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Implications of Radiotherapy Utilization in Korea from 2010 to 2019

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ABSTRACT

Background: This study was to assess the rate of radiotherapy (RT) utilization according to the modality in South Korea to identify the implications of contemporary RT patterns.

Methods: We collected information from claims and reimbursement records of the National Health Insurance Service from 2010 to 2019. We classified the location of each institution as capital (Seoul, Incheon, and Gyeonggi-do) and non-capital areas.

Results: The rate of RT utilization in total cancer patients nationwide was 24.5% in 2010, which consistently has increased to 36.1% in 2019 (annual increase estimate [AIE], 4.5%). There was an abrupt increase in patients receiving intensity-modulated RT (IMRT), with an AIE of 33.5%, and a steady decline in patients receiving three-dimensional conformal RT (3DCRT), with an AIE of -7.1%. The commonest RT modality was IMRT (44.5%), followed by 3DCRT and stereotactic RT (SRT) (37.2% and 13.5%) in 2019. An increasing trend of advanced RT (such as IMRT and SRT) utilization was observed regardless of the region, although the AIE in the capital areas was slightly higher than that in non-capital areas.

Conclusion: The utilization of overall RT application and especially of advanced modalities remarkably increased from 2010 to 2019. We also found gaps in their AIEs between capital and non-capital areas. We should ensure that advanced RT is accessible to all cancer patients across South Korea.

Keywords: Radiotherapy; Utilization; Intensity-Modulated Radiation Therapy; Stereotactic Radiotherapy; South Korea

INTRODUCTION

Cancer is a major cause of death and contributes to a high treatment burden for cure.^{1,2} As malignant tumors develop commonly in older adults, ongoing demographic changes in population growth and aging are expected to markedly increase cancer incidence and, correspondingly, the demand for anticancer treatment.³⁻⁵ Therefore, physicians need to be prepared and should focus on the current conditions of cancer occurrence and trends related to cancer management to provide patients with appropriate treatment.⁶

Author Contributions

Conceptualization: Rim CH. Supervision: Kim WC, Yoon WS. Writing - original draft: Lee J, Rim CH. Writing - review & editing: Rim CH.

Radiotherapy (RT) is considered an essential treatment modality in the management of cancer; approximately 50% of cancer patients are treated with RT in Western countries.^{7,8} Over the last two decades, remarkable advances have been made by improving sophisticated imaging and technological advances in treatment delivery systems, which has resulted in dynamic changes in the RT landscape.^{9,10} Hence, it is necessary to evaluate how often RT is being implemented for cancer patients and how it has changed with these advances.

The purpose of this study was to assess the trends in RT utilization according to the modality in South Korea to understand the evolution of contemporary RT utilization and identify the implications of changing trends.

METHODS**Data source of RT**

The Korean government has operated the National Health Insurance Service (NHIS) for over 40 years, which is primarily mandatory for all citizens and covers more than 98% of the entire population.¹¹ Information on medical activities based on claims and reimbursement records of the NHIS is provided by the Korean Health and Insurance Review and Assessment Service (HIRA).¹² We obtained 10-year data on RT utilization from 2010 to 2019 from the HIRA using the insurance codes associated with the radiation treatment plan. A total of 12 codes matching treatment planning with the following modalities were used in the analysis: 2-dimensional RT (2DRT), 3-dimensional conformal RT (3DCRT), stereotactic RT (SRT), proton RT (PRT), brachytherapy, and intensity-modulated RT (IMRT) (Table 1). The detailed methods are described in a previous study.¹³ The number of patients was used to assess the rate of RT utilization in total cancer patients (primary endpoint), whereas the number of RT applications was used to assess trends in RT utilization according to the modality (secondary endpoint). The number of patients can be 10–15% smaller than that of application due to re-irradiation in the same patient or boost planning during treatment.

