Dentition, nutritional status and adequacy of dietary intake in treatment naïve head and neck cancer patients

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ABSTRACT

Objectives: To examine the relationship of reduced numbers of occluding teeth and dietary intake (DI), nutrition impact symptoms (NIS), and weight loss (WL) in head and neck cancer (HNC) patients.

Methods: As a part of the standard of care, treatment-naïve HNC patients (n = 104) completed dental evaluation (number of teeth, total anterior/posterior occlusal teeth, Eichner Index (EI) classification), WL, DI questionnaire and HNC Symptom Checklist©. Descriptive statistics (Kruskal-Wallis, Fisher-exact, χ² tests) and (uni-) multivariable logistic regression.

Results: Overall, 42, 45 and 13% of patients were in EI-class A, B and C with a median of 8, 3, and 0 total posterior occlusal teeth. EI-class B/C patients were older, more likely to have impaired DI (OR = 3.88; 95%CI:1.63–9.26; P = 0.002) and reported interference with DI by 11 NIS (p < 0.05). DI was, however, reported as unimpaired in 77, 49 and 39% of patients in EI-class A, B and C, respectively. The subset of EI-class B/C patients with impaired DI, had more NIS interference with DI (P < 0.05; difficulty chewing, pain, early satiety, lack of energy); EI-class C patients additionally had dry mouth, thick saliva and dysphagia (P < 0.05). In logistic regression, EI-classes B/C patients with reduced (vs unimpaired) DI were more likely to have WL (OR = 10.1; 95%CI:2.0–50.0), higher NIS interference (range OR 4.3–10.7).

Conclusions: More than half of these HNC patients had reduced numbers of occlusal teeth or were edentulous. EI-class B/C patients did not necessarily have impaired DI, however the combination of EI-class B/C and a constellation of NIS, associated with reduced DI.

Clinical significance: Treatment naïve head and neck cancer (HNC) patients with reduced occlusal and masticatory performance (Eichner Index B/C) and reduced dietary intake are at high risk for weight loss. Identifying HNC patients at risk may improve their oral health, dietary intake and reduce their risk of weight loss.

1. Introduction

Head and neck cancer (HNC) patients are at high risk of cancer-associated weight loss (WL) [1, 2, 3, 4]. Cancer-associated WL is driven by a combination of reduced dietary intake (DI) and altered metabolism [5]. Of these two factors, reduced DI is likely the predominant factor driving this WL in HNC. Pain, anxiety, nausea, and depression are but a few symptoms triggering a reduction in DI, by decreasing or eliminating the central drive to eat within the brain (appetite centre). In addition, other symptoms referred to as nutrition impact symptoms (NIS) including dysphagia, xerostomia, bowel obstruction, early satiety and dental issues may contribute to reduced DI [6].

