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Dental Disease Prior to Radiotherapy in Head and Neck Cancer Patients: Clinical Registry of Dental Outcomes in Head and Neck Cancer Patients (OraRad)

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Abstract

Background—No evidence-based guidelines exist for preventive dental care before radiation therapy (RT) in head and neck cancer (HNC) patients. An ongoing multicenter, prospective cohort study, Clinical Registry of Dental Outcomes in Head and Neck Cancer Patients (OraRad) (1U01DE022939-01), is addressing this knowledge gap. The present manuscript evaluates the level of pre-RT dental disease in the OraRad cohort, factors associated with dental disease, and dental treatment recommendations made pre-RT.

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Methods—As part of OraRad, caries, periodontal disease, dental recommendations, and dental interventions performed pre-RT were assessed.

Results—Baseline measures are reported for 356 participants (77% male) with mean (SD) age 59.9 (11.0) years. Measures included mean number of teeth (22.9), participants with at least one tooth with caries (37.2%), and participants with at least 1 tooth with probing depth \geq 5 mm (47.4%). Factors associated with less extensive pre-RT dental disease included having at least a high school diploma, having dental insurance, history of routine dental care, and a smaller tumor size (T1 or T2). Based on the pre-RT dental examination, 163 (49.5%) participants had dental treatment recommended before RT, with extractions recommended most frequently.

Conclusion—Many HNC patients require dental treatment pre-RT; over one-third require extractions.

Practical Implications—Most HNC patients have some level of dental disease at the start of RT, indicating the importance of pre-RT dental evaluation. By observing dental outcomes post-RT, OraRad has the potential to determine best dental treatment recommendations for HNC patients.

Introduction

It is estimated that over 63,000 new diagnoses of head and neck cancer (HNC) of the oral cavity, pharynx, or larynx occur annually in the United States with 13,360 estimated deaths/year. The 5-year survival rate is approximately 64% for the oral cavity and pharynx and 61% for the larynx.¹ Treatment of HNC is often multi-modal, including surgical resection, chemotherapy (CT), or radiation therapy (RT). The majority (50–60%) of HNC cases have metastasized to lymph nodes or distant sites at the time of diagnosis, with the more advanced stages of HNC treated with RT and concurrent radiosensitizing chemotherapy (ChemoRT).²

The goal of cancer therapy is to eliminate rapidly dividing cancer cells while sparing non-cancerous tissue. Despite advances in cancer therapy, numerous short- and long-term head and neck side effects occur in HNC patients managed with ChemoRT. Short-term manifestations include mucositis, taste changes, infections, pain, and xerostomia. Long-term manifestations are often irreversible and include limited mouth opening (trismus), taste changes, mucosal pain, secondary cancers, salivary dysfunction, dental caries, and osteoradionecrosis (ORN).^{3–6} Oral manifestations contribute to disability, increased costs, and a diminished quality of life.^{4;7;8} It has been suggested that efforts to minimize the long-term manifestations of dental caries and ORN may be minimized with appropriate pre-RT dental care.²

Despite efforts to reduce risk of oral complications, no standard of care exists for preventive dental care before RT in HNC patients.⁹ To address this lack of standard dental treatment recommendations pre-RT, a multicenter, prospective cohort study was established: Clinical Registry of Dental Outcomes in Head and Neck Cancer Patients (OraRad) ([Clinicaltrials.gov](https://clinicaltrials.gov/ct2/show/study/NCT02057510): NCT02057510). The objective of this report was to describe the level of dental disease of OraRad HNC patients immediately before the start of RT, to describe factors associated with dental disease, and to summarize pre-dental treatment recommendations.

Methods

Study Design

OraRad is an ongoing multicenter clinical registry of HNC patients at six clinical centers: Brigham and Women's Hospital, University of Pennsylvania, Carolinas Medical Center, University of Connecticut, New York University, and University of North Carolina.¹⁰ The study received IRB approval at all enrollment sites. Consented participants are enrolled before they begin RT. Dental disease characteristics and dental interventions performed pre-RT are documented. Each participant is followed at 6-month intervals for 2 years, beginning 6 months after and ending 24 months after the start of RT. At each follow-up visit, a detailed standardized oral and dental assessment is performed. Patients are eligible if age 18 or older; diagnosed with head and neck squamous cell carcinoma (SCC) or a salivary gland cancer (SGC), or with a non-SCC, non-SGC malignancy of the head and neck region, and receiving curative RT of at least 4500 cGY to the head and neck region; having at least 1 natural tooth remaining after pre-RT dental extractions; and having no prior curative RT.

Baseline Procedures

Baseline characteristics collected include demographics (sex, age, race, ethnicity, highest grade of school completed, insurance status), cancer characteristics (type, location, TNM classification), radiation dose and location and chemotherapy utilized, oral hygiene status (routine dental care, frequency of brushing and flossing, health of gums, and use of supplemental fluoride), and dental disease characteristics including caries and periodontal assessment.