Table 1. Categorization of RT codes

Category	Treatment code	Description
2DRT	HD010	Teletherapy RT planning—Single port
	HD011	Teletherapy RT planning—Parallel opposed ports
	HD012	Teletherapy RT planning—Non-parallel opposed ports, more than 3 ports
3DCRT	HD013	Computerized RT planning—Single port
	HD014	Computerized RT planning—Parallel opposed ports
	HD015	Computerized RT planning—Non-parallel opposed ports, more than 3 ports
	HD016	Computerized RT planning—Rotational therapy
	HD018	Computerized RT planning—Three-dimensional conformal radiation therapy
SRT ^a	HD019	Computerized RT planning—Stereotactic radiosurgery and RT
PRT	HD020	Computerized RT planning—Proton therapy planning
BT	HD022	Brachytherapy-intracavity or intraluminary therapy
IMRT	HD041	Computerized RT planning—Intensity-modulated radiation therapy planning

HD017 (computerized radiotherapy planning intraoperative radiation therapy), HD021 (brachytherapy-mold therapy), and HD023 (brachytherapy-interstitial therapy) were excluded because their average number of applications were < 20 per year.

RT = radiotherapy, 2DRT = 2-dimensional radiotherapy, 3DCRT = 3-dimensional conformal radiotherapy, SRT = stereotactic radiotherapy, PRT = proton radiotherapy, BT = brachytherapy, IMRT = intensity-modulated radiotherapy.

^aSRT included both stereotactic body radiotherapy and stereotactic radiosurgery.

Data source of nationwide cancer incidence

Nationwide cancer incidence was assessed using the Korean Statistical Information Service (KOSIS) data, conducted by the Statistics Korea (<https://kosis.kr/index/index.do>). Since cancer incidence was available until 2017, incidences from 2018 and 2019 were estimated using the annual increase estimate (AIE) calculated using Poisson regression analysis. Cancer incidence in the capital and non-capital areas was calculated by multiplying the nationwide incidence with the population ratio of capital and non-capital areas, which was assessed using KOSIS.

Study endpoints

The primary endpoint was the rate of RT utilization, which was calculated as the number of patients who received RT divided by the number of all cancer patients in the same period. The secondary endpoints of this study were trends in RT utilization according to the modality between 2010 and 2019. The AIE was calculated to quantitatively assess the trends. Changing trends in advanced modality applications, including IMRT and SRT, were specifically assessed. Differences between capital and non-capital regions were assessed in terms of the primary and secondary endpoints. The capital region includes administrative districts including Seoul, Incheon, and Gyeonggi-do, whereas non-capital areas include all other administrative areas.

Statistics

Other than descriptive statistical analyses, the AIE was calculated using Poisson regression analysis. Statistically significant AIE was defined as having a *P* value of less than 0.05. All statistical analyses were performed using SPSS version 20.0 (IBM Inc., New York, NY, USA).

Ethics statement

This study was exempted from ethical review by the institutional review board because this study was conducted using only publicly available data that did not contain any personal information.

RESULTS

Rate of RT utilization from 2010 to 2019

The number of cancer patients in South Korea was 208,154 in 2010, which gradually increased to 235,072 in 2019 (AIE, 0.5%, $P < 0.001$). The rate of RT utilization was 24.5% in 2010, which increased to 36.1% in 2019 (AIE, 4.5%; 95% confidence interval [CI], 4.5, 4.6; $P < 0.001$). In the capital area, the rate of RT utilization was 33.1% in 2010, whereas it was 48.9% in 2019, with an AIE of 4.6% (95% CI, 4.5, 4.7). In the non-capital area, the rate was 16.2% in 2010 and 23.4% in 2019, with an AIE of 4.2% (95% CI, 4.1, 4.4). These data, including the evaluation process, are shown in **Table 2** and **Fig. 1**. The overall number of patients who underwent RT between 2010 and 2019 was 676,035 (**Supplementary Table 1**).

