ejprd.org - Published by Dennis Barber Journals

The Effect of a Radiation Positioning Stent (RPS) in the Reduction of Radiation Dosage to the Opposing Jaw and Maintenance of Mouth opening after Radiation Therapy

Keywords

Radiation Dosage
Head and Neck Cancer
Radiation Stents
Trismus
Mouth Opening

Authors

Dr Suresh Nayar *
(BDS, MDS, MFDSRCS, MRDRCS, FDS(Rest Dent)RCS, MPhil)

Dr Rachel Brett §
(BChD, MJDFRCS(Eng))

Naomi Clayton #
(MPhys(hons), MInstP)

Jenny Marsden °
(BSc(Hons), MSc, DipIPEM, CSci, CPhys, MIPEM, MInstP)

Address for Correspondence

Dr Suresh Nayar *

Email: suresh.nayar@ualberta.ca

* *Institute for Reconstructive Sciences in Medicine, 1W-02, 16940, 87 Avenue,Edmonton, Canada T5R 4H5*

§ *Alison Brett Dental Care, 32 Woodhorn Road, Ashington, Northumberland NE63 9AE*

\# *University Hospitals Bristol NHS Foundation Trust, Medical Physics and Bioengineering, Bristol Royal Infirmary, Bristol BS2 8HW*

° *Hull and East Yorkshire Hospitals NHS Trust, Radiation Physics Department, Queen's Centre for Oncology and Haematology, Castle Hill Hospital, Hull, UK*

Received: 29.09.2015
Accepted: 08.02.2016

doi: 10.1922/EJPRD_00005Nayar07

ABSTRACT

The effect of a radiation positioning stent (RPS) in radiation dosage reduction to the opposing jaw and maintenance of mouth opening was audited. 55 Head and Neck cancer patients who received radiotherapy were reviewed. Radiation dosages at similar points in the primary/opposing jaws were measured along with the mouth opening. Results showed a significant reduction in the radiation dosage to the opposing jaw in patients given the RPS. Mouth opening was generally maintained in patients given the RPS (77.7% improvement in mouth opening) compared to patients without RPS. Patients undergoing radiotherapy who had an RPS showed a significant reduction in radiation dosage to the opposing jaw and maintained their mouth opening in the short term.

INTRODUCTION

Radiotherapy is an important modality in the management of head and neck cancers. Radiotherapy may be used as a primary treatment, as an adjunct to surgery, in combination with chemotherapy or as palliation.[1] Along with the effects to cancer cells, ionizing radiation used in radiotherapy causes damage to normal tissues located in the field of radiation.[2] For cancers of the head and neck, surgery, chemotherapy and radiotherapy may be directly and indirectly responsible for both acute and chronic sequelae. Side effects include xerostomia, radiation caries, trismus, oral mucositis, altered taste, speech alterations and osteoradionecrosis, all of which can have a profound effect on subsequent quality of life.[3]

These effects of ionizing radiation cause not only direct effects on the oral mucosa, salivary glands and taste buds but also cause indirect effects to the oral tissues particularly the teeth, as a consequence of the direct effects.[2] Many of these patients will require oral rehabilitation after completion of oncology treatment either due to complication of cancer treatment or due to dental disease progression. Post treatment management for these patients is complicated by xerostomia, altered anatomy, trismus and dental caries.

Oral rehabilitation in these patients may entail further extractions or osseointegrated implant placement in the irradiated bone and these are fraught with risks.

For any dental treatment and management to be carried out, adequate access (mouth opening) is required. Trismus is a sequela of radiotherapy that can have an impact on chewing, swallowing, nutrition and maintenance of oral health.[2,4] Additionally it is present in 2% of all newly diagnosed patients, 36% in children with nasopharyngeal tumour and 55% of patients with malignant parapharyngeal tumours have trismus at diagnosis.[5] There is lack of clarity in literature as to what signifies trismus, and the prevalence varies from 5% to 38%.[6, 7] In spite of the morbidity associated with radiotherapy-induced trismus, the management is usually after the condition has set in.

