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Dosimetric Comparison of Sbrt Plans in Cyberknife and Helical Tomotherapy in Non-Small Cell Lung Cancers

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Abstract

It was aimed to make a dosimetric comparison by delivering the plans of patients treated with the robotic radiosurgery Cyberknife device using the density-adjusted radiotherapy (IMRT) technique in the treatment of non-small cell lung cancers (NSCLC) to the Helical Tomotherapy device. In cases where stereotactic body radiotherapy (SBRT) treatment cannot be performed in Cyberknife device, it is aimed to offer alternative treatment methods for NSCLC patients with the same cases.

In this study, the plans of 10 patients were evaluated retrospectively. For each of the 2 different techniques (Planned Target Volume), the minimum, maximum and average doses of PTV; homogeneity index and conformity index; the doses taken by the planned risky organs; the data of 20% and 50% isodoses and the statistical analysis of the values taken by the (monitor unit) were compared using the Social Sciences Statistical Package (SPSS) data analysis system. In the treatment of lung cancer patients, it was aimed to protect the critical organs at the maximum level; As Low as Reasonably Achievable principle optimization was achieved by irradiating the lesion at the destructive level.

Keywords: Lung • SBRT • Cyberknife • Helical tomotherapy

Introduction

Lung cancer is a complex type of cancer that is influenced by genetic and environmental factors caused by the uncontrolled proliferation of lung cells. Abnormally growing tissue masses are called tumors [1]. Lung cancer is the leading cause of cancer-related death in many countries, with more than 1.38 million deaths worldwide. In terms of histological methods, lung cancer can be divided into small cell lung cancer (SCLC) and non-small cell lung cancer (NSCLC). 80-85% of malignant lung tumors are NSCLC. Less than 50% of NSCLCs are tumours that can be surgically excised at the time of diagnosis. 25% of them are locally in the advanced stage [2].

Approximately 15% of lung cancer cases are identified as primary lungs at the time of pre-diagnosis. It was reported that 22% of them enlaces the regional lymphatics and 56% of them are cases of metastasis in more distant regions. A rate of 7% outside these values was considered as the cases where the cases could not be determined. Overall, a large proportion of lung cancers are known as NSCLC. When the pathological examination with proportional expression is examined, 85% of NSCLC and 15% of NSCLC are observed in lung cancer. When examined pathologically in NSCLC cases, it can be distinguished as adenocarcinoma, squamous cell cancer, and large cell cancer [3].

This study aims to investigate the possibility of SBRT lung planning techniques in Helical Tomotherapy in non-small cell lung cancers with the same cases where SBRT (Stereotactic Body Radiotherapy) treatment cannot be performed in CyberKnife® device. In this study, the use of Helical Tomotherapy and CyberKnife® robotic radiosurgery devices was aimed at dosimetrically comparing the treatment plans of 2 separate devices in patients with low and moderate risk lung cancer.

The effect of lung cancer on critical organs in radiotherapy (Table 1)

Materials and Methods

Patient selection and acquisition of images

In this study, this research was approved by İzmir Katip Çelebi University Rectorate- Non-Interventional Clinical Research Ethics Committee on 19.11.2020 with decision number 1085. Patients with non-small cell lung cancer were retrospectively followed up in the Radiation Oncology Department of İzmir Katip Çelebi University-Atatürk Training and Research Hospital. 10 patients were selected between 2018 and 2020 using the CyberKnife® device as robotic radio-surgical treatment. In this study, the advantages and disadvantages of Helical Tomotherapy SBRT and CyberKnife® SBRT planning techniques against each other in radiotherapy of patients with non-small cell lung cancer were revealed. This may serve as a guide for both current and future clinical studies. In this study, the planning systems of Accuray CyberKnife® and Accuray Helical Tomotherapy radiotherapy devices operating in the Radiation Oncology Unit of İzmir Katip Çelebi University, Atatürk Training and Research Hospital, and the "SPSS Data Analysis System" was used for the analysis of the data to be obtained from these plans.

