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# A Survey of Radiation Therapy Utilization in Korea from 2010 to 2016: Focusing on Use of Intensity-Modulated Radiation Therapy

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## ABSTRACT

**Background:** This study aimed to assess the recent changes of radiation therapy (RT) modalities in Korea. In particular, we focused on intensity-modulated radiation therapy (IMRT) utilization as the main index, presenting the application status of advanced RT.

**Methods:** We collected information from the Korean Health and Insurance Review and Assessment Service data based on the National Health Insurance Service claims and reimbursements records by using treatment codes from 2010 to 2016. We classified locating region of each institution as capital vs. non-capital areas and metropolitan vs. non-metropolitan areas to assess the regional difference in IMRT utilization in Korea.

**Results:** IMRT use has been steadily increased in Korea, with an annual increase estimate (AIE) of 37.9% from 2011 to 2016 ( $P < 0.001$ ) resulting in IMRT being the second most common RT modality following three-dimensional conformal radiotherapy. In general, an increasing trend of IMRT utilization was observed, regardless of the region. The rate of AIE in the capital areas or metropolitan areas was higher than that in non-capital areas or non-metropolitan areas (40.7% vs. 31.9%;  $P < 0.001$  and 39.7% vs. 29.4%;  $P < 0.001$ , respectively).

**Discussion:** The result of our survey showed that IMRT has become one of the most common RT modalities. IMRT is becoming popular in both metropolitan and non-metropolitan areas, while metropolitan area has faster AIE possibly due to concentration of medical resources and movement of advanced patients.

**Keywords:** Radiotherapy; Intensity-Modulated Radiation Therapy; Utilization; Korea

## INTRODUCTION

The techniques of radiation therapy (RT) have rapidly progressed in the recent decades. Among the most remarkable techniques is intensity-modulated radiation therapy (IMRT), which uses advanced planning software and the dynamic multileaf collimator to produce a highly conformal plan.<sup>1</sup> The superior target conformality of IMRT enables dose escalation to tumor, which results in better tumor control without an increase of treatment-related