Trend in RT utilization according to specific modalities

From 2010 to 2019 in South Korea, the total number of RT applications was 752,607 (**Table 3**). Among the modalities, 3DCRT was the most commonly used modality (467,133, 62.1%), followed by IMRT (149,417, 19.9%). However, during the study period, the use of 3DCRT steadily decreased, with an AIE of -7.1% (95% CI, -7.1%, -7.0%), whereas that of IMRT increased, with AIE of 33.5% (95% CI, 33.2%, 33.8%). The rate of IMRT utilization was lower than that of 3DCRT until 2018;

Table 2. Rate of RT utilization in cancer patients

Variables	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	AIE (95% CI)	P value
Rate of RT utilization in total cancer patients												
No. of all cancer patients in nation (A)	208,154	222,340	228,093	228,766	220,131	217,272	231,236	232,255	233,873 ^a	235,072 ^a		
National population (B)	49,879,811	50,111,475	50,345,324	50,558,951	50,763,158	50,951,719	51,112,971	51,230,704	51,330,879	51,337,423		
Rate of cancer patients in the whole population (A/B), %	0.417	0.444	0.453	0.452	0.434	0.426	0.452	0.453	0.456	0.458		
No. of patients receiving RT (C) ^b	51,042	55,882	59,533	64,414	64,032	65,232	74,065	74,492	82,405	84,938		
RT utilization rate (C/A), %	24.5	25.1	26.1	28.2	29.1	30.0	32.0	32.1	35.2	36.1	4.5 (4.5-4.6)	< 0.001
Rate of RT utilization in cancer patients in the capital areas												
Population ratio of capital areas (D), %	49.2	49.3	49.3	49.4	49.4	49.4	49.5	49.6	49.8	50.0		
Estimated No. of cancer patients in capital areas (D×A)	102,427	109,510	112,517	112,984	108,778	107,396	114,466	115,188	116,415	117,540		
No. of patients receiving RT in capital area (E)	33,882	37,324	39,233	42,833	42,047	43,216	49,908	50,230	55,176	57,448		
RT utilization rate in capital areas (E/(D×A)), %	33.1	34.1	34.9	37.9	38.7	40.2	43.6	43.6	47.4	48.9	4.6 (4.5-4.7)	< 0.001
Rate of RT utilization in cancer patients in the non-capital areas												
Estimated No. of cancer patients in non-capital areas ((1-D)×A)	105,727	112,830	115,576	115,782	111,353	109,876	116,770	117,067	117,458	117,532		
No. of patients receiving RT in non-capital area (F)	17,160	18,558	20,300	21,581	21,985	22,016	24,157	24,262	27,229	27,490		
RT utilization rate in non-capital areas (F/(1-D)×A), %	16.2	16.4	17.6	18.6	19.7	20.0	20.7	20.7	23.2	23.4	4.2 (4.1-4.4)	< 0.001

AIE = annual increase estimate, RT = radiotherapy, CI = confidence interval.

^aEstimated using Poisson regression analysis of data from 2010 to 2018; ^bMight be small than the number of utilizations owing to re-irradiation in the same patient or adaptive planning (additional planning during a treatment).

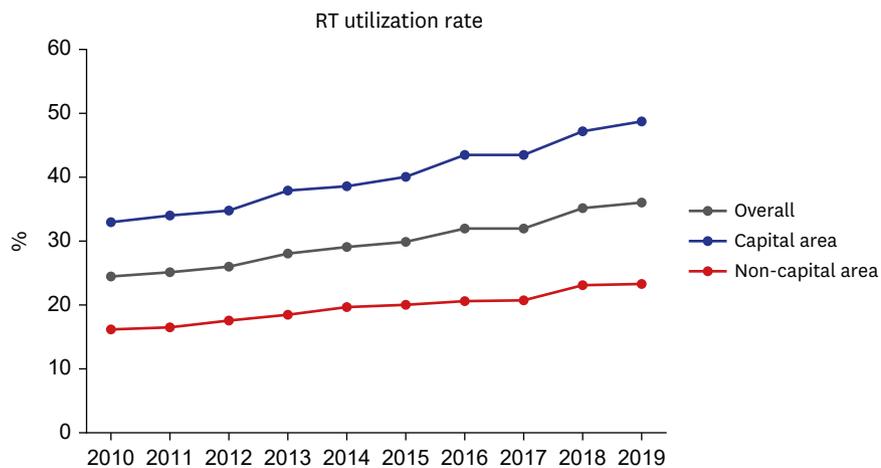


Fig. 1. Rate of RT utilization (number of patients who received RT/number of cancer patients) in total cancer patients and according to region between 2010 and 2019. RT = radiotherapy.

