

A cost-minimization analysis of measures against metallic dental restorations for head and neck radiotherapy

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ABSTRACT

The aim of this study was to compare the estimated public medical care cost of measures to address metallic dental restorations (MDRs) for head and neck radiotherapy using high-energy mega-voltage X-rays. This was considered a first step to clarify which MDR measure was more cost-effective. We estimated the medical care cost of radiotherapy for two representative MDR measures: (i) with MDR removal or (ii) without MDR removal (non-MDR removal) using magnetic resonance imaging and a spacer. A total of 5520 patients received head and neck radiation therapy in 2018. The mean number of MDRs per person was 4.1 dental crowns and 1.3 dental bridges. The mean cost per person was estimated to be 121 720 yen for MDR removal and 54 940 yen for non-MDR removal. Therefore, the difference in total public medical care cost between MDR removal and non-MDR removal was estimated to be 303 268 800 yen. Our results suggested that non-MDR removal would be more cost-effective than MDR removal for head and neck radiotherapy. In the future, a national survey and cost-effectiveness analysis via a multicenter study are necessary; these investigations should include various outcomes such as the rate of local control, status of oral mucositis, frequency of hospital visits and efforts of the medical professionals.

Keywords: head and neck radiotherapy; public medical care cost; metallic dental restoration; mouthpiece; magnetic resonance imaging

INTRODUCTION

During head and neck radiotherapy, metallic dental restorations (MDRs) within the radiation field may lead to less accurate radiotherapy. This is due not only to exacerbation of oral mucositis caused by backscatter radiation from MDRs [1, 2], but also to uncertainty

caused by metal artifacts in contouring the target volumes (TVs) such as primary tumor location and organs at risk (OARs) [3, 4].

It is well known that using a mouthpiece as a spacer and magnetic resonance imaging (MRI) are useful tools to counteract backscatter radiation [5–8] and metal artifacts [8–10], respectively. In Japan, the

radiotherapy planning guidelines of the Japanese Society for Radiation Oncology (JASTRO) recommend either MDR removal or non-MDR removal, as differing measures against MDRs for external beam radiotherapy using high-energy mega-voltage X-rays [11]. With MDR removal, radiotherapy treatment planning and actual treatment are conducted after removing MDRs. If MDRs are not removed (non-MDR removal), radiotherapy treatment planning is conducted by using MRI to identify the TVs and OARs. This is done after replacing the Hounsfield units (HUs) of the pixels in the streaks resulting from the presence of MDRs by the HUs of a soft tissue class or water class, as far as possible. After treatment planning, non-MDR removal is performed by inserting a mouthpiece as a spacer to prevent exacerbation of oral mucositis caused by backscatter radiation. As the JASTRO guidelines have recommendations for both MDR removal and non-MDR removal, measures against MDRs differ in each hospital in Japan [12]. Partly because of current efforts to eliminate cancer care disparities and to appropriately contain medical care costs, it is important to clarify the costs of MDR removal and non-MDR removal. Therefore, this study aimed to compare the public medical care costs of MDR removal and non-MDR removal to clarify which measure was more cost-effective for managing MDRs in head and neck radiotherapy.

MATERIALS AND METHODS

The number of patients with head and neck cancer, the number of MDRs per person and calculation of the public medical care cost referred to the 2018 Japanese Radiation Oncology Database, the 2016 Survey of Dental Diseases of the Ministry of Health, Labour and Welfare, and the 2020 table of dental or medical fee points of the Ministerial Notification No. 57 of the Ministry of Health, Labour and Welfare, respectively.

The eligible age group for the cost estimation was set at 40–79 years old, because this age group accounted for >95% of all head and neck cancer registrants in the 2017 Report of Head and Neck Cancer Registry of Japan Clinical Statistics of Registered Patients by the Cancer Registry Committee of the Japanese Society for Head and Neck Cancer,

The public medical care cost of MDR removal was calculated based on dental crowns and dental bridges that were most likely to generate problematic strong metal artifacts, excluding dental fillings such as dental inlays. The 2016 Survey of Dental Diseases of the Ministry of Health did not describe the location of MDRs and the number of missing teeth. Thus, the refabricated dental crowns and dental bridges (commonly used for MDRs) were assumed to be the molar crowns and the bridge between the second premolar and second molar that had the first molar missing, respectively. The materials used for MDRs, the impression method and setting material were assumed to be Au–Pd full metal, combined impression and standard glass ionomer cement, respectively. In addition, we adopted the typical dental fee points to calculate the estimated cost of MDR removal.