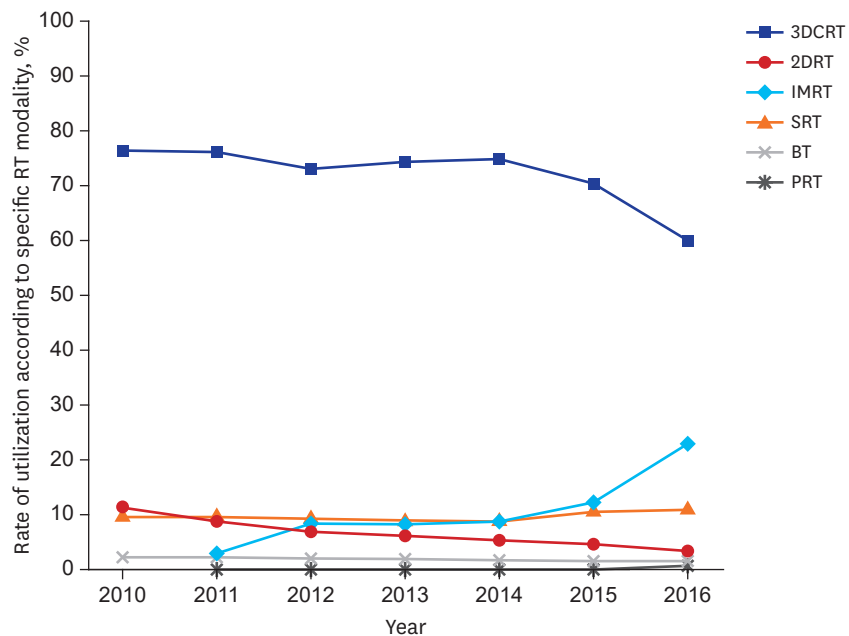




**Table 2.** Distribution of RT in Korea from 2010 to 2016 according to specific modalities

	2010	2011	2012	2013	2014	2015	2016	AIE (95% CI)	P
Number of utilization according to specific modalities									
3DCRT	42,941	46,652	47,740	53,142	53,433	51,020	49,481	-	-
2DRT	6,500	5,355	4,480	4,499	3,899	3,372	2,787	-	-
IMRT	-	1,921	5,556	5,992	6,369	9,091	19,156	-	-
SRT	5,416	5,928	6,123	6,296	6,307	7,675	9,023	-	-
BT	1,276	1,366	1,357	1,454	1,298	1,247	1,408	-	-
PRT	-	20	55	50	44	75	613	-	-
Total	56,133	61,242	65,311	71,433	71,350	72,480	82,468	-	-
Rate of utilization according to specific modalities, %									
3DCRT	76.5	76.2	73.1	74.4	74.9	70.4	60.0	-3.1 (± 0.2)	< 0.001
2DRT	11.6	8.7	6.9	6.3	5.5	4.7	3.4	-17.0 (± 0.5)	< 0.001
IMRT	-	3.1	8.5	8.4	8.9	12.5	23.2	37.9 (± 0.8)	< 0.001
SRT	9.6	9.7	9.4	8.8	8.8	10.6	10.9	2.2 (± 0.5)	< 0.001
BT	2.3	2.2	2.1	2.0	1.8	1.7	1.7	-5.2 (± 1.0)	< 0.001
PRT	-	0.0	0.1	0.1	0.1	0.1	0.7	114.1 (± 13.7)	< 0.001

RT = radiation therapy, AIE = annual increase estimate, CI = confidence interval, 3DCRT = three-dimensional conformal radiation therapy, 2DRT = two-dimensional radiation therapy, IMRT = intensity-modulated radiation therapy, SRT = stereotactic radiotherapy, BT = brachytherapy, PRT = proton therapy.



**Fig. 1.** Rate of RT utilization from 2010 to 2016 according to specific RT modalities. RT = radiation therapy, 3DCRT = three-dimensional conformal radiation therapy, 2DRT = two-dimensional radiation therapy, IMRT = intensity-modulated radiation therapy, SRT = stereotactic radiotherapy, BT = brachytherapy, PRT = proton therapy.

**IMRT utilization between the capital and non-capital areas from 2010 to 2016**

RT utilization in both the capital and non-capital areas is shown in Table 3. A total of 67% (321,734/480,417) of RTs was performed in the capital area. The proportion of RT utilization in the capital area during the past 7 years ranged from 66% to 68%. In terms of IMRT utilization, a steady increasing trend ( $P < 0.001$ , Fig. 2A) was noted from 2010 to 2016, in both capital and non-capital areas. Considering AIE from 2010 to 2016 between the capital and non-capital areas, the rate of AIE in the capital area was higher than that in non-capital areas (40.7% vs. 31.9%;  $P < 0.001$ ).