however, the rate of IMRT utilization exceeded that of 3DCRT in 2019 (44.5% vs. 37.2%). Furthermore, the use of SRT and PRT increased, with an AIE of 4.8% (95% CI, 4.5, 5.1) and 49.1% (95% CI, 46.6, 51.7), respectively, whereas that of 2DRT and brachytherapy decreased with an AIE of -26.8% (95% CI, -26.4, -26.2) and -4.1% (95% CI, -4.7, -3.5), respectively. These 10-year trends in RT utilization nationwide are summarized in **Table 3** and **Fig. 2**.

Table 3. Rate of RT utilization according to specific modalities

Modality	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Summation or AIE (95% CI)	P value
No. of utilizations according to specific modalities												
3DCRT	42,942	46,651	47,741	53,142	53,416	51,019	49,477	45,164	41,910	35,671	467,133	
2DRT	6,500	5,356	4,480	4,498	3,897	3,371	2,787	2,045	1,952	1,929	36,815	
IMRT		1,922	5,556	5,991	6,364	9,090	19,157	23,893	34,759	42,685	149,417	
SRT	5,416	5,928	6,123	6,296	6,302	7,675	9,022	9,782	11,943	12,957	81,444	
Brachy	1,277	1,366	1,357	1,453	1,297	1,246	1,408	1,455	1,472	1,540	13,871	
Proton		20	55	50	44	75	613	979	1,018	1,073	3,927	
Grand total	56,135	61,243	65,312	71,430	71,320	72,476	82,464	83,318	93,054	95,855	752,607	
Rate of utilization according to specific modalities, %												
3DCRT	76.5	76.2	73.1	74.4	74.9	70.4	60.0	54.2	45.0	37.2	-7.1 (-7.1, -7.0)	< 0.001
2DRT	11.6	8.7	6.9	6.3	5.5	4.7	3.4	2.5	2.1	2.0	-26.8 (-27.4, -26.2)	< 0.001
IMRT		3.1	8.5	8.4	8.9	12.5	23.2	28.7	37.4	44.5	33.5 (33.2, 33.8)	< 0.001
SRT	9.6	9.7	9.4	8.8	8.8	10.6	10.9	11.7	12.8	13.5	4.8 (4.5, 5.1)	< 0.001
Brachy	2.3	2.2	2.1	2.0	1.8	1.7	1.7	1.7	1.6	1.6	-4.1 (-4.7, -3.5)	< 0.001
Proton		0.0	0.1	0.1	0.1	0.1	0.7	1.2	1.1	1.1	49.1 (46.6, 51.7)	< 0.001

RT = radiotherapy, AIE = annual increase estimate, CI = confidence interval, 3DCRT = 3-dimensional conformal radiotherapy, 2DRT = 2-dimensional radiotherapy, IMRT = intensity-modulated radiotherapy, SRT = stereotactic radiotherapy, Brachy = brachytherapy, Proton = proton therapy.

