Available online at www.sciencedirect.com

ScienceDirect

journal homepage: http://www.elsevier.com/locate/rpor

Original research article

Utility of intraoral stents in external beam radiotherapy for head and neck cancer

Hiroshi Doi[a,b,*], Masao Tanooka[c], Toshihisa Ishida[c], Kuniyasu Moridera[d], Kenji Ichimiya[d], Kazuo Tarutani[a], Kazuhiro Kitajima[a], Masayuki Fujiwara[a], Hiromitsu Kishimoto[d], Norihiko Kamikonya[a]

[a] Department of Radiology, Hyogo College of Medicine, Hyogo, Japan
[b] Department of Radiation Oncology, Meiwa Cancer Clinic, Hyogo, Japan
[c] Department of Radiological Technology, Hyogo College of Medicine College Hospital, Hyogo, Japan
[d] Department of Oral and Maxillofacial Surgery, Hyogo College of Medicine, Hyogo, Japan

ARTICLE INFO

Article history:
Received 22 December 2016
Received in revised form
25 January 2017
Accepted 16 March 2017
Available online 8 May 2017

Keywords:
Intensity modulated radiation therapy
Setup error
Head and neck cancer
Bite block immobilization
Radiotherapy

ABSTRACT

Aim: This study aimed to assess the utility and stability of intraoral stent during intensity-modulated radiation therapy (IMRT).
Background: The benefits of intraoral stents in radiotherapy are unclear.
Materials and methods: We analyzed 386 setup errors in 12 patients who received IMRT for head and neck cancers without intraoral stents (intraoral stent [−]) and 183 setup errors in 6 patients who received IMRT with intraoral stents (intraoral stent [+]). All patients were matched according to the immobilization method (masks and boards). Setup errors were measured as the distance from the initial setup based on the marking on the skin and mask to the corrected position based on bone matching on cone beam computed tomography.
Results: The mean interfractional setup errors in the right–left, craniocaudal, anterior–posterior (AP), and three-dimensional (3D) directions were −0.33, 0.08, −0.25, and 2.75 mm in the intraoral stent (−) group and −0.37, 0.24, −0.63, and 2.42 mm in the intraoral stent (+) group, respectively ($P = 0.50$, 0.65, 0.01, and 0.02, respectively). The systematic errors for the same directions were 0.89, 1.46, 1.15, and 0.88 mm in the intraoral stent (−) group and 0.62, 1.69, 0.68, and 0.56 mm in the intraoral stents (+) group, respectively. The random errors were 1.43, 1.43, 1.44, and 1.22 mm in the intraoral stent (−) group and 1.06, 1.11, 1.05, and 0.92 mm in the intraoral stents (+) group, respectively.
Conclusion: Setup errors can be significantly reduced in the AP and 3D-directions by using intraoral stents.

* *Corresponding author at*: Department of Radiology, Hyogo College of Medicine, 1-1, Mukogawa-cho, Nishinomiya City, Hyogo 663-8501, Japan.
E-mail address: h-doi@hyo-med.ac.jp (H. Doi).
http://dx.doi.org/10.1016/j.rpor.2017.03.002

1. Background

Intensity-modulated radiation therapy (IMRT) has been shown to reduce xerostomia and improve the quality of life in head-and-neck cancer patients.[1] Because IMRT plans are more sensitive to positioning errors compared to conventional three-dimensional (3D) treatments, geometric errors should be taken into consideration in treatment planning or planning target volume design.[2] Immobilization of the head and neck is critical to maintaining the patient's position during and between treatment fractions. The stability and precision of the patient immobilization apparatus should also be considered when determining the treatment margins required for proper coverage of the target, and for adequate protection of normal critical tissues. To this end, thermoplastic masks have been used regularly to improve setup accuracy.[3,4]

Image-guided radiation therapy (IGRT) involves frequent two- and three-dimensional imaging during the course of radiation treatment to determine the isocenter coordinates and ensure that it corresponds to the same position that was determined using the reference imaging dataset. An example of IGRT is the combination of the cone beam computed tomography (CBCT) dataset with the planning computed tomography (CT) dataset.[4,5] IGRT relies directly on the imaging modalities utilized during planning for the reference coordinates when positioning the patient.