Table 3. Comparison of RT utilization between capital and non-capital areas

		2010	2011	2012	2013	2014	2015	2016	AIE (95% CI)	P	P (difference of AIE)
Number of utilization according to specific modalities											
3DCRT	Capital area	28,296	30,701	30,913	34,850	34,566	32,768	30,930	-	-	-
	Non-capital area	14,645	15,951	16,827	18,292	18,867	18,252	18,551	-	-	-
2DRT	Capital area	4,378	3,892	3,363	3,375	2,882	2,532	2,391	-	-	-
	Non-capital area	2,122	1,463	1,117	1,124	1,017	840	396	-	-	-
IMRT	Capital area	-	1,309	3,682	3,998	4,305	6,268	13,860	-	-	-
	Non-capital area	-	612	1,874	1,994	2,064	2,823	5,296	-	-	-
SRT	Capital area	4,283	4,604	4,721	4,730	4,771	5,809	6,991	-	-	-
	Non-capital area	1,133	1,324	1,402	1,566	1,536	1,866	2,032	-	-	-
BT	Capital area	757	833	761	897	789	767	905	-	-	-
	Non-capital area	519	533	596	557	509	480	503	-	-	-
	Total (capital area)	37,714	41,359	43,495	47,900	47,357	48,219	55,690	-	-	-
	Total (non-capital area)	18,419	19,883	21,816	23,533	23,993	24,261	26,778	-	-	-
	Grand total	56,133	61,242	65,311	71,433	71,350	72,480	82,468	-	-	-
Rate of utilization according to specific modalities, %											
3DCRT	Capital area	75.0	74.2	71.1	72.8	73.0	68.0	55.5	-3.7 (± 0.2)	< 0.001	< 0.001
	Non-capital area	79.5	80.2	77.1	77.7	78.6	75.2	69.3	-1.9 (± 0.3)	< 0.001	< 0.001
2DRT	Capital area	11.6	9.4	7.7	7.0	6.1	5.3	4.3	-14.6 (± 0.6)	< 0.001	< 0.001
	Non-capital area	11.5	7.4	5.1	4.8	4.2	3.5	1.5	-23.7 (± 0.9)	< 0.001	< 0.001
IMRT	Capital area	-	3.2	8.5	8.3	9.1	13.0	24.9	40.7 (± 1.0)	< 0.001	< 0.001
	Non-capital area	-	3.1	8.6	8.5	8.6	11.6	19.8	31.9 (± 1.3)	< 0.001	< 0.001
SRT	Capital area	11.4	11.1	10.9	9.9	10.1	12.0	12.6	1.9 (± 0.6)	< 0.001	< 0.001
	Non-capital area	6.2	6.7	6.4	6.7	6.4	7.7	7.6	3.5 (± 1.0)	< 0.001	< 0.001
BT	Capital area	2.0	2.0	1.7	1.9	1.7	1.6	1.6	-4.0 (± 0.8)	< 0.001	< 0.001
	Non-capital area	2.8	2.7	2.7	2.4	2.1	2.0	1.9	-7.2 (± 1.6)	< 0.001	< 0.001

Proton therapy was performed in the capital area only.

RT = radiation therapy, AIE = annual increase estimate, CI = confidence interval, 3DCRT = three-dimensional conformal radiation therapy, 2DRT = two-dimensional radiation therapy, IMRT = intensity-modulated radiation therapy, SRT = stereotactic radiotherapy, BT = brachytherapy.

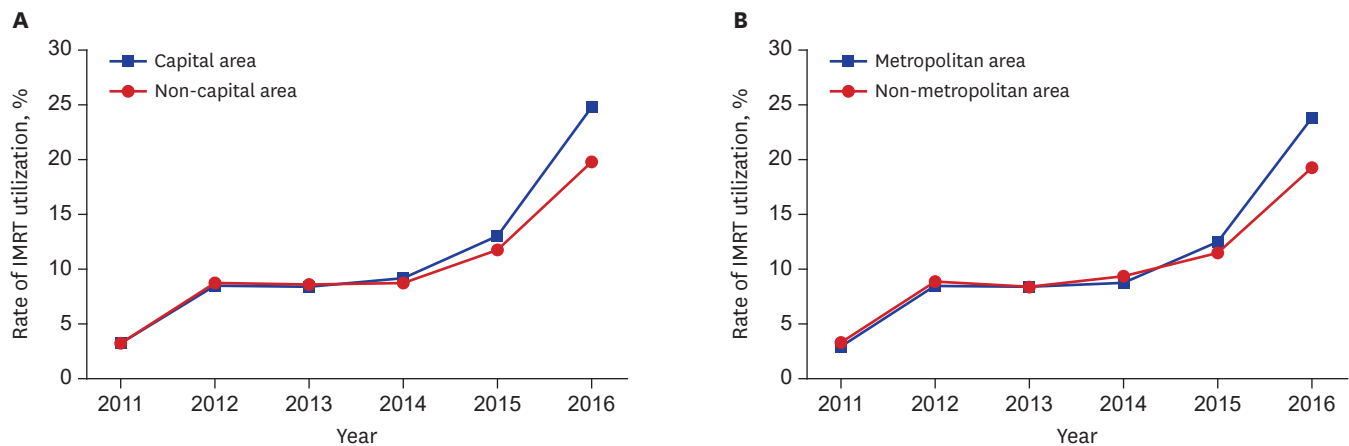


Fig. 2. Utilization of IMRT from 2010 to 2016. (A) between the capital and non-capital areas, (B) between metropolitan and non-metropolitan areas. IMRT = intensity-modulated radiation therapy.