The symptoms which can potentially impact DI in patients with HNC are legion. We previously identified 17 NIS in patients with HNC in a review of the literature [7]. One of these, dental problems, has received relatively little attention, in spite of the fact that loss or forfeiture of teeth is relatively common in patients with HNC [8]. In addition to pre-existing dental issues, surgical extraction, periodontal disease, dental caries and...
osteonecrosis may occur in consequence of cancer treatments [8, 9].
Adapting to tooth loss, specifically when it affects the ability to grind and chew food can make it challenging to maintain a normal diet. Normal adults have 32 teeth, including 8 incisors, 4 canines, 8 premolars and 12 molars. Occlusion (i.e. contact between teeth) between maxillary and mandibular teeth is required for biting and chewing. Masticatory function—the ability to grind and chew food, is reduced as the number of posterior occlusal contacts (normally n = 8) decreases [10, 11]. The loss of posterior occlusal contacts has been associated with pain and decreased chewing and swallowing ability, saliva flow and quality of life (QOL) in healthy and older adults [12, 13, 14, 15, 16, 17, 18, 19].
The relationship between tooth loss, DI and nutritional status has been the subject of multiple studies, mainly in healthy and older adults [12, 13, 14, 15, 16, 17, 18, 19]. The majority of longitudinal multivariable analyses in healthy and older adults adjusted for age, sex, race, education status or socioeconomic status which measured tooth numbers through self-reported edentulism, total number of teeth or various measures of functional tooth units found a significant association between tooth loss and altered dietary choice or DI [20, 21, 22]. There has been only one study related to dentition and nutrition in patients with cancers of the head and neck [23]. In that study 34 untreated male HNC patients were stratified according tooth loss as defined by either <5/8 posterior occluding contacts, or by < 7 total pairs of occluding teeth irrespective of their anterior or posterior positions in the mouth. Neither of these definitions of tooth loss were associated with body mass index (BMI) < 20 kg/m², serum albumin <2.7 g/dL, hemoglobin <11.9 g/dL and total lymphocyte count <1.449/µL [23].
We considered that there is a need for clarification of the potential impact of dentition on nutritional status in patients with cancers of the head and neck. To achieve this, we selected a series of tools to evaluate our patient population. The Eichner Index (EI) is a standardized classification of posterior occlusal contacts and a validated measure of dentition and masticatory performance [24, 25]. EI classification describes the existing posterior occlusal contacts between the maxilla and mandible in the bilateral premolar and molar area referred to as support zones and divides the occlusal status into three main classes (A, B, and C). EI-class A, have occlusal contacts in all four posterior support zones; EI-class B have occlusal contacts in one to three zones of contact or within the anterior area only; EI-class C, have no occlusal contacts at all. The Patient-Generated Subjective Global Assessment© (PG-SGA©), is a validated tool recommended by Oncology Dietitians Clinical Practice Group as a nutrition screening tool for oncology patients. PG-SGA© encompasses BMI, WL history, performance status (PS) and DI [26]. The Head and Neck Symptom Checklist© is a validated measure of seventeen specific NIS interfering with DI in patients with cancers of the head and neck [7, 27]. We previously showed that our population of HNC patients experience significant symptom burden prior to initiation of treatments and that the aggregate burden of symptoms was a significant independent predictor of reduced DI, WL and survival [28]. We aimed to clarify the relationship between posterior occlusal contacts, DI, NIS and cancer-associated WL in treatment-naive HNC patients.

2. Material and methods

2.1. Population cohort and data acquisition

This study was conducted in accordance with the Declaration of Helsinki and approved by the institutional research ethics board as a retrospective chart review of nutritional status. We studied a series of treatment-naïve patients referred to a single regional cancer treatment centre in northern Alberta, Canada. In this centre, patients are evaluated at the time of diagnosis by a team of surgeons, medical oncologists, radiation oncologists, dieticians and dental health professionals. Dental assessment is conducted in single outpatient dentistry clinic, prior to initiation of the cancer treatment plan. A full oral and dental examination was completed for all patients. Data were collected from January 2011–December 2012 on a random sample of this population. Demographic information, and cancer site and stage were obtained from the Alberta Cancer Registry, certified by the North American Association for Central Cancer Registries. Cancer stage was based on the American Joint Committee on Cancer (6th Edition) stage groupings for HNC: 0, I, II, III, and IV, unknown, primary. HNC tumor sites were based on the International Classification of Diseases for Oncology (ICD)-O-3 site codes.

2.2. Assessments

A trained dentist undertook the oral examinations to determine total number of teeth, functional anterior and posterior tooth units defined by natural, restored or fixed prosthetic teeth and define EI classification. Height and weight histories over the 6 months preceding clinic referral, performance status (PS) (a lay-language version of the Eastern Cooperative Oncology Group (ECOG) PS) and seven DI categories were collected using the Patient-Generated Subjective Global Assessment© (PG-SGA©). The PG-SGA© DI category “only tube feeding or nutrition by vein” was used as an exclusion criterion as our interest was specifically in patients capable of oral intake. Patient-reported height, weight and WL history are reliable [29, 30]. The Head and Neck Symptom Checklist© (HNSCOD) a validated measure of NIS effect on energy intake and WL, was used to assess 17 NIS interference with DI [7, 27]. The patient responds to the severity of each NIS’s interference with DI on a 5-point Likert scale (ranging from 1 to 5): not at all, a little bit, somewhat, quite a bit, a lot. The total NIS interference scores refer to a composite score calculated by summing the interference scores reported for all 17 NIS.

