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Research Article

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IMRT vs VMAT in Head and Neck Cancer

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Abstract

Background: IMRT and VMAT represent many advantages. It can be used to produce dose distributions that are far more conformal than those possible with standard 3DCRT. Dose distributions within the PTV can be more homogeneous and a sharper falloff dose at the PTV boundary can be achieved. This study was done to compare the IMRT and VMAT in treatment of head and neck cancer.

Materials and Methods: This study was performed in patients of head and neck carcinoma in Hanuman Prasad Poddar Cancer Hospital and Research Centre-Gorakhpur-India in july 2024.

Results: In both IMRT and VMAT there is better dose distribution with sparing of all OARs. While the treatment time is less with VMAT as compared to IMRT. All the patients tolerated well with grade 1 or 2 radiation toxicity.

Conclusion: When there is patient load with long waiting list, we can use VMAT for better précised treatment with better dose distribution and sparing OARs and sparing more time to treat other patients.

Abbreviations: Mus: Monitor Unit; OARs: Organ at Risk.

Introduction

IMRT techniques have led to improved conformal dose delivery methods. However, IMRT tends to have higher Monitor Units (MU) compared to 3DCRT technique. This contributes to higher leakage from the gantry head and consequently increased dose to normal tissues and whole body in general. This undesirable dose is likely to result in higher second tumor induction rate. It is, therefore, desirable to reduce the unnecessary scatter from the gantry head and shorten the treatment time for IMRT delivery. The removal of the flattening filter has been a logical choice to reduce the scatter. The development of IMRT eliminates the need for a flattening filter in modern linear accelerator (LINAC) systems. In recent years, the application of the Flattening Filter-Free (FFF) photon beam has been studied extensively. Forward peaked dose profile is the major characteristic of the FFF beam. Compared with the flattened beam, the FFF beam also has increased dose rate, reduced dose to Organ at Risk (OAR), neutron contamination for high-energy beams (>15 MV), and reduced uncertainty in dose calculation. Thus, clinical ap plication of the FFF beam would lead to reduced treatment time and secondary cancer risk induced by radiation. IMRT is the most conformal and efficient technique when all target volumes (gross disease, subclinical extensions, and electively treated nodes) are treated simultaneously using different fraction sizes. Such a treatment strategy has been called the Simultaneous Integrated Boost (SIB), This is in contrast to conventional radiation therapy in which the same fraction size (typically 1.8 or 2 Gy) is used for all target volumes with successive reductions in field sizes to protect critical normal structures and to limit the dose to electively treated and subclinical disease regions. An alternative approach where delivery of a rotational cone beam with variable shape and intensity is commonly called Volumetric-Modulated Arc Therapy (VMAT). In a VMAT treatment, in order to create a satisfactory dose plan with a single arc, it is necessary to optimize the field shapes and beam intensities from a large number of gantry angles. However, the field shapes are restricted by the constraints placed on MLC leave motions. The MLC leaves must be able to move to their new positions within the time required for the gantry to rotate between consecutive gantry positions. Unfortunately, the larger the sampled gantry angles, the more difficult it is for the TPS to optimize the MLC leave

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motion constraints. A novel plan optimization for a VMAT delivery was first proposed by Otto. Other optimization algorithms have since been developed. The biggest advantage of a VMAT delivery is in its delivery efficiency. Several investigators have reported significant reductions in treatment times and possible MUs over conventional IMRT. One major benefit of VMAT compared with tomotherapy is the possibility of delivering this treatment on conventional linear accelerators, which are configured to have this capability. Currently, there are several VMAT systems available under various names (RapidArc, Varian; SmartArc, Phillips; and Elekta VMAT, Elekta). Compared with fixed gantry IMRT, the potential advantages of VMAT include a large reduction in treatment time and concomitant reduction in the number of MUs required to deliver a given fraction size.

Materials and Methods

This study was performed in patients of carcinoma cervix in Hanuman Prasad Poddar Cancer Hospital and Research Centre-Gorakhpur-India.

Results

1. 10 patients with oral cavity carcinoma were planned with both IMRT and VMAT technique. There was no significant difference in maximum dose for OARs as spinal cord and parotid of unaffected side. There is good distribution of dose in PTV (Table 1).