The goal of the baseline dental examination is to document the presence and severity of dental disease immediately before the start of RT. The baseline visit is scheduled before RT, after the standard of care (SOC) pre-RT dental evaluation, and after any recommended dental treatment (e.g. extractions) is completed. The baseline pre-RT visit could take place after induction chemotherapy. Dental treatment recommended pre-RT is documented. Examiners also record whether recommended treatment was completed, and if not completed before the start of RT, whether it was eventually completed.

Participants have a baseline dental examination completed by calibrated examiners and all participants have a recent (within 6 months of the examination) panoramic radiograph available. The following dental disease characteristics are collected for each participant at baseline: number of teeth; decayed, missing, and filled surfaces (DMFS); clinical attachment loss (CAL), probing depth (PD), and bleeding on probing (BOP) at six sites per tooth; plaque index at six sites on Ramfjord teeth; tooth mobility (grade 0 = no or physiologic mobility, grade 1 = up to 1 mm buccal-lingual (B-L) direction, grade 2 = 1-2 mm B-L direction, and grade 3 = >2 mm B-L direction or depressible); furcation involvement (grade 0 = none, grade 1 = early, grade 2 = probe penetrates between the roots, grade 3 = probe passes completely underneath crown, and grade 4 = supragingival grade 3 involvement); and radiographic findings of dental implants, impacted teeth, and periapical radiolucencies.¹⁰ The dental treatment recommended was based on each site's SOC radiographic and dental

examination. The recommended treatment completed prior to the start of RT was documented.

The study's enrollment began in April, 2014 and enrollment is ongoing with an enrollment goal of 575 participants based on the primary outcome of tooth loss at 2 years.¹⁰ The current study reports baseline dental findings and dental recommendations as of June 23, 2016. Also, data is reported for 5 of 6 enrollment sites because the sixth site, UNC, recently started enrollment and had only 1 participant enrolled at the time of this analysis.

Statistical Considerations

Comparisons between enrollment centers used Fisher's exact test for categorical measures (e.g., sex, type of cancer, dental insurance [yes/no]), and one-way ANOVA for measures treated as continuous (e.g., age, DMFS, periodontal measures). Tests of associations between categorical measures (e.g., education up to completion of high school vs. beyond high school) and dental disease measures used two-sample t-tests or one-way ANOVA. All analyses were done in SAS (University Edition 3.5, SAS Institute Inc., Cary NC).

Results

Demographics

A total of 355 participants were evaluated from April, 2014 to June, 2016. The mean (standard deviation) age of participants was 59.9 (11.0) years and 77% were male (Table 1). Overall, the racial/ethnic identity included 83% white, 9% black, and 5% Hispanic. Greater than high school education was reported for 251 (71%) participants, with the highest at BWH (81%) and lowest at NYU (57%).

Cancer Characteristics

The most common cancer diagnoses were SCC (n=287, 82%) and SGC (n=39, 11%) (Table 2). The five most common primary sites included tonsil (n = 81; 23%); base of tongue (n = 68; 20%); parotid (n = 30; 9%); nasopharynx (n = 25; 7%); and larynx (n = 16; 5%). The size of the tumor was T3 or greater in 108 (31%) of participants, and nodal metastases (N score of 01 or higher) were noted in nearly three-quarters of participants (n = 257, 73.6%), with rare distant metastases (n = 4, 1.1%).

Medical and Dental Insurance Coverage

Almost all patients had some form of medical insurance (n=345, 97.2%): private insurance (n=280, 78.9%), Medicare (n=92, 25.9%), or Medicaid (n=41, 11.5%) (Table 1). More than half (n=229, 64.5%) had some type of dental insurance. Rates of private medical and dental insurance were higher at BWH and UPenn compared to other sites, with NYU having the highest rates of no insurance.

Oral Hygiene and Dental Disease Measures

Most participants (n=256, 72.5%) reported good or excellent gum health (Table 3). Over three-quarters reported brushing more than once per day and half reported flossing at least once per day. Regarding dental health, over one-third described having some problems with

their teeth, with approximately 10% reporting having problems “quite a bit” or “very much”. The majority of participants (n=254, 72.8%) reported routine dental checkups/cleanings, varying between 52% at CMC and 84% at BWH (P < 0.0001).

Dental Disease at Baseline

The mean number of teeth present pre-RT was 22.9 (SD 5.9) (Table 4). The mean DMFS score was 33.5, which included an average of 1.6 decayed surfaces/participant with 37.2% of participants having at least one tooth with a decayed surface. Periodontal measures had an average clinical attachment level (CAL) of 1.8 mm with 52% of remaining tooth sites having CAL \geq 2mm; nearly 50% of all participants had at least one tooth with a probing depth \geq 5mm. Approximately 40% (n=121) of participants had at least 1 tooth with mobility \geq 1 and 80.4% had at least 1 tooth with early furcation involvement (\geq 1). Measures of CAL and fraction of sites with BOP were highest at NYU, and fraction of sites with probing depth \geq 4mm was highest at UPenn.