Various measures have been utilized to mitigate the radiation effects to the oral cavity. Prosthodontic stents and splints are one of those measures and may provide significant benefit in facilitating delivery of the therapy to local areas thereby limiting post-radiotherapy morbidity. Such stents are employed to protect or displace vital structures, locate diseased tissues in repeatable positions during treatment (as an immobilization device), position the beam and shield tissues.[8] When this is done with collaboration of a dentist or dental specialist, customized devices can be created such as for positioning or for shielding among other uses.[9-13] At the Queen's Centre for Oncology and Haematology, in collaboration with the Consultant in Restorative Dentistry, customized stents (radiation positioning stents - RPS) replaced the prefabricated bite blocks which were once provided. The RPS were less bulky and more patient friendly.

Although the rationale for the use of an RPS is to immobilize the treatment areas, it also opens the jaws so that the opposing jaw is further away from the radiation field and thus incurs a reduced radiation dosage; however, there are no cohort studies to prove this. The effect of reduction in radiation dosage to the jaws and maintenance of mouth opening was considered to be important, especially when the patient requires oral and dental rehabilitation post cancer treatment. Resource implications also deemed it necessary to prove if the use of the RPS was providing a difference in the radiation dosages and thus of benefit to the patient, as compared with having no device at all.

The aim of this study was to:

1. Audit the effect of a custom oral Radiation Positioning Stent (RPS) in reduction of radiation dosage to the opposing jaw.
2. Review if the provision of an RPS, maintained mouth opening after completion of radiotherapy.

MATERIALS AND METHODS

All head and neck cancer patients were seen and discussed at the regional Head and Neck Cancer Multi-Disciplinary Team meetings. Those patients who required radiotherapy either as a primary or adjuvant therapy were then referred by the Clinical Oncologists to the Consultant in Restorative Dentistry for a pre-radiotherapy dental assessment. Information regarding the need for a radiation positioning stent is also obtained from the Clinical Oncologists, hence some patients do not present for stent fitting. Radiation Positioning Stents (RPS) are custom made acrylic devices fabricated from dental casts made from alginate/putty impressions and articulated using jaw registrations at around 75% mouth opening.

At the pre-radiotherapy dental assessment visit, among other investigations, the maximal mouth opening was measured inter-incisally, inter-ridge or between ridge-incisor at the midline using a metallic ruler or a Therabite gauge. All patients were scheduled to be reviewed 1-2 months post radiotherapy. At that time, among other investigations, the maximal mouth opening was measured again.

Consent for use of their treatment data were obtained from the patients. Patients who had undergone radiotherapy for treatment of head and neck cancers were separated retrospectively into two cohorts after finishing radiotherapy; one where patients were provided with a Radiation Positioning Stent (Fig 1)(RPS) and one without. Patient data for 55 consecutive patients were identified, during the time period of using the RPS, and they were divided into 24(with RPS) and 31(without RPS). The group without the RPS were sampled from all head and neck patients undergoing radiotherapy within the time frame of when the RPS was used. In the groups, the following cancers were identified – squamous cell carcinomas (51), adenoid cystic carcinoma (1), solitary plasmacytoma (1) and melanoma (1). Each jaw was either recorded as 'primary' depending of the proximity of the tumour to it and the other jaw would be recorded as the 'opposing jaw'. Of the RPS group, 16 had cancer on/near the mandible (including tongue, base of tongue, floor of mouth, larynx, lower alveolus, mandibular retromolar, tonsil, lower lip); and 8 had cancer on/near the maxilla (maxillary antrum, soft and hard palate, nasal septum). Of the non-RPS group, 24 had cancers on/near the mandible and 7 had cancers on/near the maxilla *(Figure 4)*. Although the majority of radiotherapy modality was Intensity Modulated Radiation Therapy,[42] there were 13 patients (RPS – 8; non-RPS – 5) who were treated with Conventional Radiotherapy. The radiotherapy prescription plans (dosage and number of days of treatment) ranged from 40(1), 55(2), 60(9), 66(41) & 70(2) Grays with number of days of treatment ranging from 20 to 35 days with a median of 30 days. The authors felt it was important to consider patients from both modalities, at various dose levels, to see if the overall effect of the stent, for each individual patient, could be perceived.