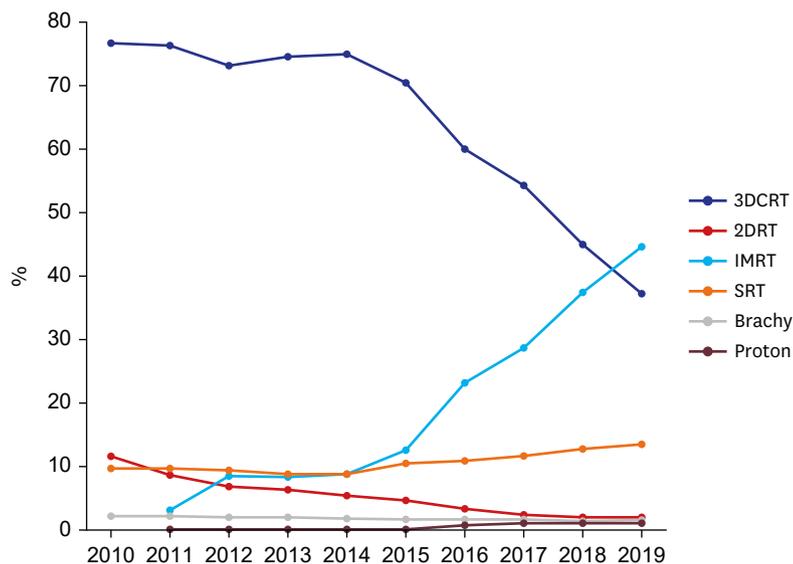


Fig. 2. Rate of RT utilization according to specific RT modality between 2010 to 2019 in South Korea. RT = radiotherapy, 3DCRT = 3-dimensional conformal radiotherapy, 2DRT = 2-dimensional radiotherapy, IMRT = intensity-modulated radiotherapy, SRT = stereotactic radiotherapy, Brachy = brachytherapy, Proton = proton therapy.

Utilization rate of specific RT modalities according to regions

From 2010 to 2019, the total number of RT applications in capital and non-capital areas were 505,841 and 246,766, which comprise 67.2% and 32.8%, respectively, of the nationwide utilization. In capital and non-capital areas, the rate of IMRT utilization was 3.2% and 3.1%, respectively, in 2011 and 45.7% and 42.1%, respectively, in 2019. The rate of IMRT utilization significantly increased in capital and non-capital areas, with an AIE of 33.8% (95% CI, 33.4, 34.2) and 32.9% (95% CI, 32.4, 33.5), respectively. The difference in the AIE between the capital and non-capital areas was significant ($P < 0.001$). The rate of SRT utilization was 11.4% and 6.2% in capital and non-capital areas, respectively, in 2010, which increased to 15.5% and 9.3%, respectively, in 2019. The rate of SRT utilization significantly increased in the capital and non-capital areas, with an AIE of 4.8% (95% CI, 4.5, 5.1) and 4.7% (95% CI, 4.2, 5.3), respectively.

Table 4. Regional comparison of radiotherapy utilization according to specific modalities

