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Original Research Article

THE DOSIMETRIC COMPARISON BETWEEN TANDEM OVOID AND TANDEM RING APPLICATOR IN CERVICAL CANCER BRACHYTHERAPY

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Abstract

AIM: The present research aims to assess the differences in dosimetry between tandem-ovoid and tandem-ring gynaecologic brachytherapy applicators utilizing diverse optimizing techniques in image-based brachytherapy.

Background: Conventionally, tandem ovoid applicators were utilized to deliver doses to tumor in intracavitary brachytherapy. Currently various types of applicators are accessible for cervical cancer brachytherapy management such as Tandem-ring, tandem-cylinder, and hybrid intracavitary, interstitial applicators.

Material and methods: We utilized a tandem-ring and Fletcher-style tandem-ovoid applicator in the same patients (30) in two fractions of brachytherapy. Four plans were generated for every patient utilizing 2 optimization techniques for all applicator utilized. A dose of 9 Gy was prescribed and plans were regulates to left point A and in previous methods, the optimization is done to attain the optional OAR dose-volume restraints. Dose-volume and dose point parameters were evaluated.

Results: For Point A normalized plan both Bladder and Sigmoid are superior in TO applicator than TR applicator but not statistically significant and the rectum doses are superior in TR applicator than TO applicator and statistically significant. When we evaluate both the optimization methods the difference is measured to be not statistically significant.

Conclusions: The findings specify that the OAR doses considerd by DVH criteria were lesser than ICRU point doses for the bladder and rectum with both tandem-ovoid and tandem-ring applicators for Point A normalized plans. The ICRU Bladder Point and rectum point doses are lesser in OAR optimized plans than in Point A normalized plans in both applicators. The 90%,100%,200 % isodose volumes are superior in Point A normalized plans than in OAR-based optimized plans in both applicators.

Keywords: Cervix cancer, Brachytherapy, Applicators, Optimization techniques, Dosimetry, tandem-ring, tandem-oviod

Introduction

Cervical cancer is the third most frequent cancer and the second most important cause of fatality in the Indian population.[1]Majority of the subjects present with locally advanced stage at presentation, and it is connected with high mortality. Simultaneous chemoradiation is the foundation of curative management of locally advanced cervical cancers.[2]The external beam radiation comprises pelvic lymph nodes, parametria, and primary tumor, to a dose sufficient to control merely microscopic disease, so the adding of brachytherapy is vital to attaining a elevated dose to the gross tumor to advance disease control and endurance.[3]It is the solitary method to offer high dose to the tumor, necessary to control cervical cancer (>85-90Gy), scant the adjacent normal structures devoid of causing unwarranted side effects.[4]Brachytherapy plays an affix role in the treatment of cervical cancer and intracavitary brachytherapy remains the most frequently practiced form of cervical brachytherapy management.

High-dose-rate (HDR) brachytherapy allows short treatment times and the capabilities to optimize the dose allocation by altering dwell times and permit better control of the dose distribution.[5.] A choice of the applicator is somewhat capricious and depends on accessibility, subjects' pelvic geometry, and with the extent of disease. So selection of an suitable applicator as per to the anatomy is essential.[6]The most frequently utilized type of applicator for curative ultimate cervical cancer brachytherapy is the tandem ovoid (T-ovoid) applicator, trailed by the tandem ring (T-ring) applicator. T-ovoid treatment suggests a range of sizes and permits for arrangement modification, while the advantages of the TR application comprise the diverse loading positions and repeatability owing to its dense constitution.[7]

Objectives

The optional dose volume objective for clinical target volume is to carry a minimum of 100% of the prescribed dose to 90% volume of the clinical target volume. And optional dose-volume constraints for organs and risk (OARs) are: <75Gy EQD2 to 2cc volume of the contoured rectum and sigmoid colon and <90Gy EQD2 to 2cc volume of contoured of the urinary bladder. Present research aims to evaluate dose-volume and point dose parameters in both applicators. We utilized two planning techniques as 9Gy to Left Point A and optimized to get the optional OAR dose-volume constraints.

Methods & Materials:

In the present research, thirty subjects were incorporated through the period October 2020 to July 2021, aged 40 to 70 years, with cancer of the cervix FIGO Stages II-IV. All subjects received external beam therapy to the entire pelvis to a dose of 50 Gy in 25 fractions on Varian True Beam machine by 3DCRT method beside with the weekly intravenous injection of Cisplatin 40mg/m2. EBRT was trailed by clinical assessment and 2 brachytherapy applications by Ir192 of 9Gy each to Point A, delivered once a week.