2.3. Statistical analyses

Means, medians, standard deviations (SD), cross-tabulation, frequency or percentages were used as descriptive statistics. Nonparametric statistical methods were used if data was non-normally distributed. Chi-square test, Fisher-exact test (categorical data) and Kruskall-Wallis test (continuous data) was used in statistical comparisons between EI-classes. Univariable logistic regression was undertaken to determine the odds ratio (OR) of having poor dentition i.e EI-class B/C vs EI-class A (reference). Univariable logistic regression was also undertaken to determine the odds ratio (OR) of having reduced DI versus normal DI (reference) in the subset of patients with dentition of EI-class B/C. Covariables in these models included: age (continuous), BMI (continuous), sex, tumor staging, stage I and II (reference) vs all other stages; ECOG PS, Normal PS (ECOG PS 0, no limitations) (reference) vs reduced PS (ECOG PS 1–4); tumor site, DI category, normal DI (DI = 0, normal food, normal amount) (reference) vs reduced DI (DI = 1 to 5, abnormal foods, reduced amount); WL, absent (reference) or present; ≤5% WL, absent (reference) or present. NIS interference score (reference) vs NIS scores ≥2. To achieve the best-fitting parsimonious multivariable logistic model, we compared it to the generalized linear modelling and used the Akaike’s Information Criterion (AIC) [AIC = deviance/n + 2df deviance/n] to determine the contribution of a given variable to the model and eliminated any variable not significantly changing the AIC. For example, we evaluated tumor stage and site as confounders and found that AIC did not change and these were therefore, eliminated as a variable in the final model. A priori alpha was p ≤ 0.05 and tests were two-tailed. Statistical analyses were performed using IBM SPSS Statistics for Windows, version 25 (SPSS, Chicago, IL).

3. Results

Owing to lack of information on effect size and variance as well as for the demographics of EI sub-group classification in our patient population, an a priori sample size calculation was not attempted. This investigation can therefore be considered exploratory. Data were collected from (January 2011–December 2012), during which time a total of 295 newly diagnosed with HNC had their initial visit to the
### Table 1. Demographic and clinical characteristics of treatment naïve head and neck cancer (HNC) patients and by Eichner Index classes.