Intraoral stents have reportedly been used in various clinical scenarios, especially to reduce the mucosal dose and prevent severe radiation-induced oral mucositis.[6–14] It has been reported that using a bite block can reduce 3D variability in patient positioning during external beam radiotherapy for head and neck tumors.[6,7] Additionally, the use of intraoral stents can reduce the effects of dental alloys in radiotherapy.[12–15] In dental therapy, intraoral stents are used in various situations including sports, anesthesia, treatment of sleep disorders, and orthodontic treatment.[16–19] These intraoral devices are often convenient enough for daily use. However, they have been less utilized for modern radiotherapy purposes, including for IMRT using IGRT with CBCT, despite their ease of use. Therefore, the benefits of intraoral stents, particularly their stability in radiotherapy, ought to be clarified. The purpose of this study was to assess the utility of intraoral stents in minimizing interfraction errors in IMRT.

2. Materials and methods

Informed consent was obtained prior to treatment from all individual participants included in the study. The institutional review board of our hospital approved this retrospective study (Approval No. 2378).

2.1. *Intraoral stent design*

Prior to utilizing intraoral stents in radiotherapy for head and neck cancers, we assessed various stent designs to identify those that would have minimal interference with radiotherapy. Plaster models of the patients were used to construct the stents. Each stent was composed of three parts made of polyethylene terephthalate: the maxillar, mandibular, and plate sections. We fabricated a removable maxilla and mandible polyethylene terephthalate splint using a vacuum former (Erkopress®). The maxillar and mandibular sections were attached in a manner that encompassed the edge-to-edge bite, and the plate was placed between them to immobilize the tongue. The intraoral stent did not contain metal to avoid radiation scattering. The stents were adjusted by a dentist to fit the oral cavity of each patient.

2.2. *Patient selection*

Between November 2013 and May 2016, 18 consecutive patients who received IMRT for head and neck tumors were retrospectively analyzed (Table 1). All patients were matched according to an immobilization method; masks and boards. Twelve consecutive patients treated between November 2013 and July 2015 received IMRT without an intraoral stent (the intraoral stent [−] group) and 6 treated from August 2015 onward used intraoral stents that were individually fitted for each (the intraoral stent [+] group).

2.3. *Radiotherapy technique*

Radiotherapy was performed as previously described.[20,21] Patients were placed in the supine position and scanned using an Aquilion LB CT unit (Toshiba, Ohtawara, Japan) while wearing a thermoplastic face mask (Aquaplast RT; Q-Fix, Avondale, PA) attached to a couch overlay device (ProBoard™ Flat Carbon Fiber Headboard (Q-Fix, Avondale, PA) for immobilization. The CT images were reconstructed with a slice thickness of 2 mm. The acquired CT dataset was transferred to a XiO® treatment planning system (Elekta, Stockholm, Sweden) and the volumes of interest were outlined. IMRT was administered using volumetric modulated arc therapy, for which plans were created using the Monaco treatment planning system (Elekta, Maryland Heights, MO, USA) and were performed using a Synergy® linear accelerator (Elekta, Crawley, UK).

2.4. *IGRT and image analysis*

IGRT was performed as previously described.[22] Daily initial setup consisted of aligning in-room lasers with mask marks and chest skin marks. A volumetric kilovoltage CBCT scan was then acquired with a linear accelerator-mounted X-ray source, XVI™ (Elekta AB, Crawley, UK). The XVI system consists of a kV X-ray source and a detector panel mounted orthogonally to the MV portal imager. A tube potential of 120 kV and a 200° gantry rotation (effectively a half-circle) with a small field of view were used. The reconstructed CBCT image was with a voxel size of 0.518 mm resolution. The planning CT imaging data was imported into the XVI system and converted to the same voxels using trilinear interpolations.

Images were assessed by radiation therapists, who were blinded to this study, by fusing the CBCT scan to the planning CT scan using commercially available software before treatment delivery in order to correct any setup errors.

Setup errors were measured as the distance from the initial set-up based on skin markings and the mask to the corrected position based on bone matching on CBCT. Setup