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Review Article

# The role of dentistry other than oral care in patients undergoing radiotherapy for head and neck cancer

Hidenobu Matsuzaki[a,b,*], Kumiko Tanaka-Matsuzaki[b,c], Fuminobu Miyazaki[b,d], Hideki Aoyama[e], Hiroki Ihara[f], Norihisa Katayama[f], Kuniaki Katsui[b,f], Kengo Himei[g], Tetsuo Takeuchi[b,d], Tomoo Onoda[b,h], Yoshihiro Kimata[b,i], Jun-ichi Asaumi[a,b,j]

[a] *Department of Oral Diagnosis and Dentomaxillofacial Radiology, Okayama University Hospital, Japan*
[b] *Okayama University Hospital Head and Neck Cancer Center, Japan*
[c] *Caries Department, Okayama University Hospital, Japan*
[d] *Room for Dental Laboratory, Okayama University Hospital, Japan*
[e] *Central Division of Radiology, Okayama University Hospital, Japan*
[f] *Department of Radiology, Okayama University Hospital, Japan*
[g] *Department of Radiology, Japanese Red Cross Society Okayama Hospital, Japan*
[h] *Department of Head and Neck Surgery, Graduate School of Medicine, Dentistry and Pharmaceutical Science, University of Okayama, Japan*
[i] *Department of Plastic and Reconstructive Surgery, Graduate School of Medicine, Dentistry and Pharmaceutical Science, University of Okayama, Japan*
[j] *Department of Oral and Maxillofacial Radiology, Okayama University Graduate School of Medicine, Dentistry and Pharmaceutical Sciences, University of Okayama, Japan*

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**KEYWORDS**
Head and neck cancer;

**Summary** The usefulness of dental approaches, such as oral management, has gained recognition among patients treated for head and neck cancer. In particular, oral management plays a very important role before, during, and after treatment in patients undergoing radiotherapy,

*Abbreviations:* LINAC, linear accelerator; CT, computed tomography; 3D CRT, three-dimensional conformal radiation therapy; IMRT, intensity modulated radiation therapy; SRT, stereotactic radiation therapy; GTV, gross tumor volume; CTV, clinical target volume; PTV, planning target volume.

* Corresponding author at: Department of Oral Diagnosis and Dentomaxillofacial Radiology, Okayama University Hospital, 5-1, Shikata-cho, 2-Chome, Kita-ku, Okayama-city, Okayama 700-8558, Japan. Fax: +81 86 235 6709.
*E-mail address:* hidenobu@md.okayama-u.ac.jp (H. Matsuzaki).

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Radiation therapy;
External irradiation;
Intensity modulated radiation therapy;
Dental metal;
Backscatter effect

chemotherapy, or a combination of both. However, specialized dentistry knowledge and techniques that are useful for patients undergoing radiotherapy for head and neck cancer have yet to be reported. Therefore, in this review article, our aim is to introduce dental approaches in radiotherapy for patients with head and neck cancer that have been developed and are currently being used at our institute.
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**Contents**

1. Introduction ........ 47
2. Radiotherapy for head and neck cancer ........ 47
3. The role of dentistry in external irradiation for head and neck cancer ........ 47
 3.1. Mouth opener ........ 48
 3.2. Mouthpiece for patient re-position ........ 49
 3.3. Approaches to dental metal ........ 50
4. Conclusions ........ 52
 Competing interests ........ 52
 References ........ 52

## 1. Introduction

Head and neck cancers account for approximately 5% of all cancers in Japan [1]. Those regions include the oral cavity, pharynx, larynx, paranasal sinuses, nasal cavity, and salivary glands. The structures of the head and neck are highly complex, in very close proximity to each other, and are formed of soft and/or hard tissues (for example, the mucosal membrane of the oral cavity, laryngopharynx, nose and sinuses, jawbones, temporomandibular joints, facial muscles, and skin).