| Demographic or clinical characteristics | All Patients | Eichner Index Class | P value* |
|----------------------------------------|--------------|---------------------|----------|
| n = 104                                | A (n, %)     | B (n, %)            | C (n, %) |
| **Eichner Index Classification (n, %)** |              |                     |          |
| A1                                     | 20 (19.2)    |                     |          |
| A2                                     | 18 (17.3)    |                     |          |
| A3                                     | 6 (5.8)      |                     |          |
| B1                                     | 1 (1.0)      |                     |          |
| B2                                     | 20 (19.2)    |                     |          |
| B3                                     | 26 (25.0)    |                     |          |
| B4                                     | 0 (0)        |                     |          |
| C1                                     | 2 (1.9)      |                     |          |
| C2                                     | 7 (6.7)      |                     |          |
| C3                                     | 4 (3.8)      |                     |          |
| Total Anterior occlusal teeth (mean, median, SD) | 5, 6 (3)     | 7, 8 (1)            | 5, 5 (2) | 0, 0 (1) | 0.000 |
| Total Posterior occlusal teeth (mean, median, SD) | 5, 5 (3)     | 8, 8 (1)            | 4, 3 (2) | 0, 0 (1) | 0.000 |
| Total number of teeth (mean, median, SD) | 22, 24 (8)   | 28, 28 (2)          | 20, 21 (4) | 5, 6 (4) | 0.000 |
| Age, years (mean, median, SD) | 57, 57 (10.5) | 54, 53 (10.6) | 59, 61 (9.2) | 67, 67 (8.9) | 0.000 |
| Male (n, %) | 84 (81) | 38 (86) | 38 (81) | 8 (61) | 0.152 |
| Weight, kg (mean, median, SD) | 80.0, 78.0 (20.0) | 82.7, 81.0 (20.8) | 78.7, 77.0 (20.2) | 74.9, 75.0 (16.3) | 0.321 |
| Height, m (mean, median, SD) | 1.7, 1.7 (0.1) | 1.7, 1.7 (0.08) | 1.7, 1.7 (0.09) | 1.7, 1.7 (0.14) | 0.868 |
| Six month percent weight loss** (WL) (mean, median, SD) | -2.8, -1.4 (6.3) | -3.2, -1.5 (5.3) | -2.6, 0.0 (7.3) | -2.5, -2.5 (6.0) | 0.615 |
| Number of patients experiencing WL (n, %) | 40 (38.4) | 16 (36.4)* | 17 (36.2)* | 7 (53.8)* | 0.543 |
| Number of patients experiencing >5% WL (n, %) | 27 (25.9) | 11 (25.0)* | 11 (23.4)* | 5 (38.5)* | 0.549 |
| Body mass index (BMI) (kg/m²) (mean, median, SD) | 26.7, 26.0 (5.4) | 27.2, 26.5 (5.1) | 26.3, 25.9 (5.6) | 26.3, 24.7 (4.7) | 0.262 |
| WHO BMI categories (n, %) | <18.5 | 3 (2.9) | 0 (0)* | 3 (6.4)* | 0 (0)* | 0.817 |
| 18.5 to 24.9 | 38 (36.5) | 15 (34.1)* | 16 (34.0)* | 7 (53.8)* | 0.437 |
| 25.0 to 29.9 | 40 (38.5) | 19 (43.2)* | 18 (38.3)* | 3 (23.1)* | 0.560 |
| 30.0 to 34.9 | 13 (12.5) | 5 (11.4)* | 6 (12.8)* | 2 (15.4)* | 0.272 |
| 35.0 to 39.9 | 8 (7.7) | 4 (9.1)* | 3 (6.4)* | 1 (7.7)* | 0.136 |
| >40.0 | 2 (1.9) | 1 (2.3)* | 1 (2.1)* | 0 (0)* | 0.000 |
| AJCC 6 Tumor Staging (n, %) | Stage I | 1 (1.0) | 0 (0)* | 0 (0)* | 1 (7.7)* | 0.437 |
| Stage II | 8 (7.7) | 3 (6.8)* | 4 (8.5)* | 1 (7.7)* | 0.014 |
| Stage III | 22 (21.2) | 11 (25.0)* | 7 (14.9)* | 4 (30.8)* | 0.014 |
| Stage IV | 66 (63.4) | 25 (56.8)* | 33 (70.3)* | 7 (53.8)* | 0.014 |
| Unknown, primary | 7 (6.7) | 4 (9.1)* | 3 (6.4)* | 0 (0)* | 0.014 |
| AJCC 6 Tumor Staging Groups (n, %) | Stage I and II | 9 (8.7) | 3 (6.8)* | 4 (8.5)* | 2 (15.4)* | 0.014 |
| Stage III, IV and unknown, primary | 95 (91.3) | 41 (93.2)* | 43 (91.5)* | 11 (84.6)* | 0.014 |
| Aggregate Tumor Site (n, %) | Oropharynx | 41 (39.4) | 16 (36.4)* | 20 (42.6)* | 5 (38.5)* | 0.272 |
| Oral cavity | 17 (16.3) | 5 (11.4)* | 10 (21.3)* | 2 (15.4)* | 0.272 |
| Hypopharynx | 6 (5.8) | 1 (2.3)* | 3 (6.4)* | 2 (15.4)* | 0.272 |
| Nasopharynx | 14 (13.5) | 9 (20.5)* | 5 (10.6)* | 0 (0)* | 0.272 |
| Larynx | 13 (12.5) | 6 (13.6)* | 3 (6.4)* | 4 (30.8)* | 0.272 |
| Salivary Glands | 6 (5.8) | 4 (9.1)* | 2 (4.3)* | 0 (0)* | 0.272 |
| Paranasal sinuses | 1 (1.0) | 0 (0)* | 1 (2.1)* | 0 (0)* | 0.272 |
| Other, ill-defined sites | 6 (5.8) | 3 (6.8)* | 3 (6.4)* | 0 (0)* | 0.272 |
| Planned Treatment (n, %) | Surgery | 5 (4.8) | 1 (2.3)* | 2 (4.3)* | 2 (15.4)* | 0.136 |
| Radiotherapy (RT) | 5 (4.8) | 1 (2.3)* | 1 (2.1)* | 3 (23.1)* | 0.136 |
| Chemotherapy (CT) | 2 (1.9) | 0 (0)* | 2 (4.3)* | 0 (0)* | 0.136 |
| Surgery/RT | 18 (17.3) | 9 (20.5)* | 9 (19.1)* | 0 (0)* | 0.136 |
| RT/CT | 47 (45.2) | 22 (50.0)* | 20 (42.6)* | 5 (38.5)* | 0.136 |
| Surgery/RT/CT | 23 (22.1) | 9 (20.5)* | 11 (23.4)* | 3 (23.1)* | 0.136 |
| Other (refused treatment, unknown) | 4 (3.8) | 2 (4.5)* | 2 (4.3)* | 0 (0)* | 0.136 |