Figure 1: Patient with Radiation Positioning Stent in situ

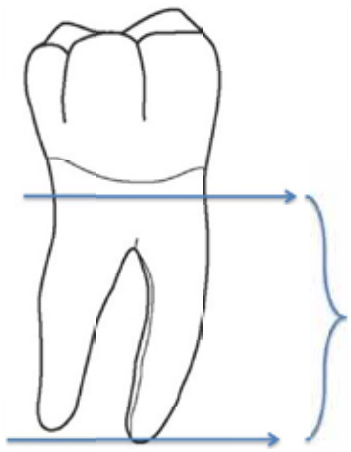

Figure 3: Shows the region between the root apex and the level of crestal bone where the radiation dosage was calculated at the five representative areas on the maxilla and mandible.

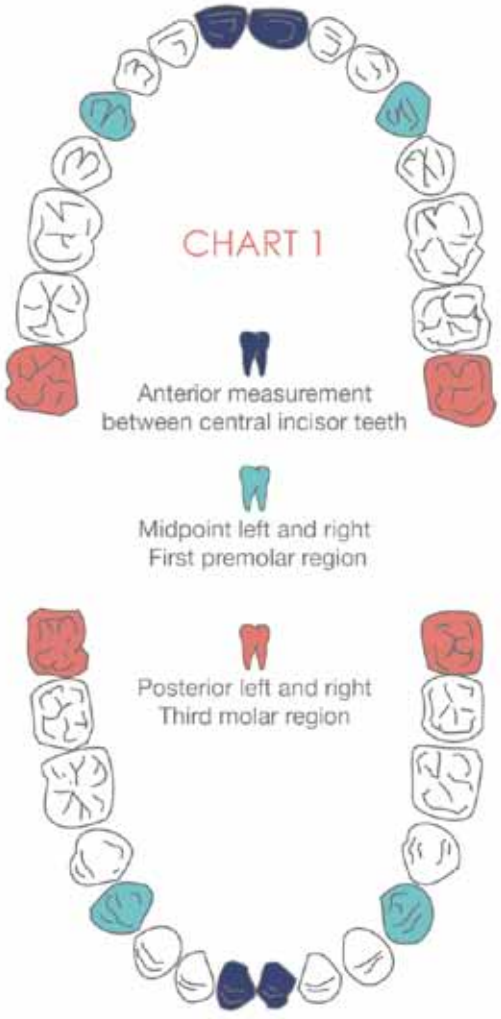

Figure 2: Shows the five representative areas for measurement of radiation dosage each on the maxilla and mandible

All the patient radiotherapy plans were retrieved from archive and loaded with the FocalPro plan review environment (CMS Medical Systems, Elekta) by the Radiation Physics Team. A pilot test was carried out to identify representative areas for measurement of radiation dosage on the maxilla and mandible using the software. The pilot test involved ensuring the user obtaining the doses was familiar with the treatment planning software, and had a process for where to visualize and position each point for dose recording, and to see if this was reproducible, for three to five patients. This resulted in five areas each on the maxilla and mandible – between the central incisors, first premolar regions and third molar regions (*Figure 2*). Using the software, the maximum and minimum radiation dose at the five points (maxilla and mandible) anywhere between the root apex and the level of the crestal bone were recorded (*Figure 3*). These recordings were checked in two planes. The anterior-most recording was checked in both axial and sagittal planes, while the two middle-point and two posterior-most recordings were checked in both axial and coronal planes. The maximum dosage recorded at these areas was used for the purpose of this study.

STATISTICAL METHOD

Analyses were performed using the SPSS (Statistical Package for the Social Sciences). Median and range were used to summarise changes in mouth opening and radiation dosage (intra-patient) differences. Difference in the radiation dose and mouth opening within a cohort group was assessed using Wilcoxon signed rank test, looking at the relative differences in radiation dose and mouth opening between the cohort groups was assessed using Mann-Whitney U test. The level of statistical significance was regarded as $p<0.05$.