In non-MDR removal, the MRI equipment was assumed to be the widely used 1.5–3.0 Tesla MRI scanner. It was also assumed that mouthpieces to use as a spacer were fabricated for the upper and lower jaw. A cost-minimization analysis was used to compare the public medical care costs of MDR removal and non-MDR removal procedures.

Table 1. The estimated number of the metallic dental restorations per person

Age (years)	Mean number per person
Dental crowns	
40–79	4.1
40–49	2.9
50–59	4.4
60–69	4.6
70–79	4.4
Dental bridges	
40–79	1.3
40–49	0.5
50–59	1.3
60–69	1.8
70–79	1.7

RESULTS AND DISCUSSION

A total of 5520 patients (4192 males and 1326 females) received head and neck radiation therapy in 2018.

Table 1 shows the estimated mean number of MDRs per person in each age group from 40 to 79 years old. The estimated mean number of MDRs per person in the entire age group was 4.1 dental crowns and 1.3 dental bridges.

Including MDRs in the radiation field may induce dose alterations, with dose enhancement and dose attenuation that cannot be accurately computed on a treatment planning system (TPS) [5, 13]. Therefore, there is concern that these dose alterations may potentially lead to severe oral mucositis and the survival of malignant cells. Moreover, metal artifacts from MDRs may negatively impact the consistency of delineation [3, 4] and cause imprecise or incorrect dose calculation [14] in radiation treatment planning. Therefore, metal artifacts from MDRs may potentially lead to decreased accuracy of the radiation treatment plan. However, concerns about having MDRs included in the radiation field are addressed by using a 3–5 mm thick mouthpiece as a spacer to avoid dose alteration areas [5–8] and adding MRI to identify the TVs and the OARs [8–10].

Based on these considerations, we assumed that there was no difference in the local control rate and the incidence rate or severity of oral mucositis between MDR removal and non-MDR removal. Thus, we used a cost-minimization analysis for this preliminary study. Table 2 shows the typical dental and medical fee points for each required process for non-MDR removal and MDR removal. Based on Table 2, the public medical care costs were estimated. Table 3 shows the minimum estimated public medical care costs of non-MDR removal and MDR removal. The mean cost per person was estimated to be 121 720 yen for MDR removal and 54 940 yen for non-MDR removal. Moreover, for all patients who received head and neck radiotherapy with MDR removal, the public medical care cost per year was estimated at a total of 671 894 400 yen. Alternatively, if all patients received head and neck radiotherapy with non-MDR removal, the public medical care cost was 303 268 800 yen. Therefore, the difference in the public medical care cost between MDR removal and non-MDR removal was estimated to be 368 625 600 yen. Based on our estimated results, it is suggested

Table 2. Typical dental and medical fee points of each procedure required for non-MDR removal and MDR removal

Non-MDR removal		MDR removal	
The public medical care fee point (points)			
Fabrication of mouthpiece		Removal of MDR	
Dental impression	222	Dental crown	42
Oral device	1500	Dental bridge	126
Fitting fee	150		
MRI examination		Refabrication of MDR	
MRI (1.5–3.0 Tesla)	1330	Dental crown	
Computer diagnosis addition	450	Crown preparation	166
Digital image addition	120	Dental impression fee	64
		Bite registration fee	18
		Crown restoration material fee	1187
		Setting fee	45
		Setting material fee	10
		Dental bridge	
		Crown preparation (two teeth)	332
		Dental impression fee	282
		Bite registration fee	76
		Retainer	100
		Crown restoration material fee (two teeth)	2166
		Pontic fee	1278
		Setting fee	150
		Setting material fee (two teeth)	20

MDR = metal dental restoration, MRI = magnetic resonance imaging.

The MDR material, impression method and setting material were assumed to be an Au–Pd full metal crown, a combined impression and a standard glass ionomer cement, respectively. In addition, the refabricated dental crowns and dental bridges were assumed to be the molar crowns and the bridge between the second premolar and second molar that had the first molar missing, respectively.

that the non-MDR removal as a measure against MDRs for head and neck radiotherapy is more cost-effective than MDR removal. However, our study did not consider the costs of working time and effort of HU replacement to delineate the TVs and OARs in radiotherapy treatment planning with non-MDR and, although the probability is lower than for computed tomography (CT), MRI may generate metal-induced artifacts. Therefore, it is believed that consensus from medical professionals involved in head and neck radiotherapy planning, such as radiation oncologists, medical physicists and radiation treatment technologists, would be necessary at the least.