Factors Associated with Dental Disease Measures

Numerous factors were associated with dental disease measures. Participants with more than a high school education (p=0.03), who had dental insurance (p=0.0009), or who had routine dental care (p<0.0001) had more teeth at baseline. Patients with a larger tumor size had more tooth sites with PD \geq 4mm (p=0.007). Participants who had dental insurance (p=0.006) or who had received routine dental care (p=0.05) had a lower proportion of tooth sites with a CAL \geq 2 mm.

Dental Treatment Recommendations and Completion Pre-RT

Based on the pre-RT dental examination, 163 (49.5%) participants had dental treatment recommended prior to RT, with dental cleaning in 137 (41.5%); recommended extractions in 116 (35.3%) participants; a new dental restoration or replacement of a restoration in 82 (25%); pre-prosthetic surgery in 21 (6.4%); and endodontic therapy in 8 (2%) (Table 5). Enrollment sites differed in treatment recommendations (e.g. the percent with recommended extractions ranged from 17 to 63%).

Recommended dental treatment was completed in 140/163 (85.9%) participants (Table 6). By dental procedure, the following proportions of participants had their recommended treatment completed: endodontic therapy 100%; pre-prosthetic surgery 100%; extractions 90.5%; dental cleaning 86.9%; and restorations 63.4%.

Discussion

This report describes the level of and factors associated with dental disease at the start of RT in HNC patients. Long-term oral complications related to RT for HNC can have a significant impact on morbidity, quality of life, and health care costs. Increased risk for dental caries has been documented in HNC patients following RT.⁵ A recent study of long-term dental complications in 314 nasopharyngeal cancer patients found an increasing incidence of dental complications from 1 year post-RT (16%) to 3 years (36%), 5 years (55%), and 7 years (74%); with a total of 35% developing dental caries and 5% developing osteoradionecrosis

during a mean follow-up of 111 months.¹¹ Worsening of periodontal disease following RT has also been reported, albeit in smaller studies.^{12–14}

Prior studies that have assessed pre-RT dental and periodontal disease have been retrospective in nature and from a single clinical site compared to OraRad, a prospective, multicenter cohort study. Niewald et al. reported a German cohort of 90 HNC patients who had received conventional RT in the range of 36–76.8 Gy. In this study, the mean number of teeth present at the beginning of RT was 10.1 (the study included edentulous patients) with the mean number of carious teeth 2.0; over half of patients had chronic periodontitis, with poor dental hygiene noted in 39% of patients.¹⁵ We similarly found that 47% of patients had a tooth with a probing depth \geq 5mm at the start of RT. Another study in Taiwan found that among 181 patients presenting for pre-RT dental evaluation, the average number of carious teeth was 2.45, while at follow-up visits up to 5 years post-RT, the mean number of carious teeth for 42 subjects was 7.18.¹⁶ Similarly, we found that patients commonly begin RT with untreated carious teeth (mean 1.2 teeth) with 37% having a decayed tooth at the start of RT.

There is currently no clear standard for dental care that needs to be completed before RT for HNC patients. A systematic review of studies that assessed elimination of oral infections pre-RT found high heterogeneity in the patient cohorts, dental screening methods, definitions of oral foci of infection, and techniques to eliminate oral infections.⁹ Additionally, 17 of 20 such studies were retrospective. Therefore, there is only a low level of evidence regarding whether removal of oral sources of infection prevents post-RT oral complications.⁹

In the current study, education level, history of routine dental care, tumor size, and dental insurance were associated with the level of presenting dental disease. Participants with education beyond high school, reporting routine dental care, and having dental insurance had more teeth at the start of RT. Similarly, participants having dental insurance and reporting routine dental care had fewer tooth sites with CAL \geq 2 mm, and participants with smaller tumors had fewer sites with probing depth \geq 4 mm. Prior studies have demonstrated an increased risk of head and neck cancer with numerous factors such as poor oral hygiene, no routine dental care, frequent gum bleeding, low socioeconomic status and lower education attainment.^{17,18} Additionally, initial dental hygiene was identified as a risk factor for dental disease with initial poor dental hygiene being associated with development of ORN.¹¹ We did not find patient-reported frequency of brushing or flossing to be associated with baseline levels of dental disease, although receiving routine dental care was associated with improved levels of dental health. As routine dental care was self-reported, these values may be inflated.

The OraRad study is a prospective, observational registry of HNC patients, with no interventional component. It was designed to maximize the benefits of a multicenter study, so that differences in baseline characteristics and pathways of care at different centers were expected and indeed desired. We found that OraRad enrollment sites differ in pre-RT treatment recommendations, reflecting real-world institutional differences and variations in treatment protocols. This provides an opportunity to describe the impact of different models of care on OraRad outcomes.