Modality	Area	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Summation or AIE (95% CI)	P value	P (difference of AIE)
No. of utilizations according to specific modalities														
3DCRT	Capital	28,296	30,701	30,913	34,850	34,552	32,768	30,930	27,661	25,460	21,424	297,555		
	Non-capital	14,646	15,950	16,828	18,292	18,864	18,251	18,547	17,503	16,450	14,247	169,578		
2DRT	Capital	4,378	3,892	3,363	3,375	2,881	2,532	2,391	1,820	1,700	1,777	28,109		
	Non-capital	2,122	1,464	1,117	1,123	1,016	839	396	225	252	152	8,706		
IMRT	Capital	NA	1,309	3,682	3,998	4,300	6,268	13,860	17,146	24,248	29,762	104,573		
	Non-capital	NA	613	1,874	1,993	2,064	2,822	5,297	6,747	10,511	12,923	44,844		
SRT	Capital	4,283	4,604	4,721	4,730	4,766	5,809	6,991	7,727	9,281	10,091	63,003		
	Non-capital	1,133	1,324	1,402	1,566	1,536	1,866	2,031	2,055	2,662	2,866	18,441		
Brachy	Capital	757	833	761	897	789	767	905	992	975	998	8,674		
	Non-capital	520	533	596	556	508	479	503	463	497	542	5,197		
Proton	Capital	NA	20	55	50	44	75	613	979	1,018	1,073	3,927		
	Non-capital	18,421	19,884	21,817	23,530	23,988	24,257	26,774	26,993	30,372	30,730	246,766		
Grand total	Capital	37,714	41,359	43,495	47,900	47,332	48,219	55,690	56,325	62,682	65,125	505,841		
	Non-capital	18,421	19,884	21,817	23,530	23,988	24,257	26,774	26,993	30,372	30,730	246,766		
Rate of utilization according to specific modalities, %														
3DCRT	Capital	75.0	74.2	71.1	72.8	73.0	68.0	55.5	49.1	40.6	32.9	-8.1 (-8.2, -8.0)	< 0.001	< 0.001
	Non-capital	79.5	80.2	77.1	77.7	78.6	75.2	69.3	64.8	54.2	46.4	-5.2 (-5.4, -5.1)	< 0.001	< 0.001
2DRT	Capital	11.6	9.4	7.7	7.0	6.1	5.3	4.3	3.2	2.7	2.7	-15.4 (-15.8, -15.1)	< 0.001	< 0.001
	Non-capital	11.5	7.4	5.1	4.8	4.2	3.5	1.5	0.8	0.8	0.5	-26.8 (-27.4, -26.2)	< 0.001	< 0.001
IMRT	Capital	NA	3.2	8.5	8.3	9.1	13.0	24.9	30.4	38.7	45.7	33.8 (33.4, 34.2)	< 0.001	< 0.001
	Non-capital	NA	3.1	8.6	8.5	8.6	11.6	19.8	25.0	34.6	42.1	32.9 (32.4, 33.5)	< 0.001	< 0.001
SRT	Capital	11.4	11.1	10.9	9.9	10.1	12.0	12.6	13.7	14.8	15.5	4.8 (4.5, 5.1)	< 0.001	< 0.001
	Non-capital	6.2	6.7	6.4	6.7	6.4	7.7	7.6	7.6	8.8	9.3	4.7 (4.2, 5.3)	< 0.001	< 0.001
Brachy	Capital	2.0	2.0	1.7	1.9	1.7	1.6	1.6	1.8	1.6	1.5	-2.8 (-3.5, -2.0)	< 0.001	< 0.001
	Non-capital	2.8	2.7	2.7	2.4	2.1	2.0	1.9	1.7	1.6	1.8	-6.3 (-7.2, -5.4)	< 0.001	< 0.001
Proton	Capital	NA	0.0	0.1	0.1	0.1	0.2	1.1	1.7	1.6	1.6			

AIE = annual increase estimate, CI = confidence interval, 3DCRT = 3-dimensional conformal radiotherapy, 2DRT = 2-dimensional radiotherapy, IMRT = intensity-modulated radiotherapy, SRT = stereotactic radiotherapy, Brachy = brachytherapy, Proton = proton therapy.