According to the 2019 Trends in Medical Care Expenditure of the Ministry of Health, Labour and Welfare [15], the national medical care expenditure and the national dental care expenditure in terms of the public medical care cost were ~43.6 trillion yen and 3.2 trillion yen, respectively. The estimated difference in public medical care cost between MDR removal and non-MDR removal was <0.00001% of the national medical care expenditure and <0.0002% of the national dental care expenditure, thereby having a minor influence on these care expenditures. However, the estimated difference in public medical care cost between MDR removal and non-MDR removal per person (66 780 yen) was 19.4% of the national medical care expenditure per person (345 000 yen) and 2.8 times the national dental care expenditure per person (24 000 yen). Therefore, it is believed that the estimated difference in public medical care cost between MDR removal and non-MDR removal is an issue that should be considered.

It has been reported that patients with head and neck cancer generally have a poor oral health status [16, 17]. A previous study in Japan reported that removal of MDRs for head and neck radiation therapy required the removal of an average of 14.4 teeth per person [18]. This number was higher than the number used in our study to estimate the public medical care cost. Therefore, the actual difference in the public medical care cost between MDR removal and non-MDR removal may be even higher than estimated. Additionally, this previous study also reported that dental visits for the removal of MDRs required from 2 to 4 days (mean 3.4 days) [18]. Alternatively, the maximum time for dental visits for mouthpiece fabrication and MRI scans was 3 days; thus, it was also suggested that a patient's burden associated with visits for non-MDR removal was less than that required for MDR removal.

Some professional societies [7, 8] have recommended non-MDR removal as a measure against MDRs for head and neck radiotherapy without addressing MDR removal. On the other hand, the radiotherapy planning guidelines of JASTRO recommend both non-MDR removal and MDR removal, and provide specifics about each process. This may be because the Japanese public healthcare insurance system is a universal health insurance system, and a patient's self-pay ratio of medical care cost is relatively low.

In a systematic literature review of the economic burden of head and neck cancer, intensity-modulated radiotherapy (IMRT) was associated with significantly higher total treatment costs than conventional radiotherapy and surgery [19]. Nevertheless, IMRT has been selected

Table 3. Estimated public medical care costs per person and the total public medical care cost per year

Non-MDR removal (two devices, one MRI scan)		MDR removal (4.1 crowns, 1.3 bridges)	
The public medical care cost per person (yen)			
Fabrications of mouthpieces		Removals of MDRs	
Dental impression	4440	Dental crowns	1720
Oral device	30 000	Dental bridges	1640
Fitting fee	1500		
MRI examination		Refabrications of MDRs	
MRI (1.5–3.0 Tesla)	13 300	Dental crowns	
Computer diagnosis addition	4500	Crown preparation	6810
Digital image addition	1200	Dental impression fee	2620
		Bite registration fee	740
		Crown restoration material fee	48 670
		Setting fee	1850
		Setting material fee	410
		Dental bridges	
		Crown preparation	44 320
		Dental impression fee	34 670
		Bite registration fee	990
		Retainer	1300
		Crown restoration material fee	28 160
		Pontic fee	16 610
		Setting fee	1950
		Setting material fee	260
Total	54 940	Total	121 720
The total public medical care cost a year (yen, $n = 5520$)			
	303 268 800		671 894 400
The difference between non-MDR removal and MDR removal for total public medical cost per year			
			368 625 600

MDR = metal dental restoration, MRI = magnetic resonance imaging.

The MDR material, impression method and setting material were assumed to be an Au–Pd full metal crown, a combined impression and a standard glass ionomer cement, respectively. In addition, the refabricated dental crowns and dental bridges were assumed to be the molar crowns and the bridge between the second premolar and second molar that had the first molar missing, respectively.

as the treatment method in many cases, because it has the potential for higher tumor control or lower treatment-related complications with IMRT. Our study suggests that non-MDR removal may be more cost-effective than MDR removal as a measure for MDRs for head and neck radiotherapy. However, it is necessary to evaluate whether the difference in public medical care cost between them is acceptable. Therefore, in the future, a national survey and cost-effectiveness analysis via a multicenter study are necessary; these investigations should include various outcomes such as the rate of local control, status of oral mucositis, frequency of hospital visits and efforts of the medical professionals.

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CONFLICT OF INTEREST

There are no conflicts of interest to declare.

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PRESENTATION AT A CONFERENCE

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