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Applying the Jaws-Only IMRT technique for the prostate cancer treatment

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ABSTRACT:Purpose/Objectives: comparison of dose distribution results between techniques of 3D-CRT and MLC-IMRT with JO-IMRT technique. Optimized implementation of JO-IMRT plans with a choice of fields for 10 prostate cancer patients.
Materials/Methods: for each patient, eight plans were generated using Prowess Panther 5.1 software, including a conventional three dimensional conformal plan (3D plan) and seven inverse DAO IMRT plans using either conventional jaw- only (JO plan) or multi-leaf collimator (MLC plan)
Results:

- The dose delivered totumor is good in both of 3D-CRT and JO-IMRT techniques,but the dose delivered to the bladder and rectum is very high.
- The results of dose distribution in the target volume of both MLC-IMRT and JO-IMRT techniques are the same. A little of discrepancy between 2 techniques is the dose distribution in the bladder and rectum. However, the results were considered clinically acceptable.
- A recommend for the process of JO-IMRT plan with 9 irradiation fields has adapted to treat prostate cancer patients.

KEYWORDS:prostate neoplasm, intensity modulated radiation therapy (IMRT), multi-leaf collimators (MLCs), Jaw only (JO), planning target volume

I. INTRODUCTION

Prostate cancer is the one of the most commonly diagnosed cancer among men throughout the world [1], [2], [3]. In the recent days, prostate cancer can be managed by several options such as surgery, chemotherapy, radiotherapy, [4], [5] etc. Radiotherapy is considered as one of the popular options to treat prostate cancer because of excellent survival rate and fewer side effects. The field of radiotherapy is evolving since the days of 3 dimensional conformal radiotherapy (3D-CRT), and it is now possible to treat the cancer using more advanced techniques such as intensity modulated radiation therapy (IMRT), proton therapy and jaws only IMRT[6], [7], [8], [9]. The improvement in radiation treatment delivery has also improved the conformal radiation dose distributions to the tumor while sparing normal tissues [10]. In JO-IMRT, the radiation beam is delivered in the form static fields and dose rate. The purpose of this study is to investigate whether the dose distribution in the target volume for IMRT plans using conventional jaws is better for 3D-CRT and MLC-IMRT plans or not. Using the DAO optimization method [11] implemented in a commercial planning system, the optimizer in our approach directly produces apertures using conventional jaws with optimized weighting factors. In this work, we conducted a planning study for ten patients with prostate cancer. For each patient, eight plans were generated using conventional jaws and MLC with inverse planning techniques and the conventional 3D conformal planning technique.

II. METHOD AND MATERIALS

We use commercially planning system Prowess Panther 5.1 [12] to create JO-IMRT plans for all patients because of prostate cancer. All patients were used for all JO-IMRT plans with 6 MV photon energy.

- JO-IMRT plan was performed for a plan with 7 fields divided to 7 segments.

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- 3D-CRT plan was performed for a plan with 4 fields.
-

Table 1 as following shows the statistical results of the dose distribution from prostate cancer treatment by the JO-IMRT and 3D-CRT

Table 1: The results of the dose distribution from JO-IMRT and 3D-CRT plans

Structure	Prescribed dose	JO-IMRT	3D-CRT
PTV: the minimum dose	≥ 63 Gy	68Gy÷ 70 Gy	68 Gy÷70 Gy
PTV: the maximum dose	≤ 77 Gy	74Gy÷ 75 Gy	73 Gy÷ 74 Gy
100% of the PTV	≥ 95 %	98%÷ 100 %	98% ÷ 100 %
40% of the bladder volume	≤ 40 Gy	36Gy÷ 37 Gy	41 Gy÷ 42 Gy
40% of the rectum volume	≤ 42 Gy	38Gy÷ 39 Gy	65 Gy÷ 67 Gy
The top of femur: the mean dose	< 41 Gy	22Gy÷ 23 Gy	38 Gy÷ 39 Gy

III.RESULTS

1) Comparison the results between JO-IMRT and 3D-CRT techniques
Patient Chen Yu L. who has cancer of prostate was treated with 2 methods JO-IMRT and 3D-CRT.
Fig.1 shows the anatomical image theposition of pelvis of patient Chen Yu L.