The method was carried out in the HDR room in lithotomy position after sedation. A Foley catheter was positioned and the balloon was filled with 7cc of contrast (2cc contrast with 5cc distilled water). Intracavitary brachytherapy was prepared with Fletcher-Suite-Delclos applicator, either with tandem and ovoids, or tandem and ring. The type of applicator and sequence of insertion were arbitrarily assigned. Subjects were indiscriminately allocated to obtain the primary insertion utilizing each ring or ovoid applicator and the other type is utilizedfor the second insertion.

Tandem was selected among 15◦ and 30◦ depending on the anatomy of the cervix. The correct length of the tandem was resolute by uterine sound and placed after dilatation of the cervical canal. For applications, 4 cm and 6 cm tandem lengths were usually utilized. The most frequent size of the ovoid for TO applications was 2.5 cm. The most widespread tandem angle utilized for TO and TR applicators were 30 degrees. Vaginal packing was complete sufficiently to move the rectum and bladder.

CT imitation was completed for all subjects and 3mm slices were taken for planning.

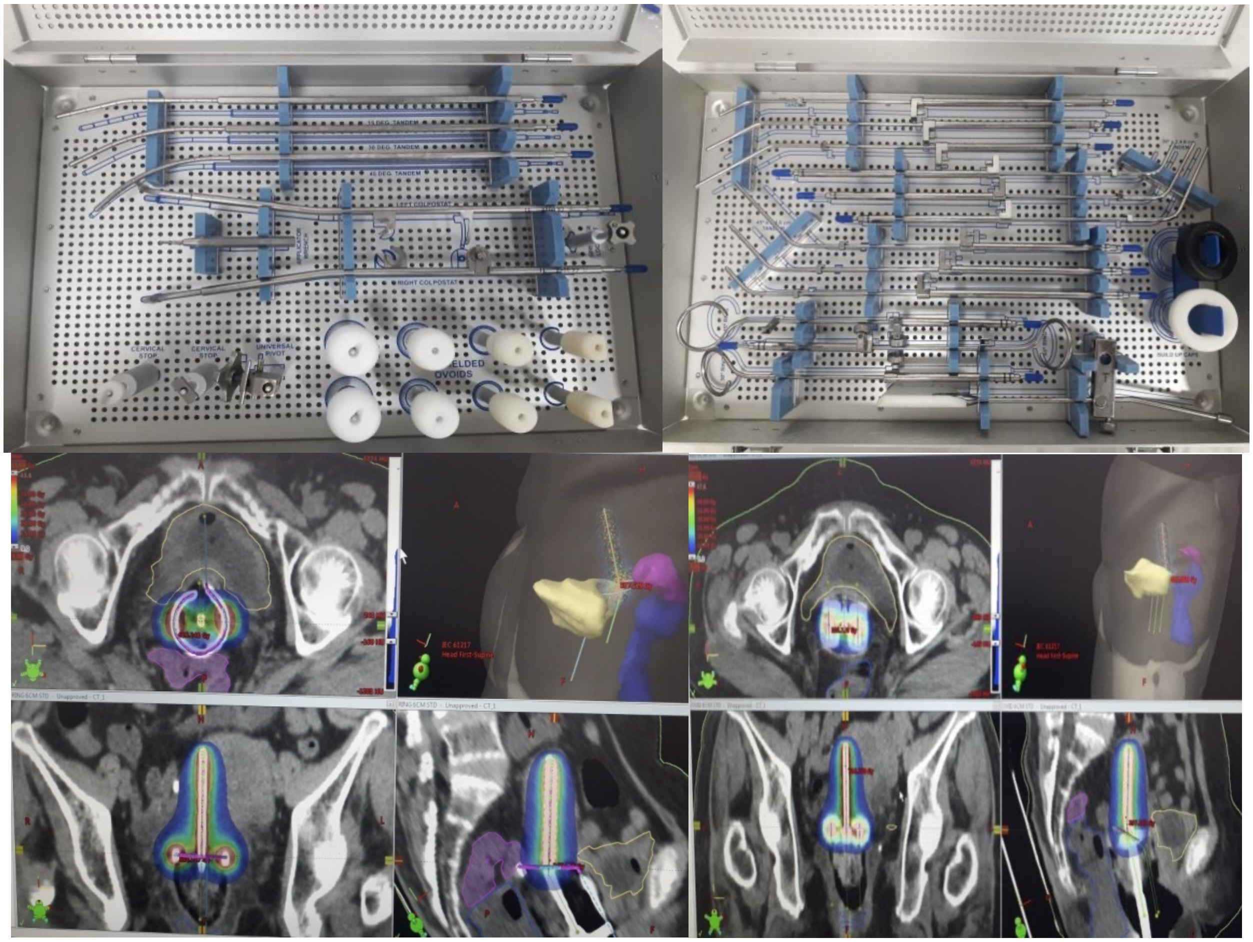
Contouring guidelines: the urinary bladder inclusive of the Foley's catheter bulb, bladder, rectum, sigmoid were countered as organ at risk. ICRU reference points, namely Point A (right and left), Left Point B, bladder, and rectal points.