In the current observational study, dental treatment recommendations and dental treatment completed pre-RT are either provided by a dentist at the enrolling site, a private dentist, or a combination of both. The patient's private dentist completed this recommendation most of the time at BWH with a review by the Oral Medicine faculty at BWH with either approval as is, or additional recommendations for oral/dental care if/as needed, while the pre-RT dental treatment plan was usually completed by a dentist at the enrollment site at U Penn, CMC, and U Conn. At NYU, the pre-RT dental treatment plan is recommended by either a dentist at the enrollment site or by their private dentist. These differences in approach to pre-RT dental treatment likely account for some differences between the sites in treatment recommendations and in dental treatment completion pre-RT.

The enrollment sites also differed in who performed pre-RT dental treatment and in the time frame in which the treatment was done. In all sites, extractions were recommended to be completed before RT. At BWH, extractions were primarily done by the patient's private dentist or oral surgeon in the community with more challenging extractions completed at BWH, whereas at U Penn, CMC and U Conn extractions were typically performed by a dentist or oral surgeon at the enrollment site. At NYU, there was a mix of extractions completed by a private dentist or oral surgeon, or by a dentist or oral surgeon at the enrollment site. Lastly, enrollment sites differed regarding who performed non-extraction dental treatment recommendations and when they were completed. At most sites (BWH, NYU, U Penn, U Conn) restorative care was deferred until after RT and was completed by the patient's private dentist, if they had one. At CMC, the pre-RT non-extraction dental treatment recommendations were primarily completed by a dentist at the enrollment site before the start of RT.

Other factors that may account for enrollment site differences include demographics, insurance, prior history of dental care, oral hygiene parameters, and cost of care. As there were a number of significant difference among study site (e.g. a higher rate of post-high school education at BWH; more racial and ethnic diversity at NYU; higher rates of medical and dental insurance at BWH and U Penn; and higher rates of routine dental care for patients at BWH and U Penn), the role of these risk factors in dental outcomes will be thoroughly assessed using the present study's complete follow-up cohort.

We found that 14.1% of patients who had pre-RT dental treatment recommended did not complete the treatment. Dental restoration was the recommended procedure that was most commonly not completed and thus most frequently deferred, with 36.6% of patients with recommended restorations not completed pre-RT. With respect to extractions, 9.5% of recommended extractions were not completed before the start of RT. Analyses of further follow-up data on completion of this study will allow us to determine whether these teeth were ever restored or extracted after completion of RT. Considering the potential for increased dental caries post-RT due to factors such as salivary hypofunction and potential direct RT damage to tooth structure, unresolved dental caries may increase the risk for non-restorable teeth post-RT, which may require more extensive dental procedures, or increase the risk of ORN.⁴

The non-interventional study design of OraRad has some inherent limitations. As noted, the SOC for assessment and treatment recommendations differs among providers at the enrollment sites. Although this does represent the reality of SOC differences between enrollment sites, this can lead to limitations of the present study. For example, differences in which teeth are recommended for extractions -- some sites recommended extraction of teeth deemed to be poor prognosis, even outside of the high-dose RT field -- may account for some differences in why certain teeth were not extracted. A factor that may have led to deferred treatment includes insufficient time to complete recommended dental work with a rapidly growing cancer needing appropriate treatment. Another limitation of the present study includes the DMFS score does not document the depth of caries, which may increase the risk of tooth loss and ORN.

The current study included a cohort of HNC patients enrolled in the OraRad registry. The majority of participants in this HNC cohort presented with some level of dental disease at the start of RT, which may increase the risk of poor outcomes. Given the current findings of a high rate of carious teeth (37%) and periodontal disease (47%), a pre-RT dental assessment is needed to address active dental disease prior to the start of RT. These participants will be followed every 6 months for 2 years, during which baseline dental disease will be assessed as a potential risk factor for future oral concerns such as caries, worsening periodontal disease, tooth loss, and ORN. Additionally, preventive programs used as SOC (e.g. high fluoride applications with or without trays) will be assessed with this complete cohort. Considering the complexity of the complications post-RT in HNC patients, the need for dental practitioners to have a strong background in HNC treatment considerations and integration of pre-RT dental care with the HNC multi-disciplinary team is vital to manage the complex logistics of completing recommended dental care. Based on the findings of this multicenter study, differences in SOC dental treatment recommendations pre- and post-RT in relation to dental outcomes will help shape guidelines for future management of HNC patients and help identify opportunities for interventions with the intent of improving care for HNC patients. Future clinical trials will also be essential to improve pre- and post-management of HNC patients.