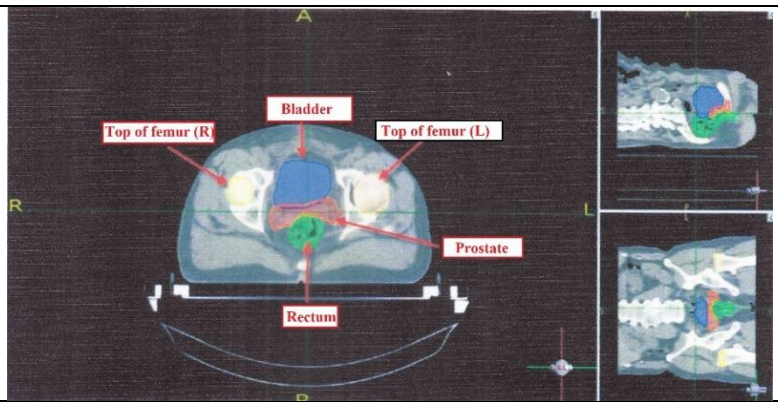

Fig.1: The anatomical position of pelvis of patient Chen Yu L.

From fig.2, we can see the dose delivered to tumor is good in both plans. The mean dose delivered to the top of femur is about 25 Gy for JO-IMRT plan while it is about 44 Gy for 3D-CRT plan. 40% of the bladder and rectum volume received the dose of 36 Gy to 38 Gy for JO-IMRT plan and it is about 42 Gy to 67 Gy for 3D-CRT plan. The IMRT technique clearly demonstrates that it has the potential to reduce the dose to healthy organs.

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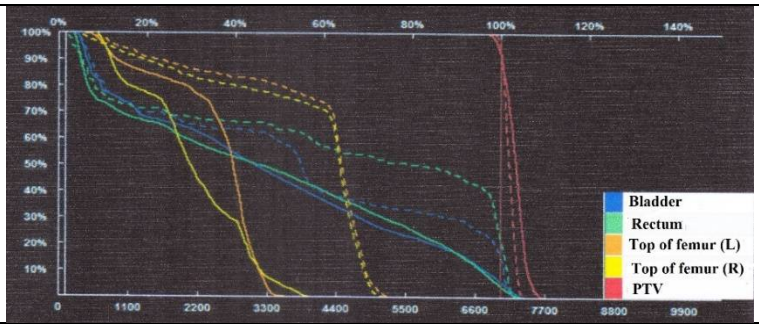

Fig.2: The dose – volume histogram of patient Chen Yu L.

The table 2 and table 3 show the dose – volume parameters for IMRT plan of patient Chen Yu L.

Table 2: The dose distribution to organs in JO-IMRT of patient Chen Yu L.

Organs	Volume	DLV(%)	D-X(cGy)			V-X(%)			Min	Max	Mean	Median	Repeat
	(cc)	100.0	50	40	33	110	100	98	(cGy)	(cGy)	(cGy)	(cGy)	(cGy)
Bladder	275.5	100.0	2666.0	3681.0	4246.0	0.0	7.2	9.8	230.7	7540.9	3035.8	2665.5	351.5
Rectum	125.8	100.0	2666.0	3842.0	4548.0	0.0	4.1	6.3	192.8	7319.0	3020.3	2659.5	268.5
Top of femur(L)	89.3	100.0	2591.0	2707.0	2785.0	0.0	0.0	0.0	502.4	3581.0	2253.7	2590.5	2809.5
Top of femur(R)	89.0	100.0	2536.0	2676.0	2755.0	0.0	0.0	0.0	562.5	3760.1	2265.3	2535.5	3115.5
PTV	62.1	100.0	7283.0	7314.0	7336.0	0.0	99.1	100.0	6864.1	7659.7	7283.3	7282.5	7268.5

Table 3: The dose distribution to organs in 3D-CRT of patient Chen Yu L.

Organs	Volume	DLV(%)	D-X(cGy)			V-X(%)			Min	Max	Mean	Median	Repeat
	(cc)	100.0	50	40	33	110	100	98	(cGy)	(cGy)	(cGy)	(cGy)	(cGy)
Bladder	275.3	100.0	3840.0	4142.0	5589.0	0.0	15.5	22.1	143.0	7229.9	3781.6	3840.5	576.5
Rectum	125.3	100.0	5615.0	6785.0	6905.0	0.0	21.9	37.1	137.8	7242.9	4366.5	5614.5	464.5
Top of femur (L)	89.3	100.0	4479.0	4560.0	4622.0	0.0	0.0	0.0	380.3	5234.7	3991.0	4477.5	4576.5
Top of femur(R)	89.2	100.0	4448.0	4514.0	4575.0	0.0	0.0	0.0	296.8	5175.1	3852.4	4447.5	4380.5
PTV	61.4	100.0	7134.0	7167.0	7189.0	0.0	94.1	100.	6887.8	7366.8	7138.4	7133.5	7219.5