Planning was done on Eclipse Planning System by Varian. A 3D plan was produced following the renewal of the applicators. Following catheter reconstruction, establishment of dwell positions was inclusive in the comparable prototype for both applicators. A standard loading prototype was chased for both tandem ovoid and tandem ring applicators. Generally, we choose 9 Gy dose to Point A. As explained above 4 plans were formed by a physicist for 2 insertions and saved for every subjects for dosimetric comparison. DVHs were produced and D2cc (dose to 2cc volume), D1cc (dose to 1cc volume), D0.1cc (dose to 0.1cc volume) was recorded for the bladder, rectum, and sigmoid. V 90 (volume covered by 90 % isodose) , V 100 (volume covered by 100 % isodose), V 200 (volume covered by 200 % isodose) were recognized. Dose point parameters like bladder point, rectal point, contralateral un-normalized point A, Left point B doses were recorded for both the applicators.

Table 1: Dwell positions for both applicators

Tandem and ovoid applicator									
Ovoid nominal diameter	1.5 and 2 cm	4	5	6	–	–	–	–	–
	2.5 and 3 cm	4	5	6	7	–	–	–	–
Tandem length	4 cm	1	3	5	7	10	13	–	–
	5 cm	1	3	5	7	10	13	16	–
	6 cm	1	3	5	7	10	13	16	20

Tandem and ring applicator									
Ring nominal diameter	26 mm	4	6	8	10	21	23	25	27
	30 mm	5	7	9	11	24	26	28	30
	34 mm	7	9	11	13	28	30	32	34
Tandem length	20 mm*	1	4	–	–	–	–	–	–
	40 mm	1	3	5	7	10	13	16#	–
	60 mm	1	3	5	7	10	13	16	20



Statistical analysis:

The recorded data was accumulated and entered in a spreadsheet computer program. (Microsoft Excel 2007) Statistical analysis was performed utilizing paired t-test to evaluate the association among dosimetric values of TO and TR applicators. For all tests, confidence level and level of significance were set at 95% and 5% respectively.

Results:

In the present research, comparison was done with both applicators by creating plans with 2 dissimilar optimization methods. Details of 40 ICBT applications in 30 subjects were assessed.

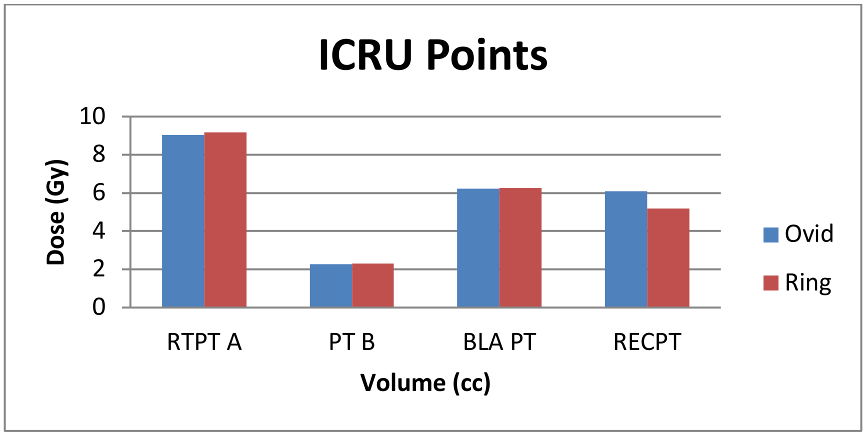
ü **Point A normalization plans comparison for both applicators:**