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Appendix

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Table 1

Demographics

Variable	All Sites	BWH	UPENN	CMC	UConn	NYU	P-value
Number of people	355	95	104	69	38	49	
Sex:							0.1798
Male	274 (77.2%)	73 (76.8%)	86 (82.7%)	52 (75.4%)	31 (81.6%)	32 (65.3%)	
Female	81 (22.8%)	22 (23.2%)	18 (17.3%)	17 (24.6%)	7 (18.4%)	17 (34.7%)	
Age (mean years (SD)):	59.9 (11.0)	61.2 (8.7)	58.9 (10.3)	60.3 (11.7)	58.7 (10.1)	59.9 (15.5)	0.5823
Highest Grade:							0.0010
High School Graduate or less	102 (28.7%)	17 (17.9%)	29 (27.9%)	24(34.8%)	11(28.9%)	21(42.9%)	
Post-High School Education	251 (70.7%)	77 (81.1%)	74 (71.2%)	45(65.2%)	26 (68.4%)	28 (57.1%)	
Decline	2 (0.6%)	1 (1.1%)	0 (0%)	0 (0%)	1 (2.6%)	0 (0%)	
Race:							0.0010
White	294 (82.8%)	91 (95.8%)	94 (90.4%)	55 (79.7%)	34 (89.5%)	20 (40.8%)	
Black	31 (8.7%)	2 (2.1%)	3 (3.9%)	11 (15.9%)	3 (7.9%)	11 (22.4%)	
Multiracial	5 (1.4%)	1 (1.1%)	1 (1.0%)	2 (2.9%)	0 (0%)	1 (2.0%)	
Asian	16 (4.5%)	1 (1.1%)	2 (2.0%)	0 (0%)	0 (0%)	13 (26.5%)	
Native Hawaiian	1 (0.3%)	0 (0%)	1 (1.0%)	0 (0%)	0 (0%)	0 (0%)	
Native American	1 (0.3%)	0 (0%)	0 (0%)	0 (0%)	1 (2.6%)	0 (0%)	
Don't Know/Declined	7 (2.0%)	0 (0%)	2 (2.0%)	1 (1.5%)	0 (0%)	4 (8.2%)	
Ethnicity:							<.0001
Hispanic	18 (5.1%)	0 (0%)	1 (1.0%)	4 (5.8%)	2 (5.3%)	11 (22.4%)	
Non-Hispanic	337 (94.9%)	95 (100%)	103 (99.0%)	65 (94.2%)	36 (94.7%)	38 (77.6%)	
Type of Med. Insurance							0.0010
No Insurance:							
No	345 (97.2%)	95 (100%)	104 (100%)	65 (94.2%)	38 (100%)	43 (87.8%)	
Yes	10 (2.8%)	0 (0%)	0 (0%)	4 (5.8%)	0 (0%)	6 (12.2%)	
Private Insurance:							<.0001
No	75 (21.1%)	7 (7.4%)	1 (1.0%)	24 (34.8%)	13 (34.2%)	30 (61.2%)	
Yes	280 (78.9%)	88 (92.6%)	103 (99.0%)	45 (65.2%)	25 (65.8%)	19 (38.8%)	
Medicare:							0.0064

Variable	All Sites	BWH	UPENN	CMC	UConn	NYU	P-value
No	263 (74.1%)	76 (80.0%)	84 (80.8%)	41 (59.4%)	30 (78.9%)	32 (65.3%)	
Yes	92 (25.9%)	19 (20.0%)	20 (19.2%)	28 (40.6%)	8 (21.1%)	17 (34.7%)	0.0005
Medicaid:							
No	314 (88.5%)	88 (92.6%)	103 (99.0%)	64 (92.8%)	30 (78.9%)	29 (59.2%)	
Yes	41 (11.5%)	7 (7.4%)	1 (0.99%)	5 (7.3%)	8 (21.1%)	20 (40.8%)	<.0001
Dental Insurance:							
No	126 (35.5%)	26 (27.4%)	24 (23.1%)	40 (58.0%)	15 (39.5%)	21 (42.9%)	
Yes	229 (64.5%)	69 (72.6%)	80 (76.9%)	29 (42.0%)	23 (60.5%)	28 (57.1%)	

Note: The sample size varies slightly between tables because different data items come from different case-report forms and not all forms were completed for all study participants at the time of the analysis