Planning of radiation therapy

CT images of primary lung cancer cases admitted to İzmir Katip Çelebi University Atatürk Training, and Research Hospital were examined. Lung cancer patients in the Accuray CyberKnife® device were archived, recorded on CD in DICOM format with their contours, and transferred to Helical Tomotherapy planning systems. This provided contour reliability and prevented our error ratio. It allowed us to use the same safety margins and target doses.

Accuray CyberKnife® MultiPlan Treatment Planning System (TPS v 4.0.0) and Helical Tomotherapy TPS Accuray precisionTM 1.1 were used. Images were taken at 1 mm cross-sectional intervals with immobilization tools under CT scanning clinical protocols. All necessary permissions have been obtained during this process (Figures 1 and 2).

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Table 1. Conventional scoring system of RTOG radiation-induced lung injury. MV: Mechanical Ventilation RTOG: Radiation therapy oncology group; SY: Respiratory Failure [4].

EARLY (<90)	LATE (>90)	Stage
Mild symptoms; dry cough or exercise dyspnea	Asymptomatic or mild symptoms (dry cough etc.) Mild radiological changes	1
Persistent cough requiring narcotic antitussive agents, minimal exercises dyspnea	Moderately symptomatic fibrosis or pneumonitis (heavy cough) Subspherical fever, Irregular radiological changes	2
Cough unresponsive to narcotic antitussive agents, clinical or radiological signs of acute pneumonia, intermittent oxygen requirement	Severe symptomatic fibrosis or pneumonitis, Intense radiological changes	3
SY requiring continuous oxygen or MV Death	Severe SY, need for continuous oxygen therapy or MV Death	4 5

Data analysis method

Parameters such as tumour volume, dose prescription, critical organ doses, average and standard deviation of HI, CI and NCI values of the plans made in Tomotherapy and CyberKnife® devices, volumetric isodose values of critical organs, treatment times per fraction in the plans were evaluated with IBM SPSS Data Analysis Method (Figures 3-12) (Table 2).

Discussion and Conclusion

In this study, for 10 non-small cell lung cancer patients (Table 3), Robotic Radiosurgery CyberKnife® and Helical Tomotherapy devices, which are two different treatment techniques using Multiplan and Tomotherapy HDA treatment planning systems, were evaluated by examining the doses of PTV, critical organs and DVH. A specific study was also conducted by looking at 20% and 50% isodoses in this study.