ICRU Point doses with TR and TO applicators are desribed in Table 2. There was no statistically significant dissimilarity with both applicators apart from Rectal point dose and the standard error of difference = 0.288

Table 2: ICRU Points Dose between two variables

ICRU Point dose (Gy)	TO (mean dose)	TR (mean dose)	Difference in mean	P value
Point A	9.054 ± 0.256	9.176 ± 0.412	-0.122	0.09
Point B	2.255± 0.11	2.294 ± 0.134	0.039	0.21
Bladder Point	6.214 ± 1.90	6.267 ± 2.48	0.053	0.2
Rectum Point	6.091 ±0.846	5.198 ± 1.206	0.893	0.001*

* indicates statistically significance at p≤0.05
Test applied paired t test

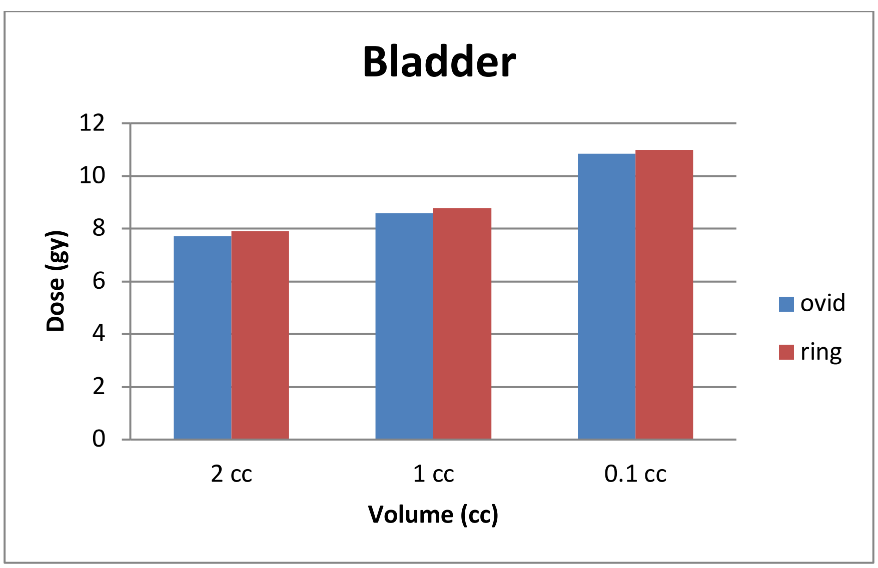


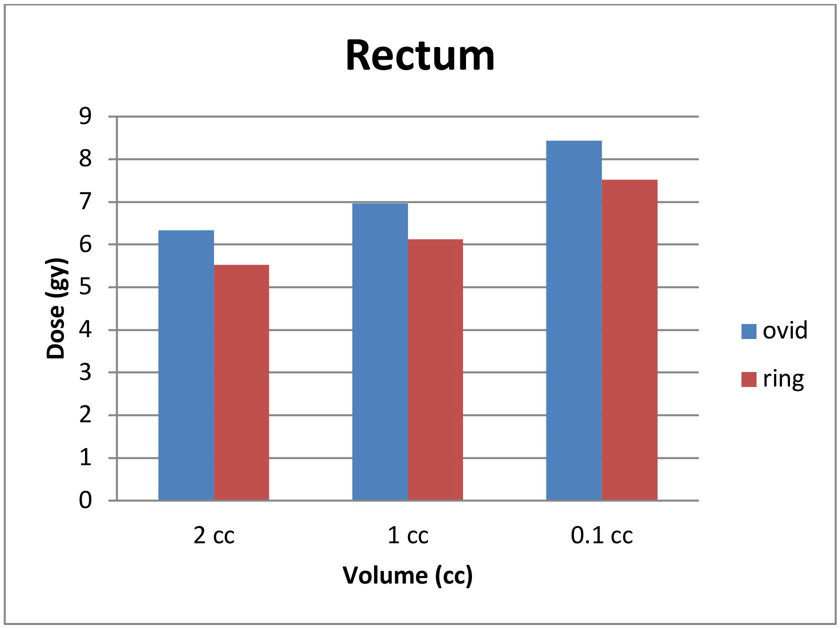
Volumetric OAR doses, D2cc, D1cc, D0.1 cc to the bladder, the sigmoid, and small bowel is described in Table 3. There was no statistically significant dissimilarity with both applicators in terms of OAR doses. The dissimilarity in D2cc rectum doses is measured to be statistically significant and the disparity in D1cc and D0.1cc of the rectum is measured to be not statistically significant. The standard error of difference = 0.366 for D2cc of the rectum.