The most common histopathological type of head and neck cancer is squamous cell carcinoma, which is a malignant tumor arising from the epithelium in many parts of the head and neck. As the other types of head and neck cancers, salivary gland tumors include various histopathological subtypes of cancer, though their incidence is rare. The treatment plan for head and neck cancer varies according to the histopathological type, tumor location, cancer stage, and age and general health of the patient. Treatment of head and neck cancer commonly includes surgery, radiotherapy, chemotherapy, or a combination of these modalities. Patients with head and neck cancer, who receive radiotherapy and/or chemotherapy, might be suffering with various oral treatment-related complications secondary to drug toxicity. The most common oral complications are oral mucositis, decrease in saliva, taste disorders, and pain. These complications, especially pain due to oral mucositis, might cause a decrease in oral intake of water and food. As a result, patients can suffer from dehydration and malnutrition. Such severe complications sometimes may also lead to disruption of treatment, including treatment suspension or discontinuation thereby affecting patient survivorship.

To prevent severe oral complications, oral management based on dentistry before, during, and after treatment is becoming a common approach for patients undergoing radiotherapy for head and neck cancer. However, there are various dentistry-based alternative approaches that differ from the usual radiotherapy-related oral management for patients with head and neck cancer. In this review, we introduce our specialized dentistry-based approaches for patients undergoing radiotherapy for head and neck cancer.

## 2. Radiotherapy for head and neck cancer

Radiotherapy for head and neck cancer is generally classified into external irradiation and brachytherapy. External irradiation is the most common form of radiotherapy. It generally involves the use of a linear accelerator (LINAC) that directs X-ray and/or electron beam from outside the body into the tumor (Fig. 1A). Particle radiotherapy, with proton or carbon ion beams, has recently become widespread, and it is also classified as external irradiation. Brachytherapy is a localized treatment for head and neck cancers in which radioactive sources are placed directly within (interstitial brachytherapy) or near (intracavitary brachytherapy) the tumor site. Therefore, brachytherapy is generally used for patients with early-stage cancer, commonly without nodal metastasis, especially in the oral cavity and oropharynx. Brachytherapy for head and neck cancers is also divided into low-dose rate (Ir-192, Au-198, and Cs-137) and high-dose rate brachytherapy (Ir-192 and Co-60) depending on the dose rate of the radioactive source (Fig. 1B and C). However, brachytherapy is a unique treatment which needs an isolation room or special treatment system, and few institutes have the necessary equipment and facilities to apply this type of radiotherapy.

## 3. The role of dentistry in external irradiation for head and neck cancer

For the external irradiation for head and neck cancers, a linear accelerator (LINAC) is most commonly used. This equipment can be used to treat not only the head and neck region, but also all areas of the body. The general steps of

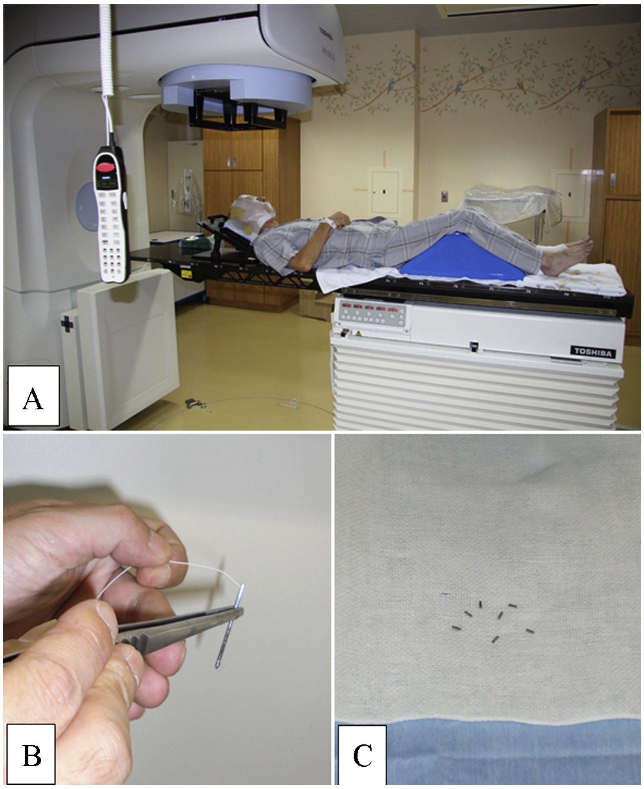


**Figure 1** External irradiation by linear accelerator machine (A) and radioactive sources (low-dose rate) for brachytherapy (B; Cs-137 needle, C; Au-198 grains).