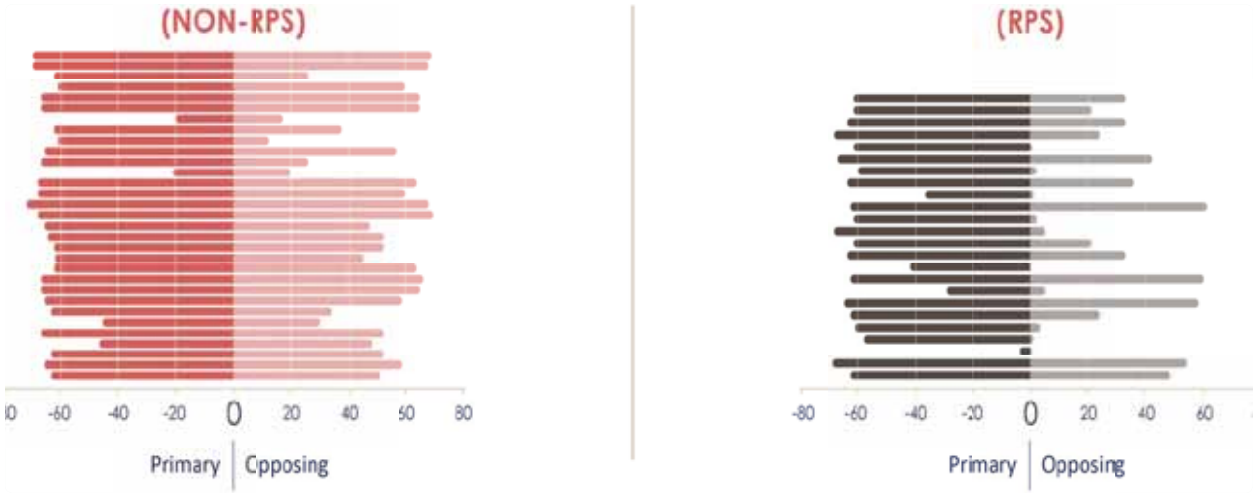

Figure 4: Shows two graphs representing the radiation dosage reading between the two cohorts. On the left is the NON-RPS and represents the patient cohort without RPS. On the right side is the RPS and represents the patient cohort with RPS. The left bars on each graph represent the primary jaw and the right bars on each graph represent the opposing jaw. The radiation dosage in Grays is denoted on the X-axis.

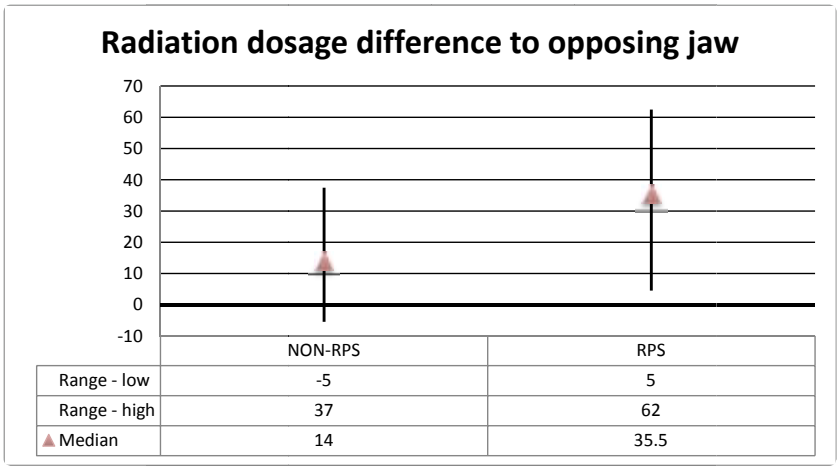

Figure 5: Comparison graph showing median and range of the difference in radiation dosage between the primary and opposing jaw with and without the RPS. (Y axis represents radiation dosage in Grays)