### IMRT utilization between metropolitan and non-metropolitan areas from 2010 to 2016

Table 4 shows the comparison of RT modality utilization between the metropolitan and non-metropolitan areas. A total of 86% (410,771/480,417) of RTs was performed in the metropolitan areas. The proportion of RT utilization in the metropolitan areas was consistent per year, ranging from 85% to 86%. With respect to IMRT utilization, increasing patterns were observed in both metropolitan and non-metropolitan areas ( $P < 0.001$ , Fig. 2B), which is similar to the results for comparison of RT utilization between capital and non-capital

**Table 4.** Comparison of RT utilization between metropolitan and non-metropolitan areas

		2010	2011	2012	2013	2014	2015	2016	AIE (95% CI)	P	P (difference of AIE)
Number of utilization according to specific modalities											
3DCRT	Metropolitan	36,481	39,579	40,036	44,690	44,813	42,327	40,812	-	-	-
	Non-metropolitan	6,460	7,073	7,704	8,452	8,620	8,693	8,669	-	-	-
2DRT	Metropolitan	5,775	5,012	4,266	4,351	3,726	3,229	2,728	-	-	-
	Non-metropolitan	725	343	214	148	173	143	59	-	-	-
IMRT	Metropolitan	-	1,628	4,699	5,143	5,382	7,825	16,828	-	-	-
	Non-metropolitan	-	293	857	849	987	1,266	2,328	-	-	-
SRT	Metropolitan	4,962	5,390	5,568	5,774	5,759	6,980	8,254	-	-	-
	Non-metropolitan	454	538	555	522	548	695	769	-	-	-
BT	Metropolitan	1,056	1,139	1,118	1,240	1,100	1,048	1,196	-	-	-
	Non-metropolitan	220	227	239	214	198	199	212	-	-	-
Total (metropolitan)		48,274	52,768	55,742	61,248	60,824	61,484	70,431	-	-	-
Total (non-metropolitan)		7,859	8,474	9,569	10,185	10,526	10,996	12,037	-	-	-
Grand total		56,133	61,242	65,311	71,433	71,350	72,480	82,468	-	-	-
Rate of utilization according to specific modalities, %											
3DCRT	Metropolitan	75.6	75.0	71.8	73.0	73.7	68.8	57.9	-3.4 (± 0.2)	< 0.001	< 0.001
	Non-metropolitan	82.2	83.5	80.5	83.0	81.9	79.1	72.0	-1.8 (± 0.4)	< 0.001	< 0.001
2DRT	Metropolitan	12.0	9.5	7.7	7.1	6.1	5.3	3.9	-15.7 (± 0.5)	< 0.001	< 0.001
	Non-metropolitan	9.2	4.0	2.2	1.5	1.6	1.3	0.5	-36.2 (± 1.7)	< 0.001	< 0.001
IMRT	Metropolitan	-	3.1	8.4	8.4	8.8	12.7	23.9	39.4 (± 0.9)	< 0.001	< 0.001
	Non-metropolitan	-	3.5	9.0	8.3	9.4	11.5	19.3	29.4 (± 2.0)	< 0.001	< 0.001
SRT	Metropolitan	10.3	10.2	10.0	9.4	9.5	11.4	11.7	2.4 (± 0.5)	< 0.001	< 0.001
	Non-metropolitan	5.8	6.3	5.8	5.1	5.2	6.3	6.4	1.0 (± 1.6)	0.189	
BT	Metropolitan	2.2	2.2	2.0	2.0	1.8	1.7	1.7	-4.6 (± 0.9)	< 0.001	< 0.001
	Non-metropolitan	2.8	2.7	2.5	2.1	1.9	1.8	1.8	-8.4 (± 2.3)	< 0.001	< 0.001

Proton therapy was performed in the metropolitan area only.

RT = radiation therapy, AIE = annual increase estimate, CI = confidence interval, 3DCRT = three-dimensional conformal radiation therapy, 2DRT = two-dimensional radiation therapy, IMRT = intensity-modulated radiation therapy, SRT = stereotactic radiotherapy, BT = brachytherapy.

areas. The metropolitan areas showed a higher AIE of IMRT use than non-metropolitan areas (39.7% vs. 29.4%;  $P < 0.001$ ).