the treatment using LINAC for patients with head and neck cancer are as follows: patient fixation, computed tomography (CT) scan for radiotherapy, radiotherapy treatment planning, verification of the treatment plan, and execution of radiation treatment. For external irradiation, the patient fixation is very important to ensure the reproducibility of each treatment (interfraction) and to avoid patient motion during irradiation (intrafraction). Therefore, patients with head and neck cancer are fixed by a so called mask, which is an immobilization tool made of thermoplastics (Fig. 2A and B). For patient fixation in external irradiation, some dentistry techniques are useful, as detailed in the following subsections.

### 3.1. Mouth opener

During external beam radiotherapy (three-dimensional conformal radiation therapy [3D CRT]) using LINAC, radiotherapy treatment beams (irradiation field) are shaped by multi-leaf collimators to irradiate the desired regions and to avoid the unnecessary exposure of other regions (Fig. 3A—D). In radiotherapy for head and neck cancer, one of the regions in which exposure should be avoided as much as possible is the oral cavity to prevent the development of adverse events such as oral mucositis (Fig. 4A and B). Therefore, to avoid exposure of the oral cavity and its components (i.e., the upper and lower lip, maxilla and mandible, and tongue), it is recommended perform 3D CRT with the patient's mouth open. In our institute, we are using two types (type A and type B) of disposable mouth openers for this purpose (Fig. 5A and B).

The type A mouth opener is simple and optimized to open the patient's mouth. Using a type A of mouth opener, we can ensure that the upper and/or lower lip, and maxilla and/or mandible are outside of the irradiation fields. We use this type of mouth openers in patient with pharyngeal cancers, and others whose oral cavity do not need to be irradiated (Fig. 6A and B). The type B mouth opener allows the patient to press down the tongue, and it maintains the mouth open to avoid exposure of the tongue (Figs. 5B, 7 A). We use the type B mouth opener for the patients with nasal or paranasal tumors, as well as tumors in other regions (Fig. 7A—C).

Our mouth openers are characterized by some particular features. Because tray resin is used, they are inexpensive and easy to manufacture. It is possible to fix the mouth opener to the shell, and improve reproducibility of an original position of the mouth opener used in a previous treatment session (Fig. 8A and B). Furthermore, the mouth opener mouthpiece can be easily washed with cleaning products to ensure hygiene.

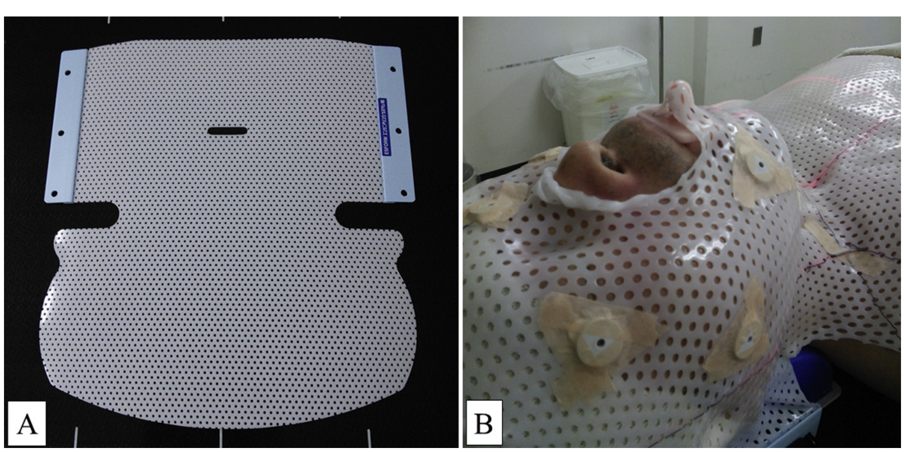


**Figure 2** Thermoplastic shell.
A. A shell for head and neck before heating.
B. The state of a patient after fixation with a shell.

