Tissue Retraction for Head and Neck Radiotherapy in Edentulous Patients

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In order to protect healthy tissues during head and neck radiotherapy, it is essential to maintain a consistent position of the irradiated area within and between all therapy sessions.1 For this purpose, thermoplastic head masks are used in combination with tissue retraction devices (TRDs).2 TRDs are intended to both fix the position of the mandible and to space irradiated tissue from healthy tissue. The fixation allows for precise radiation delivery to the target tissue, while the spacing protects the surrounding healthy tissues, thus mitigating oral sequelae.3,4 TRDs can minimize radiation-induced xerostomia by sparing salivary glands5 and can reduce radiation-induced mucositis, which affects up to 60% of patients with resulting pain, superinfection, and dysphagia.6 However, TRD retention is difficult to achieve in edentulous patients, and no method has yet been described. Traditionally, TRDs require complex fabrication, including dental impressions, stone models, sculpting of a wax model, and conversion into acrylic resin.7 CAD/CAM processes could facilitate their fabrication and clinical implementation.

CASE REPORT

An edentulous 67-year-old female patient was referred from the Department of Radiation Oncology for the provision of a TRD. The device was made in three steps:
(1) construction in the dental chair using the patient’s existing complete dentures; (2) digitization using a 3D scanner; and (3) fabrication using a 3D printer.

The patient’s maxillary and mandibular complete dentures were fixed intraorally using a double plate of bite registration wax (Beauty Pink Hard Wax, Integra Miltex). To facilitate breathing during irradiation, the wax plate was partially cut out in the anterior region, and the patient was guided into a slightly protruded mandible position, aiming for an increased posterior airway space (Fig 1).

For digitization, complete dentures and wax registration were removed from the mouth en bloc and scanned from the maxillary and mandibular sides (D2000, 3Shape). The dentures were then separated, and additional scans of the maxillary side of the registration
plate and the outer surface of the maxillary denture were performed. The alignment of these four scans resulted in the digitized TRD, which was exported as a standard tessellation language (STL) file (Fig 2).

The scanning and matching process took 20 minutes, after which the patient received the dentures back. Printing was performed in layers of 50 µm (PRO2, Asiga) using dental splint resin (Freeprint Splint 2.0, Detax), followed by the removal of printing supports, cleaning in an ultrasonic alcohol bath, and curing through a xenon flashlight curing machine (Fig 3).

At the next appointment, the usual thermoplastic immobilization mask for head and neck radiation was fabricated with the printed TRD placed intraorally. Contrast-enhanced computed tomography (CT) imaging was performed for irradiation planning, with the

Fig 2  STL file of the digitized prostheses with the bite registration wax.
patient wearing both the TRD and immobilization mask (Figs 4 and 5). The patient was able to insert and remove the TRD independently, and it showed good adherence. The integrity of the TRD and its correct positioning were checked before each radiation treatment and remained unchanged over the entire irradiation period.

To evaluate fabrication accuracy, surface deviations between the STL construction file and the 3D-printed TRD were analyzed. After removing the residual 3D-printing supports and before surface finishing, the maxillary and mandibular TRD sides were scanned using the laboratory scanner. The scans were aligned with the STL reference file (Fig 2) using best-fit algorithms (Geomagic Design X, 3D Systems). Geometric accuracy of the fabrication was analyzed using absolute mesh deviations between the STL construction file (intended shape) and the 3D-printed

Fig 3 3D-printed and postprocessed tissue retraction device.
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TRD sides (actual shape), with “mean value” measuring trueness, and “standard deviation” measuring precision. Printing showed a trueness of 90 µm and a precision of 102 µm; both values are in the range of fabrication errors of conventional complete dentures.

**DISCUSSION**

Although tooth-borne TRDs are effective in reducing side effects such as radio-induced mucositis or xerostomia, to the best of the present authors’ knowledge, no method has been described for edentulous patients. The likely reason is the difficulty of ensuring retention at the alveolar ridges of the maxilla and mandible. Advances in 3D scanning and printing allow for reproduction of the surfaces of the patient’s complete dentures for fabrication of TRDs, avoiding conventional impressions and further technical work steps.