Tables 2 and 3 show in detail the dose – volume parameters of patient Chen Yu L. Both of plans provide enough the dose to 95% volume of the tumor, thus achieving 100% of the prescribed dose and there is no position the received doseis higher than 110% of the prescribed dose. The mean dose delivered to the top of femur is fewer than 40 Gy. The dose distribution in 40% volume of the bladder and rectum is significant different between JO-IMRT and 3D-CRT plan. The discrepancy is very difficult to overcome.

Fig. 3 and fig. 4 show the dose distribution of 3D and 2D from 3D-CRT and JO-IMRT illustrated as follows:

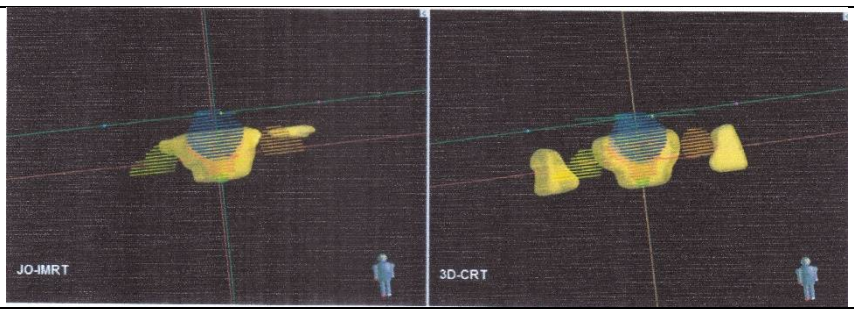

Fig.3: The dose distribution from 3D images of 3D-CRT plan and JO-IMRT plan of patient Chen Yu L.

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Fig.3 shows the dose distribution is very high at very close to two top of femurs (2 yellow blocks with 50 Gy next to 2 top of femurs)

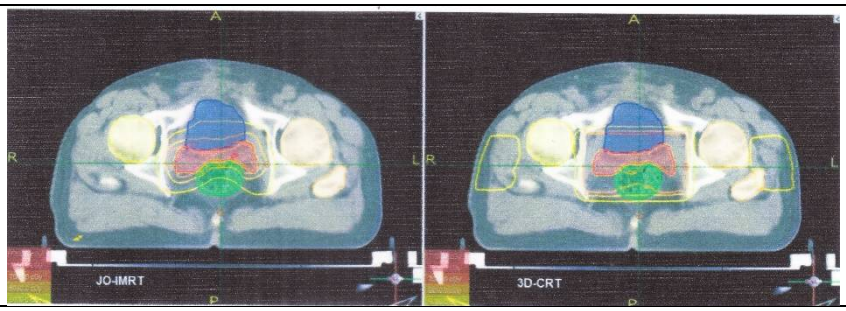

Fig.4: The dose distribution from 2D images of 3D-CRT and JO-IMRT plan of patient Chen Yu L.

Fig.4 shows the isodose of 70 Gy (red line) is very close to PTV for JO-IMRT plan while it is a wide area for 3D-CRT. The high dose distribution of the 3D-CRT plan causes the rectum to lose its function. The high dose delivered to the bladder makes it punctured or inflamed. Therefore, we concluded that JO-IMRT provides the superior dose distribution and it is very meaningful in high dose treatment and we can develop radical cancer treatment by radiation.

2) Comparison the results between JO-IMRT and MCL-IMRT techniques:

Patient Hua Minh D. has cancer of prostate (T3N0M0).
Prescribed dose of patient Nguyen Khac T. as follows:
PTV: 70 Gy at 2Gy/fraction/day.
40% of the bladder volume received the dose fewer than 40 Gy.
40% of the rectum volume received the dose fewer than 40 Gy.
Top of femur received the mean dose fewer than 41Gy.

Fig.5 shows dose distribution of JO-IMRT and MLC-IMRT plans of patient Hua Minh D.