Table 2

Cancer Characteristics

Variable	All Sites	BWH	UPENN	CMC	UConn	NYU	P-value
Number of people	349	97	102	68	38	44	0.9572
Type of Cancer:							
SCC	288 (82.5%)	81 (83.5%)	86 (84.3%)	56 (82.4%)	32 (84.2%)	33 (75.0%)	
SGC	38 (10.9%)	9 (9.3%)	10 (7.8%)	8 (11.7%)	4 (10.5%)	7 (15.9%)	
Non-SCC/Non-Salivary	23 (6.6%)	7 (7.2%)	6 (7.8%)	4 (5.9%)	2 (5.3%)	4 (9.1%)	
Primary Tumor Site							-
Base of Tongue	68 (19.5%)	25 (25.8%)	19 (18.6%)	10 (14.7%)	6 (15.8%)	8 (18.2%)	
Buccal/Labial Mucosa	6 (1.7%)	0 (0%)	1 (1.0%)	2 (2.9%)	1 (2.6%)	2 (4.5%)	
Epiglottis	2 (0.6%)	1 (1.0%)	0 (0%)	0 (0%)	1 (2.6%)	0 (0%)	
Floor of Mouth	3 (0.9%)	2 (2.1%)	0 (0%)	0 (0%)	0 (0%)	1 (2.3%)	
Gingiva/Alveolar Ridge	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Hard Plate	6 (1.7%)	4 (4.1%)	0 (0%)	0 (0%)	0 (0%)	2 (4.5%)	
Hypopharynx	8 (2.3%)	2 (2.1%)	3 (3.0%)	1 (1.5%)	2 (5.3%)	0 (0%)	
Larynx	16 (4.6%)	4 (4.1%)	2 (2.0%)	5 (7.4%)	2 (5.3%)	3 (6.8%)	
Lip	3 (0.9%)	2 (2.1%)	0 (0%)	0 (0%)	0 (0%)	1 (2.3%)	
Mandible	3 (0.9%)	1 (1.0%)	0 (0%)	2 (2.9%)	0 (0%)	0 (0%)	
Maxilla	1 (0.3%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (2.3%)	
Maxillary Sinus	3 (0.9%)	0 (0%)	3 (3.0%)	0 (0%)	0 (0%)	0 (0%)	
Nasal Cavity	2 (0.6%)	0 (0%)	0 (0%)	1 (1.5%)	0 (0%)	1 (2.3%)	
Nasopharynx	25 (7.2%)	3 (3.1%)	7 (6.9%)	6 (8.8%)	1 (2.6%)	8 (18.2%)	
Neck	7 (2.0%)	3 (3.1%)	1 (1.0%)	3 (4.4%)	0 (0%)	0 (0%)	
Oral Cavity	2 (0.6%)	2 (2.1%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Oral Tongue	23 (6.6%)	5 (5.2%)	5 (5.0%)	7 (10.3%)	3 (7.9%)	3 (6.8%)	
Oropharynx	9 (2.6%)	1 (1.0%)	3 (3.0%)	0 (0%)	2 (5.3%)	3 (6.8%)	
Paranasal Sinus/Orbit	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Parotid	30 (8.6%)	8 (8.2%)	11 (10.9%)	5 (7.4%)	3 (7.9%)	3 (6.8%)	
Pharynx	1 (0.3%)	0 (0%)	0 (0%)	1 (1.5%)	0 (0%)	0 (0%)	
Retromolar Trigone	1 (0.3%)	1 (1.0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	

Variable	All Sites	BWH	UPENN	CMC	UConn	NYU	P-value
Soft Palate	4 (1.1%)	1 (1.0%)	1 (1.0%)	1 (1.5%)	1 (2.6%)	0 (0%)	
Sublingual Gland	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Submandibular Gland	5 (1.4%)	1 (1.0%)	0 (0%)	3 (4.4%)	1 (2.6%)	0 (0%)	
Tonsil	81 (23.2%)	18 (18.6%)	35 (34.3%)	18 (26.5%)	7 (18.4%)	3 (6.8%)	
Unknown	20 (5.7%)	6 (6.2%)	5 (4.9%)	2 (2.9%)	4 (10.5%)	3 (6.8%)	
Other	20 (5.7%)	7 (7.2%)	6 (5.9%)	1 (1.5%)	4 (10.5%)	2 (4.5%)	
Cancer							
Classification							
T:							0.1708
0	13 (3.7%)	8 (8.3%)	0 (0%)	2 (2.9%)	0 (0%)	3 (6.8%)	
1	91 (26.1%)	24 (24.7%)	31 (30.4%)	20 (29.4%)	9 (23.7%)	7 (15.9%)	
2	120 (34.4%)	33 (34.0%)	36 (35.3%)	25 (36.8%)	11 (28.9%)	15 (34.1%)	
3	55 (15.8%)	15 (15.5%)	16 (15.7%)	9 (13.2%)	8 (21.1%)	7 (15.9%)	
4	53 (15.2%)	16 (16.5%)	13 (12.7%)	10 (14.7%)	6 (15.8%)	8 (18.2%)	
X	17 (4.9%)	1 (1.0%)	6 (5.9%)	2 (2.9%)	4 (10.5%)	4 (9.1%)	
M:							0.0010
0	327 (93.7%)	86 (88.7%)	101 (99.0%)	67 (98.5%)	38 (100%)	35 (79.5%)	
1	4 (1.1%)	3 (3.1%)	0 (0%)	1 (1.5%)	0 (0%)	0 (0%)	
X	18 (5.2%)	8 (8.3%)	1 (1.0%)	0 (0%)	0 (0%)	9 (20.5%)	
N:							0.3377
00	82 (23.5%)	17 (17.5%)	23 (22.5%)	16 (23.5%)	12 (31.6%)	14 (31.8%)	
0X	10 (2.9%)	3 (3.1%)	1 (1.0%)	1 (1.5%)	0 (0%)	5 (11.4%)	
01	42 (12.0%)	13 (13.4%)	10 (9.9%)	10 (14.7%)	4 (10.5%)	5 (11.4%)	
2a	32 (9.2%)	9 (9.3%)	14 (13.7%)	5 (7.4%)	2 (5.3%)	2 (4.6%)	
2b	119 (34.1%)	37 (38.1%)	39 (38.2%)	23 (33.8%)	12 (31.6%)	8 (18.2%)	
2c	46 (13.2%)	12 (12.4%)	12 (11.8%)	9 (13.2%)	5 (13.2%)	8 (18.2%)	
03	18 (5.2%)	6 (6.2%)	2 (2.9%)	4 (5.9%)	3 (7.9%)	2 (4.6%)	