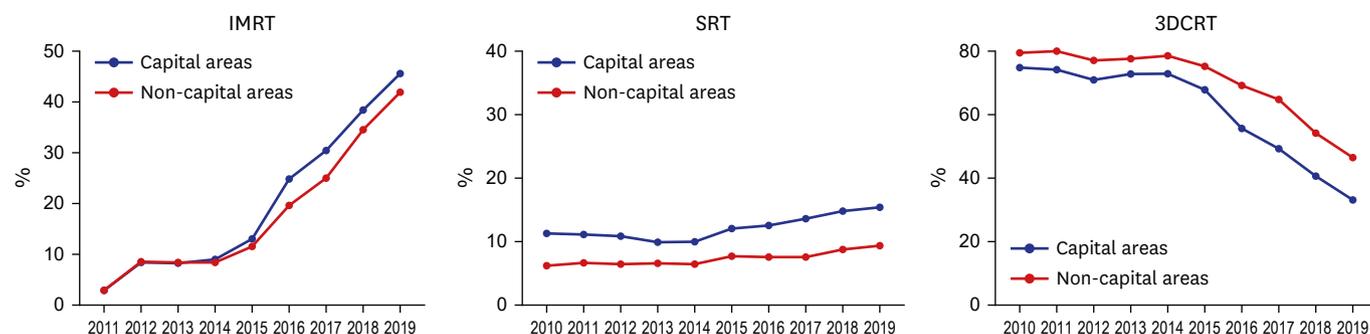


Fig. 3. Rate of advanced modality RT and 3DCRT utilization according to region (capital areas [blue lines] vs. non-capital areas [red lines]). RT = radiotherapy, 3DCRT = 3-dimensional conformal radiotherapy, IMRT = intensity-modulated radiotherapy, SRT = stereotactic radiotherapy.

The difference in the AIE between the areas was significant ($P < 0.001$) despite a small numeral gap of 0.1% between AIEs. The rate of 3DCRT utilization continuously decreased in both the capital and non-capital areas. In the capital and non-capital areas, the rate of 3DCRT utilization was 75% and 79.5%, respectively, in 2010, which decreased to 32.9% and 46.4%, respectively, in 2019, with an AIE of -8.1% (95% CI, $-8.2, -8.0$) and -5.2% (95% CI, $-5.4, -5.1$), respectively. The difference in the AIE between the areas was significant ($P < 0.001$), demonstrating that the decrease was abrupt in the capital area. The comparative data between capital and non-capital areas are summarized in **Table 4**. Trends in the utilization of advanced modalities and 3DCRT are described in **Fig. 3**.

DISCUSSION

In the current study, we have reported the trends in RT utilization according to the modality and region in South Korea from 2010 to 2019. The rate of RT utilization gradually increased from 24.5% (2010) to 36.1% (2019). There was an abrupt increase in the use of IMRT utilization, coupled with a decline in the use of 3DCRT. IMRT has been more widely used than 3DCRT since 2019 and had the highest utilization rate. Moreover, the use of SRT has also been on the rise over the past decade, although increase in its utilization rate has been slower than of IMRT. The AIE regarding the trend toward a decrease in 3DCRT utilization and an increase in IMRT and SRT utilization was significantly higher in the capital area than in the non-capital area.

In the last decade, the rate of RT utilization has increased nationwide, with an AIE of 4.5%, including the capital and non-capital areas, with an AIE of 4.6% and 4.2%, respectively. In 2010, Smith et al.¹⁴ predicted that the demand for RT would increase rapidly from 2010 to 2020, and our results are consistent with the forecast. This growing trend stems from the increase in cancer incidence, which was attributed to the development of medicines, enhancement of quality of life, and a corresponding increase in life expectancy.¹⁵ We observed a steady decline in the percentage of patients receiving 3DCRT (AIE, -7.1%) and an abrupt increase in the percentage of patients receiving IMRT (AIE, 33.5%), a trend similar to that observed in our previous study.¹³ In particular, the rate of IMRT utilization has increased noticeably since 2016, which was associated with the extension of national insurance for IMRT by the NHIS. In 2016, the NHIS announced that the national insurance will cover IMRT for all tumors, if IMRT was implemented to spare an organ at risk or to reduce the irradiated dose to normal organs, aiming to reduce RT complications. In addition, we found that the rate of SRT utilization has increased untiringly in the last decade and has sustained above 10% since 2015. Similar to the reason for increasing IMRT utilization, the increase in SRT utilization was due to the change in the NHIS policy, which expanded the coverage of SRT from craniospinal tumors or inoperable lung cancer to whole body tumors in 2015. In these comprehensive insurance environments, the utilization of advanced RT has grown, indicating that the use of IMRT outpaced that of 3DCRT, and the utilization rate of SRT reached 13.5% in 2019.