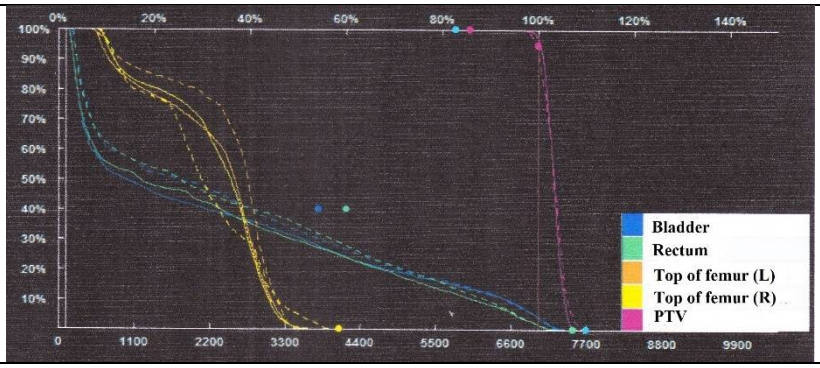

Fig.5: The dose distribution histogram of patient Hua Minh D. (MLC-IMRT and JO-IMRT plans)

The solid lines represent results of MLC-IMRT and the broken lines represent results of JO-IMRT of patient Hua Minh D. Fig.5 show the dose distribution of JO-IMRT is better than that of MLC-IMRT. It is seen clearly at the rectum. Looking at the table 4 and table 5, we can evaluate in detail the volumes:

Table 4: The dose distribution to organs in MLC-IMRT of patient Hua Minh D.

Organs	Volume	DLV(%)	D-X(cGy)			V-X(%)			Min	Max	Mean	Median	Repeat
	(cc)	100.0	66	40	33	110	100	95	(cGy)	(cGy)	(cGy)	(cGy)	(cGy)
Bladder	275.5	100.0	940.0	3652.0	4212.0	0.0	5.9	12.4	228.9	7481.1	3011.7	2644.5	298.5

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Rectum	125.8	100.0	819.0	3812.0	4512.0	0.0	3.1	9.0	191.3	7260.9	2996.3	2638.5	302.5
Top of femur(L)	89.3	100.0	2163.0	2685.0	2763.0	0.0	0.0	0.0	498.4	3552.6	2235.9	2569.5	2602.5
Top of femur(R)	89.0	100.0	2163.0	2655.0	2733.0	0.0	0.0	0.0	558.0	3730.3	2247.3	2515.5	2933.5
PTV	62.1	100.0	7176.0	7256.0	7278.0	0.0	97.4	100.	6809.6	7598.9	7225.5	7224.5	7220.5

From table 4, there is 100% PTV received the dose of 95% and no region received doses greater than 110% of the prescribed dose. The top of femur received the mean dose of 22 Gy. 40% volume of the rectum and bladder received the dose of 38 Gy and 36 Gy respectively. All parameters are considered clinically acceptable. This is a plan with the very good dose distribution for the prostate cancer treatment.

Table 5: The dose distribution to organs in JO-IMRT of patient Hua Minh D.

Organs	Volume	DLV(%)	D-X(cGy)			V-X(%)			Min	Max	Mean	Median	Repeat
	(cc)	100.0	66	40	33	110	100	95	(cGy)	(cGy)	(cGy)	(cGy)	(cGy)
Bladder	275.5	100.0	1701.0	3914.0	4509.0	0.0	6.0	11.8	271.5	7436.1	3304.7	3098.5	503.5
Rectum	125.8	100.0	1474.0	4218.0	4868.0	0.0	4.3	11.0	235.7	7361.2	3279.7	3173.5	345.5
Top of femur(L)	89.3	100.0	2547.0	2843.0	2896.0	0.0	0.0	0.0	474.7	3598.6	2471.4	2761.5	2779.5
Top of femur(R)	89.0	100.0	1809.0	2333.0	2557.0	0.0	0.0	0.0	587.3	3965.4	2111.8	2081.5	3019.5
PTV	62.1	100.0	7172.0	7282.0	7310.0	0.1	92.3	100.	6753.8	7709.8	7233.3	7242.5	7238.5

From table 5, we observed that 100% PTV received 95 % prescribed dose and 0.1 % PTV received 110 % the dose. The top of femur received the mean dose of 24 Gy. 40% the rectum volume and 40% bladder volume received the dose of 42 Gy and 39 Gy, respectively. The dose distribution from JO-IMRT plan is worse than that from MLC-IMRT plan for the prostate cancer treatment.