Table 3

Oral hygiene and Dental Disease Measures

Variable	All Sites	BWH	UPENN	CMC	UConn	NYU	P-value
Number of people	353	95	104	69	38	47	
How often brush:							0.6790
More than once/day	275 (77.7%)	73 (76.8%)	84 (80.8%)	56 (81.2%)	26 (68.4%)	36 (76.6%)	
Once/day	64 (18.4%)	17 (17.9%)	17 (16.3%)	10 (14.5%)	11 (28.9%)	9 (19.1%)	
4-6X/week	5 (1.4%)	2 (2.1%)	1 (1.0%)	1 (1.5%)	1 (2.6%)	0 (0%)	
1-3X/week	8 (2.3%)	3 (3.2%)	2 (1.9%)	2 (2.9%)	0 (0%)	1 (2.1%)	
Less than 1X/week	1 (0.3%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (2.1%)	
Dental Floss:							0.0015
More than once/day	67 (18.9%)	19 (20.0%)	18 (17.3%)	20 (29.0%)	1 (2.6%)	9 (19.1%)	
Once/day	110 (31.1%)	35 (36.8%)	35 (33.7%)	19 (27.5%)	12 (31.6%)	9 (19.1%)	
4-6X/week	23 (6.5%)	10 (10.5%)	8 (7.7%)	4 (5.8%)	1 (2.6%)	0 (0%)	
1-3X/week	65 (18.4%)	17 (17.9%)	20 (19.2%)	13 (18.8%)	6 (15.8%)	9 (19.1%)	
Less than 1X/week	88 (24.9%)	14 (14.7%)	23 (22.1%)	13 (18.8%)	18 (47.4%)	20 (42.6%)	
Health of Gums:							0.1794
Excellent	48 (13.6%)	17 (17.9%)	14 (13.5%)	9 (13.0%)	4 (10.5%)	4 (8.51%)	
Good	208 (58.8%)	58 (61.1%)	61 (58.7%)	43 (62.3%)	17 (44.7%)	29 (61.7%)	
Fair	78 (22.0%)	17 (17.9%)	27 (26.0%)	12 (17.4%)	12 (31.6%)	10 (21.3%)	
Poor	14 (4.0%)	3 (3.2%)	2 (1.9%)	4 (5.8%)	3 (7.9%)	2 (4.3%)	
Very Poor	5 (1.4%)	0 (0%)	0 (0%)	1 (1.5%)	2 (5.3%)	2 (4.3%)	
Do you use supplemental fluoride:							0.0005
Yes	144 (40.7%)	49 (51.6%)	61 (58.7%)	23 (33.3%)	8 (21.1%)	6 (12.8%)	
No	206 (58.2%)	46 (48.4%)	42 (40.4%)	46 (66.7%)	30 (78.9%)	39 (83.0%)	
Not Sure	3 (0.8%)	0 (0%)	1 (1.0%)	0 (0%)	0 (0%)	2 (4.3%)	
Do you have problems with your teeth?							0.2214
Not at All	234 (66.1%)	65 (68.4%)	67 (64.4%)	49 (71.0%)	20 (52.6%)	33 (70.2%)	
A Little	84 (23.7%)	17 (17.9%)	30 (28.8%)	13 (18.8%)	13 (34.2%)	11 (23.4%)	
Quite a Bit	23 (6.5%)	11 (11.6%)	5 (4.8%)	4 (5.8%)	2 (5.3%)	1 (2.1%)	
Very Much	12 (3.4%)	2 (2.1%)	2 (1.9%)	3 (4.4%)	3 (7.9%)	2 (4.3%)	

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Variable	All Sites	BWH	UPENN	CMC	UConn	NYU	P-value
Routine Check up/Cleaning							
Yes	254 (72.8%)	80 (84.2%)	85 (81.7%)	36 (52.2%)	25 (65.8%)	28 (59.6%)	<.0001
No	100 (28.3%)	15 (15.8%)	19 (18.3%)	33 (47.8%)	13 (34.2%)	19 (40.4%)	