As a result of Mann Whitney performed for Dmax(Gy) data of PTV,

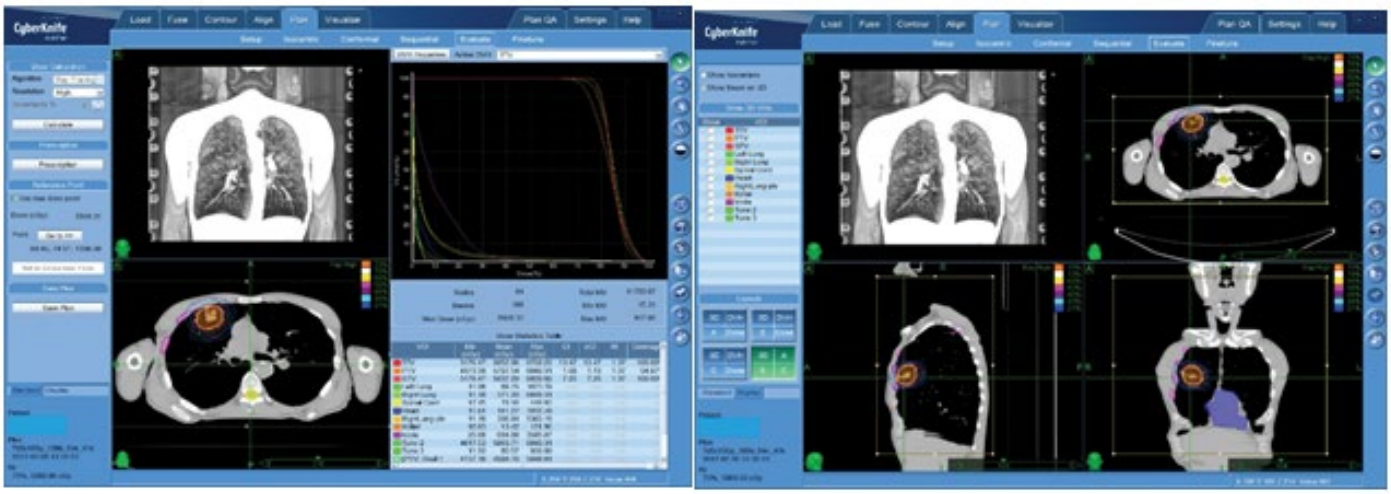

Figure 1. Example of a patient's plan for multiplan treatment planning.

Figure 2. Example of a patient's plan in the hi-art treatment planning system.

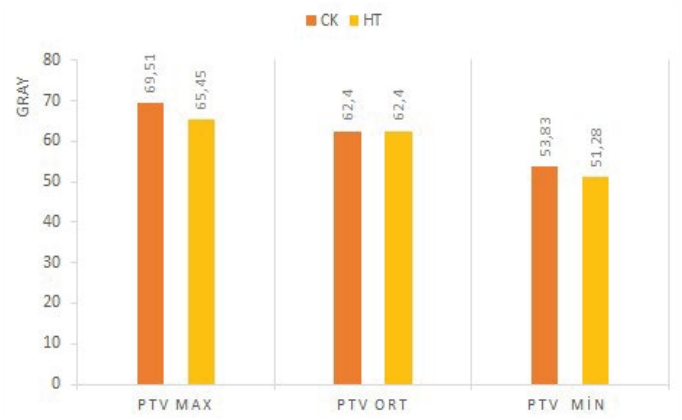

Figure 3. Graphical display of ptv maximum, average and minimum values in spss program.

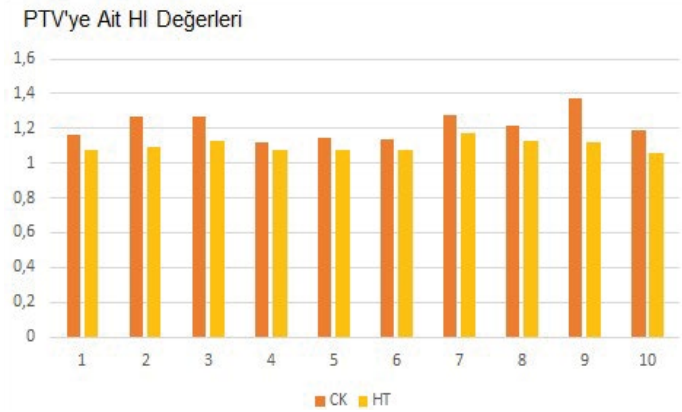

Figure 4. Graphical display of HI values of PTV.

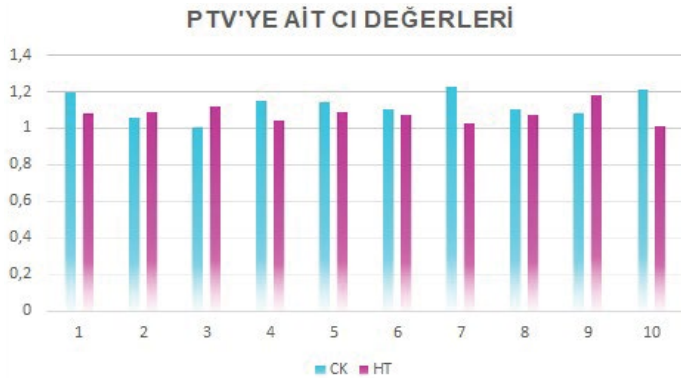

Figure 5. Graphical display of CI values of PTV.