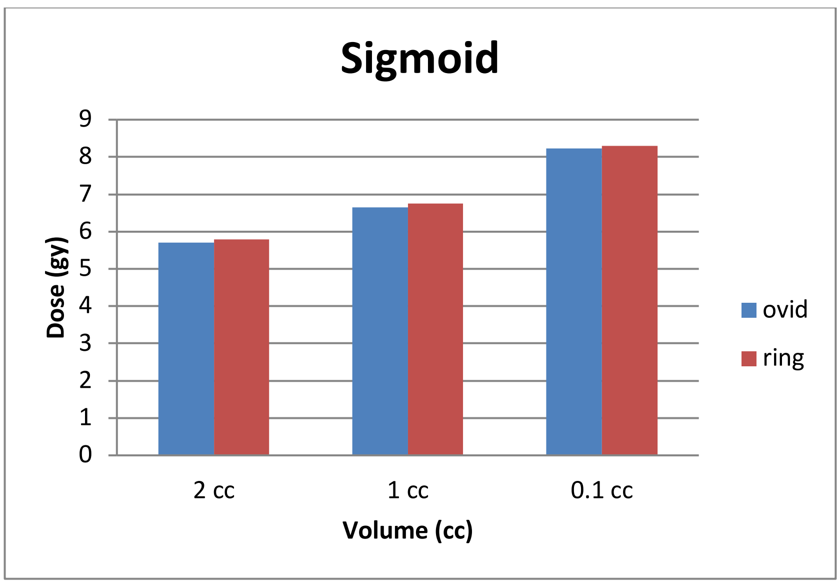
Table 3: OAR doses with TO and TR applicators

OAR	Dose to OAR	TO (mean dose)	TR (mean dose)	Difference in mean	P value
Bladder	D2cc	7.725 ± 2.52	7.897 ± 2.74	-0.172	0.1
	D 1cc	8.590 ± 2.14	8.78 ± 3.21	-0.192	0.09
	D 0.1cc	10.84 ± 3.84	10.99 ± 4.124	-0.153	0.20
Rectum	D2cc	6.33 ± 2.12	5.52 ± 1.44	0.81	0.004*
	D 1cc	6.96 ± 2.25	6.12 ± 1.64	0.84	0.2
	D 0.1cc	8.44 ± 3.122	7.52 ± 2.52	0.92	0.30
Sigmoid	D2cc	5.710 ± 2.12	5.79 ± 1.29	-0.082	0.47
	D 1cc	6.65 ± 2.48	6.75 ± 1.34	-0.1	0.1
	D 0.1cc	8.23 ± 3.10	8.30 ± 1.85	-0.07	0.07

* indicates statistically significance at $p \leq 0.05$
Test applied paired t test





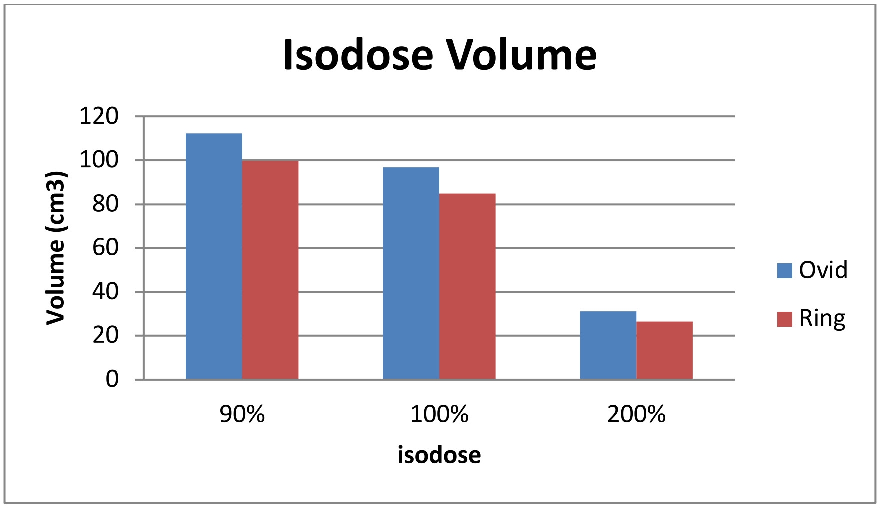


Volumes treated with dissimilar isodose lines are described in Table 4. There was no statistically significant disparity with both applicators for volumes like V90, V100, V200.