Fig.6 and fig.7 show the dose distribution of 3D and 2D from JO-IMRT and MLC-IMRT

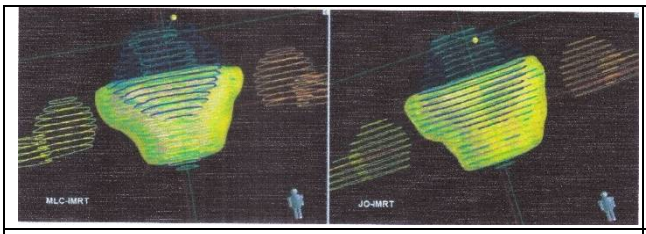

Fig.3: The dose distribution from 3D images of MLC-IMRT and JO-IMRT plans (patient Hua Minh D.)

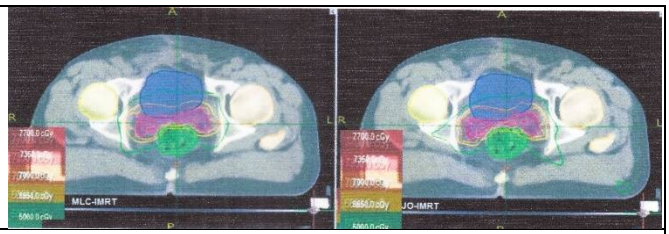

Fig.4: The dose distribution from 2D images of MLC-IMRT and JO-IMRT plans (patient Hua Minh D.)

From3D and 2D images, we observed that the dose distribution of 3D and 2D from JO-IMRT and MLC-IMRT is similar. Thus, the JO-IMRT plan is accepted as the normal IMRT plan.

3) Optimizing the dose distribution of JO-IMRT plan:

We figured out a plan with 9 fields that reached all criteria of a perfect plan (see table 6).

Table 6: Statistical results of the dose distribution from prostate cancer treatment plans by the JO-IMRT:

Structure	Prescribed dose	5 fields	6 fields	7 fields	8 fields	9 fields
PTV: min dose	≥ 60 Gy	62÷65	63÷65	64÷66	63÷66	65÷66
PTV: max dose	≤ 73 Gy	68÷73	68÷73	70÷72	70÷73	70÷72
100% PTV	≥ 95%	**94**÷100	**93**÷100	95÷100	95÷100	95÷100
40% of bladder volume	≤ 40Gy	33÷40	35÷**42**	35÷**46**	33÷39	30÷38

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40% of rectum volume	≤ 42 Gy	40÷**44**	**43÷46**	42÷**50**	40÷42	35÷40
The top of femurs: mean dose	< 41 Gy	27÷33	31÷40	33÷**43**	23÷29	23÷27

The bold values in the table are not satisfactory to the plan.
9 fields is the result of this work and it is recommended for prostate cancer treatment process by the JO-IMRT technique.

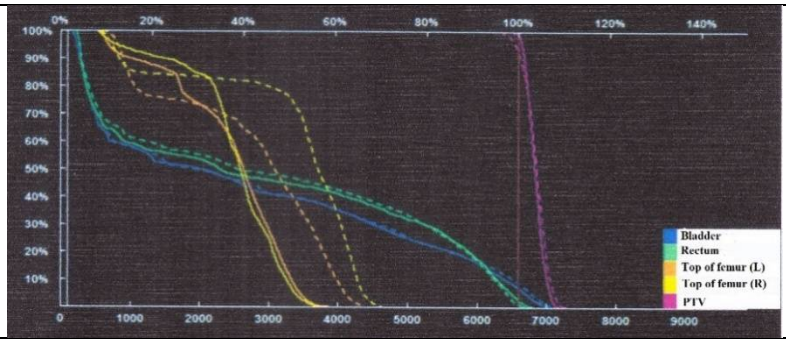

Fig.8: DVH curves of the 9 field plan (solid lines) and the 5 field plan (broken lines) of patient Hua Minh D.

In the histogram, we can see that the dose distribution delivered to PTV and the top of femurs from 5 field plan is worse than that from the 9 field plan. The bladder volume and the rectum volume received the same dose.

Table 7: The dose distribution to organs from 5 field JO-IMRT plan of patient Hua Minh D.