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Table 1 (continued)

| Demographic or clinical characteristics | All Patients | Eichner Index Class | P value* |
|----------------------------------------|--------------|---------------------|----------|
|                                          | n = 104      | A (n, %)            | B (n, %) | C (n, %) |
|                                        |              | 44 (42.3)          | 47 (45.1) | 13 (12.5) | 0.271 |
| ECOG Performance Status (PS) (n, %)    |              |                     |          |          |
| ECOG PS 0, no limitations              | 46 (44.2)    | 21 (47.7)%          | 20 (42.6)% | 5 (38.5)% |
| ECOG PS 1, not my normal self          | 38 (36.5)    | 18 (40.9)%          | 15 (31.9)% | 5 (38.5)% |
| ECOG PS 2, not feeling up to most things | 14 (13.5)  | 4 (9.1)%            | 9 (19.1)%  | 1 (7.7)%  |
| ECOG PS 3, able to do little           | 4 (3.8)      | 0 (0)%              | 2 (4.3)%    | 2 (15.4)%  |
| ECOG PS 4, bedridden                   | 1 (1.0)      | 0 (0)%              | 1 (2.1)%    | 0 (0)%    |
| Missing                                 | 1 (1.0)      | 1 (2.3)%            | 0 (0)%        | 0 (0)%      |
| ECOG Performance Status (PS) groups (n, %) |          |                     |          |          |
| Normal PS, ECOG PS 0                   | 46 (44.2)    | 21 (47.7)%          | 20 (42.6)% | 5 (38.5)% |
| Reduced PS, ECOG PS 1-4                | 57 (54.8)    | 22 (50.0)%          | 27 (57.4)% | 8 (61.5)% |
| Dietary Intake (DI) Category (n, %)    |              |                     |          |          |
| DI – 0, Normal food, normal amount     | 62 (59.6)    | 34 (77.3)%          | 23 (48.9)% | 5 (38.5)% |
| DI – 1, Normal food, less than normal  | 26 (25.0)    | 7 (15.9)%           | 14 (28.9)% | 5 (38.5)% |
| DI – 2, Little solid food              | 11 (10.6)    | 3 (6.8)%            | 6 (12.8)%   | 2 (15.4)%  |
| DI – 3, Very little of anything        | 5 (2.9)      | 0 (0)%              | 2 (4.3)%    | 1 (7.7)%  |
| DI – 4, Only liquids                   | 1 (1.0)      | 0 (0)%              | 1 (2.1)%    | 0 (0)%    |
| DI – 5, Only nutritional supplements   | 1 (1.0)      | 0 (0)%              | 1 (2.1)%    | 0 (0)%    |
| DI Category (n, %)                     |              |                     |          |          |
| Normal DI, DI – 0                      | 62 (59.6)    | 34 (77.3)%          | 23 (48.9)% | 5 (38.5)% |
| Reduced DI, DI – 1-5                   | 42 (40.3)    | 10 (22.7)%          | 24 (51.1)% | 8 (61.5)% |
| Total Nutrition Impact Symptom interference score (mean, median, SD) | 23, 20 (10) | 18, 18 (6)%     | 26, 23 (12)% | 25, 27 (13)% | 0.000 |

Abbreviations: AJCC, American Joint Committee on Cancer; BMI, Body Mass Index; CT, Chemotherapy; DI, Dietary Intake; ECOG, Eastern Cooperative Oncology Group; EI, Eichner Index; NIS, Nutrition Impact Symptom; PS, Performance Status; RT, Radiotherapy; SD, Standard Deviation; WHO, World Health Organization; WL, Weight Loss.

Each subscript letter denotes a subset of the Eichner Index class whose column proportions significantly do not differ from each other at the 0.05 level.