The main advantage of the described TRD is that both arches were rigidly connected. In combination with the head mask, this provided a fixed mandibular position and a defined compartment for the tongue, which immobilized it and separated it from the surrounding tissue. The compartment was constructed according to the specifications of the treating radiation oncologists and was defined by the floor of the mouth, the lingual parts of the mandibular denture, and an intermaxillary spacer at the level of the occlusal plane, which forms a

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**Fig 4** Initial computed tomography imaging without the tissue retraction device. The tongue lies in the oral cavity in direct contact with the palate and alveolar ridge.

**Fig 5** Computed tomography imaging for treatment planning. The tissue retraction device formed a compartment separating the tongue from the surrounding tissues of the palate and alveolar ridge.
slight curvature corresponding to the convexity of the back of the tongue.

The fixation of the tongue allows for more precise irradiation of the target tongue tumor. In addition, the TRDs are intended to reduce side effects like radio-induced mucositis and xerostomia,\(^3\) which is achieved by retracting the surrounding healthy tissue, thus minimizing the radiation dose to the mucosa and salivary glands. This can maintain chewing and swallowing function and can have a significant impact on quality of life.\(^3\)

Another well-known side effect of head and neck radiotherapy is trismus. Many patients develop reduced mouth opening during irradiation, which could interfere with placing and wearing the TRD. In a worst-case scenario, the TRD is no longer tolerated and radiotherapy has to be re-planned with new imaging, resulting in possible therapy delay. Therefore, it is important not to adjust a TRD to maximum mouth opening, but to anticipate a loss of mouth opening. Hence, it has been suggested to limit TRDs to a mouth opening of 70%.\(^3\) This value was not exceeded in the present case. Moreover, in case of a strong trismus, the device could have been reduced in the vestibular parts while maintaining its function. Conversely, there is evidence that TRDs may reduce the occurrence of trismus. It has been hypothesized that this could be related to a reduced mucositis rate that the daily application of the device could provide a kind of training function for mouth opening.\(^9\) Thus, a certain mouth opening through the TRD could even constitute a protective factor with regard to trismus, which has to be evaluated in further studies.\(^8\)

In the present case, the patient was able to wear the device for the entire radiation period. Normal food intake was possible during and after irradiation, and pain from oral mucositis was kept at a low level. Positioning of target volume was checked before each treatment session and remained consistent for the entire radiation period.

CONCLUSIONS

Tissue retraction for head and neck radiotherapy is a challenge in edentulous patients. This clinical case report shows that 3D scanning and printing technology allows the resource-efficient fabrication of TRDs for edentulous patients. This enables a more precise irradiation of the target region and a reduction of side effects in healthy surrounding tissue.

ACKNOWLEDGMENTS

The authors report no conflicts of interest.

REFERENCES


Immediate Placement of Single Implants With or Without Immediate Provisionalization in the Maxillary Aesthetic Region: A 5-year Comparative Study

The aim of this study was to compare marginal bone level changes around immediately placed and immediately provisionalized implants with immediately placed and delayed provisionalized implants in the esthetic region after 5 years of function. A total of 40 patients with a failing tooth in the maxillary anterior region were randomly assigned immediate implant placement with immediate (group A: n = 20) or delayed (group B: n = 20) provisionalization. Definitive crown placement occurred 3 months after provisionalization. The primary outcome was change in marginal bone level. In addition, survival rates, buccal bone thickness, soft peri-implant tissues, esthetics, and patient-reported outcomes were assessed. After 5 years, the mean mesial and distal marginal bone level changes were 0.71 ± 0.68 mm and 0.71 ± 0.71 mm, respectively, in group A, and 0.49 ± 0.52 mm and 0.54 ± 0.64 mm, respectively, in group B; the difference between the groups was not significant (P = .305 and P = .477, respectively). Implant and restoration survival were both 100%. No clinically relevant differences in buccal bone thickness, mid-facial peri-implant mucosal level, esthetics, or patient outcomes were observed. The mean marginal bone level changes following immediate implant placement and provisionalization were comparable with immediate implant placement and delayed provisionalization.