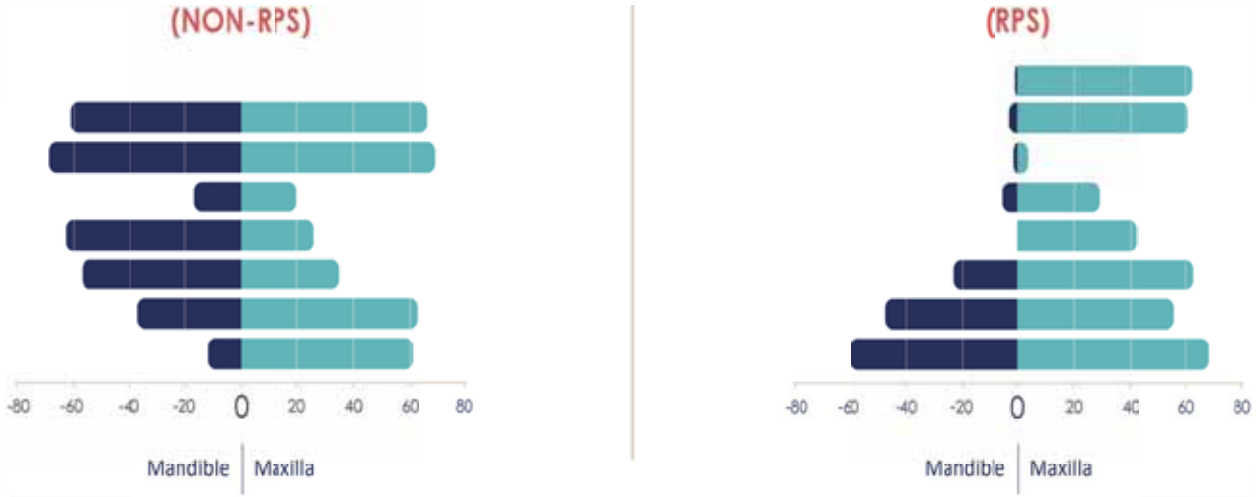

Figure 6: Illustrates radiation dosage to the mandible in maxillary tumours in patients with and without RPS

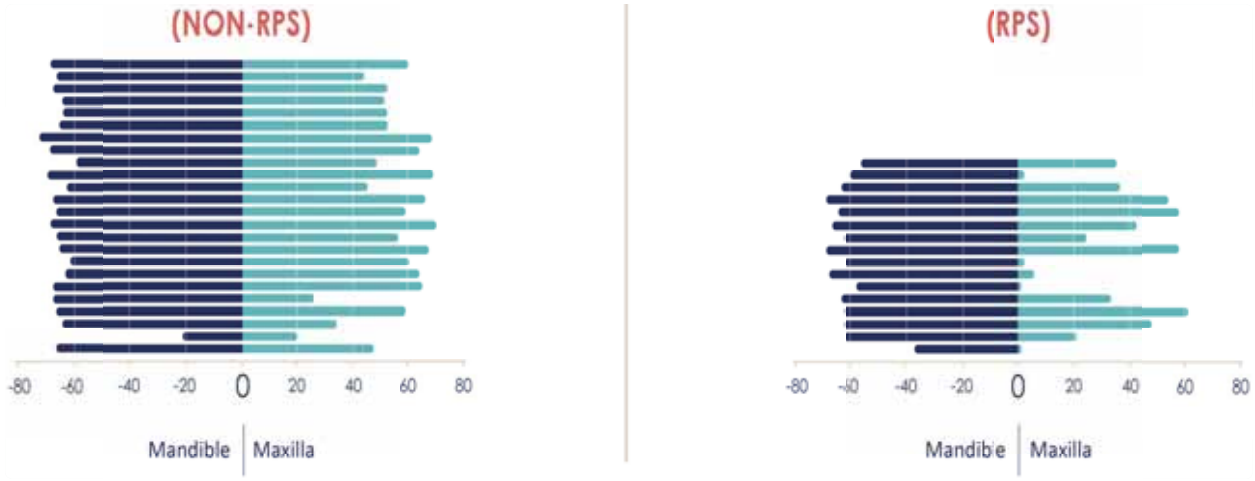

Figure 7: Illustrates radiation dosage to the maxilla in mandibular tumours in patients with and without RPS