Organs	Volume	DLV(%)	D-X(cGy)			V-X(%)			Min	Max	Mean	Median	Repeat
	(cc)	100.0	66	40	33	110	100	95	(cGy)	(cGy)	(cGy)	(cGy)	(cGy)
Bladder	378.8	100.0	552.0	3374.0	4229.0	0.0	8.9	14.0	142.1	7287.9	2754.2	1896.5	298.5
Rectum	149.4	100.0	741.0	4301.0	5043.0	0.0	1.1	10.0	218.5	6787.1	3035.9	2547.5	295.5
Top of femur(L)	89.3	100.0	2595.0	3344.0	3513.0	0.0	0.0	0.0	616.7	4538.6	2741.5	3078.5	3656.5
Top of femur(R)	89.0	100.0	3522.0	3894.0	4005.0	0.0	0.0	0.0	576.5	4665.5	3328.7	3710.5	4123.5
PTV	62.1	100.0	6799.0	6906.0	6936.0	0.2	92.5	100.	6317.3	7287.9	6855.9	6863.5	6804.5

See at the table 8, it is the dose distribution to organs from 9 fields. That is results received from the JO-IMRT plan.

Table 8: The dose distribution to organs from 9 field JO-IMRT plan of patient Hua Minh D.

Organs	Volume	DLV(%)	D-X(cGy)			V-X(%)			Min	Max	Mean	Median	Repeat
	(cc)	100.0	66	40	33	110	100	95	(cGy)	(cGy)	(cGy)	(cGy)	(cGy)
Bladder	378.8	100.0	557.0	3297.0	4236.0	0.0	7.0	12.2	164.7	7124.6	2726.3	2014.5	256.5
Rectum	145.4	100.0	596.0	3957.0	4721.0	0.0	2.4	9.3	225.0	6831.6	2868.5	2223.5	277.5
Top of femur(L)	89.3	100.0	2333.0	2787.0	2909.0	0.0	0.0	0.0	553.7	4050.6	2442.0	2642.5	2672.5
Top of femur(R)	89.0	100.0	2391.0	2702.0	2810.0	0.0	0.0	0.0	524.3	3749.2	2503.2	2594.5	2396.5
PTV	62.1	100.0	6786.0	6878.0	6902.0	0.0	99.2	100.	6529.2	7193.2	6844.6	6839.5	6913.5

The 8 field plan is evaluated as follows:
The dose distribution from the 8 field plan was evaluated to be quite good nearly equivalent to all volume. A representative dose volume histogram is illustrated in fig.9:

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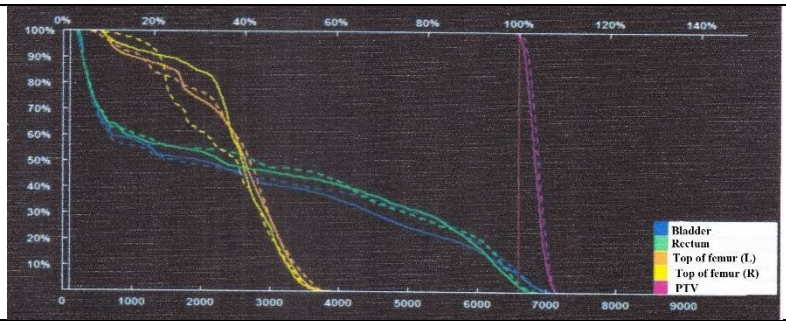

Fig.9: DVH curves of the 8 field plan (solid lines) and the 9 field plan (broken lines) of patient Hua Minh D.

The table 9 shows the dose – volume parameters of the 8 field JO-IMRT of patient Hua Minh D.

Table 9: The dose distribution to organs from 8 field JO-IMRT plan of patient Pham Minh K.

Organs	Volume	DLV(%)	D-X(cGy)			V-X(%)			Min	Max	Mean	Median	Repeat
	(cc)	100.0	66	40	33	110	100	95	(cGy)	(cGy)	(cGy)	(cGy)	(cGy)
Bladder	378.8	100.0	521.0	3569.0	4738.0	0.0	8.1	15.2	179.8	7158.7	2840.6	1610.5	258.5
Rectum	149.4	100.0	623.0	4147.0	4671.0	0.0	3.4	14.4	203.6	6916.3	3012.9	2778.5	269.5
Top of femur(L)	89.3	100.0	2340.0	2848.0	2940.0	0.0	0.0	0.0	385.1	3963.5	2469.5	2708.5	2965.5
Top of femur(R)	89.0	100.0	1783.0	2682.0	2820.0	0.0	0.0	0.0	372.6	3860.8	2319.9	2517.5	1468.5
PTV	62.1	100.0	6840.0	6915.0	6944.0	0.0	99.6	100.	6547.7	7154.4	6889.3	6888.5	6886.5