## DISCUSSION

This survey assessed the utilization of RT, specifically IMRT, and its comparison between regional areas with socioeconomic differences. In our analysis of IMRT utilization in Korea from 2010 to 2016, an increasing trend of IMRT use was predominant. Presently, advances in RT techniques have significantly altered the RT implementation landscape.<sup>20-22</sup> The benefits of IMRT, such as reducing toxicity, maximizing quality of life, and maintaining disease control,<sup>1,6,8,9,20</sup> contributed to the change in RT practice.

We observed that the utilization of IMRT showed a steady increase from 2012 to 2015, with an abrupt increase from 2011 to 2012 and from 2015 to 2016. In particular, IMRT utilization in Korea increased by an average rate of 1.3% between 2012 and 2015, by 5.4% from 2011 to 2012, and by 10.7% from 2015 to 2016. In 2011, the Korean NHIS announced that the national insurance will cover IMRT for patients with head and neck cancer, prostate cancer, brain tumor, spinal tumor, and recurrent or persistent tumors previously treated with RT. Thereafter, in 2016, NHIS announced subsequently that the national insurance on IMRT will cover all tumors if IMRT was implemented to spare an organ at risk or to reduce irradiated dose to normal organ. As such, the remarkable growth of IMRT use at both periods was associated with the extension of the national insurance for IMRT utilization by the NHIS.

Notably, the increasing pattern of IMRT use has been found in all institutions across Korea, regardless of the geographical region that encompasses and socioeconomic differences. As previously mentioned, the Korean NHIS covers more than 98% of the population.<sup>18</sup> It facilitates patient access to advanced medical care by reducing the economic burden and leads to the implementation of advanced medical treatment in each institution.<sup>21,23</sup> Korea's universal healthcare system has lowered the socioeconomic barriers to advanced medical services, such as IMRT. However, in the current survey, a difference was noted in the increasing degree of IMRT utilization. The capital and the metropolitan areas had higher AIE of IMRT utilization than non-capital areas and non-metropolitan areas (40.7% vs. 31.9% and 39.7% vs. 29.4%, respectively). These differences were associated with both the concentration of medical institutions and the movement of patients who have advanced disease and are candidates for recent treatment from non-capital areas or non-metropolitan areas to urban areas depending on their willingness, rather than inadequate access to advanced medical care.<sup>15,24</sup>

The increase in use of IMRT is a global trend. Mell et al.<sup>25</sup> reported that only 32% of radiation oncologists in the United States used IMRT in 2002, whereas 73.2% used IMRT in 2004.<sup>26</sup> In the United Kingdom, 45.8% of radiation oncology centers performed IMRT in 2007<sup>27</sup> and 76% in 2010.<sup>28</sup> In Canada, only 37% of radiation oncology centers implemented IMRT in 2006, whereas 72% of these centers performed IMRT for all patients who could benefit from the treatment in 2010.<sup>29</sup> In our study, the rate of IMRT use in Korea has steadily increased, but it was only 23.2% in 2016, which is still lower than the rates in the abovementioned countries. This suggests that the treatment efficiency of RT can be improved with continuous increase of IMRT treatment in Korea.

Our study has several limitations. Because the claims and reimbursement records from the HIRA include only the insured treatment, uninsured cases, including uninsured benign disease or RT for foreign patients, cannot be analyzed. Thus, the total number of RT utilization in this survey might be smaller than the actual number of implemented treatment. Moreover, we assumed that the use of IMRT can be an indicator of the accessibility of advanced medical care because possession of the equipment capable of IMRT is directly connected to the socioeconomic burden of each institution. Therefore, we hypothesized that IMRT implementation implied a strong commitment to perform recent treatments. However, we also agree that this hypothesis has its limitations because it was strongly related to the viewpoint of radiation oncologists.

In conclusion, the number of patients who received IMRT in Korea has shown a steady increase in the past 6 years. Furthermore, the increasing trend of IMRT utilization had the same patterns regardless of geographical region with political and socioeconomic difference, although the rate of increase varied. Regarding the increase of IMRT utilization being a global trend, this survey detailed the status of IMRT implementation and showed that IMRT has become one of the most common RT modalities for cancer treatment in Korea.

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