* Percent weight loss (WL) was based on weight reported in previous 6 months; if missing, the one month time frame for reported percent WL was substituted where available (ie, previous 1 month). Percent WL was calculated as follows [current weight in kg – previous six month weight in kg]/previous six month weight in kg x 100%.

Dental clinic and new patient outpatient oncology clinic at the cancer treatment center. A random sample of 132 (45% of the population) were selected and of these 28 (21%) patients were excluded due to missing data or reliance on tube feeding or nutrition by vein, leaving 104 patients in the final analysis.

Demographic and clinical characteristics are presented for all patients and by EI-class (Table 1). Overall, the population was 80% male, 91% presented with cancer stage III or IV, over half of tumors were within the oral cavity or oropharynx area, 60% were overweight or obese, 55% presented with cancer stage III or IV, over half of tumors were within the oral cavity or oropharynx area, 60% were overweight or obese, 55% presented with reduced PS, 40% had a reduced DI. The entire range of the 10 EI-subclasses was represented, with the exception of sub-class B4. Overall, 42, 45 and 13% of patients were in EI-class A, B and C respectively, with a median of 8, 3, and 0 total posterior occlusal teeth. One patient was edentulous. PS and cancer stages were not significantly different between EI-classes A, B and C (Table 1). The laryngeal tumor site varied between EI-class B and C and some tumor sites were not represented in all EI-classes. Across the EI-classes, patients were increasingly likely to experience reduction in the amount of food intake and while only 6.6% of patients in EI-class A were taking “little solid food” or “only liquids”, while 12% of EI-class B and 15% of EI-class C patients had difficulty consuming “solid food”. EI class C was a small group and the possibility that this group had greater nutritional impairments could not be evaluated. For this reason several planned analyses were conducted with pooled EI-class B and C patients.

Unimpaired DI, as defined by normal food in normal amount decreased across the EI-classes, and was reported by 77, 49 and 39% of patients in EI-class A, B and C, respectively. This was unexpected, especially for EI-class C patients, to experience no impairment of DI in spite of having zero posterior occlusal contacts and a median of only 3 teeth in total. Indeed WL and body mass index (BMI) were not significantly different across EI classes (Table 1). Patients in EI-classes B/C patients clearly included 2 subsets, those managing normal intake in normal amounts with a mean % WL = - 0.36 (S.D. = 3.02) and those who were experiencing reduced DI with a mean % WL = - 4.51 (S.D. = 8.72).

3.1. Nutrition impact symptoms (NIS)

Aggregate NIS interference score as well as individual NIS interference scores are shown. Aggregate NIS score was significantly higher in EI-class B and C patients versus EI-class A (Table 1), so these patients had both fewer occlusal supports and a more complex symptom burden. EI-class B or C patients reported higher NIS interference compared to EI-class A (p ≤ 0.05) for 11 of 17 symptoms evaluated (Table 2). Six NIS, diarrhea, vomiting, constipation, altered smell and other were rare and occurred in ≤6% of patients. As expected, the most prevalent symptom showing differential prevalence across EI-classes was difficulty chewing, affecting 9.1%, 42.6% and 53.8% of patients in EI-classes A, B and C, respectively. The second most prevalent NIS was dysphagia, reported by 18.2, 40.4 and 53.8% of patients in EI Classes A, B and C, respectively. Next, both dry mouth and thick saliva impaired DI in 4.5%, 17–19%, and 30.6%. Pain affected ~50% or more of patients in EI-classes B and C, respectively. The second most prevalent NIS was dysphagia, reported by 18.2, 40.4 and 53.8% of patients in EI Classes A, B and C, respectively.
| Nutrition Impact Symptom interference score equal to 1 vs ≥ 2 for all treatment naïve head and neck cancer patients and by Eichner Index Class. | All Patients Eichner Index (EI) Class | P-value<sup>a</sup> |
|-------------------------------------------------|----------------------------------|-----------------|
| **No Dysphagia** 70 (67.3) 36 (81.8) | A (n = 44) B (n = 47) C (n = 13) | 0.016 |
| No Other (lack of money, etc) 6 (5.8) 1 (2.3) 4 (8.5) | 7 (5.3) 7 (5.3) 7 (5.3) | 0.023 |
| Vomiting 2 (1.9) 0 (0) 2 (4.3) | 0 (0) 0 (0) 0 (0) | 0.000 |
| No Nausea 92 (88.5) 41 (90.9) 13 (100.0) | 0 (0) 0 (0) 0 (0) | 0.000 |
| No Diarrhea 99 (95.2) 44 (100.0) | 0 (0) 0 (0) 0 (0) | 0.000 |
| No Anxiety 79 (76.0) 37 (84.1) | 32 (68.1) 10 (76.9) | 0.198 |
| Loss of Appetite 77 (74.0) 38 (86.4) | 29 (61.7) 10 (76.9) | 0.023 |
| Loss of Appetite 27 (26.0) 6 (13.6) | 18 (38.3) 3 (23.1) | 0.000 |
| No Smear Bother(some) 101 (97.1) 44 (100.0) | 43 (91.5) 12 (92.3) | 0.396 |
| No Vomiting 102 (98.1) 44 (100.0) | 41 (87.2) 12 (92.3) | 0.034 |
| Constipation 7 (6.7) 0 (0) | 6 (12.8) 1 (7.7) | 0.000 |
| No Nausea 92 (88.5) 41 (90.9) | 38 (80.9) 13 (100.0) | 0.067 |
| No Smear Bother(some) 3 (2.9) 0 (0) | 3 (6.4) 0 (0) | 0.000 |
| No Other (lack of money, etc) 98 (94.2) 43 (97.7) | 43 (91.5) 12 (92.3) | 0.000 |
| Other (lack of money, etc) 6 (5.8) 1 (2.3) | 4 (8.5) 1 (7.7) | 0.000 |