After planning for 10 patients with prostate cancer were randomly selected for this study, we suggest the 9 field JO-IMRT for the case of prostate cancer treatment.
We achieved some results for receiving the dose of target volume from IMRT plan for the case of prostate cancer:

Irradiated region	Volume (cc)
Region received 50% of the prescribed dose from the 5 field plan	1733.34
Region received 50% of the prescribed dose from the 6 field plan	1560.66
Region received 50% of the prescribed dose from the 7 field plan	1605.93
Region received 50% of the prescribed dose from the 8 field plan	1642.13
Region received 50% of the prescribed dose from the 9 field plan	1231.44

IV. CONCLUSION

From a radiobiological point view, the JO-IMRT appears to be an effective strategy for the treatment of prostate cancers. The use of 6 MV photons with 9 fields would appear to create good dose distributions.
IMRT seems to be the most effective modality for treating complex target geometries and for delivering simultaneous integrated boosts. In particular for prostate cancer, the simultaneous treatment of the prostate and pelvic lymph nodes lends itself perfectly to IMRT, allowing the prostate to receive a higher daily dose per fraction, as well as minimizing the amount of small bowel in the field, while at the same time sparing the rectum and bladder adequately. Inverse-planned IMRT is, however, a complex procedure, and to safely implement it, an extensive patient- and machine-specific quality assurance program is required.

Our results prove that the 9 field JO-IMRT plan has adapted to treat prostate cancer patients.

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REFERENCES

[1].John Nguyen, "Method for intensity modulated radiation treatment using independent collimator jaws, United States Patent, 2007
[2].Followill D, Geis P, Boyer A, "Estimates of whole body dose equivalent produced by beam intensity modulated conformal therapy", Int J Radiation Oncology Biology Phys, 38, 667-672, 1997
[3].Arno J. Mundt, John C. Roeske, "Intensity modulated radiation therapy, Hamilton, London, 2005
[4].Pirzkall A, Carol MP, et al. "the effect of beam energy and number of fields on photon based IMRT for deep-seated targets", Int.J Radiation Oncology Biology Phys, 53, 434-442, 2002
[5].Radiation therapy oncology group, "A phase evaluation of preoperative Chemotherapy utilizing intensity modulated radiation therapy (IMRT) in combination with capecitabine and oxaliplatin for patients with locally advanced rectal cancer, American college of Radiology
[6].Monika Pietrowska, Karol Jelonek, Joanna Polanska, Anna Wojakowska, Lukasz Marczak, EwaChawinska, AleksandaChmwa, WojciechMajewski, LeszchMiszczyk, piotrWidlak, "Partial body irradiation in patients with prostate cancer treated with IMRT has little effect on the composition of serum proteome", Proteomes 3, 117-131, 2015
[7].Yongkok Kim, Lynn J. Verhey, Ping Xia, "A feasibility study of using conventional jaws to deliver IMRT plans in the treatment of prostate cancer", Physics in Medicine and Biology, volume 52, N8
[8].Parker W, Patrocinio H, "Practical aspects of inverse planned intensity modulated radiation therapy for prostate cancer: a radiation treatment planner's perspective, Jun12, suppl(2), 48-52, 2005
[9].Corletto D, Iori M, Palusco M, Brait L, Broggi S, Ceresoll G, Lotti C, Calandrino R, Florino C, "Inverse and forward optimization of one-and two dimensional intensity modulated radiation therapy based treatment of concave shaped planning target volumes: the case of prostate cancer, Radiotheroncol, Feb, 66(2), 185-195, 2003
[10].De Meerleer Go, Vakaet LA, De Gersen WR, De Wagter C, De Naever B, De neve W, "radiotherapy of prostate cancer with or without modulated beams: a planning comparison", Int. J. RadiatOncolBiolPhys, 47 (3), 639-648, 2000, Jun1
[11].D. M Shepard, M.A. Earl, X.A. Li, S. Naqvi, C. Yu, "Direct Aperture Optimization: A turnkey solution for step and shoot IMRT", Med. Phys 29(6), pages 1007-1018, June 2002
[12].Prowess Inc, Prowess Panther User Manual version 5.1, Prowess Inc, california