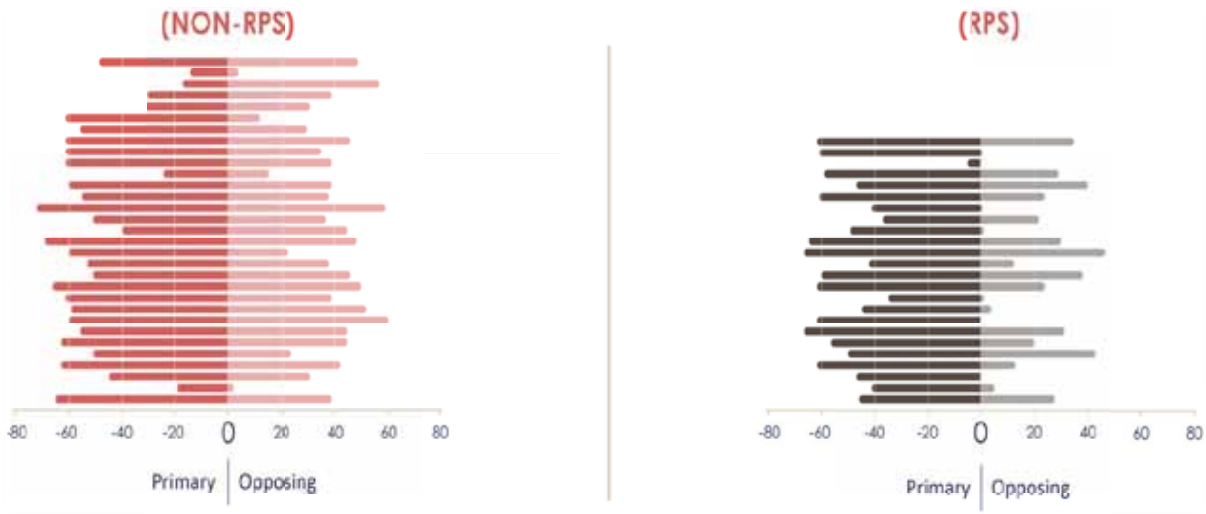

Figure 8: Radiation dosage reading between the two cohorts when the right and left third molar readings were excluded from the maxilla and mandible.

Figure 9: Comparison of mouth opening pre and post radiotherapy in patients with and without RPS

RESULTS

The maximum radiation dose (in Grays) at each of the five points in the maxilla and mandible were recorded in both cohorts *(Figure 4)*. Statistical analysis showed that there was a difference in the doses to the primary jaw and opposing jaw in both the RPS and non-RPS groups, with the primary jaw receiving more radiation ($p<0.01$), as expected. However, it also showed that there, was also a disparity between the RPS and non-RPS groups, with the RPS group showing a greater difference in radiation doses between the jaws ($p<0.01$). Figure 5 shows the median and range (high and low) of the difference in radiation dosage between the primary and opposing jaws, with and without the RPS.

The radiation dosages to the jaws were compared with the cases categorized into tumours of the maxilla and mandible. Figure 6 illustrates the difference in radiation dosage to the mandible, in tumours of the maxilla, with and without RPS. Although in the graph, there appears to be a visible reduction in the dosage to the mandible, statistically there was no difference seen between the two groups. Figure 7 illustrates the difference in radiation dosage to the maxilla, in tumours of the mandible, with and without the RPS. Statistically there was a significant difference in dose reduction to the maxilla between the RPS and non-RPS groups ($p<0.01$).

The data evaluation revealed that even with the RPS there were some cases that showed no dose reduction to the opposing jaw. The radiotherapy plans for these cases (RPS & NON-RPS) were considered and it was found that all these cases had a large PTV (Planning target volume). This was likely because of tumours involving structures near both jaws, oropharyngeal tumours or involving large nodes. Most of these tumours were situated nearer to the posterior parts of the jaws and with the reduction in jaw separation as one moves posteriorly, large doses were recorded in both jaws. When the right and left representative third molar regions in the maxilla and mandible were removed from the data, there was a significant fall in the radiation dosage to the opposing jaw in both the RPS and non-RPS groups and between the RPS and non-RPS groups as well, which was statistically significant ($p<0.01$) *(Figure 8)*.

Figure 9 illustrates the difference in the mouth opening readings for patients in both cohorts prior to and after radiotherapy. Statistical analysis showed a significant difference in the mouth opening between the two cohorts after completion of radiotherapy with the non-RPS group experiencing reduced mouth opening ($p<0.01$). Comparing the median change in mouth opening pre & post radiotherapy between the groups revealed a 77.7% improvement in mouth opening for the RPS group. Figure 10 illustrates the median and range (high and low) of the two cohorts and the difference in the mouth opening between the two groups is evident.