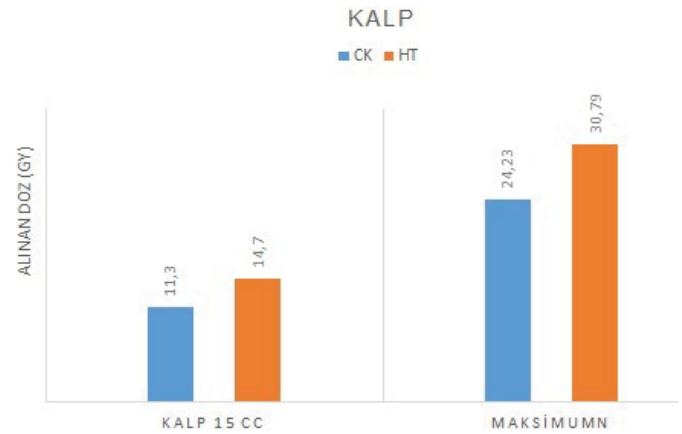

Figure 6. Comparison graph of 15 cc and maximum dose data received by the heart.

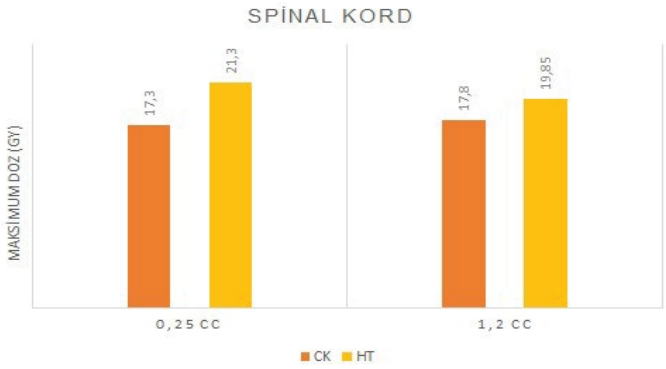

Figure 7. Comparison graph of 0.25 cc and 1.2 cc doses of spinal cord.

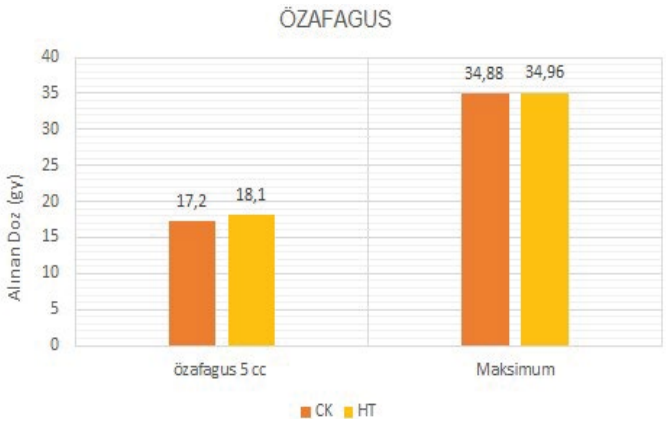

Figure 8. Comparison graph of 5 cc and maximum of esophagus.

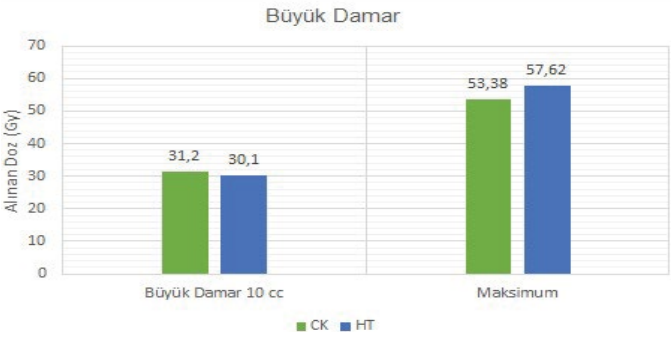

Figure 9. Comparison of 10cc and maximum in the great vessel.