Table 4: Volumes treated with different isodose lines

Volume	TO (cm^3)	TR (cm^3)	Difference in mean	P value
V90	112.20 ± 14.72	99.98 ± 6.52	12.22	0.002*
V100	96.80 ± 12.79	84.87 ± 5.32	11.93	0.05*
V200	31.21 ± 4.20	26.47 ± 2.51	4.74	0.01*

* indicates statistically significance at $p \leq 0.05$
Test applied paired t test

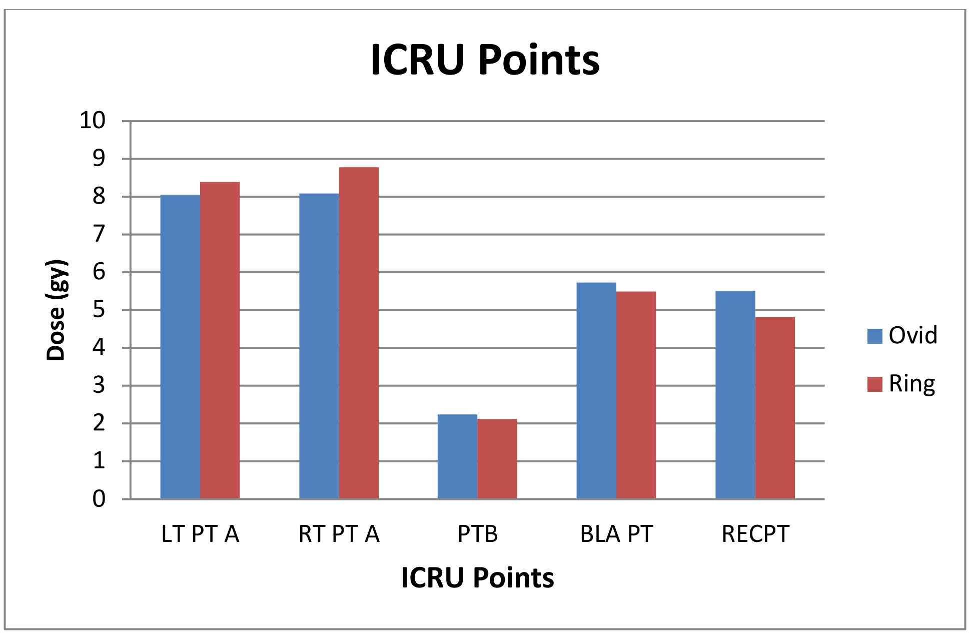


ü **Optimized Plans(Recommended OAR constraints):**
ICRU Point doses with TR and TO applicators are described in Table 5. There was no statistically significant dissimilarity with both applicators except Rectal point dose and the standard error of difference = 0.287

Table 5: ICRU Point doses with TO and TR applicators

ICRU Point dose (Gy)	TO (mean dose)	TR (mean dose)	Difference in mean	P value
Left Point A	8.052 ± 1.245	8.398 ± 1.090	-0.346	0.06
Right Point A	8.095 ± 1.387	8.78 ± 1.241	-0.685	0.102
Point B	2.24± 0.30	2.12 ± 0021	-0.12	0.24
Bladder Point	5.74 ± 1.63	5.49 ± 2.20	0.25	0.09
Rectum Point	5.510 ±1.012	4.810 ± 0.87	0.7	≤0.03