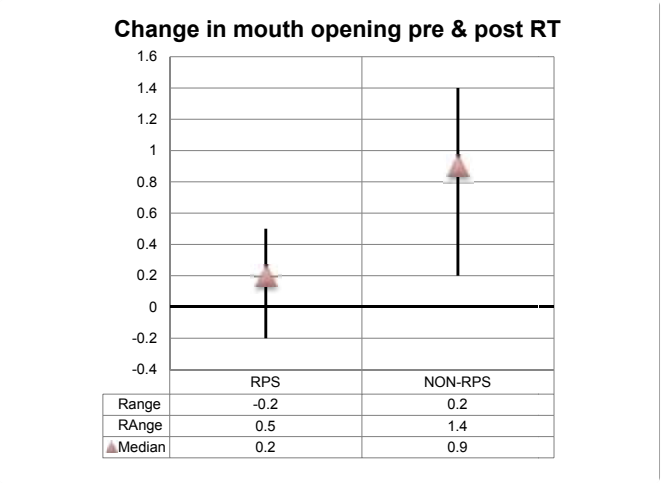

Figure 10: Comparison graph showing median and range of the difference in mouth opening between the two cohorts (Y axis represents the difference measured in centimeters)

DISCUSSION

Reducing radiation dosage to the unaffected regions of the jaw without compromising cancer treatments is important as most of these patients will require oral and dental rehabilitation, which may require invasive surgical procedures. Such procedures in an irradiated area can have adverse outcomes such as poor soft tissue healing and, potentially, osteoradionecrosis. So any measure to reduce or eliminate radiation dosage will improve the chance of success of dental treatment for this group of patients.

The results from this study have demonstrated that the use of a Radiation Positioning Stent (RPS) significantly reduces the radiation dosage to the opposing jaw. This effect was more pronounced when the primary tumour was in or near the mandible with significant reduction in radiation dosage to the maxilla. However, that was not the case when the primary tumour was in or near the maxilla. This could either be due to the small numbers in this study or due to the presence of neck nodes, which need to be included in the planning target volume.

It was also observed that when the posterior representative areas were removed from the calculations, there was a significant reduction in the dose to the opposing arch with the RPS group. Dental implants for head and neck cancer patients are more frequently placed in the anterior region of maxilla and mandible. With the reduction in the radiation dosage to the anterior region with an RPS, the chances of success with implants can only improve.

A literature search revealed very few articles concerning radiation positioning stents with most being case reports.[9, 11, 13-15] A study by Goel *et al* looked at the use of positioning stents in lingual carcinoma patients. There were 48 subjects selected with half given positioning stents and the other half formed the control group. It was reported that there was decreased incidence and severity of mucositis and xerostomia among the study group.[12]

When the issue of mouth opening was assessed in the present study, it was evident that at the 1-2 month post radiotherapy review, the mouth opening of the patients with RPS was reasonably maintained when compared to patients who did not have use of the RPS. Anecdotal experience reveals that due to radiation induced mucositis, patients tend not to stretch their oral cavity during radiotherapy. However, within the RPS group, they would have had to open their mouth on a daily basis to insert and keep the RPS in, while undergoing radiotherapy. This, perhaps, would have helped them to maintain mouth opening. In a study by Wang *et al*,[16] who looked at the degree of radiation-induced trismus pre- and post radiotherapy for nasopharnygeal cancer over a period of time, there was a dramatic rate of decrease in maximal interincisal distance (MID) at 1 and 9 months post radiotherapy. Most of our RPS patients were seen 1-2 months post radiotherapy and did not experience this decrease in MID. This could be due to the constant use of the RPS during radiotherapy, which would have kept the jaws apart intentionally and perhaps prevented fibrosis/scarring of the muscles of mastication. However, there was no follow-up after this period and it is difficult to determine if the mouth opening was maintained in the long term. In the non-RPS group the median reduction in mouth opening pre and post radiotherapy was nearly one centimetre which could significantly affect oral hygiene maintenance and in oral and dental rehabilitation.