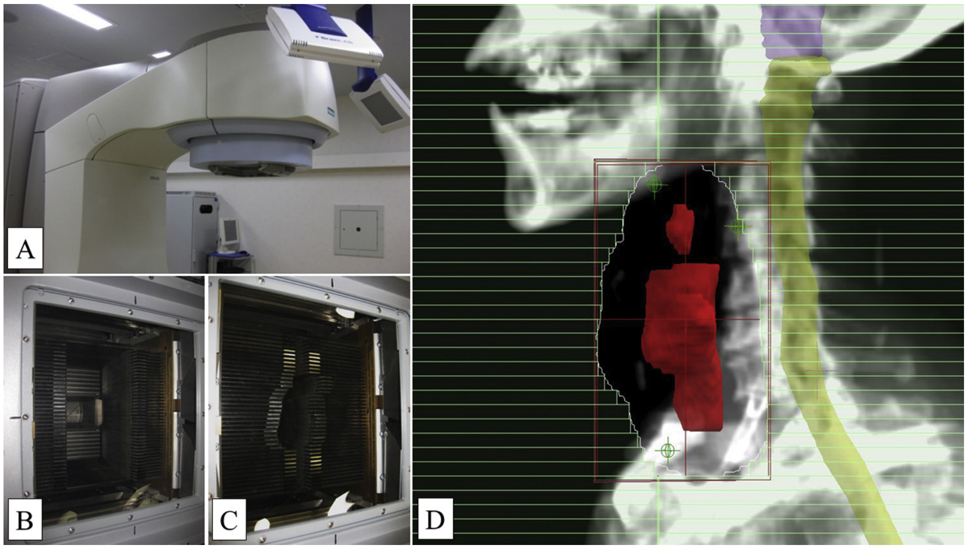


**Figure 3** Multi-leaf collimators of linear accelerator and irradiation field in a treatment planning system.
A. Gantry of the linear accelerator.
B. Multi-leaf collimators of full open position.
C. Position after shaping the multi-leaf collimators.
D. Irradiation field on treatment planning system.

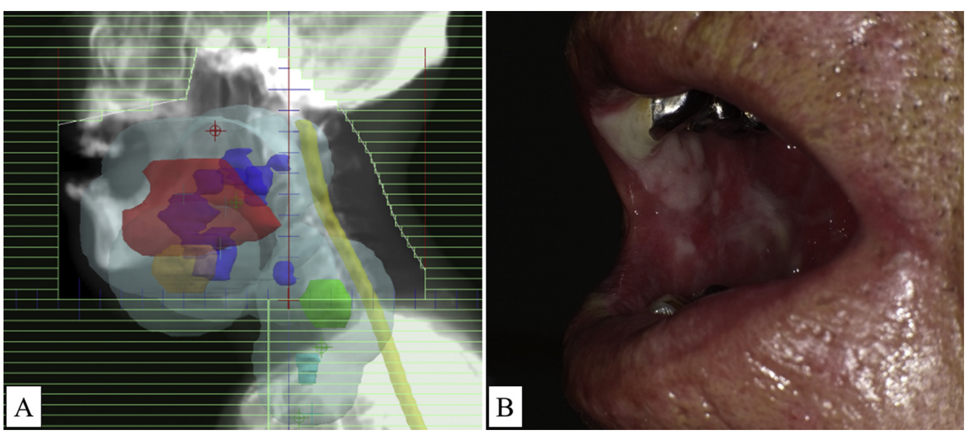


**Figure 4** Post-operative irradiation for a patient with tongue cancer.
A. Irradiation field in the treatment planning system. In this case, the oral cavity could not be spared because it was necessary to irradiate the primary site (tongue).
B. This patient developed grade 2 to grade 3 oral mucositis (National cancer institute—Common Terminology Criteria for Adverse Events Version 3.0).

## 3.2. Mouthpiece for patient re-position

Recently, high-precision radiotherapy, such as intensity modulated radiation therapy (IMRT) and stereotactic radiation therapy (SRT) have become widely used because they are more effective in avoiding side effects in comparison with 3D CRT. The IMRT modality has the advantage of allowing a more precise dose delivery to the tumor site and simultaneously reduces the exposure of normal tissues. Therefore, an accurate and reproducible fixation of the patient is even more important in IMRT than in 3D CRT [2,3].