* indicates statistically significance at p≤0.05
Test applied paired t test

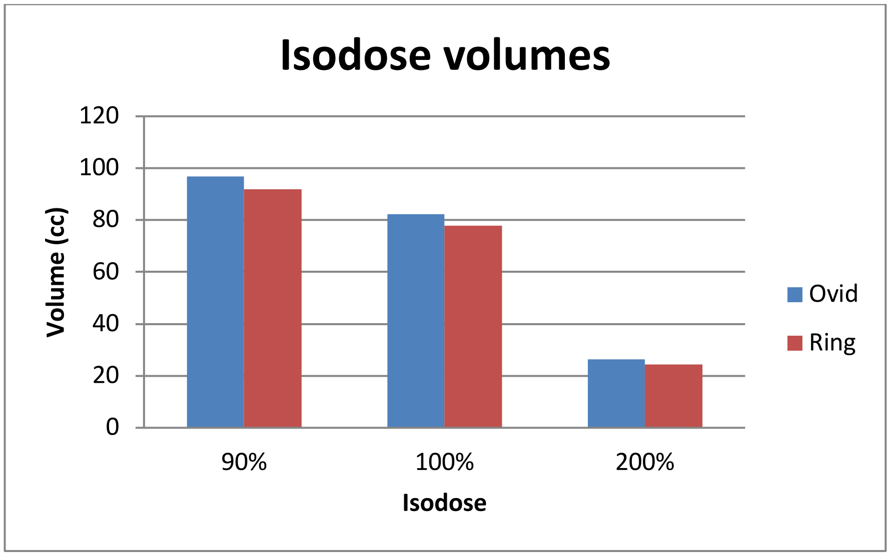


Volumes treated with diverse isodose lines are described in Table 6. There was no statistically significant dissimilarity with both applicators for volumes like V90, V100, V200.

Table 6: Volumes treated with different isodose lines

Volume	TO (cm^3)	TR (cm^3)	Difference in mean	P value
V90	96.78 ± 15.96	91.90 ± 13.54	4.88	0.06
V100	82.20 ± 13.99	77.80 ± 11.60	4.4	0.1
V200	26.30 ± 5.31	24.295 ± 4.19	2.01	0.21

* indicates statistically significance at p≤0.05
Test applied paired t test



Discussion:

The geometry of both applicator systems is dissimilar although both are based on the Manchester system. The TO application system consists of 3 applicators and has supple geometry as the division and the comparative longitudinal position of the applicators can be attuned. The ring applicator system is a fixed-geometry two-applicator system, where the tandem and the single ring applicator can be set merely at a scrupulous slot. TR applicator is utilized in sight of amplified subject comfort, applicability where anatomy does not authorize tradition of TO applicator. TO and TR applicators are utilized interchangeably in numerous institutions. Producer of TR applicator maintains it to be dosimetrically correspondent to TR applicator

Superior radiotherapy doses for chemoradiotherapy and brachytherapy for complex cervical cancer have been exposed to recover local tumor control. In recent times, the EMBRACE I research exposed that 98% of local recurrences were observe within intermediate-risk CTVs and HR-CTVs. The Retro-EMBRACE research also exposed correlations of local tumor control with volume, dose, and whole management time.

Erickson et al in desribed significantly elevated bladder and rectal point doses with TO applicator contrast to TR applicator and brachytherapy planning was Xray based in their research [9]. But in the present research, given that brachytherapy planning was CT-based we recognized volumetric doses like D2cc, D1cc, D0.1cc to OARs like the rectum, bladder, sigmoid. The current research demonstrates a significantly advanced bladder and sigmoid dose with the TR applicator but is statistically not noteworthy.

A research by Rangarajan et al and Levin *et al* demonstrated that there were no significant dissimilarity in point A dose and OAR doses with both TR and TO applicators and TR applicators treated a lesser volume contrast to TO applicators and the disparity was statistically significant. Although in the present research there is no dissimilarity in Point A doses and OAR doses apart from rectum doses with both TR and TO applicators and a significantly superior treatment volume with the TO applicator.

The **Vinin NV** conducted a research and described that there was no significant dissimilarity in point A dose, volumetric OAR doses, and volumes treated with different isodose with TR and TO applicators and recommended that both applicators are dosimetrically correspondent. In present research, both applicators utilizing both optimizing methods too demonstrate comparable findings apart from rectum doses and treatment volumes.

Conclusion

Tandem Ovoid and Tandem Ring applicators are frequently utilized gynaecological intracavitary applicators. There is insignificant dissimilarity in dosimetry among the two applicators. There was no statistically significant dissimilarity in both planning methods for both applicators for Bladder doses, Rectum doses (D1cc & D0.1 cc), sigmoid doses, Point A doses, Point B doses, Bladder point doses, except rectum D2cc doses, and rectal point doses. However this dissimilarity is around the similar for both the methods. For 90%,100%, 200% for volumes of isodoses there is enormously statistically significant in PTA regularize plan and no statistically significant dissimilarity in OAR-based optimized plan.

The choices of the applicator depend on the subject's anatomy and the choice of the radiation oncologist. The assortment of planning methods depends on a physicist and oncologist. TR is usually chosen for subjects whose pelvic anatomy does not permit the assignment of two ovoids. ovoids. Other clinical suggestions of the slight dosimetric dissimilarity should be assessed in follow-up researches.

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