It remains to be seen if the mouth opening is preserved in the long term. It would be prudent to conduct more long-term studies with more patients to come to a concrete conclusion as to whether the use of an RPS does maintain mouth opening. This would make provision of oral rehabilitation and dental management much easier for these patients due to improved oral access both for the dentist and the patient.

CONCLUSION

Within the limits of this study, it can be concluded that use of a Radiation Positioning Stent decreases the radiation dosage to the opposing arch. This effect is especially evident in tumours of the mandible with significant reduction of radiation dosage to the maxilla. And with the reduction in radiation dosage to the anterior regions of the opposing arch, it can only improve implant placement and survival. There was also evidence of short-term maintenance of mouth opening in patients who were provided with the RPS with a 77.7% improvement in mouth opening when compared to the non-RPS group.

ACKNOWLEDGEMENT

The authors would like to acknowledge the help of Mrs Heide Dagg in design of the figures.

REFERENCES

1. Dobbs, J., A. Barrett, and D. Ash, *Practical Radiotherapy Planning*. 2nd ed. 1992: Hodder Education.
2. Vissink, A., *et al*., ORAL SEQUELAE OF HEAD AND NECK RADIOTHERAPY. *Critical Reviews in Oral Biology & Medicine*, 2003. **14**(3):199-212
3. Vissink, A., *et al*., PREVENTION AND TREATMENT OF THE CONSEQUENCES OF HEAD AND NECK RADIOTHERAPY. *Critical Reviews in Oral Biology & Medicine*, 2003. **14**(3):213-225
4. Epstein, J.B., *et al*., Quality of life and oral function in patients treated with radiation therapy for head and neck cancer. *Head & Neck*, 2001. **23**(5):389-398
5. Dijkstra, P.U., P.M. Huisman, and J.L.N. Roodenburg, Criteria for trismus in head and neck oncology. *International Journal of Oral and Maxillofacial Surgery*, 2006. **5**(4):337
6. Steelman, R. and J. Sokol, Quantification of trismus following irradiation of the temporomandibular joint. *Missouri Dental Journal* (Jefferson City, Mo.), 1986. **66**(6):21-23
7. Thomas, F., *et al*., Radiotherapy alone for oropharyngeal carcinomas: the role of fraction size (2 Gy vs 2.5 Gy) on local control and early and late complications. *International Journal Of Radiation Oncology*, Biology, Physics, 1988. **15**(5):1097-1102
8. Beumer, J., T. Curtis, and D. Firtell, *Maxillofacial rehabilitation: prosthodontic and surgical considerations*. 1979, St Louis: C.V. Mosby Co.
9. Johnson, B., *et al*., Fabrication of customized tongue-displacing stents: Considerations for use in patients receiving head and neck radiotherapy. *J Am Dent Assoc*, 2013. **144**(6):594-600
10. Kaanders, J.H., *et al*., Devices valuable in head and neck radiotherapy. *Int J Radiat Oncol Biol Phys*, 1992. **23**(3):639-45
11. Verrone, J.R., *et al*., Impact of intraoral stent on the side effects of radiotherapy for oral cancer. *Head & Neck*, 2013. **35**(7):E213-E217
12. Goel, A., *et al*., Use of positioning stents in lingual carcinoma patients subjected to radiotherapy. *International Journal of Prosthodontics*, 2010. **23**(5): 450-452
13. Dirican, B., *et al*., In vitro evaluation of head and neck radiation shields used to reduce exit dose. *International Journal of Prosthodontics*, 2006. **19**(5): 462-466
14. Wang, R. and A. Boyle, A convenient method for guarding against localized mucositis during radiation therapy. *J Prosthodont*, 1994. **3**(4): 198-201
15. Wang, R.R. and L.W. Olmsted, A direct method for fabricating tongue-shielding stent. *The Journal of Prosthetic Dentistry*, 1995(2):171
16. Wang, C.J., *et al*., The degree and time-course assessment of radiation-induced trismus occurring after radiotherapy for nasopharyngeal cancer. *Laryngoscope*, 2005. **115**(8):1458-60