In radiotherapy treatment plans, target volumes to be irradiated are clearly defined as gross tumor volume (GTV), clinical target volume (CTV), and planning target volume (PTV). The GTV is the tumor volume, and it is generally confirmed by diagnostic images, inspection, and/or palpation of both the primary and metastatic lesions. The CTV is the tissue volume, including the GTV and any regions of subclinical disease, and prophylactic lymph node area. Commonly, in radiotherapy for head and neck cancers, a 5-mm to 10-mm (or greater) margin is added around the GTVs. Considering internal organ motion and variation in daily setup (set-up margin), the PTV is expanded from 5 mm to 10 mm around the CTVs. In high-precision radiotherapy such as IMRT, it is important to decrease the PTV margin caused by organ movement and set-up error. Therefore, for head and neck IMRT, there is a ready-made patient immobilization mouthpiece used to decrease head and neck rotation, flexion and

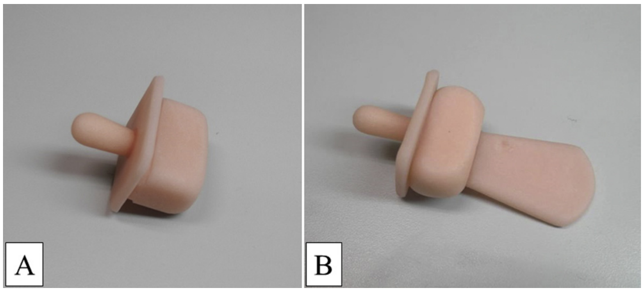


**Figure 5** Mouth openers made of tray resin.
A. A mouth opener (type A) to ensure placement of the upper and/or lower lip, and maxilla and/or mandible outside of the irradiation fields.
B. A mouth opener (type B) that allows the patient to press down the tongue in addition to keeping the mouth open.

extension (Fig. 9A). However, those ready-made products are generally designed to fit the oral cavity of Westerners, and may be too large to be adapted to that of Japanese individuals. Therefore, we designed an order-made mouthpiece for IMRT, consisting of thermoplastic splinting material and tray resin (Fig. 9B). We have also adapted the size of the mouthpiece considering the possible pain caused while attaching and detaching the mouthpiece caused by oral mucositis. Once it is fixed to the shell, this mouthpiece will immobilize the patient's head and decrease head and neck rotation, flexion and extension (Fig. 9C and D). However, some adjustments are needed for use in edentulous patient or patients that are missing many teeth.

## 3.3. Approaches to dental metal

In the head and neck regions, the existing dental metal is not only disruptive for the diagnosis but for radiotherapy treatment planning as well. One of the effects of dental metal is electronic backscatter, which may damage the surrounding soft tissue [4,5]. Reitemeier et al. reported that backscatter effects on the surface of dental materials caused an increase of up to 170% of the radiation dose measured with-

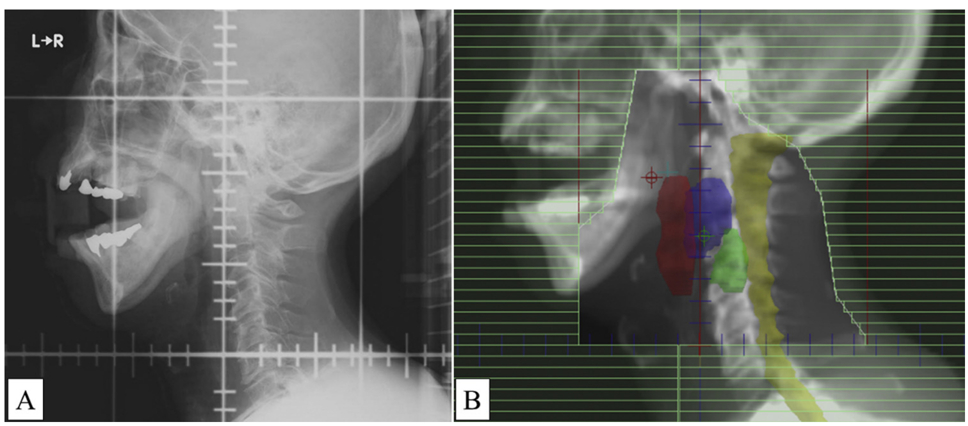


**Figure 6** Definitive irradiation for a patient with oropharyngeal cancer.
A. Lateral radiograph of the patient.
B. Irradiation field in a treatment planning system. By opening mouth using mouth opener, it was possible to avoid the exposure of the maxilla and upper lip.