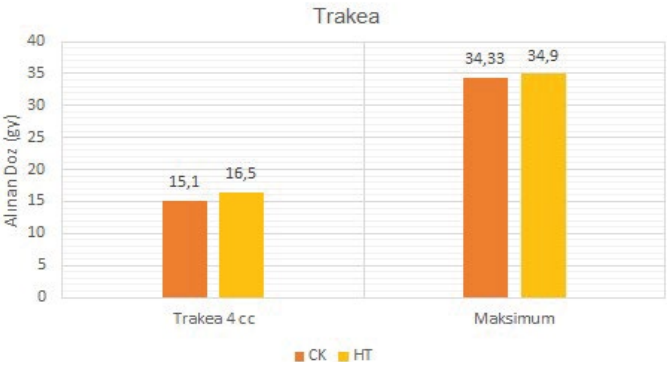

Figure 10. Comparison of trachea 4cc and maximum.

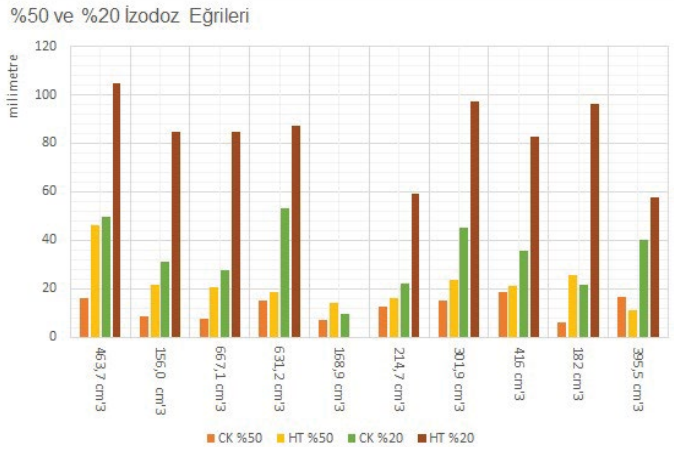

Figure 11. Comparison chart of isodoses at 50% and 20%.

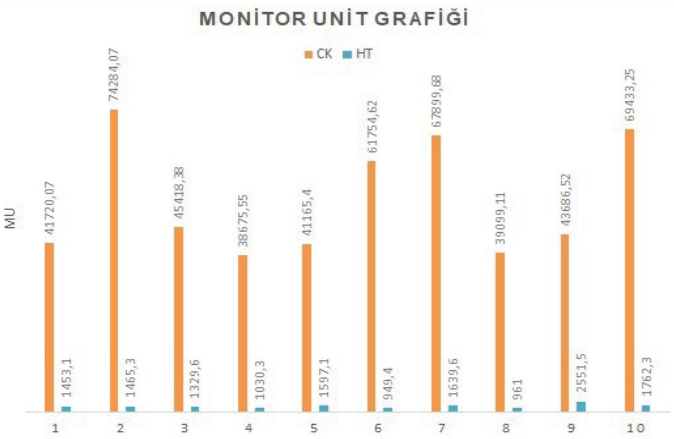

Figure 12. Comparison graph of the monitor unit.

Table 2. General evaluation of the patients according to the parameters.

Number of the Patients		Parameters	Mann Whitney P Values
PTV		Dmax	0,19
		Davg	0,019
		Dmin	0,762
		HI	0,143
		CI	0,130
QAR	Heart	Dmax	0,285
		15 cc	0,200
	Spinal Cord	Dmax	0,581
		0,25 cc	0,681
		1,2 cc	0,037
	Esophagus	Dmax	0,546
		5 cc	0,583
	Great Vessel	Dmax	0,546
		10 cc	0,654
	Trachea	Dmax	0,846
		4 cc	0,624
	MU		0,001
ISODOSE		50%	0,486
		20%	0,004

Table 3. Patient fraction chart.

