, it is difficult to use this type of rectal retractor when a patient has a narrow or fibrotic vaginal vault, particularly when the patient was not fully relaxed with pre-medication. Secondly, it is not appropriate to use a rectal retractor on the posterior portion of the cervix and or posterior vaginal wall when the disease is present or suspected to exist because of the risk of an inadequate coverage of the tumor volume. The forced insertion of a rectal retractor for patients with a narrow vagina sometimes causes laceration of the cervicovaginal mucosa. For this patient group, conventional individualized gauze packing would be a more appropriate way of reducing the rectal dose.

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