Each subscript letter denotes a subset of the Eichner Index class whose column proportions significantly do not differ from each other at the 0.05 level.  
* Fisher's Exact test or Chi-square test applied (2-sided).

Logistic regression was also undertaken to determine the odds ratio (OR) of having reduced dietary intake versus normal dietary intake (reference) in the subset of patients with dentition of EI-class B/C. At the univariable level (Table 3), age, sex, BMI, cancer stage, tumor site, dry mouth and depression were not significantly related to reduced DI while any %WL ≥ 5% WL, reduced PS, eight NIS and total NIS interference score were significantly associated with EI-classes B/C with reduced DI compared to EI-classes B/C with normal DI. In the multivariable analysis (Table 4), owing to sample size considerations, a single aggregate NIS score was included in this analysis, rather than the 10 individual symptoms that were significantly more frequent in patients in EI-class B/C. The multivariable analysis demonstrates that total NIS interference score and reduced PS were significantly associated with EI-classes B/C with reduced DI compared to EI-classes B/C with normal DI.

### 4. Discussion

Our study shows that patients with cancers of the head and neck present with a wide range of total numbers of teeth and that they vary from a complete set of posterior over occlusal surfaces, to none at all. We found that 57% of the treatment naïve HNC patients had some degree of reduced posterior occlusal contact, which is similar to that reported by
Table 3. Univariable logistic regression analysis comparing Eichner Index (EI) reference classes.

| Variable                              | EI-class A (N = 44) | EI-classes B/C with normal Dietary Intake (DI) (N = 28) | EI-class A | EI-classes B/C with normal DI |
|----------------------------------------|---------------------|----------------------------------------------------------|------------|--------------------------------|
| Reduced DI, DI − 0                     | 3.88 (1.63–9.26)    | 0.002                                                    |            |                                |
| Nutrition Impact Symptoms (NIS)        |                      |                                                          |            |                                |
| CHEWING DIFFICULTY                    | 8.18 (2.59–25.75)   | 7.00 (2.19–22.34)                                        | 0.000      | 0.001                          |
| DYSPHAGIA                              | 3.44 (1.37–8.64)    | 4.38 (1.44–13.28)                                        | 0.009      | 0.009                          |
| THICK SALIVA                           | 5.80 (1.23–27.25)   | 6.81 (1.35–34.15)                                        | 0.026      | 0.020                          |
| SORE MOUTH                             | 5.00 (1.56–15.94)   | 9.44 (2.36–37.70)                                        | 0.007      | 0.001                          |
| DRY MOUTH                              | 5.25 (1.11–24.81)   | 3.26 (0.78–13.54)                                        | 0.036      | 0.104                          |
| PAIN                                   | 6.33 (2.33–17.21)   | 7.66 (2.42–24.25)                                        | 0.000      | 0.001                          |
| LOSS of APPETITE                       | 3.41 (1.24–9.37)    | 6.80 (1.91–24.11)                                        | 0.017      | 0.003                          |
| FEELING FULL                           | 4.15 (1.11–15.5)    | 4.36 (1.07–17.74)                                        | 0.034      | 0.039                          |
| DEPRESSION                             | 4.55 (1.22–16.88)   | 1.00 (0.31–3.22)                                         | 0.023      | 1.000                          |
| LACK of ENERGY                         | 23.15 (2.97–180.28) | 10.71 (2.67–42.85)                                       | 0.003      | 0.001                          |
| TOTAL NIS INTERFERENCE SCORE           | 1.10 (1.03–1.17)    | 1.11 (1.03–1.20)                                         | 0.003      | 0.003                          |