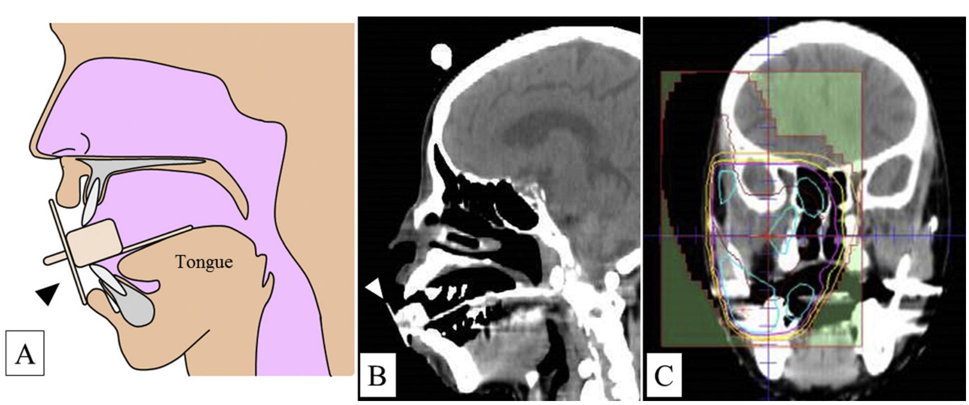


**Figure 7** Patient with paranasal (right maxillary sinus) sinus cancer.
A. Schema using type B mouth opener.
B. A multi-planner sagittal image reconstruction of a treatment planning CT image. The tongue of the patient had been pressed down by the type B mouth opener.
C. Dose distributions for patient on the coronal image.

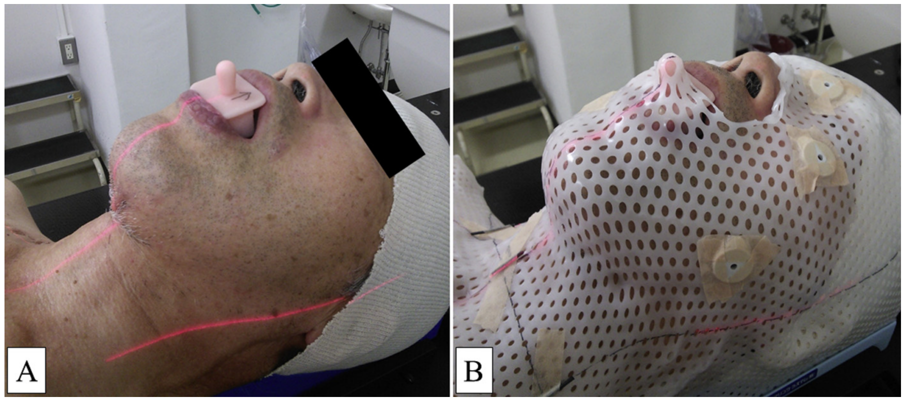


**Figure 8** Fixation of the edge of the mouth opener and shell.
A. Patient with a mouth opener (before immobilization by shell).
B. The edge of mouth opener is fixed to the shell.