Number of patients	Fraction (Gy)
8	5 × 10
1	3 × 18
1	3 × 19

a statistically insignificant difference was found (P=0.19). A statistically significant difference was found due to Mann Whitney performed for Dort (Gy) data of PTV (P=0.019). No statistically significant difference was found as a result of Mann Whitney performed for Dmin(Gy) data of PTV (P=0.762). As a result of the Independent T-Test for HI data of PTV, a statistically insignificant difference was found (P=0.143). As a result of the Independent Test for PTV CI data, statistically insignificant differences were found (P=0.130). Similar non-significant differences were found in the coverage data (P=0.131). When we performed the statistical analysis of the heart, an Independent T-Test was applied at the maximum dose it received, and no significant difference was found (P=0.193). There was no significant difference in the Independent T-Test for the 15 cc volume of the heart (P=0,200). In the statistical analysis of the spinal cord, no significant difference was found by applying the Independent T-Test in the Dmax data analysis (P=0.581). However, no significant difference was found in the Independent T-Test for 0.25 cc volume of the spinal cord (P=0.681). Similarly, no significant difference was found by applying Wilcoxon Test on the 1.2 cc volume of the spinal cord (P=0.037). When we performed statistical evaluations for the oesophagus, an Independent T-Test was applied for the maximum dose (P=0.546). No significant differences were found in the Independent T-Test we applied for the max dose and 5 cc volume of the oesophagus (P=0.583). In evaluating the statistical data for the Great Vessel, an Independent T-Test was applied for the maximum dose and 10 cc volume (P=0.546). Similarly, no significant difference was found for the maximum dose and 10cc volume of the great vessel (P=0.654). In the statistical analysis of the Trachea, an Independent T-Test was applied for the maximum dose, and no significant differences were determined (P=0.846). For the evaluations of the Trachea in 4 cc volume, no significant difference was found by applying the Independent T-Test (P=0.624). Independent T-Test was applied for the isodose distribution of 20%, and no significant difference was found (P =0.004). Isodose distribution of 50% was applied Mann Whitney Test, and a significant difference was found (P =0.486). Mann Whitney Test was applied for the statistical data for the Monitor Unit value, and a significant difference was found (P=0.001). Collins et al. investigated how CyberKnife® radiosurgery is associated with non-surgical patients with small, peripheral stage NSCLC. As a result of this research, CyberKnife® offered a well-tolerated treatment option. The administered doses were effective and sufficient limits were helpful for optimal early control in the study [4,5]. In the study conducted by Kannarunimit et al., with CyberKnife®, Helical Tomotherapy, and VMAT, in which SBRT was performed in lung tumour cases, the CI value was calculated as a mean deviation in CyberKnife® device; CyberKnife® 1.11 ± 0.09, 1.10 ± 0.05 for Tomotherapy, 1.11 ± 0.05 for VMAT, and p-value was calculated as 0.88. Since the p-value was greater than 0.05, they found that there was no significant difference between the groups they matched. In their study, where they performed stereotactic body radiotherapy for central lung tumours with CyberKnife® radiosurgery, Helical Tomotherapy and VMAT, MU/fraction and min/fraction data were examined for three different devices, and they found that p-value was less than 0.05in their study. In this case, in the study where there is a significant difference, the Helical Tomotherapy device shows lower MU/fraction and min/fraction data compared to the CyberKnife® device [6].

In general, considering all parameters, we observed that the treatment with the Accuray Robotic Radiosurgery Cyberknife device better enlaced and irradiated the tumour in terms of the protection feature of the critical organs. However, in institutions or organizations where there is no Cyberknife device, treatment with Accuray Helical Tomotherapy has also been a good option. In our results, when the treatment plans made with both devices were examined, acceptable results were obtained for the clinic.

Recommendation

It is recommended that future studies be planned so that more cancer patients and more techniques or devices can be evaluated.

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