Table 1:

	IMRT		VMAT	
SL.NO	Spinal Cord {max} dosein Gy	Parotid{max} dosein Gy	Spinal Cord{max} dosein Gy	Parotid{max} dose in Gy
1	38.6	13	43.5	12
2	39.8	18.1	30.4	12
3	41.8	17.5	35.6	13
4	43.5	14.1	41.7	13.5
5	43.9	15	37.3	11.5
6	40.3	13.4	40.5	12
7	40.3	15.7	38.7	12.3
8	44.6	13	40.6	11.8
9	44.4	13.8	39.6	12.5
10	40.5	14.3	40.9	13.5

2. Patient treated on Halcyon Varian machine were observed who underwent IMRT and VMAT in aspect of no MUs used and their treatment time (Table 2,3).

Table 2: List of patients treated with IMRT: no of MUs and treatment time.

SL.NO.	IMRT	
	Mu	Treatment Time
1	1797.3	2.7
2	685.9	1.03
3	1606	2.41
4	2051.5	3.08
5	1916.2	2.87
6	572.4	0.86
7	1384.7	2.08
8	1624	2.44
9	1656.8	2.49
10	1639.1	2.46
11	1744.4	2.62
12	2145.5	3.22
13	2271.7	3.41
14	1639	2.46
15	1888.2	2.83
16	1852.6	2.78
17	1791.7	2.69

Table 3: List of patients treated with VMAT: no of MUs and treatment time.

SL.NO.	VMAT	
	Mu	Treatment Time
1	477.4	0.72
2	531.9	0.8
3	550.6	0.83
4	736.4	1.1
5	598.8	0.9
6	456.6	0.68
7	466.4	0.7
8	371.5	0.56
9	543.7	0.82
10	616.5	0.92
11	539.9	0.81
12	647.6	0.97
13	598.6	0.9
14	621.1	0.93
15	513.9	0.77
16	413.6	0.6
17	583.3	0.87

As we can say that both IMRT and VMAT give better dose coverage of PTV and with limited dose to OARs. The no of MUs and treatment time is less with VMAT in comparison to IMRT [1,11].

Conclusion

When there is patient load with long waiting list, we can use VMAT for better précised treatment with better dose distribution and sparing OARs and sparing more time to treat other patients.

Discussion

In the studies comparing IMRT and VMAT, it is typically reported that each of these IMRT approaches yield treatment plans of improved quality when compared to 3D-CRT. It is also commonly observed that there are differences in the plans produced using these IMRT techniques. The differences are typically seen in indicators such as conformity index, homogeneity index and PTV conformation. It is important to realize that despite the differences, each technique is capable of producing adequate plans for treatment. In fact, results have demonstrated that the plan quality achieved using fixed-gantry IMRT and VMAT are of comparable quality. The absolute difference observed in dose are small in most cases, thus the clinical significance is unclear. More long-term studies are needed to determine if the differences in dose distribution observed are of any real long-term significance. Each technique has its own advantages and disadvantages. A study by Oliver et al. directly compared the planning Like tomotherapy, VMAT plans take longer than fixedgantry IMRT plans to generate. Yoo et al. reported that optimization and dose calculation took 2 and 5 minutes for conventional IMRT and approximately 15-20 minutes and 5 minutes for VMAT, respectively. VMAT planning systems are still in the early stages of clinical application. Further improvement of the optimization and dose calculation process will continue to advance the planning process. An important consideration of plan quality is integral dose, as previously discussed, when using fixed-gantry IMRT techniques, the volume of tissues receiving a low dose is increased when compared with 3D-CRT. Similar observations have also been reported for VMAT. Reports are conflicting as to which technique produces the greater integral doses. The higher integral doses reported in both techniques increase the chance of radiation-induced secondary malignancies. An advantage of VMAT has over the fixed-gantry technique is that in the rotating gantry techniques, the uncertainty in selecting the optimal gantry angles for treatment is eliminated. In the fixed-gantry technique, the most effective gantry angle may not be obvious. This can result in loss of useful directions before the initiation of optimization. In VMAT, the optimizer can have 360 degree of rotation. The both techniques are also capable of delivering non-coplanar fields. For some intracranial and head and neck tumors, the use of noncoplanar arcs can provide significant dosimetric benefits because of preferential sparing of adjacent sensitive structures. The treatment times using VMAT are reduced because fewer MUs are required to deliver the therapeutic dose distribution via a single arc. Such a reduction in beam-on time can have a strong impact on clinical throughput (i.e., patients treated per day and waitlist reduction). Also, if a patient spends less time on the treatment couch, the chance of geometrical miss due to intra-fractional movement is reduced. The time saved by reducing beam-on time could be used to implement more online imaging technologies without increasing the total time in the treatment room.

Acknowledgements

None.

Conflict of Interest

None.

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