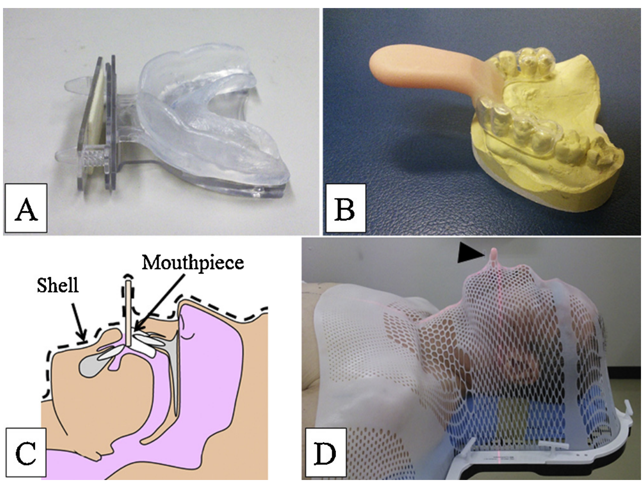


**Figure 9** Immobilization of the patient's head using a mouthpiece for intensity modulated radiation therapy.
A. A ready-made mouthpiece for patient immobilization (Precise Bite: CIVCO Medical Solutions, Kalona, Iowa, USA).
B. An order-made mouthpiece consisting of thermoplastic splinting material and tray resin.
C. Schema using order-made mouthpiece.
D. The edge of order-made mouthpiece is fixed to the shell.

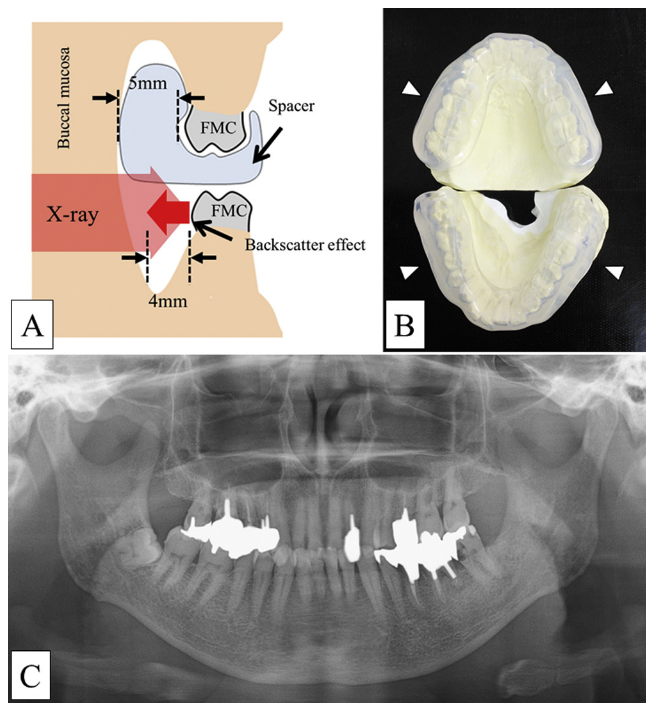


**Figure 10** Patient with many dental metal restorations.
A. Schema for the explanation of the backscatter effect and spacer.
B. Spacers made of soft type thermoflex material sheet.
C. Panoramic radiograph showing many dental metal restorations.

out the materials. Furthermore, they also reported that the extent of the backscatter effect was a maximum within a 4-mm. Therefore, we made a space retainer, called spacer. It has a 5-mm thickness, which helps decrease the backscatter effect on the surrounding normal tissues (Fig. 10A). We made it using a soft-type thermoflex material sheet to help reduce the possible pain caused by the attachment and detachment of the spacer in patients with oral mucositis (Fig. 10B). However, the best way to avoid backscatter effects is the removal of all dental metals in the oral cavity. In patients with many dental metal restorations (Fig. 10C), removing of all dental metals may not be possible as it may decrease the patient's quality of life. For such patients, we use spacers to avoid removing dental metals.

The other effect of dental metals is that they create metal artifacts on CT images. Because the dose distribution of the radiotherapy treatment plan is calculated by radiation treatment planning systems based on CT values, the presence of such metal artifacts in CT images can be misleading, thereby causing inaccurate dose distribution [6]. Especially, high-precision radiotherapy modalities, such as IMRT and SRT, require accurate dose calculations in radiation treatment planning. However, removing all dental metals in the patients with many dental metal restorations is not a realistic measure as described above. Thus, regarding those patients, the area density of the metal artifact in the treatment planning CT images are replaced by density of