Table 4

Dental Disease at Baseline

Variable	All Sites	BWH	UPENN	CMC	UConn	NYU	P-value
# of Teeth (mean(SD)) DMFS* :	22.9 (5.9)	23.5 (5.6)	24.1 (4.3)	21.7 (6.7)	22.0 (7.6)	21.2 (5.8)	0.0173
Score (mean(SD))	33.5 (19.9)	39.0 (21.5)	34.8 (20.0)	29.1 (18.0)	29.1 (16.3)	28.2 (18.9)	0.0023
D	1.6 (3.6)	0.7(2.0)	2.3 (4.2)	1.8 (3.2)	1.6 (2.8)	1.7 (5.5)	0.0673
M	4.5 (5.8)	3.2 (5.0)	3.5 (4.2)	5.8 (6.8)	5.3 (7.8)	6.4 (5.9)	0.0037
F	27.3 (20.7)	35.1 (22.1)	29.1 (19.6)	21.5 (19.3)	22.2 (17.5)	20.2 (19.2)	<0001
Whole Mouth Avg. CAL (mm mean(SD))**	1.8 (0.9)	1.8 (0.6)	1.5 (0.9)	1.8 (0.6)	1.7 (1.1)	2.4 (1.1)	<0001
% (SD) sites with CAL 2mm	52.0% (25.8)	55.3% (21.4)	38.1% (22.3)	55.0% (20.2)	45.2% (27.7)	74.7% (25.8)	<0001
Whole Mouth Avg. PD (mm mean (SD))#	2.4 (0.5)	2.3 (0.5)	2.8 (0.4)	2.4 (0.5)	2.1 (0.4)	2.2 (0.5)	<0001
% (SD) sites with PD 4mm	12.2% (13.5)	8.5% (9.2)	22.2% (22.2)	8.6% (13.2)	7.8% (9.6)	7.8% (8.6)	<0001
% (SD) sites with BOP##	13.6% (15.2)	8.0% (9.2)	12.5% (9.1)	14.1% (13.0)	9.6% (9.7)	28.9% (26.3)	<0001
Mouth avg. (SD) Plaque Index	0.9 (0.6)	0.7 (0.6)	1.1 (0.4)	0.4 (0.4)	1.0 (0.7)	1.2 (0.5)	<0001
# (%) w/ 1 tooth Mobility>0	121 (39.7%)	42 (51.9%)	28 (32.9%)	17 (29.3%)	13 (35.1%)	21 (47.7%)	0.02433
# (%) w/ > 1 tooth Furcation >0	230 (80.4%)	72 (94.7%)	71 (88.8%)	32 (62.7%)	26 (70.3%)	29 (69.0%)	<0001
Radiographic							
N forms filed	356	95	104	69	38	49	
Any Dental Implants (# (%))	23 (6.5%)	13 (13.7%)	5 (4.8%)	2 (2.9%)	2 (5.3%)	1 (2.0%)	0.0280

* DMFS=Decayed, Missing, Filled Surfaces

** CAL=Clinical Attachment Loss

PD=Probing Depth

BOP=Bleeding on Probing

Table 5

Number and Percent of Participants with Recommended Procedures

Variable	All Sites	BWH	UPENN	CMC	UConn	NYU
Number participants Participants w/ Recorded Procedures*	329 (49.5%)	93 (43.0%)	92 (31.5%)	68 (83.2%)	38 (47.4%)	38 (50.0%)
Dental Cleaning	163 (41.6%)	40 (75.2%)	29 (0%)	52 (76.5%)	5 (13.2%)	10 (26.3%)
Extraction	116 (35.3%)	16 (17.2%)	27 (29.3%)	43 (63.2%)	14 (36.8%)	16 (42.1%)
Any Restoration	82 (24.9%)	30 (32.3%)	1 (1.1%)	41 (60.3%)	6 (15.8%)	4 (10.5%)
Pre-Prosthetic Surgery	21 (6.4%)	0 (0%)	0 (0%)	20 (29.4%)	1 (2.6%)	0 (0%)
Endodontic Therapy	8 (2.4%)	3 (3.2%)	1 (1.1%)	4 (5.9%)	0 (0%)	0 (0%)

* number (%) with any procedure recommended

Table 6

Percent of Recommended Procedures Completed

Variable	All Sites	BWH	UPENN	CMC	UConn	NYU
People w/ Comp. Proc.*	140 (85.9%)	33 (82.5%)	25 (86.2%)	55 (96.5%)	14 (77.8%)	13 (68.4%)
Dental Cleaning	119 (86.9%)	61 (87.1%)	NR	50 (96.2%)	4 (80%)	4 (40%)
Extraction	105 (90.5%)	13 (81.3%)	23 (85.2%)	43 (100%)	13 (92.9%)	13 (81.3%)
Any Restoration	52 (63.4%)	26 (86.7%)	1 (100%)	24 (58.5%)	1 (16.7%)	0 (0%)
Pre-Prosthetic Surgery	21 (100%)	NR**	NR	20 (100%)	1 (100%)	NR
Endodontic Therapy	8 (100%)	3 (100%)	1 (100%)	4 (100%)	NR	NR

* number of people with recommended procedures completed (% of those with recommended procedures)

** not recommended for any patient with the initial pre-RT dental treatment plan