These practice changes were the reflection of the increased incidence and the updated practice guidelines of several high incidence malignancies in Korea, which influenced the national insurance policy to be changed accordingly. According to the recent cancer statistics in South Korea, common cancer types, with more than 10,000 new cases per year, included cancers of stomach, colorectum, liver, lung, breast, and prostate (except thyroid cancer).¹⁶ Among them, RT utilization has steadily increased recently in treating cancers of breast, lung, prostate, and liver, in which the advanced RT modalities were commonly utilized. Moreover, along with the increasing proportion of the long-term cancer survivors, the awareness regarding the need to reduce sequelae related to cancer management has emerged.¹⁷ Consequently, the intention of RT has expanded beyond the cure of cancer to include reducing toxicity, which affects patient quality of life.^{9,10,18,19} Therefore, it can be speculated that the use of advanced RT modalities such as IMRT and SRT, which have enabled the irradiation of tumors with high radiation doses and reduced treatment-related toxicity, has increased nationwide. Specifically, IMRT uses advanced planning software and a dynamic multileaf collimator to produce a highly conformal plan that enables dose escalation to tumor and protection to normal organs.^{18,20} SRT delivers high doses precisely

in a short treatment time by implementing numerous beams, frequent use of noncoplanar beam arrangements, use of inhomogeneous dose distributions, and advanced image monitoring,^{21,22} which distinguish SRT from conventional RT. It has been reported that IMRT provides the improvement in therapeutic ratio compared to 3DCRT.²³⁻²⁵ Several meta-analyses demonstrated that IMRT decreases the incidence of radiation-induced toxicities without compromising oncologic outcomes, in the setting of primary treatment application as well as repeated RT courses.²⁶⁻²⁹ IMRT has been used with application rates ranging from 40% to 76% globally, which is on the way to replace conventional RT modality (e.g., 3DCRT).^{15,30,31} SRT started the dissemination for management in a variety of disease sites, including oligometastases and spine, lung, prostate, liver, and head and neck tumors.^{10,32,33} Overall, our study showed that changes in RT practice patterns were directed toward improving tumor control and reducing post-RT complications. Thereafter, to provide optimal advanced RT to cancer patients while executing its unique properties within these increasing utilizations of advanced RT, a strategy related to qualitative evaluation that monitors whether advanced RT is performed while maintaining its quality might be required.³⁴⁻³⁶

We found small gaps in the annual increase of IMRT and/or SRT and correlating gaps in the annual decrease in 3DCRT and 2DRT between the capital and non-capital areas. These differences between the capital and non-capital areas were not associated with inadequate access to advanced medical care in non-capital areas, but they were associated with the concentration of medical institutions in the capital area and patients preference for hospitals located in the capital area,³⁷ which was mentioned in a previous study.¹³ More than 50% of medical resources, in terms of general hospitals and medical doctors, are concentrated in the capital areas of South Korea.²⁶ This phenomenon can be accelerated further as cancer patients become increasingly knowledgeable about their disease and treatment including RT. We should strive to establish balanced settlement of facilities capable of providing advanced RT across South Korea, so that all cancer patients can access optimal treatments with convenience.^{8,38} As application of advanced RT modalities becomes common, efforts to standardize RT techniques and reduce technical difference are necessary, to assure quality of treatment across all regions.

This study has several limitations. Because the claims and reimbursement records from the HIRA include only insured treatment, uninsured patients such as those with benign diseases that are not covered by insurance or foreigners were excluded. In addition, while our data simply examined the national rate of RT utilization according to the modality and region, it did not reflect RT fractionation patterns (e.g., hypofractionation), suggesting the use of RT advances.

In conclusion, our results show the growing utilization of advanced RT during the past 10 years regardless of the administrative region, showing that IMRT adoption ranked the highest and SRT continued to increase as a latecomer. The growth trend of advanced RT applications has reflected the practical implication of RT, which was toward reducing treatment-related toxicity and improving the therapeutic ratio. Accordingly, we should ensure nationwide implementation of advanced RT, which is suitable as a future standard RT modality.

SUPPLEMENTARY MATERIAL

Supplementary Table 1

Number of patients received radiotherapy according to specific modalities

[Click here to view](#)

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