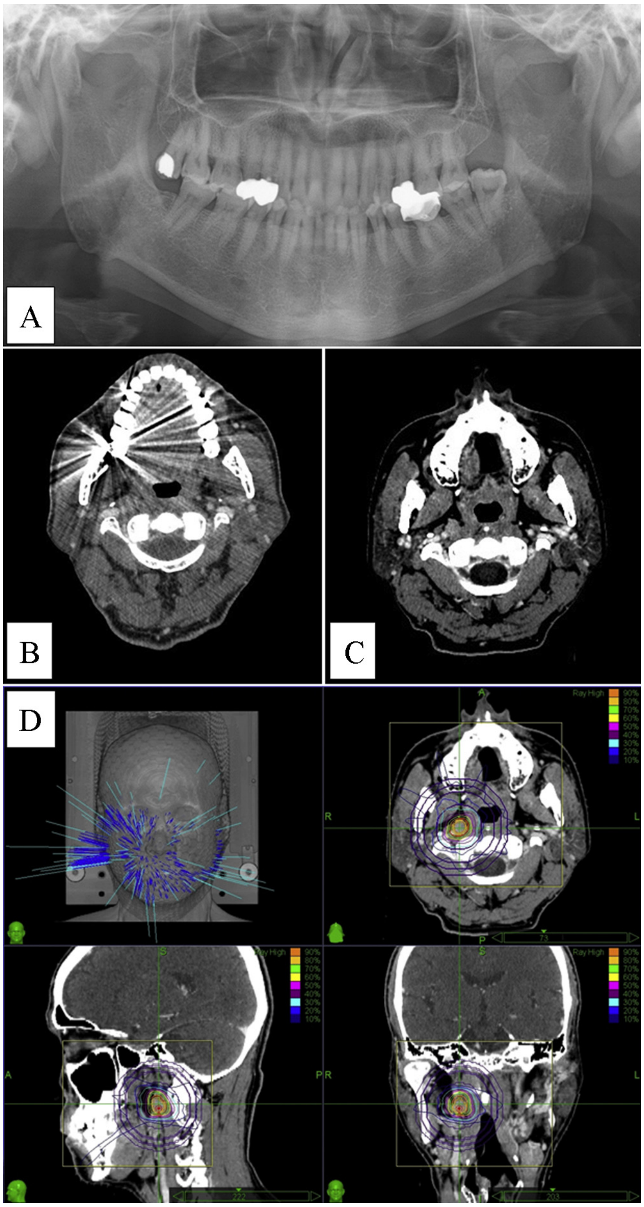


**Figure 11** Patient with secondary retropharyngeal lymph node metastasis from thyroid cancer.
A. Panoramic radiography showing five dental metal restorations.
B. The metastatic lymph node is unclear because of artifact caused by the dental metal restorations in contrast-enhanced CT image.
C. The treatment planning contrast-enhanced T image for stereotactic radiation therapy showing the mass corresponding to a metastatic lymph node visualized clearly after removing dental metal restorations.
D. The image of dose distributions with a CyberKnife (Accuray Inc., Sunnyvale, CA, USA).

soft tissue, on treatment planning systems as an alternative. However, as illustrated in Fig. 11A, in case of patients with few dental metal restorations, we will actively remove the dental metals because it is unlikely that it will affect their quality of life. The contrast-enhanced CT image in Fig. 11B is from a patient with secondary retropharyngeal lymph node metastasis from thyroid cancer. However, the metastatic lymph node was unclear because of the artifact caused by dental metal restorations. The treatment plan for this patient involved stereotactic radiation therapy with a CyberKnife (Accuray Inc., Sunnyvale, CA, USA). In that case, we removed all dental metal restorations before the procedure. As the results, the treatment planning contrast-enhanced CT image (Fig. 11C) for SRT showed the mass of the metastatic lymph node much more clearly than in the previous image before dental metal restoration removal. The images of dose distributions are shown in Fig. 11D.

## 4. Conclusions

Recently, particle beam therapy has become a popular and widely used form of radiotherapy because it allows even greater precision than previous modalities. However, the patient fixation methods undertaken during high-precision radiotherapy for the treatment of head and neck cancers have not evolved as dramatically. However, by applying the knowledge of dentistry as we have done, it is possible to provide higher treatment accuracy for the radiotherapy of head and neck cancers. As further investigation, it is necessary to investigate, in detail, the fixation accuracy of patients using mouthpieces as the ones described above, to assess whether or not the use of these devices and the spacer are effective in reducing the effects of mucositis.

## Competing interests

No conflict of interest.

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