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

Kouji Katsura1,2,*, Yoshihiko Soga3, Sadatomo Zenda4, Hiromi Nishi5, Marie Soga1, Masatoshi Usubuchi6, Sachiyo Mitsunaga7, Ken Tomizuka8, Tetsuhito Konishi9, Wakako Yatsuoka10, Takao Ueno10, Tadanobu Aragaki11 and Takafumi Hayashi1,2

1Department of Oral Radiology, Niigata University Medical and Dental Hospital, Japan
2Division of Oral and Maxillofacial Radiology, Faculty of Dentistry and Graduate School of Medical and Dental Sciences, Niigata University, Japan
3Division of Hospital Dentistry, Okayama University Hospital, Japan
4Department of Radiation Oncology, National Cancer Center Hospital East, Japan
5Department of General Dentistry, Hiroshima University Hospital, Japan
6Department of Dentistry, Miyagi Cancer Center, Japan
7Department of Oral and Maxillofacial Surgery, Kanagawa Cancer Center, Japan
8Department of Dentistry, The Cancer Institute Hospital of Japanese Foundation for Cancer Research, Japan
9Department of Dentistry, National Cancer Center Hospital East, Japan
10Dental Division, National Cancer Center Hospital, Japan
11Division of Dentistry and Oral Surgery, Gunma Prefectural Cancer Center, Japan

*Corresponding author: Division of Oral and Maxillofacial Radiology, Faculty of Dentistry and Graduate School of Medical and Dental Sciences, Niigata University, 2-5274 Gakkocho-dori, Chuou-ku, Niigata City, Niigata 951-8514, Japan. Tel: +81-25-227-0810; Email: katsu@dent.niigata-u.ac.jp

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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. 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. 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.

### 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). 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 and cause imprecise or incorrect dose calculation 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 and adding MRI to identify the TVs and the OARs.

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

| Age (years) | Mean number per person |
|-------------|------------------------|
| 40–49       | 2.9                    |
| 50–59       | 4.4                    |
| 60–69       | 4.6                    |
| 70–79       | 4.4                    |
| 40–79       | 4.1                    |
| 40–49       | 0.5                    |
| 50–59       | 1.3                    |
| 60–69       | 1.8                    |
| 70–79       | 1.7                    |
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)** | **Removal of MDR** |
| Fabrication of mouthpiece | Dental crown |
| Dental impression | 222 | 42 |
| Oral device | 1500 | 126 |
| Fitting fee | 150 | |
| **MRI examination** | **Oral device** |
| MRI (1.5–3.0 Tesla) | 1330 | |
| Computer diagnosis addition | 450 | |
| Digital image addition | 120 | |
| **Crown restoration material fee** | **Setting fee** |
| 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.

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)** | **Removals of MDRs** |
| Fabrications of mouthpieces                | Dental crowns 1720                  |
| Dental impression                          | Dental bridges 1640                 |
| Oral device                                |                                      |
| Fitting fee                                |                                      |
| MRI examination                            |                                      |
| MRI (1.5–3.0 Tesla)                        | Crowns preparation 6810             |
| Computer diagnosis addition                | Dental impression fee 2620           |
| Digital image addition                     | Bite registration fee 740            |
|                                           | Crown restoration material fee 48 670|
|                                           | Setting fee 1850                     |
|                                           | Setting material fee 410             |
| **Total**                                  | **Total**                            |
| 54 940                                     | 121 720                              |

The total public medical care cost per 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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