Abbreviations: AJCC, American Joint Committee on Cancer; BMI, Body Mass Index; CI, confidence interval; DI, Dietary Intake; ECOG, Eastern Cooperative Oncology Group; EI, Eichner Index; NIS, Nutrition Impact Symptoms; OR, odds ratio; PS, Performance Status; ref, reference group; vs, versus; WL, Weight Loss.

Friedman et al. (2008) [23], in a sample of 34 male HNC patients. In our sample EI class was strongly related to the patient's subjective experience of chewing difficulty. Posterior occlusal contacts are considered essential for mastication and swallowing, thus any reduction to these contacts would be expected to make it challenging to maintain optimal DI [11, 12, 13, 14, 15]. Reduced numbers of occlusal surfaces associated overall with impairments of DI and these results concur with reports on healthy and older adult subjects [9, 10, 13, 14, 20]. However, we found that many patients experience no impairment of DI and were able to maintain their body weight in spite of having as few as five teeth in total and zero posterior occlusal surfaces. The absence of occlusal surfaces is not necessarily an absolute impairment to achieving normal DI. Patients with EI-class B/C who were nutritionally successful had a relatively limited number of additional NIS and obstacles to DI. It is possible that EI-class B/C patients over preceding years have developed dietary strategies to maintain oral intake with fewer teeth. Thus, it would be most interesting to understand what dietary strategies are adopted by persons with EI-class B/C in order to maintain their body weight. This might involve selection of foods of high energy density and high-protein density, however a prospectively conducted study of dietary habits would be required to understand this further. Patients with EI-class B/C experienced nutritional impairment, when difficulty chewing was present in combination with a burden of additional symptoms, notably dysphagia, thick saliva, dry mouth and pain. This combination of deficits in mastication and salivation, combined with difficult and painful swallowing would be particularly detrimental to ingestion of solid food.

Patients with HNC are at high risk for severe impairment of food intake. Screening and assessment for malnutrition in patients with HNC are recommended in Clinical Nutrition [31] and French Society of Otorhinolaryngology [32] clinical practice guidelines. Several validated screening tools are recommended such as the PG-SGA® used here and the Nutrition Risk Index [32]. The application of validated tools for screening
of nutritional risk is especially important because high BMI at diagnosis as seen here and by others [33] cannot be taken to mean that nutrition risk is absent. Nutritional assessment at this tumor site is focused on symptoms impacting oral intake. It is rare for any person with HNC to necessarily have impaired DI, however the combination of EI-class B/C and a constellation of NIS, associated with reduced DI. Optimizing the dental status and NIS management may improve DI and reduce the risk of future WL of HNC patients.

Catherine Kubrak PhD RN declares copyrights for the instrument “Head and neck symptom checklist” and reports no other conflicts of interests to declare.

We have full control of all the primary data and we agree to allow the journal to review the data if requested.

Declarations

Author contribution statement

C. Kubrak: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

A. Farhangfar: Conceived and designed the experiments; Performed the experiments; Contributed reagents, materials, analysis tools or data.

V. Baracos: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

M. Woynorowski and W. Preshing: Performed the experiments; Contributed reagents, materials, analysis tools or data.

N. Jha: Contributed reagents, materials, analysis tools or data.

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Competing interest statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.
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